Lecture Notes in Electrical Engineering 185

Jiuping Xu
Masoom Yasinzai
Benjamin Lev *Editors*

Proceedings of the Sixth International Conference on Management Science and Engineering Management

Focused on Electrical and Information Technology

Volume 1

Springer

Lecture Notes in Electrical Engineering

Volume 185

For further volumes:
http://www.springer.com/series/7818

Jiuping Xu · Masoom Yasinzai
Benjamin Lev
Editors

Proceedings of the Sixth International Conference on Management Science and Engineering Management

Focused on Electrical and Information Technology

Springer

Editors
Jiuping Xu
Sichuan University
Chengdu
People's Republic of China

Masoom Yasinzai
Quaid-i-Azam University
Islamabad
Pakistan

Benjamin Lev
LeBow College of Business
Drexel University
Philadelphia, PA
USA

ISSN 1876-1100 ISSN 1876-1119 (electronic)
ISBN 978-1-4471-4599-8 ISBN 978-1-4471-4600-1 (eBook)
DOI 10.1007/978-1-4471-4600-1
Springer London Heidelberg New York Dordrecht

Library of Congress Control Number: 2012947985

© Springer-Verlag London 2013

The Walmart names and logos and all related product and service names, design marks and slogans are the trademarks or service marks of Walmart Stores, Inc.

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

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

Preface

Welcome to the proceedings of the Sixth International Conference on Management Science and Engineering Management (ICMSEM2012) held from November 11 to 14, 2012 at Quaid-i-Azam University, Islamabad, Pakistan.

International Conference on Management Science and Engineering Management is the annual conference organized by the International Society of Management Science and Engineering Management. 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. 1090 papers from 33 countries were received and 90 papers from 10 countries were accepted for presentation or poster display at the conference after a serious review. These papers are from countries including USA, UK, Spain, Portugal, Turkey, China, Azerbaijan, India, Pakistan. They are classified into 8 parts in the proceedings which are Computer and Networks, Information Technology, Decision Support System, Industrial Engineering, Supply Chain Management, Project Management, Manufacturing and Ecological Engineering. The key issues of the sixth 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 support from National Natural Science Foundation of China and help from Quaid-i-Zam 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.

11-14 November 2012 *ICMSEM General and Program Chairs*
Islamabad, Pakistan

Contents

Part I Computer and Networks

Part II Information Technology

Part III Decision Support System

Part IV Industrial Engineering

Part V Supply Chain Management

Part VI Project Management

Part VII Manufacturing

Part VIII Ecological Engineering

Organization

ICMSEM 2012 was organized by International Society of Management Science and Engineering Management, supported by Sichuan University (Chengdu, China), Quaid-i-Azam University (Islamabad, Pakistan) and The National Natural Science Foundation of China. It was held in cooperation with Lecture Notes in Electrical Engineering (LNEE) of Springer.

Executive Committee

General Chairs:	Prof. Jiuping Xu, Sichuan University, China Prof. Masoom Yasinzai, Quaid-I-Azam University, Pakistan
Program Committee Chairs:	Prof. Hajiyev Asaf, National Academy of Sciences of Azerbaijan, Azerbaijan Prof. Shavkat Ayupov, Academy of Sciences of Uzbekistan, Uzbekistan Prof. Le Dung Trang, Abdus Salam ICTP, Vietnamese & French Prof. Benjamin Lev, Drexel University, USA Prof. Nicolas Markatos, National Technical University of Athens, Greece Prof. José Antonio de la Peña Mena, Mexican Academy of Sciences, Mexico Prof. Alberto Pignotti, University of Buenos Aires, Argentina Prof. Baldev Raj, Indian National Academy of Engineering,

	India Prof. Roshdi Rashed, National Center of Scientific Research, France Prof. Juan Ignacio Ramos Sobrados, Universidad de Málaga, Spain
Organizing Committee Chair:	Prof. Eatzaz Ahmed, Quaid-I-Azam University, Pakistan
Local Arrangement Committee Chair:	Mr. Muhammad Junaid, School of Management Sciences, Quaid-i-Azam University Islamabad, Pakistan
Local Arrangement Committee:	Dr. Abdul Qayyum, School of Management Sciences, Quaid-i-Azam University Islamabad, Pakistan Ms. Perkha Khan, School of Management Sciences, Quaid-i-Azam University Islamabad, Pakistan Mr. Asif Abbas Naqvi, School of Management Sciences, Quaid-i-Azam University Islamabad, Pakistan Mr. Burhan Ali Shah, School of Management Sciences, Quaid-i-Azam University Islamabad, Pakistan
Program Committee:	Prof. Mohammad Z. Abu-Sbeih, King Fahd University of Petroleum and Minerals, Saudi Arabia Prof. Joseph G. Aguayo, University of Concepcion, Chile Prof. Basem S. Attili, United Arab Emirates University, United Arab Emirates Prof. Alain Billionnet, Ecole National Superieure Informatics for Industry and Enterprise, France Prof. Borut Buchmeister, University of Maribor, Slovenia Prof. Daria Bugajewska, Adam Mickiewicz University, Poland Prof. Saibal Chattopadhyay, Indian Institute of Management, India Prof. Edwin Cheng, Hong Kong Polytechnic University, Hong Kong Prof. Anthony Shun Fung Chiu, De La Salle University, Philippines Prof. Jeong-Whan Choi, Department of Mathematics, Korea Prof. Kaharudin Dimyati, University of Malaya, Malaysia

Prof. Behloul Djilali, University of Sciences and Technology Houari Boumediene, Algeria
Prof. Eid Hassan Doha, Cairo University, Giza, Egypt
Prof. O'Regan Donal, National University of Ireland, Ireland
Dr. Siham El-Kafafi, Manukau Institute of Technology, New Zealand
Prof. Christodoulos A. Floudas, Princeton University, USA
Prof. Masao Fukushima, Kyoto University, Japan
Prof. Oleg Granichin, Sankt-Petersburg State University, Russia
Prof. Bernard Han, Western Michigan University, USA
Dr. Rene Henrion, Humboldt University, Germany
Prof. Voratas Kachitvichyanukul, Asian Institute of Technology, Thailand
Prof. Il Bong Jung, Kyungpook National University, Korea
Prof. Arne Løkketangen, Molde University College, Norway
Dr. Andres Medaglia, University of the Andes, Colombia
Prof. Venkat Murali, Rhodes University, South Africa
Prof. Shmuel S. Oren, University of California, USA
Prof. Dr. Turgut Öziş, Ege University,Turkey
Prof. Panos M. Pardalos, University of Florida, USA
Prof. Gianni Di Pillo, Sapienza University of Rome, Italy
Prof. Nasrudin Abd Rahim, University of Malaya, Malaysia
Prof. Celso Ribeiro, Fluminense Federal University, Brazil
Prof. Hsin Rau, Chung Yuan Christian University, Taiwan
Prof. Jan Joachim Ruckmann, University of Birmingham, UK
Prof. Martin Skitmore, Queensland University of Technology, Australia
Prof. Frits C. R. Spieksma, Katholieke University Leuven, Belgium
Prof. Yong Tan, University of Washington, USA
Prof. Albert P. M. Wagelmans, Erasmus University Rotterdam, Netherlands
Prof. Desheng Dash Wu, University of Toronto, Canada

	Prof. Hong Yan, Hong Kong Polytechnic University, Hong Kong
Secretary-General:	Prof. Zhineng Hu, Sichuan University, China
Under-Secretary General:	Dr. Yanfang Ma, Sichuan University, China Dr. Yan Tu, Sichuan University, China Dr. Cuiying Feng, Sichuan University, China
Secretaries:	Xiaoling Song, Zongmin Li, Ziqiang Zeng, Muhammad Hashim, Qiurui Liu, Muhammad Nazim, Abid Nadeem, Usman Yousaf, Ali Raza, Abdul Razzaq, Wasim Abbas Shaheen

Chapter 1
Advancements of Engineering Management based on Electrical and Information Technology for The Sixth ICMSEM

Jiuping Xu

Abstract Engineering management based on electrical and information technology (EMEI) can be defined as is an interdisciplinary subject that focuses on solving the engineering management problems based on the engineering background in on a the platform of networks and computer and networks, information technology, project management, decision support systems, industrial engineering, supply chain management, manufacturing, and ecological engineering. In this paper, an overview of six ICMSEMs is firstly presented with the goal of fostering international research collaboration in EMEI. Secondly, this paper provides the investigates the key issues of the sixth ICMSEM to follow the trend of the technology development. Thirdly, the course of EMEI development in EMEI shows has been shown to have a positive effects on in both the academic research and practice guidance application. Its continuous development has brought on an upsurge in resulted in an increase in research and which tends to indicates an increasing trend of development trend. From 2007 to 2012, The ICMSEM from 2007 to 2012 are closely concerned focused on with the trend of EMEI development for EMEI and has reflects reflected the EMEI advancements in EMEI to some extent. Then,In this paper, an evaluation of the sixth conference is used to highlight the EMEI progress. With its the new breakthrough in conference organization, ICMSEM provides a convenient and exclusive platform for academic exchange and communication and will continue to play a role in promoting the EMEI advancements in EMEI in the future. Furthermore, the a unique research Computer-based Research Paradigm idea of Computer-based Research Paradigm is put forward to interpret the outstanding ICMSEM and promote the EMEI development of EMEI. Last but not the least,Finally, this paper expresses our appreciation for those who have made contribution ed to ICMSEM and those who have shown interest to in EMEI.

J. Xu (✉)
Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, P. R. China
State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University, Chengdu 610064, P. R. China
e-mail: xujiuping@scu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_1, © Springer-Verlag London 2013

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

1.1 Overview of the Previous Five ICMSEMs

Management Science (MS) and Engineering Management (EM), because of their focus on computer, networks and information technology, have significant effects on engineering project management, decision making, evaluation and forecast, supply chain management, risk management and ecological engineering management. MSEM and EMEI have had significant international economic development in recent years and is becoming a popular topic for management research. 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.

Since 2007, ICMSEM has been successfully held five times in Chengdu, Chongqing, Bangkok (Thailand), Taiwan and Macau. The proceedings of the previous four ICMSEM have been archived by ISTP retrieval and the proceedings of the First and the Third ICMSEM have been archived by EI retrieval. The proceedings of the Fifth ICMSEM (2011) have been delivered to both ISTP and EI retrieval. The sixth conference will be held in Quaid-i-Azam University, Islamabad, Pakistan on November 11-14, 2012. The total number of received and accepted papers in all six ICMSEMs are shown in Fig. 1.1.

The previous five ICMSEMs had great achievements with more than 5592 papers received from nearly 40 countries and nearly 480 papers accepted for presentation or poster display at the conference after a thorough referee review [27, 28]. The accepted papers were from more than 20 countries, including the UK, the USA, Germany, Spain, Portugal, Australia, Japan, Korea, Brazil, Turkey, India, Azerbaijan, Pakistan, China and Thailand. Papers in the previous five 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 Chain, Financial Management, Enterprise Management, Environment Resources Management, Knowledge Management, Risk and Emergency Management, and Service Management.

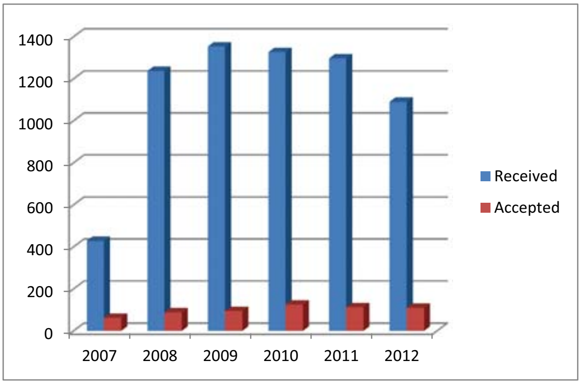


Fig. 1.1 The total number of received and accepted papers in the ICMSEM for the first six years

1.2 Key Issues of the Sixth ICMSEM

The sixth ICMSEM will be held in November 11-14, 2012 in Islamabad, Pakistan and will be a further development of the previous five years' conferences. This year, 1090 papers from 33 countries have been received and 90 papers from 10 countries have been accepted for presentation or poster display at the conference. The papers accepted are from many countries including the USA, the UK, Spain, Portugal, Turkey, China, Azerbaijan, India, and Pakistan. They are classified into 8 parts in the proceedings: Computer and Networks, Information Technology, Decision Support System, Industrial Engineering, Supply Chain Management, Project Management, Manufacturing and Ecological Engineering. The key issues at the sixth ICMSEM covers 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, Heuristics Algorithms, Risk Control, and Carbon Credits. Besides these, 78 are papers sponsored by national funds, 52 by provincial funds and 11 papers by school funds. All papers in the proceedings have already 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 on year. Figs. 1.1 and 1.2 show the total number of papers and fund support for the ICMSEM over the first six years, respectively, which shows the upsurge of the ICMSEM in not only the total number of received and accepted papers, but also the fund support on all levels in the ICMSEM over the first six years. Throughout these years, to ensure the quality

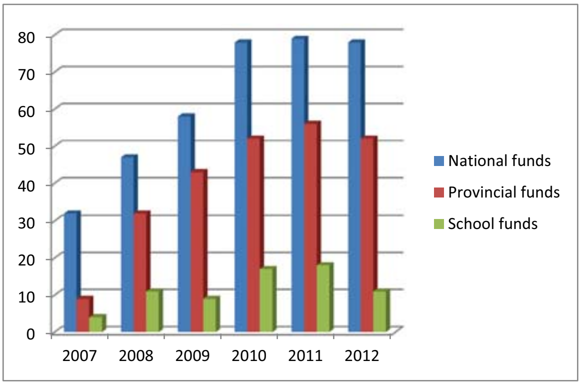


Fig. 1.2 The total number of fund supports on all levels in the ICMSEM for the first six years

of the papers accepted, this paper has always maintained a small acceptance rate. For fund support, national funding has been the highest every year and there has been a significant growth in all types of fund support over the years.

Compared with the proceedings of the fifth ICMSEM, the proceedings of the sixth ICMSEM concentrate on solving management problems in a unique way based on engineering problems and computer-based techniques. The research papers are divided into 8 sections covering the most popular issues of the day. The sixth proceedings are closely related to the principle of the sixth ICMSEM to maintain and contribute to the international standard.

Computers and networks provide a platform for solving practical management problems in a convenient way. They are the basic tools in EMEI. In this section, Rizwan and Irfan propose a Secure Routing Protocol (SRP) OLSR Message for Mobile social networks and successfully implement it. Oepomo studies and compares several iterative procedures based on the Oepomo, Power, and QR methods for solving dominant eigenvalues of essentially positive matrices. Ascending and descending techniques lead to a new iterative method and a new algorithm, which are compared to the Power and QR methods in terms of speed of convergence, number of required mathematical operations, and effectiveness to numerically calculate dominant eigenvalues of essentially positive matrices. Ge et al investigates the mathematical modeling of the maintenance effects in an optimal maintenance model, which was motivated by the Arithmetic Reduction of Intensity model with memory (ARI) and is used to unveil the quality of the maintenance performed according to current state or condition of equipment rather than its virtual age. Research in this section has an excellent combination of computer-based techniques and practical guidance.

Information technology (IT) is also an appropriate technical platform for discussing management problems, and it is ”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 [30]. IT is becoming more and more important in modern society. Liu et al puts forward that the IT industry is changing from product-oriented to service-oriented, and as a result, IT service management has become more and more important. They indicate that the integration of IT and business means that IT service quality becomes more and more important. Further research develops an index system for IT service quality evaluation in the development of enterprise IT management after systematically analyzing the research of service and IT service quality. Huang and Wang present a preliminary research framework for technology diffusion based on patent information.

Decision support systems, the third section, is a class of computer- based information systems that support knowledge management, decision making, and management reporting. These systems aim at supporting decision making activities. Decision support systems assist managers in making decisions in a highly uncertain and complex environment. As decision making affects every domain in EMEI, the significance of decision support systems is obvious. Fausto and Marta present a dual optimization problem that consists of finding optimal routes of the principal and capillary routes, and employ a recurrent neural network approach, which involves not only unsupervised learning to train the neurons, but also an integrated approach where the Genetic Algorithm is utilized to train neurons so as to obtain a model with the least error. Ali et al proposes a new method to find overloaded nodes at an upper level threshold (peak load), and also performs PMs consolidation at the lower-level threshold and puts an idle server into a sleep state, by using the Best Fit Decreasing based on TOPSIS, one of the most efficient Multi Criteria Decision Making techniques. Wang et al builds a new three-dimensional TSP programming model to overcome the optimal path in a low-level picker-to-part system problem, and designs the corresponding genetic algorithm and program code running on Matlab to solve the model.

Industrial engineering is a branch of engineering dealing with the optimization of complex processes or systems. Its underlying concepts overlap considerably with certain business-oriented disciplines such as operations management, but the engineering side tends to emphasize extensive mathematical proficiency and usage of quantitative methods. In this part, Hu and Zhang predict the energy consumption for heavy industry enterprises by applying a BP neural network framework and the Adaboost algorithm. Lv et al analyze the sustainable development abilities of twenty nine branches in the industry from aspects of economic development and resource environment protection. Zhao and Kong measured the impact of monetary policy on urban and rural prices, finding that significant differences exist. Zhang et al proposed a new approach towards safety assessment on cranes in service. A Fault Tree Analysis is implemented to determine the common types of accidents and causations, based on a literature research and the practical assessment of special equipment safety.

Supply chain management (SCM) is an interconnected businesses network which is involved in the ultimate provision of product and service packages required by end customers [32]. Supply chain management spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption (supply chain). In this part, supply chain process design and improvement, supply chain operations and marketing, financial and organization structure are involved, and they reflect the current leading-edge supply chain management research. Rashid explores the impact of quick response (QR) issue on demand driven supply chain management (SCM) and establishes an objective measure for the implementation of QR in an apparel supply chain to remain competitive in a global fashion market. Xu and Xiong set up three equilibrium models using equilibrium theory, such as the decentralized decision model when all agents make decisions to maximize their own profits, the brand-profit-maximum model when two dominant manufacturers make decisions to maximize the profits of their own brands, and the channel-profit-maximum model when two dominant retailers make decisions to maximize the profits of their channels. Xu et al studies short life cycle product supply chain contract coordination problems based on demand uncertainty and relevance to retailers' promotional effort level.

Project management is the discipline of planning, organizing, securing and managing resources to bring about the successful completion of specific project goals and objectives. In this part, the scholars tend to accomplish desired goals and objectives using restricted resources efficiently and effectively. Ma defines the concept and connotations of large enterprise groups, then describes and analyzes the main content and the framework model for the governance of large enterprise groups. Qu et al establishes a model group for the diffusion process of primary and contingent products, and explores the impact of free samples on the diffusion process considering repeat purchases, multiple-unit purchase and various pricing strategies under supply restrictions. Zhong et al develops a new model which considers multiple-unit adoptions as a diffusion process under the influence of supply constraints based on the Bass model to determine the optimal combination of production scales and marketing strategies for a corporation.

Manufacturing is the use of machines, tools and labor to produce goods for use or sale. The term may refer to a range of human activity, from handicrafts to high tech, but is most commonly applied to industrial production, in which raw materials are transformed into finished goods on a large scale. In this section, Javed and Ghafoor conduct an export margin analysis and quantify the impact of the major factors influencing rice exports from Pakistan to the United Kingdom for two varieties of rice super basmati and coarse rice. Bu and Sun discuss an early earning mechanism from the perspectives of both the organizational guarantee of risk management and forecasting techniques using a Bayesian Model in the hope of assisting enterprises to predict and reduce the credit transaction risks. Li and Wang propose a model to simulate mankind's abstract logical thinking and use intuitive thought to measure enterprise technological innovation risk.

The final part is Ecological Engineering. Ecological engineering arises from an intent to integrate the ecology and engineering sectors that focus on the design, monitoring and construction of ecosystems [29]. According to Mitsch [34], "the design of sustainable ecosystems intends to integrate human society with its natural environment for the benefit of both" Barrett [33] offers a more literal definition of the term, "the design, construction, operation and management of landscape/aquatic structures and associated plant and animal communities to benefit humanity and, often, nature." Research on Ecological Engineering 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 [29]. Suo and Wu attempted to utilize the Agent frame and methods to try to solve the complicated decision. Firstly, they analyzed the decision-makers and the shareholders, and their roles in cross-border water resource conflict management in China. On this basis, they analyze the application feasibility of the Agent framework in our country and its approaches in technique and focus on an analytical framework of administrative networks, decision makers, technological capability and other factors. Finally, some management policy suggestions for the application of this framework are provided. Yu et al uses a systematic scientific method based on the classification of different types of low carbon technology, analyzes the constraints in the regional low carbon technology development process and shows that low carbon technology has public product attributes, and regional synergetic development is a necessary channel in the promotion of the overall sustainable development of low carbon technology.

Not all papers are listed here. Readers are strongly recommended to read the proceedings for more information about current research on EMEI.

1.3 Development Trends for EMEI based on the First Six ICMSEMs

In this section, a review of EMEI is presented as a summary of past research approaches with an aim to understanding their effects on future EMEI research and practice. We hope to answer three research questions: (1) What are the EMEI development trends showcased in the first six ICMSEMs? (2) Does ICMSEM research coincide with the trends in the international EMEI journals? and (3) What is the future of 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 inferences. The fundamental factor that distinguishes a systematic review from a traditional review of the literature is its comprehensive and unbiased search. In order to answer the three questions, two sets of papers have to be reviewed: all papers included in the proceedings of ICMSEM and the relevant research paper in EMEI journals.

1.3.1 Identification Procedure

The fundamental factor which distinguishes a systematic review from a traditional review of the literature is a comprehensive and unbiased search. In order to answer the three questions, two sets of papers have to be reviewed: all papers in the ICM-SEM proceedings and the main research in EMEI journals.

In order to find the EMEI research, the EMEI search terms and keywords have to be identified. This paper starts with a systematic search with the identification of 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 paper respectively chose 9 terms, which are of significance and common EMEI concerns, as the main search terms. These terms are shown in Table 1.2 which are different to the keywords according to EMEI trends . A secondary search was done based on references found in our primary studies. We also subdivided these search terms. For example, to find papers on heuristic algorithms, this paper uses almost all existing heuristics algorithms, such as genetic algorithms, ant colony optimization, particle swarm optimization, simulated annealing, the bee algorithm, meta-heuristics algorithm, and so on. In order to avoid overlooking any important research, additional searches were performed directly on key journals and authors.

This study considers three electronic bases as shown in Table 1.1. The research was performed in April 2012, and papers published from 2007 to April 2012 were selected. The identification process yielded 356046 articles, which formed the basis of the next step in the selection process.

Papers were then selected based on an exclusion criteria as follows:

1. 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 147875.
2. 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 97315.

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

These 97315 papers make up the initial document database. Following this, we eliminated more documents according to the following criteria:

Table 1.2 The main keywords used in the literature selection

Terms for		Terms for
○ Computer Engineering ○ Software engineering ○ Information Technology ○ Control Systems ○ Aerospace & Electronics ○ Industrial Informatics ○ Heuristics Algorithms ○ Risk Management ○ Bioengineering ○ Signal Processing ○ Project Management	and	• Electrical Engineering • Circuits and Systems • Electric Power • Engineering Management • Automatic Control • Intelligent Transportation • Computer and Networks • Supply chain • Materials engineering • Evolutionary Computation • Wireless Communications

1. The papers which solved engineering problems only from a pure technical perspective were eliminated. We entered the keywords “Management” into the initial document database, and 17159 documents were obtained.
2. Considering the engineering background of this research, we entered the keywords relevant to engineering management such as “engineering”, “engineering management”, “civil engineering” and “construction” to 17159 documents, and deleted the duplication. The number of articles was reduced to 2701.
3. In these 2701 papers, there were descriptions of books and journals. These were eliminated and the number of articles was reduced to 1289.
4. Based on this, this paper scrutinized abstracts and established 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 because of an indirect relationship to EMEI. Thus, the number of articles was reduced to 1056.

From the six criteria above, the final number of papers selected for review was 1056. The final reviewed papers are 1056 in international EMEI related journals and 590 papers from ICMSEM.

1.3.2 Survey of ICMSEM papers

In this section, we survey the development trends in the first six ICMSEM. Here, it is necessary to review articles published in all proceedings of the ICMSEM. Six ICMSEM proceedings have been published, and each contains 62 papers, 87 papers, 94 papers, 125 papers, 112 papers and 110 papers respectively. There is an upward trend in the development momentum as seen from the trend of the total number of papers in the ICMSEM proceedings. In fact, in the past ten years, rapid development has been achieved in the field of EMEI in two ways, theoretical and methodological research, and applications which have a close as well as important connection with the actuality. Nowadays, with the rapid development of computer and information science, there is a great deal of research on MS under the EM background using information technology, computers and networks. Thus, following this trend, these articles published in all six proceedings are divided into two groups: papers using these technologies and papers not using these technologies.

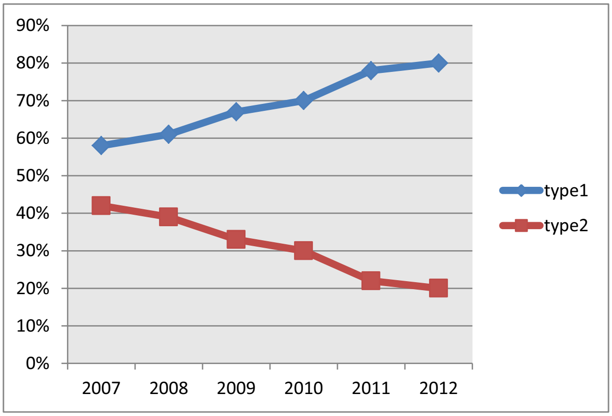


Fig. 1.3 The distribution of the articles in ICMSEM according to the two types for EMEI

Fig. 1.3 shows the distribution of the articles. We can see that most of these papers fall into the type 1, i.e., more research is using information technology or computer and networks in ICMSEM. It can also be seen that an increasing amount of scholars are doing research in an EMEI frame which emphasizes actual management background, effective theories and methods, and significant engineering practice. In addition, 22 engineering fields distribution of the articles according to EMEI engineering practice are shown in Table 1.3. We can see that there is an upsurge of research in ICMSEM and the number of research areas is expanding. For example, in the first four conferences, we received few papers on aviation engineering or earthquake engineering, but in the fifth, six papers on aviation engineering were published.

Xu [26] proposed 11 main engineering fields; construction, ecology, logistics, finance, computers, software, performance, knowledge, transportation, aviation and safety. From the table, we find that all 11 fields have been paid attention to in the fifth conference proceedings. At the same time, some new fields such as earthquake engineering also have been paid attention. In addition, ecological engineering is still a highlight of these proceedings. Aviation engineering is a branch of engineering behind the design, construction and science of aircraft and spacecraft [3] and has many elements including control engineering, materials science, fluid mechanics, electrotechnology, and risk and reliability [4]. Of these elements, risk is an important topic, especially in civil aviation industry [5]. In our proceedings, many papers are related to the civil aviation risk analysis . Safety engineering is an applied science strongly related to systems engineering and the subset system safety engineering.

Table 1.3 The distribution of the articles published in the proceedings of ICMSEM according to the engineering fields

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

Safety engineering assures that a life-critical system behaves as needed even when pieces fail. The theories of safety engineering have been applied to many fields including operator management, traffic control, aviation, food engineering, software engineering, and accident analysis [6–8].

In conclusion, we find two trends according to the articles of the first six ICMSEM: (1) More and more scholars are doing research in an EMEI framework which emphasizes actual management background, effective theories and methods, and significant engineering practice. (2) An increasing range of engineering fields are involved.

1.3.3 Evaluation of the First Six ICMSEMs

In this section, we evaluate the first six ICMSEMs and determine whether the trends above are coincident with the trends in EMEI journals.

Comparing with documents in EMEI journals, we found that there is a common trend between the ICMSEM and EMEI journals (see Fig. 1.4). In both the ICMSEM and EMEI journals, more than 50 percent of papers belong to research type 1, namely using information technology or computers and network in their papers. We can see that there is an obvious increasing momentum towards type 1 which reflects the fact that an increasing number of scholars are interested 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) which indicates than there is an excellent research momentum developing in EMEI.

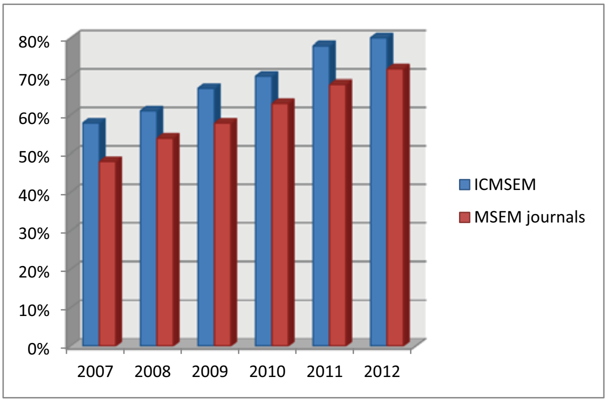


Fig. 1.4 Comparison between ICMSEM and EMEI journals according to the research type 1

We can also see that, more papers belong to the type 1 in the ICMSEM than the EMEI journals, as our conference always emphasizes the combination of MS and EM. This is a highlight of ICMSEM. Compared to other subjects, EMEI has particular objectives in the research, basic problems to solve, analytical methods to apply universally and technological tools. Essentially, EMEI places equal stress on theory and practice. The understanding of EMEI includes new theories and new methods, as well as the successful application of the theories and methods. In EMEI research, it is very important to link theory with practice. Practical research focusses on the framework of the problem and stresses that we make 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 the 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.

Using this type 1 research method, scholars found new and important practical research problems, so it is apparent that a wider range of engineering fields are being considered. Take the vehicle routing problem (VRP), which belongs to transportation engineering and scheduling problems in construction engineering, as an example. In recent years, VRP has attracted wider attention and been studied in both scientific and practical fields. During the last fifty years, many different formulations have been proposed. Since VRP was first proposed by Danzig and Ramser [9], it has been furthered by many other scholars [10–16]. A new class of problems, VRPTW was then advanced which can be defined as; that after giving a set of depots, a homogeneous fleet of vehicles and a set of known demand locations, a set of closed routes needs to be found which originate and end at the depots to service all demands to minimize travel costs, while the service at each demand must start within an associated time window [14–16]. Resource-constrained multiple project scheduling problems (rc-mPSP) have been addressed by a number of researchers — Brucker et al [17], Kim et al [18], Lova et al [19], Baptiste et al [20], Neumann and Schwindt [21], Scheiberg and Stretton [22] and Fricke and Shenhar [23], etc. Furthermore, many studies have started to explore the issue of how to manage an organization with multiple projects. In [23], Fricke and Shenhar considered the importance of multiple project factors which differed from factors in the management of a traditional single project, and these factors are consistent with other emerging research in the product development environment. Lova and Tormos [19, 24, 25] analyzed the effect of schedule generation schemes, such as serial or parallel, and priority rules that set the latest completion time, minimum total slack, maximum total work content, shortest activity from a short project, and first come first serve in single project and multiple project environments.

In the last section, we found 11 main engineering fields and one rising engineering fields in the ICMSEM according to the first six conference proceedings. Xu [26] also pointed out that the 11 fields received more attention in EMEI journals before 2012. Now, we investigate those articles in EMEI journals from July, 2012 from the 1056 documents, and 590 papers are found. Fig. 1.5 shows that the 11 fields which received more attention in the ICMSEM also have interest in EMEI journals.

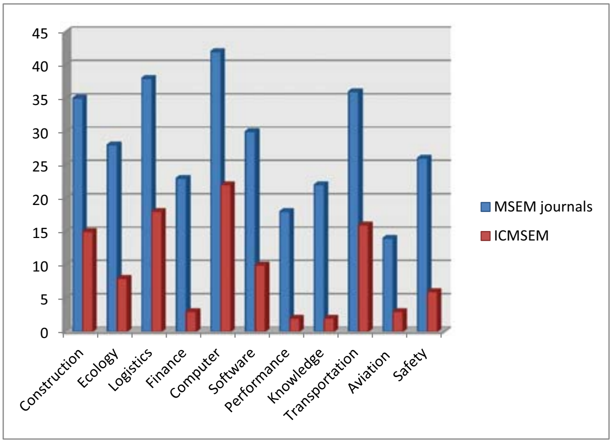


Fig. 1.5 Comparison between ICMSEM and EMEI journals according to 11 main engineering fields

All in all, it can be seen that the ICMSEM research reflects the EMEI development trends. Present vitality in research may bring an upsurge of a new round of research in the coming years.

1.4 Novel EMEI Research Ideas: Computer-based Research Paradigms

EMEI is a multidisciplinary field with a wide range of research areas focusing on a combination of practical management problems based on an engineering background and computer-based techniques for obtaining feasible solutions. Future EMEI research must be closely related to actual engineering management problems with the help of computer technology, such as simulation, and programming. Based on the ICMSEM findings, construction engineering, ecological engineering, logistics engineering, financial engineering, and computer engineering are appearing more regularly in the EMEI research domain, and computer-based methods for determining feasible solutions are becoming increasingly common.

EMEI is a combination of MS and EM, which emphasize actual management, effective theories and methods, and significant engineering practice. One common phenomenon often found in recent conference proceedings is that some authors presented research which , while of great practical significance, failed to give a model with a solution algorithm which meant the model was unable to solve problems with practical data. Some authors may choose a problem that is 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. An excellent EMEI paper should integrate the background of the problem, a mathematical model, and an effective solution method with a significant application. But doing these together is often difficult. 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 the engineering fields? All these questions must be answered under a new paradigm following a certain methodology. This new paradigm will enable researchers to draw scientific results and conclusions under the guidance of science, and will play a significant guiding role in conducting scientific research.

Novel research ideas for the computer-based research paradigm (C-based RP) are put forward to guide an excellent paper, which needs to express the essential relationships between the research, the model and the problem based on computer technology. The C-based RP can also be used in EMEI research, which can be depicted as solving practical engineering management problems based on computer-based methods. Here, R stands for research that includes research specifics, research background, research base, research reality, research framework, and applied research; M refers to models that include concept models, physical models, physical mathematical models, mathematical physical models, algorithm designed models and specific description models, and P represents problems that include a particular problem, a class of problems, abstract problems, problem restoration, problem solution, and problem settlement. The specific relationship among Research, Model, and Problem and the detailed process of C-based RP is shown in diagram in Fig. 1.6. The main steps for the C-based RP used in the sixth ICMSEM are illustrated as follows: firstly, practical management with an engineering background should be transformed to management science problems, including the establishment of a reasonable system, a definition of the basic MS concepts in the practical problem, and the building of the management conceptual model, the physical model and the mathematical model; secondly, basic research on the management model should be developed through a serious of feasible methods and techniques, in which the main tools adopted are mathematically-related and computer-related tools; thirdly, the proposed models should be applied to practical instances for evaluation. Furthermore, the advances made in the proposed model should be able to be shown through comparison with older related research. Lastly but very importantly, new engineering management theories and advanced techniques can be formulated based on research of past and current practice.

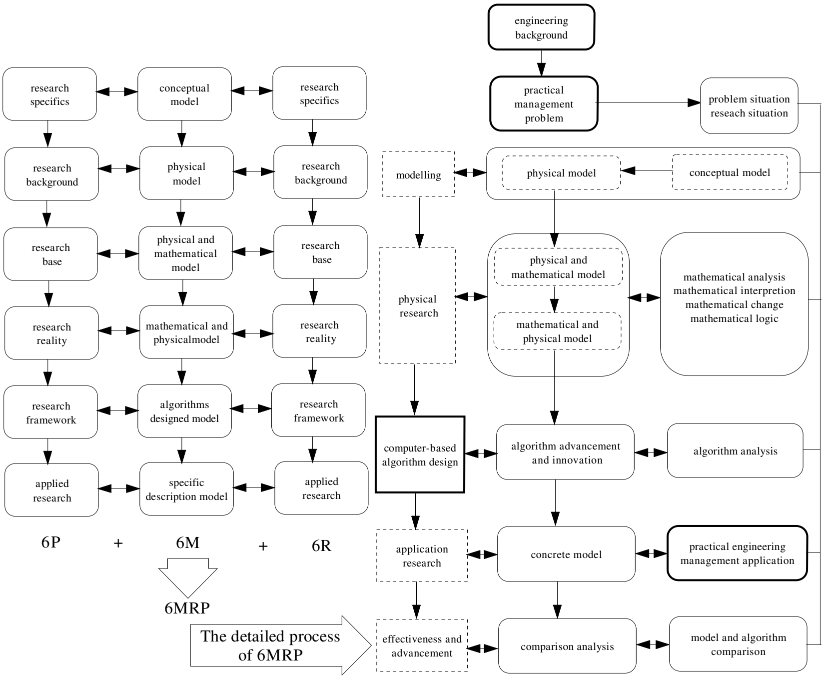


Fig. 1.6 Specific relationship among Research, Model, Problem and the detailed process of C-based RP

Generally, C-based RP is understood to follow a certain structural process. Though step order may vary with the subject matter and researcher, the following key steps are usually part of most formal research, both basic and applied:

(1) Research Topic Selected: the subject addressed in your article should be worthy of investigation;

(2) Conceptual Model Presented: the information presented should be new;

(3) Physical Model Modelling: this model should be a new and original contribution;

(4) Physical Mathematical Model Builded: the mathematical development should be correct;

(5) Mathematical Physical Model Verified: the proofs should be correct;

(6) Algorithm Improved and Innovated : this part should make a valuable contribution to the field of knowledge or practice.

We present a detailed explanation of each key step below. The first thing needed is the observation and formation of the topic: This consists of focusing on the subject area of interest and following that subject area to conduct subject related research. The subject area should not be randomly chosen since that requires reading a vast amount of literature on the topic to determine the gap in the literature the researcher intends to narrow. A keen interest in the chosen subject area is advisable. The research will have to be justified by linking its importance to existing knowledge of the topic. The specific requirements include: (1) Find new problems (significance of problem: academic and rational thinking); (2) Establish new model; (3) Put forward new algorithm; (4) Solve a problem successfully; (5) Indicate the new research direction or fields. Fig. 1.7 shows the flowchart for research topic selection.

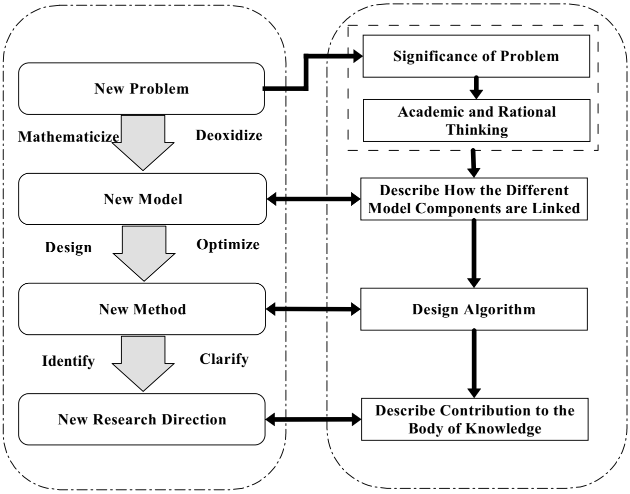


Fig. 1.7 Flowchart of research topic selection

Secondly, a conceptual model definition should be provided: description of a conceptual model by relating it to practical concepts; and details in regards to defining the variables and how they will be measured/assessed in the study. Specific requirements include: (1) Put forward the significance of the conceptual model of the problem that must be solved; (2) Describe the important meaning of the solution for this problem; (3) Review previous research work. Appreciate the contribution to the body of knowledge, and then introduce your work as a new point of departure; (4) Give the mentality and motivation for solving this problem, that is the theme of the paper (title); (5) Describe the important content of this paper according to a logical structure for the reader. The ideal route for conceptual model presentation is illustrated in Fig. 1.8. Based on the conceptual model presented above, the modeling of a physical model can be implemented. Specific requirements include: (1) State the reasoning behind the conceptual model in the first part; (2) Describe the physical modeling; (3) Determine using insight the key element of the problem , for example, uncertainty, indetermination, unsureness, and at the same time the specialization; (4) This part must be easily understood. After physical model modeling, the 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. In contrast to physical mathematical models, mathematical physical models need to point to the physical significance under

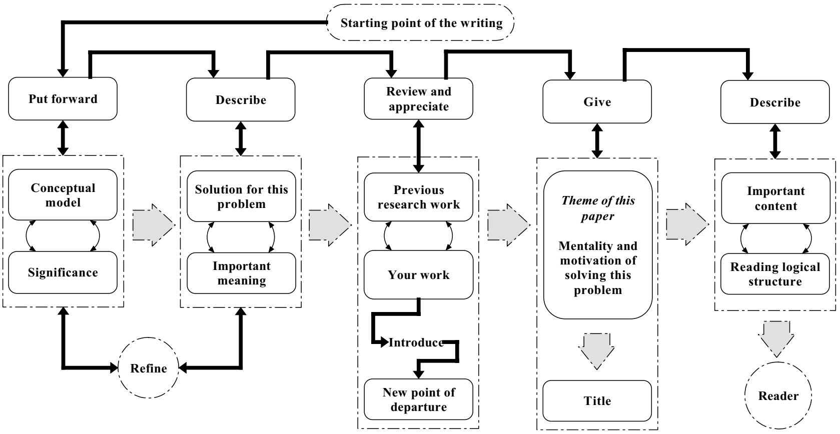


Fig. 1.8 Ideal route of conceptual model presentation

a mathematical form, in which the conversion of the mathematical equations can be recovered to the physical model. Finally, an improved and innovative algorithm should be developed to solve the above model. Specific requirements include: (1) Highlight the newly developed innovative parts of the algorithm instead of elaborating the existing algorithm with old ideas; (2) Try to clearly discuss the existence of the solution, the error estimation and the convergence speed.

C-based RP is an effective paradigm that can be widely used in various scientific research fields and can contribute to research in all areas in a standardized and efficient manner. In EMEI areas, especially in management problems with engineering backgrounds, C-based RP will be well reflected through its rigorous logical and effective applicability, and will play an outstanding role in guiding the practical side of research.

1.5 Appreciations 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, I want to take this opportunity to thank the National Natural Science Foundation of China (NSFC) for their support, Quaid-i-Zam University for the help in conference organization and Springer-Verlag Press for the wonderful publication of the proceedings. We also want to give appreciation to Prof. Benjamin Lev and Prof. Masoom Yasinzai as the General Chairs, Prof. Juan Ignacio Ramos Sobrados and Prof. Nicolas Markatos as Program Committee Chairs, Prof. Eatzaz Ahmed as Organizing Committee Chair, along with all members of the International Program Committee, 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, 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 the research in EMEI is in continuous development across the world. There must 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 on 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.

Acknowledgements This research was supported by the Key Program of National Natural Science Foundation of China (grant no. 70831005). The author gratefully acknowledges Yanfang Ma, Zongmin Li, Ziqiang Zeng, Yan Tu, Xiaoling Song, Cuiying Feng etc who supported the research.

References

1. Kitchenham B (2004) Procedures for performing systematic reviews. Technical Report 1-28, Keele University
2. Kitchenham B, Mendes E, Travassos GH (2006) A systematic review of cross vs. within-company cost estimation studies. In: Proceedings of the 10th International Conference on Evaluation and Assessment in Soft Engineering, pages 89–98, UK
3. Blockley R, Shyy W (2010) Encyclopedia of aerospace engineering. Wiley & Sons
4. Gruntman M (2007) The time for academic departments in astronautical engineering. In: AIAA SPACE 2007 Conference & Exposition Agenda
5. Lee W (2006) Risk assessment modeling in aviation safety management. Journal of Air Transport Management 12:267–273
6. Grunske L, Kaiser B, Reussner H (2005) Specification and evaluation of safety properties in a component-based software engineering process. Springer
7. Lutz R (2000) Software engineering for safety: A roadmap, the future of software engineering. ACM Press
8. Kletz T (2001) An engineer's view of human error. Institution of Chemical Engineers
9. Dantzig GB, Ramser JH (1959) The truck dispatching problem. Management Science 80–91
10. Zhang X, Tang L (2007) Disruption management for the vehicle routing problem with time windows. Advanced Intelligent Computing Theories and Applications 225–234
11. Li JQ, Mirchandani PB, Borenstein D (2009) Real-time vehicle rerouting problems with time windows. European Journal of Operational Research 194:711–727
12. Mu Q, Fu Z, Lysgaard J et al (2010) Disruption management of the vehicle routing problem with vehicle breakdown. Journal of the Operational Research Society 62:742–749
13. Mu Q, Eglese RW (2011) Disrupted capacitated vehicle routing problem with order release delay. Annals of Operations Research 1–16
14. Pavone M, Bisnik N, Frazzoli E et al (2009) A stochastic and dynamic vehicle routing problem with time windows and customer impatience. Mobile Networks and Applications 14:350–364
15. Kallehauge B, Larsen J, Madsen OBG et al (2005) Vehicle routing problem with time windows. Column Generation 67–98
16. Yang Y, Xu JP (2008) A class of multiobjective vehicle routing optimal model under fuzzy random environment and its application. World Journal of Modelling and Simulation 4:112–119
17. Brucker P, Drexl A, Mohring R et al (2005) Resource constrained project scheduling: Notation, models and methods. European Journal of Operational Research 112:3–41
18. Kim KW, Yun YS, Yoon JM et al (2005) Hybrid genetic algorithm with adaptive abilities for resource-constrained multiple project scheduling. Computers in Industry 56:143–160
19. Lova A, Tormos P (2002) Combining random sampling and backward-forward heuristics for resource-constrained multi-project scheduling. In: Proceedings of the 8th Conference on Project Management and Scheduling 244–248
20. Baptiste P, Le Pape C, Nuijten W (2004) Constraint-based scheduling: Applying constraint programming to scheduling problems. Springer, NewYork
21. Neumann K, Schwindt C (2002) Project scheduling with inventory constraints. Mathematical Methods of Operations Research 56:513–533
22. Scheiberg M, Stretton J (1994) Multiproject planning: Turing portfolio indices. International Journal of Project Management 12:107–114

23. Fricke SE, Shenhar AJ (2000) Managing multiple engineering projects in a manufacturing support enviroment. IEEE Transaction on Engineering Management 17:258–268
24. Lova A, Maroto C, Tormos P (2000) Analysis of scheduling schemes & heuristic rules performance in resource-constrained multiple project scheduling. Annals of Operations Research 102:408–424
25. Tormos P, Lova A (2001) A competitive heuristic solution technique for resource-constrained project sheduling. Annals of Operations Research 102:65–81
26. Xu JP (2009) Advancements of management science and engineering management based on The Third ICMSEM. In: Proceedings of the Third International Conference on Management Science and Engineering Management 1–8
27. Xu JP (2010) Advancements of management science and engineering management based on The Fourth ICMSEM. In: Proceedings of the Fourth International Conference on Management Science and Engineering Management 1–9
28. Xu JP (2011) Advancements of management science and engineering management based on The Fifth ICMSEM. In: Proceedings of the Fifth International Conference on Management Science and Engineering Management 1–9
29. Xu JP, Li ZM (2012) A review on Ecological Engineering based Engineering Management. The International Journal of Management Science, Omega 40:368–378
30. ITAA (2008) Information Technology Association of America. http://www.connectlive.com/ events/itaa/
31. Hubbard D (2009) The failure of risk management: Why it's broken and how to fix it. John Wiley & Sons
32. Harland C (1996) Supply chain management: Relationships, chains and networks. British Journal of Management 7:63–81
33. Barrett K (1999) Ecological engineering in water resources: The benefits of collaborating with nature. Journal of the International Water Resources Association 24:182–188
34. Mitsch W, Jorgensen S (1989) Introduction to ecological engineering. In Mitsch W, Jorgensen S (Eds.), Ecological Engineering: An Introduction to Ecotechnology, 3–12. John Wiley & Sons, New York

Part I
Computer and Networks

Chapter 2

Recurrent Neural Network and Genetic Algorithm Approaches for a Dual Route Optimization Problem: A Real Case Study

Fausto Pedro García Márquez and Marta Ramos Martín Nieto

Abstract This paper describes a real case study has been considered. It presents a dual optimization problem that consists in finding the optimal routes in the called principal and capillary routes. The problem has been considered as a travel salesman problem with time windows (TSPTW). The restrictions of Miller et al have been used in order to reduce the computational cost [56]. A recurrent neural network approach is employed, which involves not just unsupervised learning to train neurons, but an integrated approach where Genetic Algorithm is utilized for training neurons so as to obtain a model with the least error.

Keywords Logistics · Recurrent Neural Network · Genetic Algorithm · Travelling Salesman Problem

2.1 Introduction

The current crisis in the global economy and the stiff competition has led many firms to recognize the importance of managing their logistic network for organizational effectiveness, improved customer value, better utilization of resources, and increased profitability. The logistics business in Spain continues rising mainly by the new electronics market. In 2008 the turnover of logistics activities was 3.745 m€, 1.5% compared to previous year. Despite the upward trend, the strategic sector analysis done by DBK shows that the problem of declining business performance of the sector is as a result of rising fuel prices. The same study claim that the industry is in a process of concentration, with the disappearance of small operators [2]. This requires that firms need to optimize its efficiency, e.g. recalculating the routes in order to minimize costs. To reduce the logistics costs related to transportation routes

---

F. García Márquez (✉) · M. Nieto
Ingenium Research Group, Universidad Castilla-La Mancha, Ciudad Real 13005, Spain
e-mail: FaustoPedro.Garcia@uclm.es

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_2,

is a goal sought by all firms, where the transportation costs are easily controlled in the value chain.

There is a difference between national and international transport by road, and the distribution within the city and its close environment (widespread distribution). It has been more important in nowadays, where many firms need to do their deliveries at close proximity. However, when transportation at national and international levels is involved, more benefits can be achieved by a good planning strategy. The national and international transport by road, e.g. transport between urban centres, requires large vehicles carrying its maximum load. A good route planning can reduce the costs significantly, especially when the increasing in oil prices makes any unnecessary kilometre a profit to the company.

In Spain there are approximately 225 logistic firms, but only 4 of them have the majority of market (more than 40% of the total). In this study the biggest one, with 3577 vehicles and 411 great vehicles, has been considered. The company is focused on the distribution into cities by road. The routes are interconnected through ships, i.e. a high capacity logistic centres that are strategically located. The company has designed its domestic routes based on its own experience. This paper presents a meta-heuristic method that determines the routes that involve the major number of cities in order to increase flexibility, leading the vehicle deliver and pick up in these cities, trying to minimize the distance travelled and its costs.

The problem can be approximated to a series of problems similar to the travel salesman problem with time windows (TSPTW). TSPTW tries to find a final solution including sub-path not connected and that meet the constraints of the travel salesman problem (TSP) considering the time windows constrains. The restrictions of Miller et al have been used in order to reduce the computational cost [56]. The main purposes of the method are to provide a quick solution and flexible enough to be used in a dynamic scheduling environment, and to develop a new solution procedure that is capable of exploiting the special characteristics of the problem.

Drawing upon the state of the art presented in next section is developed a recurrent neural network approach, which involves not just unsupervised learning to train neurons, but an integrated approach where Genetic Algorithm is utilized for training neurons so as to obtain a model with the least error.

The paper is organized as follows. Sect. 2.2 elaborates on the problem faced along with the considered case study. Sect. 2.3 describes TSP modelling for the problem and a brief state of the art on TSP and applied heuristics. Sect. 2.4 provides the working of heuristics and computational experience for the recurrent neural network approach and genetic algorithm, and finally Sect. 2.5 and 2.6 explain the results and conclusion respectively.

2.2 Case Study

2.2.1 Background

The main problem is the profitability of routes for the logistic companies. This research paper analyses cases where a direct route between two cities minimize the distances, but it should not be considered from the cost point of view because the shipping volume is not significant enough. On the other hand, with a significant shipment, it is economically more profitable that when only the distance between two cities are considered. Therefore the transport logistics should be designed considering the service effectiveness.

The main objective is to satisfy the customers with greater effectiveness and efficiency, especially with the competence. Routes are constructed to dispatch a fleet of homogenous or heterogeneous vehicles to service a set of customers from a single distribution depot. Each vehicle has a fixed capacity and each customer has a known demand that must be fully satisfied. The objective is to provide each vehicle with a route that maximize the cities visited and the total distance travelled by the fleet (or the total travel cost incurred by the fleet), minimising the costs.

The problem is characterized as follows: From a principal depot the products must be delivered in given quantities to certain customers. A number of vehicles with different capacities are available. All the vehicles that are employed in the solution must cover a route, starting and ending at the principal depot, and the products are delivered to one or more customers in the route. The problem consists in determining the allocation of the customers among routes and the sequence in which the customers shall be visited on a route. The objective is to find a solution which minimizes the total transportation costs. Furthermore, the solution must satisfy the restrictions that every customer is visited exactly once in the capillary routes where the demanded quantities are delivered, but it is not necessary for the principal route. The transportation costs are specified, where the costs are not necessarily identical in the two directions between two cities.

In this paper the meta-heuristics method of the recurrent neural network is proposed to solve the dual problem, in order to increase the flexibility in the routes and minimizing costs. The following considerations have been considered:

1. The principal route will be covered by a large-capacity truck. For practical purposes, it will be considered a big commercial vehicle.
2. Capillary routes (routes between a principal city and the near small cities) will be covered by trucks of medium/small capacities, considered a light commercial vehicle.
3. The First-Input-First-Output (FIFO) method is followed when multiple vehicles are present to transhipment transport.
4. The fuel consumption is taken as an average value of 30 liters per 100 km for a big vehicle, and 15 liters per 100 km for a light commercial vehicle.
5. The diesel price is fixed as 1 €/liter.

6. The maximum speed considered are the legally permissible for a vehicle of these characteristics according to the Spanish laws.

2.2.2 Principal and Capillary Routes

A real case study has been considered, which the principal route consists in determining the route for sending a product set from Barcelona to Toledo (Spain). The route considered by the company is:
Main Route 1: Barcelona-Madrid; Main Route 2: Madrid-Toledo; Capillary route: Toledodifferent towns close to Toledo.

The Madrid-Barcelona route is the same to the Barcelona-Madrid. The total distance is 1223 km, and the time estimated is 14 hours and 41 minutes, with a total cost of 366.93 €.

A first approach in this case study is to employ a route which passes through the maximum number of cities as possible minimizing costs, with the objective of maximise the flexibility. It will lead to the vehicle pick up or deliver products in those cities.

A big capacity vehicle covers this route, denoted as 'vehicle A', leaving the origin city with a certain quantity of product. If there is excess of products, they will be transported by other vehicles.

The solution proposed by the company is: Vehicles follow the route assigned to arrive in Madrid. The vehicles are unloaded and are available to be loaded again. The vehicles leave for Barcelona and the availability of products in order to fill the vehicles is not assured. The vehicle A must to wait to be fill, creating waiting time that increases the logistic costs. The vehicle A can be then loaded for shipment to Cuenca (an intermediate city), and other trucks that make the route Cuenca-Madrid-Cuenca are unloaded in Madrid.

The vehicle A will serve as a logistical support, which means that normally it will be loaded partially. It will be loaded completely in Teruel (city in the middle of the route). The products will be unloaded in Cuenca, first destination from Madrid, and then loaded with new products to be shipped in Teruel, next destination before to arrive to Barcelona, last destination. The same process followed for the city of Cuenca is applicable to the city of Teruel as it has been abovementioned.

This procedure done by the logistic company justifies the need of visiting the maximum number of logistic cities in any route. But if the vehicle visits many cities appears delay problems or the increasing of the costs.

When the vehicle arrives from Madrid to Toledo (a direct route that will not be considered in the dual problem), the products require to be served in different towns close to Toledo. It is done following capillary routes.

The case study considers a new vehicle that visits ten towns, starting and finishing in Toledo. In any town that is visited the vehicle need to deliver and to pick up products according to the orders processed in the previous day (for delivery) or in any specific day (in the case of pick up). The assigned route by the company is:

Toledo → Torrijos → Bargas → Mocejón → Añver de Tajo → Recas → Yuncos → Illescas → Esquivias → Fuensalida → Toledo.

The total distance covered is 209.9 km, and the time is 2 h 41 min.

In this paper a solution is found out for the dual problem, maximizing the logistic centres visited and minimizing the distance covered, considering the restrictions of the current time and costs given by the company.

2.3 Dual Problem Formulation

2.3.1 Travelling salesman problem (TSP) approach for the primary distribution

TSP consists in finding a route with the shortest distance that visit all the nodes (cities) and only once each, starting in a city and returning to the starting city [3]. TSP has been very important because the algorithms developed to solve it do not guarantee to solve it with optimality within reasonable computational cost. Therefore a great number of heuristics and heuristics algorithms have been developed to solve this problem in approximately form. TSP is a NP-hard problem in combinatorial optimization that requires finding a shortest Hamiltonian tour on n given cities [14, 15]. Cities are represented by nodes in a graph, or by points in the Euclidean plane. The distances between n cities are stored in a distance matrix D with elements d_{ij}, being d_{ij} the distance between cities i and j, where the diagonal elements d_{ii} are zero, i.e. there is not distance between a city and itself. A common assumption is that the triangle inequality holds, that is $d_{ij} \leq d_{ik} + d_{kj}$, $\forall i, j, k = 1, \cdots, n$. Also, the symmetrical assumption, $d_{ij} = d_{ji}$, it is the same distance from i to j than from j to i. A review of previous works on TSP using different heuristics is provided in Table 2.1.

Table 2.1 Literature summary: different heuristic methods for solving TSP

Methods	References
Branch-and-bound	[42, 52, 53, 56]
2-opt	[20, 27, 37, 38, 46, 48, 54]
Insertion	[22–24, 29, 32]
Neural Network	[49, 55]
Simulated Annealing	[30, 33, 45]
Tabu Search	[16–19, 21, 25–28, 31, 35, 36, 43]
Exact Methods	[39, 41, 44, 47, 50]
Genetic Algorithm	[40, 48, 51]

The heuristics algorithms developed for solving the TSP presents low computational cost and provides solutions near to the optimal. Different approaches have leaded different formulations for solving the TSP as a linear programming problem, with integer/mixed integer variables [4, 14]. Many managerial problems, like routing problems, facility location problems, scheduling problems, network design problems, can be modelled as TSP. A great number of articles have appeared with detailed literature reviews for TSP, e.g. [10–13].

The problem presented in this paper is formulated as a TSP approach for the principal distribution with the travel cycle known as a Hamiltonian cycle, i.e. the problem is defined by the graph $G = (V, E)$, where $V \in \Re^2$ is a set of n cities, and E is a set of arcs connecting these cities, but in this approach the cities can be visited more than once. Under these conditions, the problem can be formulated as:

$$\min \sum_{i<k} c_{ij} x_{ij}, \tag{2.1}$$

where x_{ij} is the binary decision variable that when $i < j$ has the following values:

$$x_{ij} \begin{cases} 1, & \text{if the arc joining cities } i \text{ and } j \text{ is used in solution if the arc joining cities} \\ & i \text{ and } j \text{ is used in solution} \\ 0, & \text{otherwise} \end{cases} \tag{2.2}$$

subject to the constraints:

$$\text{s.t.} \begin{cases} \sum\limits_{i<k} x_{ik} + \sum\limits_{j<k} x_{kj} = 2 \\ k = 1, 2, \cdots, n \\ \sum\limits_{i,j \in S} x_{ij} \leq |S| - 1 \\ S \subset V, \quad 3 \leq |S| \leq n - 3, \quad x_{ij} \in \{0, 1\} \\ i, j = 1, 2, \cdots, n, \quad i < j \end{cases} \tag{2.3}$$

being Equation (2.1) the objective function. C is the associated cost matrix to the matrix E, compounds by the elements c_{ij} that represents the "distance" (expressed in physical distance, cost, time, etc.) between the cities i and j, where $c_{ij} \leq c_{ik} + c_{kj}$ for all $i, j \in V$, to be Euclidean. The constraints ensure that:
(i) All cities are connected to each other.
(ii) Elimination of sub-path S since the sub-path should not be defined for $|S| = 2$ and $|n - 2|$. because restrictions (iii) and (iv) ensure that between two cities no sub-path is generated.

The model Equation (2.1) contains $n(n-1)$ binary variables, with $2n$ constraints and $2^n - 2(n-1)$ sub-path constraints that need to be removed, making it very complex and computational costly. The restrictions proposed by Miller et al [56] have been considered which can reduce the number of sub-path, also referred to as disposal restrictions. In these new restrictions is necessary to consider the new variables $u_i (i = 2, \cdots, n)$ given by:

$$u_i - u_j + (n-1)x_{ij} \leq n - 2, \; i, j = 2, \cdots, n, \; i \neq j, \tag{2.4}$$

$$1 \leq u_i \leq n - 1, \; i = 2, \cdots, n. \tag{2.5}$$

The restriction Equation (2.4) indicates that the solution does not contain a sub-path in all cities SIV and all subpath contains more than n cities. The restriction Equation (2.5) ensures that the u_i variables are defined only for each sub-path. This formulation has been employed for solving the principal distribution, e.g. the transport between the cities of Barcelona and Madrid, considering the main cities between them, where it is possible to visit a city more than once.

TSPs can also be represented as integer and linear programming problems. In this paper it will employed for the capillary formulation problem. The integer programming (IP) formulation is based on the assignment problem with additional constraint of no sub-tours:

$$\begin{cases} \min \sum\limits_{i=1}^{n} \sum\limits_{j=1}^{n} c_{ij} x_{ij} \\ \text{s.t.} \begin{cases} \sum\limits_{i=1}^{n} x_{ij} = 1, & \text{for all } j \\ \sum\limits_{j=1}^{n} x_{ij} = 1, & \text{for all } i \\ x_{ij} \in \{0,1\} & \text{for all } i, j, \end{cases} \end{cases} \tag{2.6}$$

where Equation (2.6) is the objective function and the constraints Equation (2.6) ensure that each city is visited exactly once. TSP can be also expressed as a linear programming (LP) formulation by the Equation (2.7).

$$\min \sum_{i=1}^{m} w_i x_i = w^T x, \quad x \in S, \tag{2.7}$$

where m is the number of edges in G, w_i is the weight of edge and x is the incidence vector that indicates the presence or absence of each edge in the tour. There are a number of algorithms used to find optimal tours, but none are feasible for large instances since they all grow exponentially. This formation has been employed for solving the capillary route problem.

2.4 Recurrent Neural Network and Genetic Algorithm Approaches (RNNGA)

Neural networks (NN) represent the operating mechanism of the human brain, based on a fair degree of some simple computational nodes called neurons. The knowledge is acquired through a learning process, and the connection interneuron (synaptic weights) would be used for the storage of knowledge. Artificial NN are networks comprising of large quantities of highly interconnected simple computational elements. They use data from previous steps incorporating information from multiple indicators, being a nonparametric model [1]. Time and data are required for learning and training the network. Once the network is trained and completed, it can determine feasible solutions to similar problems. Fig. 2.1 shows the structure of a

NN where each neuron receives information from neurons that are found in a layer closer to the input layer, and sends the output to a layer that is closer to the output layer. The types of links in the NN consist of synaptic and activation links, and the way in which neurons in the network structure are assigned determines its architecture. NN are non-linear statistical data modelling tools used to model complex relationships between inputs and outputs or to find patterns in data. Recurrent Neural Network (RNN) refers to a special type of neural network where the output of previous iteration is used as an input for the next iteration. There are many systems in the real world whose behaviour depends on their current state, such systems can be modelled by RNN. When the NN is applied to problems involving nonlinear dynamical or state dependent systems, NN with feedbacks can in some cases provide significant advantages over purely feed forward neural network (FNN).

There are some input neurons and one feedback neuron. The feedback neuron takes previous iteration's output as input while the other neurons take a fixed input. The output of the input layer is passed to hidden layer; output of interaction of hidden layer neurons is passed to the output, therefore it gets an output. The associated weights are calculated by applying some algorithm, e.g. back propagation using gradients. In this research work a genetic algorithm (GA) is used to determine the weights.

Back propagation method using gradients for training has been successfully applied to FNN [6, 7, 9]. However this training algorithm has not been successful for recurrent NN due to complexities [5]. Training algorithms for RNN, based on the error gradient, are very unstable in their search for a minimum and require much computational time when the number of neurons is high [5]. This is the main reason where it is proposed a GA to evaluate weights.

The fitness function error is calculated as follow: Firstly, the weights in the network are set according to the weight vector; then the network is evaluated against the training sequence. It will lead to determinate the sum-squared-difference between training sequence and the known target values employed in the training sequence in each vector. The GA is adjusted to the weights, being the network represented by a chromosome and the weight link in summarised in one gene. There are many chromosomes that make up the population, therefore, many different neural networks are evolved until the minimum value of the mean-squared-error is satisfied. The fitness function evaluates the mean squared error in the training process for each NN, being the main objective to minimise the function.

The output of the network can now be represented as:

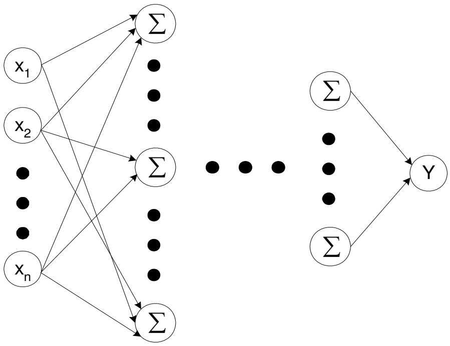
$$Y(t) = f\left(\sum_{j=1}^{N}\left(f\left(\sum_{i=1}^{10} U_{ij}X_i(t)\right)W_j\right)\right), \tag{2.8}$$

$$X_{10}(t) = Y(t-1), \tag{2.9}$$

$$X_{10}(0) = 0, \tag{2.10}$$

where
$Y(t)$ = Output in iteration t;
$X_j(t)$ = Input i at iteration t;

Fig. 2.1 The system structure of a recurrent neural network



U_{ij} = Weights between input and the hidden layer;
W_j = Weights between hidden layer and the output node;
f = Activation function;
N = is the number of neurons in the hidden layer.

The nomenclature followed is that U_{ij} connects jth node in input layer to ith node in hidden layer, similarly for W_j.

Let d be the desired output for kth input, the error will be

$$Z_k(t) = |Y_k(t) - d_k|. \tag{2.11}$$

The objective function for the GA is Z, which is the mean of square of errors for all values of inputs of X_j's. Mathematically

$$Z(t) = \sum_{k=1}^{n} Z_k(t) \times Z_k(t)/n. \tag{2.12}$$

The steps for GA employed are summarized in Fig. 2.2.

The value of t is determined from the condition on mean square error (MSE) falling below a particular value

$$Z(t) \leq \alpha. \tag{2.13}$$

The method of obtaining the optimum values of the number of neurons in the hidden layer, and the Mutation and crossover fraction in the genetic algorithm parameters, is called parameter tuning, which is set by trials of different combination of the above parameters. The activation function used here is a sigmoid function given by:

$$f = \frac{1}{1 + e^{-a(x-c)}}, \tag{2.14}$$

a and c has been considered as 1, and the bias in the network has been made 0.

2.5 Results

The matrices of distances required in all algorithms are defines by the Table 2.2 for the principal route, Table 2.3 for the capillary route:

Table 2.2 Distance matrix. Madrid-Barcelona route

	Barcelona	Zaragoza	Madrid	Cuenca	Teruel	Lleida
Barcelona	0	290.6	606.5	486.5	367.5	151.8
Zaragoza	290.6	0	320.9	255.8	176.0	141.1
Madrid	606.5	320.9	0	164.4	293.9	460.8
Cuenca	486.5	255.8	164.4	0	129.8	368.9
Teruel	367.5	176.0	293.9	129.8	0	249.9
Lleida	151.8	141.1	460.8	368.9	249.9	0

Table 2.3 Distance matrix. Capillary Routes

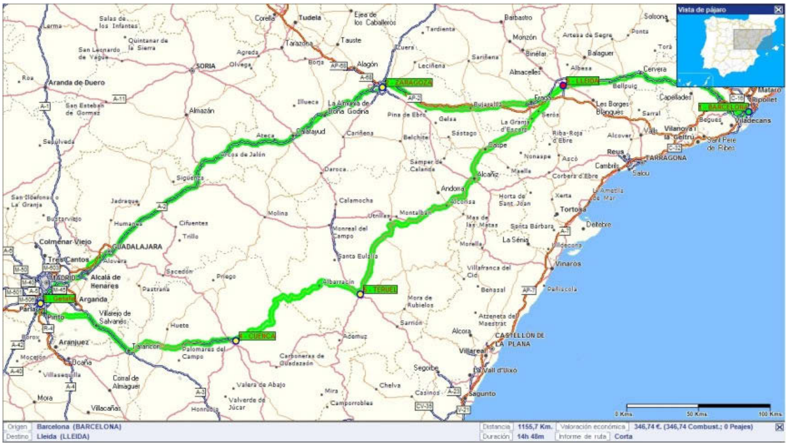
	Toledo	Bargas	Torrijos	Fuens-alida	Recas	Illescas	Yuncos	Esquivias	Añover Tajo	Mocejón
Toledo	0	9.90	27.2	28.0	24.7	34.4	29.9	42.8	32.0	14.7
Bargas	9.90	0	24.4	24.5	15.1	26.5	22.0	34.8	26.9	10.6
Torrijos	27.22	24.4	0	10.8	37.8	50.4	45.6	58.9	51.4	35.1
Fuensalida	28.0	24.5	10.8	0	31.2	40.9	36.2	49.5	51.5	35.1
Recas	24.7	15.1	37.8	31.2	0	19.6	14.8	28.1	22.6	16.0
Illescas	34.4	26.5	50.4	40.9	19.6	0	4.80	8.50	19.5	25.6
Yuncos	29.9	22.0	45.6	36.2	8.14	4.80	0	13.4	15.0	21.1
Esquivias	42.8	34.8	58.9	49.5	28.1	8.50	13.4	0	21.9	34.0
Añover Tajo	32.0	26.9	51.4	51.5	22.6	19.5	15.0	21.9	0	19.0
Mocejón	14.7	10.6	35.1	35.1	16.0	25.6	21.1	34.0	19.0	0

Table 2.4 Reference route provided by the company

Reference Solution	Route 1	Route 2	Capillary Route	Total
Total distance (km)	1223	114	209.9	1558.1
Number of Cities visited	2	2	1	5
Time	14h41	1h28	2h41	18h50
Fuel Cost (€)	366.93	34.22	31.49	432.64

RNNGA provides the following main route(see Fig. 2.2):
Barcelona → Zaragoza → Madrid → Cuenca → Teruel → Lleida → Barcelona, with a total distance of 1307.4 Km, only 84.4 km more than the reference route, but it presents better flexibility with two additional cities that are visited, employing 7 minutes more to cover the route than the reference route, with an extra cost of 20.19 €.

The capillary route found by RNNGA is (see Fig. 2.3):
Toledo → Torrijos → Bargas → Fuensalida → Recas → Añver de Tajo → Illescas → Yuncos → Esquivias → Mocejón → Toledo



Origen Barcelona (BARCELONA)
Destino Lleida (LLEIDA)
Distancia 1155,7 Km.
Duración 14h 48m
Valoración económica 346,74 €. (346,74 Combust.; 0 Peajes)
Informe de ruta Corta

Fig. 2.2 Optimal solution for the principal route obtained by RNNGA

Origen Toledo (TOLEDO)
Destino Toledo (TOLEDO)
Distancia 216,7 Km.
Duración 2h 38m
Valoración económica 32,51 €. (32,51 Combust.; 0 Peajes)
Informe de ruta Corta

Fig. 2.3 Route capillary provides by RNNGA

with a distance of 216.3 Km, 6.4 km more than reference route, with a fuel cost of € 32.51, reducing 4 minutes the reference route.

The total distance and the cost of the main routes will be added the Madrid-Toledo trajectory (57 Km), covered in 44 minutes with a cost of 17.11 € (fuel). Table 2.5 shows the results of the routes found by RNNGA.

Table 2.5 Solution provided by the RNNGA

	RNNGA			
	Route 1	Route 2	Capillary route	Total
Total distance (km)	1307.4	114	216.3	1637.7
Number of cities visited	5	2	1	8
Duration	14h48	1h28	2h38	18h54
Fuel cost (€)	346,74	34.22	32.51	413.47

2.6 Conclusions

A real case study has been considered, which the principal route consists in determining the route for sending a product set from Barcelona to Toledo (Spain). A first approach in this case study is to employ a route which passes through the maximum number of cities as possible minimizing costs, with the objective of maximise the flexibility. It will lead to the vehicle pick up or deliver products in those cities.

When the vehicle arrives from Madrid to Toledo (a direct route that will not be considered in the dual problem), the products require to be served in different towns close to Toledo. It is done following capillary routes. The case study considers a new vehicle that visits ten towns, starting and finishing in Toledo.

The problem can be approximated to a series of problems similar to the travel salesman problem with time windows (TSPTW). TSPTW tries to find a final solution including sub-path not connected and that meet the constraints of the travel salesman problem (TSP) considering the time windows constrains. The restrictions of Miller et al have been used in order to reduce the computational cost [56]. The main purposes of the method are to provide a quick solution and flexible enough to be used in a dynamic scheduling environment, and to develop a new solution procedure that is capable of exploiting the special characteristics of the problem.

This paper presents a meta-heuristic method that determines the routes that involve the major number of cities in order to increase flexibility, leading the vehicle deliver and pick up in these cities, trying to minimize the distance travelled and its costs.

A recurrent neural network approach is employed, which involves not just unsupervised learning to train neurons, but an integrated approach where Genetic Algorithm is utilized for training neurons so as to obtain a model with the least error.

References

1. Aleksander I, Morton H (1990) An introduction to neural computing. Chapman & Hall, London
2. DBK (2009) Transporte de mercancías por carretera, DBK
3. Nilsson NJ (1982) Principles of artificial intelligence. Editing Birkhauser, New York

4. Junger M, Reinelt G, Rinaldi G (1997) The travelling salesman problem. Handbooks in Operations Research and Management Science 7:225–330
5. Blanco A, Delgado M, Pegalajar MC (2000) A genetic algorithm to obtain the optimal recurrent neural network. International Journal of Approximate Reasoning 23:67–83
6. Bourlard H, Wellekens C (1989) Speech pattern discrimination and multi-layered perceptrons. Computer Speech and Language 3:1–19
7. Le Cun Y, Boser B, Denker J et al (1989) Backpropagation applied to handwritten zip code recognition. Neural Computation 1:541–551
8. Sejnowski T, Rosenberg C (1987) Parallel networks that learn to pronounce English text. Complex Systems 1:145–168
9. Waibel A, Hanazawa T, Hinton G et al (1989) Phoneme recognition using time delay neural networks. IEEE Transactions on Acoustics, Speech, and Signal Processing 37:328–339
10. Bellmore M, Nemhauser GL (1968) The traveling salesman problem: A survey. Operations Research 16:538–588
11. Bodin L (1975) A toxonomic structure for vehicle routing and scheduling problems. Computers and Urban Society 1:11–29
12. Gillett B, Miller L (1974) A heuristic algorithm for the vehicle dispatch problem. Operations Research 22:340–340
13. Turner WC, Fouids L, Ghare PM (1974) Transportation routing problem — A survey. AIIE Transactions 6:288–301
14. Lawler EL, Lenstra JK, Rinnooy AHG et al (1985) The traveling salesman problem. Wiley, New York
15. Gutin G, Punnen A (2002) The traveling salesman problem and its variations. Kluwer Academic Publishers
16. Ahr D and Reinelt G (2006) A tabu search algorithm for the minmax k-chinese postman problem. Computers & Operations Research 33:3403–3422
17. Augerat P, Belenguer E, Benavent JM et al (1998) Separating capacity constraints in the CVRP using tabu search. European Journal of Operational Research 106:546–557
18. Badeau P, Gendreau M, Guertin F et al (1997) A parallel tabu search heuristic for the vehicle routing problem with time windows. Transportation Research 5:109–122
19. Barbarosoglu G, Ozgur D (1999) A tabu search algorithm for the vehicle routing problem. Computers and Operations Research 26:255–270
20. Bianchessi N, Righini G (2007) Heuristic algorithms for the vehicle routing problem with simultaneous pick-up and delivery. Computers & Operations Research 34:578–594
21. Brandao J, Mercer A (1997) A tabu search algorithm for the multi-trip vehicle routing and scheduling problem. European Journal of Operational Research 100:180–191
22. Breedam AV (2001) Comparing descent heuristics and metaheuristics for the vehicle routing problem. Computers & Operations Research 24:289–315
23. Chao IM (2002) A tabu search method for the truck and trailer routing problem. Computers & Operations Research 29:33–51
24. Daniels RL, Rummel JL, Schantz R (1998) A model for warehouse order picking. European Journal of Operational Research 105:1–17
25. Garcia BL, Potvin JY, Rousseau JM (1994) A parallel implementation of the tabu search heuristic for vehicle routing problems with time window constraints. Computers & Operations Research 21:1025–1033
26. Gendreau M, Laporte G, Sguin R (1996) A tabu search heuristic for the vehicle routing problem with stochastic demands and customers. Operations Research 44:469–477
27. Gendreau M, Laporte G, Vigo D (1999). Heuristics for the traveling salesman problem with pickup and delivery. Computers & Operations Research 26:699–714
28. Hertz A, Laporte G, Mittaz M (2000) A tabu search heuristic for the capacitated arc routing problem. Operations Research 48:129–135
29. Lau HC, Sim M, Teo KM (2003) Vehicle routing problem with time windows and a limited number of vehicles. European Journal of Operational Research 148:559–569

30. Malek M, Guruswamy M, Pandya M et al (1989) Serial and parallel simulated annealing and tabu search algorithms for the traveling salesman problem. Annals of Operations Research 21:59–84
31. Montane FAT, Galvao RD (2006) A tabu search algorithm for the vehicle routing problem with simultaneous pick-up and delivery service. Computers & Operations Research 33:595–619
32. Nanry WP, Barnes JW (2000) Solving the pickup and delivery problem with time windows using reactive tabu search. Transportation Research Part B: Methodological 34:107–121
33. Osman IH (1993) Metastrategy simulated annealing and tabu search algorithms for the vehicle routing problem. Annals of Operations Research 41:421–451
34. Potvin JY, Kervahut T, Garcia BL et al (1996) The vehicle routing problem with time windows — part I: Tabu search. INFORMS Journal of Computing 8:158–164
35. Scheuerer S (2006) A tabu search heuristic for the truck and trailer routing problem. Computers & Operations Research 33:894–909
36. Semet F, Taillard E (1993) Solving real-life vehicle routing problems efficiently using taboo search. Annals of Operations Research 41:469–488
37. Tarantilis CD (2005) Solving the vehicle routing problem with adaptive memory programming methodology. Computers & Operations Research 32:2309–2327
38. Tarantilis CD, Kiranoudis CT (2007) A flexible adaptive memory-based algorithm for real-life transportation operations: Two case studies from dairy and construction sector. European Journal of Operational Research 179:806–822
39. Carpaneto G, Toth P (1980) Some new branching and bounding criteria for the asymmetric traveling salesman problem. Management Science 26:736–743
40. Gen M, Cheng R (1997) Genetic algorithms and engineering design. Wiley, New York
41. Fischetti M, Toth P (1989) An additive bounding procedure for combinatorial optimization problems. Operations Research 37:319–328
42. Finke G, Claus A, Gunn E (1984) A two-commodity network flow approach to the traveling salesman problem. Congressus Numerantium 41:167–178
43. Glover F (1990) Artificial intelligence, heuristic frameworks and tabu search. Managerial & Decision Economics 11:365–378
44. Gouveia L, Pires JM (1999) The asymmetric travelling salesman problem and a reformulation of the Miller-Tucker-Zemlin constraints. European Journal of Operational Research 112:134–146
45. Kirkpatrick S, Gelatt CD Jr, Vecchi MP (1985) Configuration space analysis of travelling salesman problem. Journal Physique 46:1277–1292
46. Lin S, Kernighan BW (1973) An effective heuristic algorithm for travelling salesman problem. Operations Research 21:498–516
47. Lysgaard J (1999) Cluster based branching for the asymmetric travelling salesman problem. European Journal of Operational Research 119:314–325
48. Potvin JY (1996) Genetic algorithms for the travelling salesman problem. Annals of Operations Research 63:339–370
49. Shirrish B, Nigel J, Kabuka MR (1993) A boolean neural network approach for the travelling salesman problem. IEEE Transactions on Computers 42:1271–1278
50. Wong R (1980) Integer programming formulations of the travelling salesman problem. In: Proceedings of the IEEE International Conference of Circuits and Computers 149–152
51. Moon C, Kim J, Choi G et al (2002) An efficient genetic algorithm for the travelling salesman problem with precedence constraints. European Journal of Operational Research 140:606–617
52. Little J, Murty K, Sweeney D et al (1963) An algorithm for the traveling salesman problem. Operations Research 11:972–89
53. Balas E, Toth P (1985) Branch and bound methods. In: Lawler EL, Lenstra JK, Rinnooy Kan AHG, Shmoys DB (Eds.), The traveling salesman problem. Wiley, New York
54. Verhoeven MGA, Aarts EHL, Swinkels PCJ (1995) A parallel 2-opt algorithm for the travelling salesman problem. Future Generation Computer Systems 11:175–182

55. Burke LI (1994) Neural methods for the traveling salesman problem: Insights from operations research. Neural Networks 7:681-690
56. Miller CE, Tucker AW, Zemlin RA (1960) Integer programming formulation of travelling salesman problems. Journal of the ACM 3:326–329

Chapter 3
Influence Factors Theoretical Model of Agribusiness Brand Marketing Strategy

Yu Ding, Yanmei Xu and Yi Peng

Abstract Currently, as problems of food safety becoming increasingly serious, researches on agribusiness brand marketing related with food safety have been concerned. It is of vital importance to study influencing factors of agribusiness marketing strategy, function mechanism of influencing factors in order to get excellent performance with appropriate brand marketing strategy. Literature review, deep interview, comprehensive observation and brain-storm are adopted in theoretical model construction of brand marketing influencing factors and proposition of eight hypotheses, which are proved by large samples of questionnaires. The results are: the dynamic capability and market orientation of agribusiness are connected with brand image strategy, brand location strategy, brand extension strategy and brand relations strategy. The dynamic capability could be improved by acquiring unique resources, upgrading market strain capability, enhancing resources integration capability and reforming group policies. Similarly, market orientation could be upgraded from four aspects including competitor orientation, consumer orientation, information processing ability and function coordination so as to enhance the level of brand marketing strategy of agribusiness.

Keywords Agribusiness · Brand marketing strategy · Dynamic capability · Market orientation · Theoretical model

---

Y. Ding
School of Management, Graduate University of Chinese Academy of Science, Beijing 100080, P. R. China
School of Economics and Trade, Xinjiang Agricultural University, Urumqi 830052, P. R. China

Y. Xu (✉)
School of Management, Graduate University of Chinese Academy of Science, Beijing 100080, P. R. China
e-mail: xuyanmei@gucas.ac.cn

Y. Peng
School of Economics and Management, Zhejiang Sci-Tech University, Hangzhou 310018, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_3,

3.1 Introduction

Nowadays, China's food safety problems are very severe. Thus, agribusiness brand marketing research related to food safety has aroused the concern of academics.

Agribusiness should undertake their social responsibilities and gain the public recognition of safety and reliability of the products. Meaning while, they should enhance public acceptance of their products and maximize their own profits by using resources effectively. Therefore, brand marketing research is very important. But at present, the documents about the relationship between influence factors of agribusiness brand marketing strategy and brand marketing strategy as well as the promotion of profits to brand marketing strategy are in scarcity and lack of thorough study. That highlights the theory value and practical significance of this study.

This paper attempts to analyze the agribusiness brand marketing strategy the relationship between the agribusiness brand marketing strategy and influence factors according to characteristics of agribusiness. Tries to study the influence mechanism of influence factors on brand marketing and construction of theoretical model of influence factors. Therefore, the research conduces to guide practice of agribusiness brand marketing and contributes to excellent performance of agribusiness in China.

Literature review, deep interview, comprehensive observation, brain-storm are adopted in study model proposing and theoretical inference, which are tested and revised by large samples.

3.2 Related Theory and Brand Marketing Strategy

On the basis of many comprehensive modes of consumer behavior theory, agribusiness brand marketing is a systematic and continuing process and needs comprehensive, sustainable support of resources and others from agribusiness. So consumer behavior theory is of great significance to agribusiness marketing especially for marketing strategy, which is reflected by the following: agribusiness brand marketing strategy is based on consumer behavior theory and supported by dynamic capability of agribusiness along with market orientation to ensure that strategy is guaranteed by strategic capability of agribusiness and resonates with consumers to achieve excellent performance.

By analyzing marketing theory, we can see consumer is the first ingredient and the marketing orientation is of great value to theory. That is of significance to guide the study of agribusiness brand marketing strategy and provide theoretical basis and enlightenment.

After analyzing the communication theory of integrated marketing, we know integrated marketing communication is a systematic engineering that integrates various resources including marketing, strategy, finance and technology. Namely, dynamic capability and market orientation of agribusiness influence the integration range and degree of agribusiness brand marketing thus influence the selection of strategy and effect of practice.

Brand marketing theory consists of brand image theory, brand location theory, brand extension theory, the theory of brand equity and brand relations theory. Correspondingly, brand image strategy should focus on the consumers as one of marketing strategies; Brand location theory indicates that brand location of agribusiness can be used as one of the brand marketing strategies of agribusiness. And brand location is based on competition of products in differentiation and diversification. Brand extension theory shows that brand extension can be used as one of the brand marketing strategies of agribusiness. And brand extension is the brand's heritage and innovation. Brand relations theory shows that brand relations can be used as one of the brand marketing strategies of agribusiness. It highlights the importance of brand relations strategy.

3.3 Influence Factors of Agribusiness Brand Marketing Strategy

3.3.1 Dynamic Capability

According to the resource-based view proposed by Barney [1, 2] and Amit and Schoemaker [3], competitive advantages of the agribusiness come from valuable, scarce, inimitable and irreplaceable resources and capability. The idea of dynamic capability proposed by Priem and Butler [4] and Teece and Pisano [5] makes up the defects of resource-based view and extends the connotation of resource-based view. The idea of dynamic capability is widely accepted as a new idea since Teece et al [6] defined dynamic capability as integrating, establishing and resetting internal and external resources of enterprises to cope with rapid change of environments. Dynamic capability emphasizes on environmental changes, protracted nature, dynamic nature and heterogeneity. All that have influenced brand marketing and proved by study of many scholars including [5–13].

Many scholars including Eisenhardt and Martin [7], King and Tucci [14], Song et al [15], Danneels [16] have studied the relationship between dynamic capability and enterprise marketing and concluded that dynamic capability is very significant to explain the competitive advantages of enterprise. And the relationship between dynamic capability and marketing especially with brand marketing needs further study as they have certain correlation.

As enterprises are in dynamic changing environments, some scholars called the existing environments as high-pressure competition. So dynamic capability emphasizes that enterprises should flexibly apply resources and capacity to adapt to the changes of external environments. Agribusiness marketing strategy is based on constant changes of market and tries to maximize the profits and improving performance by using resources and capacity. So dynamic capability corresponds with marketing aim of agribusiness. Teece et al [6] considers that dynamic capability has active effect on performance of agribusiness. However, there are different ideas proposed by Eisenhardt and Martin [7], Zott [17], Zahra et al [11].

From the above all, we can conclude dynamic capability is capable of influencing internal activities and marketing strategy of agribusiness. Certainlyfurther study is necessary to find whether dynamic capability affects marketing strategy directly or indirectly.

3.3.2 Market Orientation

As an international hot research field [18–20], market orientation has become one of core ideas of modern enterprise marketing management, eg. [21, 22], Slater and Narver [18] developed market-oriented measurement scale-MARKOR.

On the basis of study on relationship of market orientation and marketing performance made by Atuahene Gima in 2005 [23], Atuahene Gima and Ko in 2001 [24], Atuahene Gima, Slater, and Olson in 2005 [25], Baker and Sinkula in 2007 [26], Verhees and Meulenberg in 2004 [27], Van Riel, Lemmink, and Ouwersloot in 2004 [28], Perry and Shao in 2005 [29], Kahn in 2001 [30], Kyriakopoulos and Moorman in 2004 [31], Zhang and Duan in 2010 and 2011 [32, 33], it can be concluded that market orientation has a great influence on marketing performance and different dimensions of market orientation affect the marketing performance variously along with the differences in environments and samples.

Narver and Slater defined the market orientation according to the cultural point of view in 1994 [18], while Kohli and Jaworski defined according to the behavior perspective in 1990 [20]. Different perspectives mean different implementation paths but both emphasize that enterprises should create values for consumers. In existing documents, some scholars believe that the market orientation is the pioneer of innovation performance e.g., [34, 35]. However, emphasis on market orientation may lead to ignoring of technical risks brought by technical innovation. That can be made up by dynamic capability and makes the enterprises adapt to the rapid changing environments better. So combining the market orientation and dynamic capability could make the enterprises acquire long-term competitive advantages. This shows a further study about how market orientation, dynamic capability and market orientation together affect the brand marketing strategy is needed.

3.4 Analysis on Function Mechanism of Influence Factors of Agribusiness Brand Marketing Strategy

3.4.1 Dynamic Capability of Agribusiness

Dynamic capability of agribusiness derives from resources of agribusiness and embodies the capability of dealing with rapid changing environments making using of resources.

In the light of resource-based view raised by Barney [1, 2], this article argues that land resources, farmers' resources, human resources and social capital are elements form resources and ability of agribusiness. All these elements are concerned with the existing and developing of agribusiness and difficult to copy due to the uniqueness.

According to the study of dynamic capability made by Teece [6, 8, 13] and other scholars, the capability of dealing with rapid changing environments making using of resources mainly reflected in many ways such as responding to market changes, capability of resources integration, reforming of group policies all that.

3.4.2 Market Orientation of Agribusiness

On the basis of organizational culture and behaviors of agribusiness, market orientation of agribusiness implies guiding the employers of agribusiness to understand customers' requirements, market trends and competitive activities. Consequently, that helps agribusiness to gain competitive advantages and serve for marketing of agribusiness. The paper believes market orientation is embodied in customer orientation, competition orientation, market information processing and function coordination, etc.

3.4.3 Brand Marketing Strategy of Agribusiness

Though brand marketing theory is mainly based on marketing theory, but connotation of brand marketing has brand-related attributes and shows a wide range of brand marketing theory. Shen and Hu [36] divided the theory of brand marketing strategy into the theory of brand image, brand location theory, brand extension theory, the theory of brand equity and brand relations theory. While marketing theory was divided as theory of brand image, brand decision theory and brand choice theory by Mei [37]. The former is adopted in this paper. Taking the development environment of agribusiness into consideration, the paper argues that brand image strategy, brand location strategy, brand extension strategy, as well as brand relations strategy are suitable for brand marketing strategy of agribusiness. Those promote the brand marketing of agribusiness from different perspectives.

3.5 The Impact of Market Orientation and Dynamic Capability of Agribusiness on Brand Image Strategy

Brand image strategy mainly focuses on the brand image of agribusiness and its influence in the minds of consumers. Due to the economic development and social progress, consumers' awareness of brand also advances with the times. If the brand image of agribusiness can not keep up with the pace of economic and social development, the brand image of agribusiness in the minds of consumers will be gradually weakened. Therefore, agribusiness should constantly update its corporate brand image according to the economic and social development. How to update the brand image of agribusiness? This paper holds that dynamic capability and market orientation have an important impact on updating the brand image of the agribusiness.

Firstly, agribusiness provides consumers with services through market orientation, and valuable market information could be obtained from consumers at the same time. Then analyze the changes of consumers' awareness on brand image and the practical reform proposal put forward by its functional departments. In this way, the agribusiness can work out a solution to update its corporate brand image based on market orientation. Therefore, this paper considers that market orientation of agribusiness has an important impact on brand image strategy.

Secondly, this paper considers the dynamic capability of agribusiness can play a significant role in promoting the corporate brand image updating. Taking advantage of market strain capability, agribusiness can promptly spot the changes in consumers' recognition of brand image, especially consumers' preferences for the new brand image. Based on this, the agribusiness plays a role in integrating resource, transforming the group policies and updating the brand image according to the preferences of consumers. Therefore, the brand image can always be recognized by consumers and so does the influence of the corporate brand image. So, this paper considers that dynamic capability of the agribusiness has an important impact on brand image strategy.

Therefore, this paper believes that market orientation and dynamic capabilities affect the marketing strategy.

3.6 The Impact of Market Orientation and Dynamic Capability of Agribusiness on Brand Location Strategy

The core of the brand location strategy lies in the perfect match of brand location and target consumer groups. With the continuous development of economy and society, the demand of consumers shows a trend of diversification. How to meet the needs of different consumer groups through brand location strategy? This article believes that strategic capability of the agribusiness could solve this problem.

Firstly, the agribusiness should understand the specific needs of different consumer groups through customer orientation, grasp the strategic measures implemented by the competitors through competitor-orientation. Then, through market information analysis, agribusiness could fully grasp the market segmentation, market competition, market opportunities on similar products and through coordination and cooperation of the departments, select the product location of agribusiness. Finally, target market of agribusiness could be selected and different brand marketing could also be conducted. This shows that market orientation of agribusiness is a good guide for brand location strategy.

Secondly, since consumers' demand has the characteristics of dynamic change, the ability of agribusiness to coping with market changes is particularly important in this regard. Namely, agribusiness should find out the changes of consumer demands timely through market orientation, cope with market changes, integrate the resources of the agribusiness and coordinate the actions of the various departments of the agribusiness to meet the changing needs of consumers.

Therefore, this paper believes that both market orientation and dynamic capabilities exert a great impact on brand location strategy of agribusiness.

3.7 The Impact of Market Orientation and Dynamic Capability of Agribusiness on Brand Extension Strategy

Brand extension strategy mainly refers to the application of the well-known brands to the new products while conducting product diversification or product portfolio strategy. It is a behavior of benefits and risks. New products can increase awareness, occupy rapidly the target market and reduce the marketing costs; but, if the new products do not meet the expectations of the target consumers, it will damage the image and status of the well-known brand in the minds of consumers and affect the value of the corporate brand. In fact, the process of brand extension of agribusiness is a game between benefits and risks. How to play the game is the crux of the problem. This article believes that the strategic capability of the agribusiness could provide some guidance.

Firstly, agribusiness should have a clear understanding of the corporate brand image and its location in the minds of consumers while serving consumers through customer orientation. Based on this, agribusiness could delve further consumers' expectation toward corporate brand and the future direction of development. Then, through market information processing, agribusiness could analyze the specific perception of the target consumer in the brand of agribusiness as well as appropriate type of product. Finally, through function coordination, the agribusiness unify the brand awareness toward its products, which contributes to the making of correct brand extension strategy to maximize brand profits and minimize brand risks at the same time.

Secondly, due to the dynamic nature of consumer brand awareness for agribusiness, it is necessary for the agribusiness to grasp the consumers' perception of the corporate brand so as to adjust its brand extension strategy in time by reacting to market conditions. The brand extension of agribusiness is a systematic project, which involves the consumer information, new product development, corporate marketing strategy. So it is necessary for agribusiness to integrate various resources, reform group policies at the same time so as to earn more profits and avoid risks in the implementation of the brand extension strategy.

Therefore, this paper believes that both market orientation and dynamic capabilities play an important role in guiding the brand extension strategy of agribusiness and have an important impact on brand extension strategy.

3.8 The Impact of Market Orientation and Dynamic Capability of Agribusiness on Brand Relation Strategy

Brand relations strategy is mainly dealing with the relationship between brand and brand, consumer and brand, product and brand, marketing and brand, other stakeholders and brand, etc. What should the agribusiness do to handle these relationships? This paper believes that the strategic capability of the agribusiness could provide some guidance.

Firstly, through customer-orientation and market information processing, the agribusiness can better handle the relationship between consumer and brand, through the coordination of functions can better deal with the relationship between brand and brand, product and brand, as well as marketing and brand. Competitor orientation of the agribusiness is also helpful to deal with the relationship between a good brand and competitive brands. Therefore, market orientation of agribusiness has an important guidance significance to brand relation strategy.

Secondly, with market strain capability, the agribusiness could grasp the information of consumers and competitors in time; through the integration of enterprise resources and reforming of group policies, they could adjust the methods of cooperating brand relations. It is helpful for the agribusiness to better implement their brand relation strategy.

Therefore, this paper believes that both market orientation and dynamic capabilities are beneficial to brand relations strategy of the agribusiness and have an important impact on brand relation strategy.

3.9 The Theoretical Model of Brand Marketing Strategy Influencing Factors of Agribusiness

This paper has described brand marketing strategy of agribusiness as well as the function mechanism of impact of brand marketing strategy influencing factors. Based on the above analysis, construction of theoretical model of brand marketing strategy influencing factors of agribusiness is studied in this paper as shown in Fig. 3.1.

The two constructs of agribusiness influencing factors separately affect the four of constructs brand marketing strategy. Based on the theoretical model, we propose the following hypothesis:

Hypothesis 1. The dynamic capability of the agribusiness has an important effect on brand image strategy;

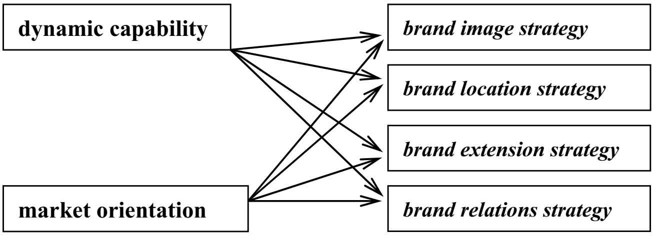


Fig. 3.1 Theoretical model of the influencing factors of agribusiness' brand marketing strategy

Hypothesis 2. The dynamic capability of the agribusiness has an important effect on brand location strategy;
Hypothesis 3. The dynamic capability of the agribusiness has an important effect on brand extension strategy;
Hypothesis 4. The dynamic capability of the agribusiness has an important effect on brand relations strategy;
Hypothesis 5. The market orientation of agribusiness has an important effect on brand image strategy;
Hypothesis 6. The market orientation of agribusiness has an important effect on the brand location strategy;
Hypothesis 7. The market orientation of agribusiness has an important effect on brand extension strategy;
Hypothesis 8. The market orientation of agribusiness has an important effect on brand relations strategy.

3.10 Large Sample Analysis

3.10.1 Measurement of Variables

According to the relative documents and research features, index system of theoretical model is constructed by revising and developing existing scales.

Dynamic capability. Based on relative definition of dynamic capability and research features, the paper argues that four indexes including unique resources, market strain ability, resources integration ability and group policies reforming ability should be taken into consideration in measuring dynamic capability.

Market Orientation. On the basis of relative definition of market orientation, mature scales research features, this paper argues that competitor orientation, customer orientation, market information processing and function coordination should be taken into consideration in measuring market orientation.

Brand Image Strategy. According to the connotation and function of brand image strategy, the paper argues that function image, experiencing image and symbol image are included in measuring brand image strategy.

Brand Location Strategy. According to the connotation and function of brand location strategy, the paper argues that objective market division, product differentiation and price difference should be taken into consideration in brand location strategy measuring.

Brand Extension Strategy. According to the connotation and function of brand extension strategy, the paper argues that brand popularity, product diversification and product correlation should be taken into consideration in brand extension strategy measuring.

Brand Relations Strategy. According to the connotation of brand relations strategy, the paper argues that relation between brand and consumers, the relation between brand and products, the relation between brand and brand, the relation between brand and stakeholders should be taken into consideration in brand relations strategy measuring.

3.10.2 Design, Issuring and Taking-back of Questionnaire

After analyzing the primary cases, a further analysis of theoretical model with large samples is needed. The questionnaire is mainly aimed at grassroots staff of marketing department and middle-senior managers of agribusiness, requiring the respondents to finish the questionnaire according to the actual situations of enterprises and individual understanding. Likert 7 grade scale is adopted in questionnaire.

Relative experts have been invited to modify the description of specific measuring items after the primary design is finished. Trial test is done among twenty relevant people and correction on the basis of trial test to improve the validity of questionnaire.

296 people from 37 different industries from different areas are chosen for investigation, with 8 people from different departments including strategy planning, production and marketing departments. The effective recovery is 87.2% with 296 questionnaires delivered, 277 returned, and 19 invalid.

SPSS 17.0 and AMOS 7.0 are adopted in data analysis. SPSS 17.0 is mainly used for sample descriptive statistics, correlation analysis, factor analysis, regression analysis and so on. While AMOS 7.0 is mainly for confirmatory factor analysis and path analysis.

3.10.3 Descriptive Statistics of Large Samples

In order to get representative samples, agribusiness of uniform scale are chosen in sample survey, male accounts 75.2% of the overall, people aged below 35 accounts

79.1%,bachelors and masters occupy 80.2%. All that is consistent with features of gender, youth,and education level. People from marketing department account for a half, which is in conformity with marketing subject and position forming as well as provide reasonable data for the study. Considering features of industries, food industry accounts for 43%. That is relative with marketing as marketing food industry is representative.

3.10.4 Correlation Analysis

As Table 3.1 shown, the correlation coefficient of main variables including dynamic capability, market orientation, absorption capability, image strategy, location strategy, extension strategy, relations strategy, innovation strategy and so on is significant on the level of $p < 0.01$.That indicates the correlation of variables is better and needs further analysis.

Table 3.1 Correlation analysis of the main variables

	1	2	3	4	5	6	7	8
Dynamic capability	1							
Market orientation	.560**	1						
Absorptive capacity	.359**	.394**	1					
Image strategy	.325**	.382**	.527**	1				
Location strategy	.334**	.252**	.331**	.346**	1			
Extension strategy	.251**	.309**	.252**	.296**	.304**	1		
Relations strategy	.377**	.351**	.412**	.360**	.293**	.208**	1	
Marketing performance	.325**	.363**	.413**	.547**	.481**	.418**	.282**	1
Mean	5.36	5.08	5.06	5.14	5.31	4.90	5.01	5.04
Variance	0.67	0.97	0.65	0.65	0.62	0.74	0.70	0.65

Note: ** indicates significant on the $p < 0.01$'s level.

3.10.5 Factor Analysis

SPSS 17.0 is used for exploratory factor analysis and results are: KMO is 0.873, Bartlett hemisphere inspection is significant on the level of $p < 0.01$. That indicates data is suitable for factor analysis. 33 measurement items are analyzed into 8 principal component factors with exploratory factor analysis. Confirmatory factor analysis is done with AMOS7.0 to test reliability and validity of exploratory factor analysis. The results are shown in Table 3.2.

As exploratory factor and confirmatory factor analysis shown, the questionnaire is of good validity with factors loading of concepts are bigger than 0.5. The result of

Table 3.2 Test on reliability and validity

Content of the item	Factor loadings	Alpha
Dynamic capability		
has a unique resource relatively	0.58	0.736
has strong ability to respond to market changes	0.52	
has strong ability to Integrate resources	0.76	
has strong ability to transform organizational practices	0.73	
Market orientation		
business activities with competitor-oriented	0.71	0.842
business activities with customer-oriented	0.77	
has strong market information processing activities	0.85	
has strong coordination ability between the business functions	0.70	
Brand image strategy		
pay more attention to the functional image of the products or services	0.83	0.824
pay more attention to the experiential image of the products or services	0.79	
pay more attention to the symbolic image of the products or services	0.73	
Brand location strategy		
pay more attention to the target market's segments of the products or services	0.67	0.763
pay more attention to the differentiation of the products or services	0.84	
pay more attention the price difference of the products or services	0.66	
Brand extension strategy		
has high brand awareness of the products or services	0.71	0.719
has more abundant species of the products or services	0.78	
has high correlation between the products or services	0.55	
Brand relations strategy		
handles better the relationship between brands and consumers	0.83	0.774
handles better the relationship between the brand and the product	0.70	
handles better the relationship between the brand and the brand	0.59	
handles better the relationship between brands and stakeholders	0.60	

Note: factor loadings is all significance on the $p < 0.001$'s level.

reliability analysis shows cronbach of each concept is greater than 0.7, which means the questionnaire is reliable.

3.10.6 Path Analysis

According to the requirements of research, brand marketing influencing factors model consists of two sub models and path analysis is done. The results are shown in

Fig. 3.2 and Fig. 3.3. Fitting indexes of model 1, $\chi 2$ is 147.647, df is 113, $\chi 2/df$ is

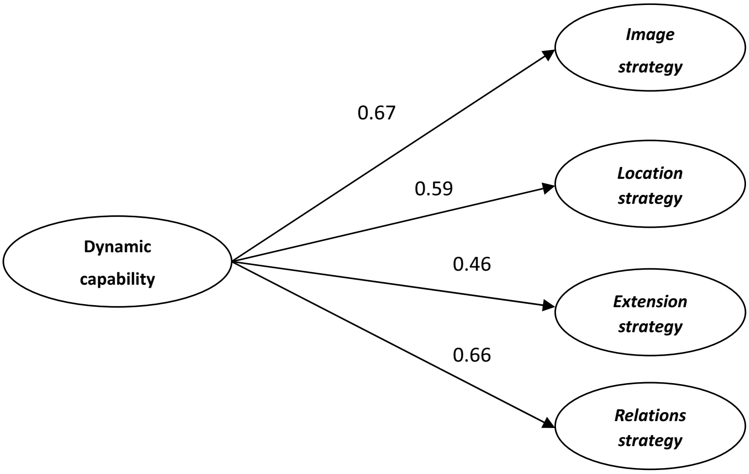


Fig. 3.2 Model 1 of the influencing factors of agribusiness' brand marketing strategy

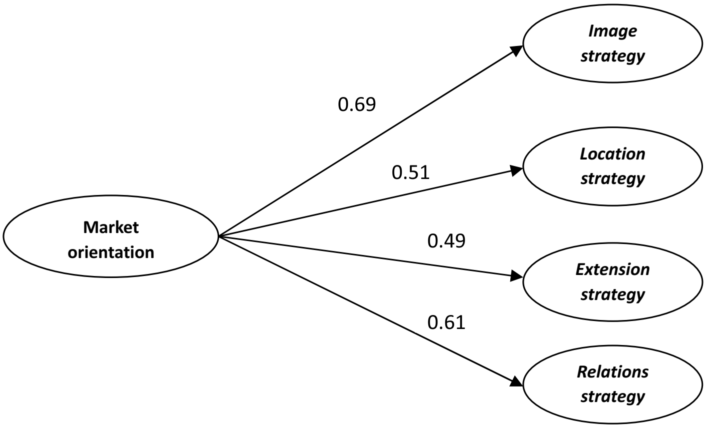


Fig. 3.3 Model 2 of the influencing factors of agribusiness' brand marketing strategy

1.307. RMSEA is 0.035, GFI is 0.937 and CFI is 0.974. That suggests fitting indexes are in conformity with requirements of struction equation model. Model 1 fits well with the sample data. The path coefficient of dynamic capability and image strategy is 0.67 and is more remarkable when $P < 0.01$ proving hypothesis 1. The path coefficient of dynamic capability and location strategy is 0.59 and is more remarkable when $P < 0.01$ proving hypothesis 2. The path coefficient of dynamic capability and extension strategy is 0.46 and is more remarkable when $P < 0.01$ proving hypothesis 3. The path coefficient of dynamic capability and relations strategy is 0.66 and is more remarkable when $P < 0.01$ proving hypothesis 4.

Fitting indexes of model 2, $\chi 2$ are 191.675, df is 111, $\chi 2/df$ is 1.727. RMSEA is 0.053, GFI is 0.918 and CFI is 0.947. That suggests fitting indexes are in conformity with requirements of struction equation model. Model 2 fits well with the sample data. The path coefficient of market orientation and image strategy is 0.69 and is more remarkable when $P < 0.01$, proving hypothesis 5. The path coefficient of market orientation and location strategy is 0.51 and is more remarkable when $P < 0.01$, proving hypothesis 6. The path coefficient of market orientation and extension strategy is 0.49 and is more remarkable when $P < 0.01$, proving hypothesis 7. The path coefficient of market orientation and relations strategy is 0.61 and is more remarkable when $P < 0.01$, proving hypothesis 8.

So eight hypotheses are proved by the results of path analysis.

3.11 Conclusions

Influencing factors theoretical model of agribusiness brand marketing strategy and eight hypotheses are proposed in this paper. And eight hypotheses are proved by large samples with questionnaires as well as theoretical model is confirmed.

The conclusions are: dynamic capability and market orientation both have great influence on brand image strategy, brand location strategy, brand extension strategy and brand relations strategy.

As dynamic capability has great effect on brand marketing strategy, the level of marketing strategy could be upgraded by improving dynamic capability. That can be enhanced from four aspects including acquiring unique resources, improving market strain capability, improving resources integration capability and improving reforming group policies, according to the theoretical model.

It is shown that market orientation has great effect on brand marketing strategy. So upgrading market orientation is helpful to improve the level of marketing strategy. Based on theoretical model, marketing strategy level could be improved from four aspects including competitor orientation, customers orientation, market information processing and function coordination.

Acknowledgements This study was supported by the natural science foundation of Zhejiang province "research on organizational innovation and Performance improvement of private capital's involving in agricultural industrialization in Zhejiang Province" (No: Y6090628) and by Surface project of China Post-doctoral science foundation "theory and empirical research on private capital's involving in agricultural industrialization" (No: 20100471731).

References

1. Barney JB (1986) Strategic factor markets: Expectations, luck, and business strategy. Management Science 32:1231–1241
2. Barney JB (1991) Firm resources and sustained competitive advantage. Journal of Management 17:99–120
3. Amit R, Schoemaker PJH (1993) Strategic assets and organizational rent. Strategic Management Journal 14:33–46
4. Priem RL, Butler JE (2001) Is the resource-based "view" a useful perspective for strategic management research? Academy of Management Review 26:22–40
5. Teece DJ, Pisano G (1994) The dynamic capabilities of firms: An introduction. Industrial and Corporate Change 3:537–556
6. Teece DJ, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. Strategic Management Journal 18:509–533
7. Eisenhardt KM, Martin JA (2000) Dynamic capabilities: What are they? Strategic Management Journal 22:1105–1121
8. Teece DJ (2000) Strategics for managing knowledge assets: The role of firm structure and industrial context. Long Range Planning 33:35–54
9. Zollo M, Winter SG (2002) Deliberate learning and the evolution of dynamic capabilities. Organization Science 13:339–351
10. Winter SG (2003) Understanding dynamic capabilities. Strategic Management Journal 24:991–995
11. Zahra SA, Sapienza HJ, Davidsson P (2006) Entrepreneurship and dynamic capabilities: A review, model and research agenda. Journal of Management Studies 43:917–955
12. Helfat CE, Finkelstein S, Mitchell W et al (2007) Dynamic capabilities: Understanding strategic change in organization's. Blackwell, London
13. Teece DJ (2007) Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal 28:1319–1350
14. King AA, Tucci CL (2002) Incumbent entry into new market niches: The role of experience and managerial choice in the creation of dynamic capabilities. Management Science 48:171–186
15. Song M et al (2005) Marketing and technology resource complementarity: An analysis of their interaction effect in two environmental contexts. Strategic Management Journal 26:259–276
16. Danneels E (2008) Organizational antecedents of second-order competences. Strategic Management Journal 29:519–543
17. Zott C (2003) Dynamic capabilities and the emergence of intraindustry differential firm performance: Insights from a simulation study. Strategic Management Journal 24:97–125
18. Slater SF, Narver JC (1994) Does competitive environment moderate the market orientation-performance relationship? Journal of Marketing 58:46–55
19. Day GS (1990) Market driven strategy: processes for creating value. New York Free Press
20. Kohli AK, Jaworski BJ (1990) Market orientation: The construct, research propositions, and managerial implications. Journal of Marketing 54:1–18
21. Gebhardt G, Carpenter G, Sherry J (2006) Creating a market orientation: A longitudinal multifirm, grounded analysis of cultural transformation. Journal of Marketing 70:37–55
22. Hunt S, Lambe C (2000) Marketing's contribution to business strategy: Market orientation, relationship marketing and resource advantage theory. International Journal of Management Review 2:17–43
23. Atuahene-Gima K (2005) Resolving the capability-rigidity paradox in new product innovation. Journal of Marketing 69:61–83
24. Atuahene-Gima K, Ko A (2001) An empirical investigation of the effect of market orientation and entrepreneurial orientation alignment on product innovation. Organization Science 12:24–73

25. Atuahene-Gima K, Slater SF, Olson EM (2005) The contingent value of responsive and proactive market orientations for product innovation. Journal of Product Innovation Management 22:464–482
26. Baker WE, Sinkula JM (2007) Does market orientation facilitate balanced innovation programs? An organizational learning perspective. Journal of Product Innovation Management 24:316–34
27. Verhees FJHM, Meulenberg MTG (2004) Market orientation, innovativeness, product innovation, and performance in small firms. Journal of Small Business Management 42:134–154
28. Van Riel ACR, Lemmink J, Ouwersloot H (2004) High-technology service innovation success: A decision-making perspective. Journal of Product Innovation Management 21:348–359
29. Perry M, Shao AT (2005) Incumbents in a dynamic internet related services market: Does customer and competitive orientation hinder or help performance? Industrial Marketing Management 34:590–601
30. Kahn KB (2001) Market orientation, interdepartmental integration, and product development performance. Journal of Product Innovation Management 18:314–323
31. Kyriakopoulos K, Moorman C (2004) Tradeoffs in marketing exploitation and exploration strategies: The overlooked role of market orientation. International Journal of Research in Marketing 21:219–240
32. Zhang J, Duan YL (2010) Empirical research on market-oriented and innovation-oriented of manufacturing enterprises' impact on new product performance in China. Nankai Business Review 13:81–89 (In Chinese)
33. Zhang J, Duan YL (2011) Impact of market-oriented on the types of innovation and product innovation performance. Scientific Research Management 32:68–77 (In Chinese)
34. Baker WE, Sinkula JM (2005) Environmental marketing strategy and firm performance: Effects on new product performance and market share. Journal of the Academy of Marketing Science 33:461–475
35. Gotteland D, Boule JM (2006) The market orientation-new product performance relationship: Redefining the moderating role of environmental conditions. International Journal of Research in Marketing 23:171–185
36. Shen P, Hu Z (2008) Brand marketing theory: Retrospect and explore. Henan Commercial College 21 (In Chinese)
37. Mei X (2006) Brand marketing strategy based on consumer behavior. Changchun University of Science and Technology, Master's degree thesis (In Chinese)

Chapter 4
Determining Oil Well Debit Using Oulet Temperature Information Processing

Abbas Rzayev, Gambar Guluyev, Agayev Bikes and Abdurrachmanova Asude

Abstract Developed a new method determining oil well debit using measuring outlet flow temperature values. Proposed mathematical model allowing calculate temperature profile of the fluid along well-bore for determining oil well debit, taking into consideration geothermal gradient in the rock, surrounding the well-bore. It has been shown, that unlike the existing methods proposed the new method allowed very easily determined instantly oil well debit.

Keywords Thermodynamics · Heat friction · Heat capacity · Heat transmission · Energy · Entropy · Enthalpy

4.1 Introduction

Calculation of temperature profile of the fluid along well-bore (well-lifting tube) for determining well debit in the case non-stationary termic field in the rock, surrounding the well-bore (WB) is one of the topical problems on the oil field exploitation. A large number of investigations has been published on this effect [1–9]. As a result of integrated analysis it has been revealed that changes of temperature in the WB are characterize hydro-and thermodynamic processes taking place in the productive interval. In such case information of oil stratum (OS) thermal motion may be derived by fluid flow temperature and pressure measuring in well-bore (WB). WB temperature changes summary thermal processes taking place both in the OS and WT characterized. Well bottom hole temperature controlled by OS thermal phenomenon. In vertical (lifting) flow are accomplished series energetical transformation: growing or fall potential energy; kinetic and internal energy change; heat exchanges between fluid and rocks; mixture fluids and gazes in a productivity interval entering from

---

A. Rzayev (✉) · G. Guluyev · A. Bikes · A. Asude
Institute of Cybernetics of ANAS, Institute of Information Technologies, Baku AZ1141, Azerbaijan
e-mail: abbas_r@mail.ru

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_4,

the different horizons with different temperature, bringing to the calorimetrical temperature effect; adiabatical expansion effect in WB; OS Joul-Tomson drossel effect etc. It is established that thermogram (temperature curve) measuring in WB may be using as debitogram [1, 3, 8].

4.2 Problem Formulation

Problem determining oil mixture flow (OMF) temperature in the well throw out in general case is related to WB ascension flow (AF) investigation.

Heat conducting flow (HCF) in homogeneous horizontal bedding rock, surrounding of well is very close to radial. HCF rate in element of height d_Z on the temperature drop $\Delta T(z)$ between rock and OMF may be specified by following Equations:

$$\frac{dQ(z,t)}{d_z} = \lambda K(t)\Delta T(z), \tag{4.1}$$

$$K(t) = \frac{2\pi}{\ln\left[1+(\frac{\pi at}{r_0^2})^{\frac{1}{2}}\right]},$$

$$a = \frac{H}{l}a_1 + \frac{l-H}{l}a_g, \tag{4.2}$$

where λ is the heat conductivity coefficient $(\frac{Kkal}{MS^0C})$;$K(t)$ is the indimensioned coefficient of heat exchange between flow and surrounding; r_0 is radius $WB(M)$; a is the sum total casing annulus temperature conductivity (m^2/s); a_l, a_g and H are the relative OM and gas temperature conductivity (m^2/s) and H are the liquid column in the casing annulus (M); l is well depth (M).

In the case variable temperature drop the Equation (4.1) acquired following form:

$$\frac{dQ(z,t)}{d_z} = \lambda \int_0^t K(t-\tau)\frac{\partial \Delta T(z,\tau)}{\partial \tau} d_\tau. \tag{4.3}$$

WB vertical flow energy balance described using following Equations:

$$G\frac{\partial}{\partial z}\left[I - A(z + \frac{\upsilon^2}{2g})\right] + F\gamma\left(T\frac{\partial S}{\partial t} + A\frac{v}{g}\frac{\partial v}{\partial t}\right) = \lambda \int_0^t K(t-\tau)\frac{\partial \Delta T(z,\tau)}{\partial \tau} d_\tau,$$

$$G = F\gamma\upsilon, \tag{4.4}$$

where: G is the stream flow weight (kr/s); F is the cross-sectional area flow (m^2); γ is the specific weight (kr/m^3); A is the heat equivalent of work $(2.344\frac{\text{Kkal}}{\text{K}\Gamma.\text{M}})$; υ is the flow rate (M/S); $T_n(z)$ is the rock temperature as function of depth z(℃); $T(z,t)$ is the flow temperature (℃); S is thermodynamic function (entropy) of systems $\frac{\text{Kkal}}{℃}$; I is the thermodynamic function (enthalpy) of system Kkal.

So far as values of coefficient $K(t)$ has time dependence, then vertical flow in WB it never can not come to the strict stationary. But thanks to damping character of Equation (4.2), the coefficient $K(t)$ changes very slow. In such case one can decide

$K(t) = const$ and one can using Nyuton's known heat transmission Equation:

$$\frac{dQ(z,t)}{dF(z)} = \alpha \Delta T(z,t), \tag{4.5}$$

where $F(z)$ is the heat transmission area (m^2); α is the heat transmission coefficient $\frac{Kkal}{MS℃}$ then energy Equations (4.2), (4.4) and (4.5) are allowed determine WB temperature distribution. In this connection convenient thermodynamic functions dS and dI replaced by

$$dS = \frac{Cp}{T}dT - A\left(\frac{\partial V}{\partial T}\right)_p dP,$$

$$dI = CpdT + AV\left[1 - \frac{T}{V}\left(\frac{\partial V}{\partial T}\right)_p\right]dp \tag{4.6}$$

and Equation (4.4) lead to following form:

$$GCp\left[\frac{\partial T}{\partial z} + \varepsilon_1\frac{\partial P}{\partial z} + \frac{A}{Cp}\left(1 + \frac{vdv}{gdz}\right)\right] + F\gamma Cp\left[\frac{\partial T}{\partial t} - m_s\frac{\partial P}{\partial t} + \frac{Av}{Cpg}\cdot\frac{\partial v}{\partial t}\right]$$

$$= \lambda \int_0^t K(t-\tau)\frac{\partial \Delta T(z,\tau)}{\partial \tau}d\tau, \tag{4.7}$$

$$\mu_S = \frac{AV}{C_p}\cdot\alpha T,\ \varepsilon_1 = \frac{AV}{C_p} - \mu_S,\ C_p = \left(\frac{\partial .I}{\partial T}\right)_p, \tag{4.8}$$

where V is the volume substance unite mass (m^3/kr); m_s is the differential adiabatic coefficient $(\frac{℃}{M\Pi a})$; C_p is the specific isobar heat capacity $(\frac{Kkal}{℃})$.

Equation (4.7) is basis for analytical investigation WB vertical flow temperature.

4.3 Problem Solution

I version. In the case constant value of the stream flow weight G_0 and the WB cross sectional area F_0 we have $\frac{\partial v}{\partial z} = 0$; $\frac{\partial P}{\partial t} = 0$ and on laminar flow:

$$\frac{\partial P}{\partial z} = \frac{P_h - P_b}{l},$$

where P_h and P_b are the relative well-head and bottom hole pressures ($M\Pi a$), Equation (4.7) get simplified:

$$\frac{\partial T}{\partial z} + \frac{1}{v}\frac{\partial T}{\partial t} - M = \frac{\lambda}{G_0 Cp}\int_0^t K(t-\tau)d\Delta T(z,t), \tag{4.9}$$

$$v = \frac{G_0}{F\gamma}, \quad M = \frac{A}{Cp}\left[\frac{P_h - P_b}{l} - 1\right].$$

In the case $z = 0$ geothermic temperature distribution may be described using Equations

$$T_\Gamma(z) = T_0 - \Gamma_z = T_0 - \frac{\partial T}{\partial z}z,$$

where T_0 is the bottom hole temperature (℃); Γ is the geothermic gradient (℃$/M$).

In result solution of equation in condition $z > vt$ (when well vertical flow temperature spreaded as flow rate) we have

$$T(z,t) = T_0 - \Gamma_z + (M + \Gamma)\frac{CpG_0}{2\pi r_0 \alpha}\left[1 - \exp\left(-\frac{2\alpha}{r_0\gamma Cp}t\right)\right], \tag{4.10}$$

$$\alpha = \frac{H}{l}\alpha_1 + \frac{l - H}{l}\alpha_2, \tag{4.11}$$

where: $\alpha_1 = f_1\rho_l; \alpha_2 = f_2\rho_2; \rho_l = \beta\rho_0 + (1-\beta)\rho_w$.

ρ_l is the liquid density $(2/\mathrm{m}^3)$; ρ_w is the relative gas, oil and water density $(2/\mathrm{m}^3)$.

Geometrical interpretation physical meaning results in coordinates $[h,T]$ are plotted in Fig. 4.1.

After well starting temperature change in the WB from the bottom hole to the well-head in the case immediate well contacting with surrounding rocks characterized by straight lines 1, 2, 3, 4 which are parallels to the geothermic gradient A_0C_0. Consequently temperature increasing in the WB will same in all the depths from the well-head to the crossing points C_n in which moving up (C_1, C_2, C_3, C_4) at a flow rates v. For instance at the moment t_2 temperature epure in the WB interpreted with curve $C_0C_2A_2$.

Bottom hole temperature jump as a result of the Joul-Tomson drosseling effect then connective transmitted up at a flow rate v. In such case well-head or well-outlet OM flow temperature depend more of volume of stream flow than of bottom hole temperature [1]. Thought in the paper do not taking into consideration great casing annulus areas influence to the well outlet flow temperature. As shown from the table the relative values of the thermal conductivity of the liquid column and gas column present in the casing annulus order less than WB Wall thermal conductivity. Consequently well outlet OM flow temperature will depends not only of the volume of stream flow, also of the bottom hole temperature and of the gas column and the liquid column. As shown from the Fig. 4.1 the line D_4B_0 is not parallel to the geothermic gradient and consequently well outlet flow temperature will more $B_0B_0^*$ than noted [1].

Straight A_0C_0 represents geothermal, that is WB temperature distribution before well action $t \leq 0$. l is the well depth; $H, l - H$ is the relative liquid (oil, water) and gaseus columns in the casing annulus.

Curve B_0C_0 corresponding temperature establishing in WB after well start action $\Delta T(0,t) = 0$. Maximum increasing flow temperature value over geothermic line following of Equation (4.10) on $t \longrightarrow \infty$ has

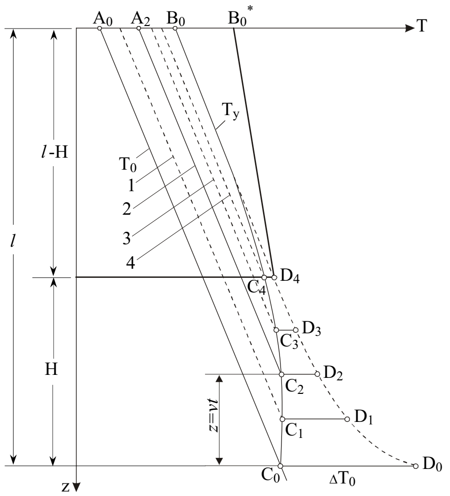


Fig. 4.1 Temperature curves on the oil WB constructed using Nyutons heat exchange low

$$\Delta T_{AB}\max = (M+\Gamma)\frac{CpG_0}{2\pi\Gamma\alpha}. \tag{4.12}$$

As it is shown from Equation (4.10) ~ Equation (4.12) main influence to the well outlet OM flow temperature and heat transmission coefficient rendered liquid column H and column $l-H$ in the casing annulus.

where C is the experimental constant, value in which for different gazes and is changes at interval from 94 to 396.

As shown from the Fig. 4.2 values thermal conductivity of fluid and gaze order less than value WB Wall thermal conductivity. This confirmed with data bringing in [4] (see Table 4.1).

Table 4.1 Material properties

Property	Gaz	Water	Sand (rock)	Steel
Heat capacity	3.055	4.214	0.856	0.502
Thermal conductivity	0.08	0.72	2.25	16.27
Molecular weight	16	18		

II version. In the case OM motion in the WB (lifting pipe) taking place the energy losing on the friction. In such case losing energy is transition to the heat and it is turn changed flow temperature. Heat is increased by the energy loss, part of which go to the heating up self OM, but other part is radiated through WB wall.

If Q is oil well debit (m^3/s), γ is specific weight (Kq/m^3), then all the losing energy on the friction at the section h of the WB at the unit time is $Q\gamma h$ and it transition to the heat:

$$\varpi = \frac{Q\gamma h}{E}, \quad h = \lambda \frac{l}{D_{\varpi}} \cdot \frac{v_2}{g},$$

where: E is mechanical equivalent of the work (425 $\frac{(Kq \cdot m)}{Kkal}$); v is WB rate flow; λ is coefficient characterized WB liquid and flow; D_{ϖ} is effective diameter of WB (M); l is oil well depth (M); g is gravity acceleration (m/S^2); h is losing pressure (M).

Consequently on the length dx of the section of WB heat formatted quantity will be:

$$\varpi = \frac{Q\gamma i}{E} dx, \tag{4.13}$$

where, $i = \frac{h}{l}$ is the hydraulical slope (M/KM).

According to cooling law of Nyuton total loss of the warm through WB wall may be specified by the following Equation:

$$\pi \Pi K (T - t_0) dx, \tag{4.14}$$

where T is the OM temperature in the considering section of WB (℃); t_0 is the external environmental temperature (℃); K is the WB heat transmission coefficient $(\mathrm{Kkal}/(\mathrm{M}_2 \cdot \mathrm{S} \cdot {}^{\circ}\mathrm{C}))$

Total OM heat losing on the section dx will be $-Q\gamma C dT$, where C is the heat capacity $(\mathrm{Kkal}/Kq \cdot {}^{\circ}\mathrm{C}))$.

Thus, taking into consideration Equation (4.1) $\sim$ Equation (4.3) we have heat balance:

$$\begin{aligned} -Q\gamma C dT &= \pi \Pi K (T - t_0) dx - \frac{Q\gamma i}{E} dx, \\ -dT &= a(T - t_0 - b) dx, \end{aligned} \tag{4.15}$$

where

$$a = \frac{\pi \Pi K}{Q\gamma C}, \tag{4.16}$$

$$b = \frac{Q\gamma i}{\pi K \Pi E}. \tag{4.17}$$

Taking into consideration geothermal gradient of rock surrounding WB $\frac{dt_0}{dx} = -k$ and $t_0 = T_p - kx$ we have:

$$-\frac{1}{a} dT = (T + kx - T_p - b) dx. \tag{4.18}$$

In result of integration Equation (4.18) we have heat balance: in condition $x = o, t = T_p$ we are get:

$$T = T_p - kx + b + \frac{k}{a} + \left(-b - \frac{k}{a} \right) e^{-ax}, \tag{4.19}$$

where T_p is temperature in the bottom holl (℃).

Thus as a result we have distribution of temperature on the well depth from bottom hole to the well head.

If do not considered losing work on the friction, that is $b = 0$ one can received temperature determination law in following form

$$T_1 = T_p - kx + \frac{k}{a} - \frac{k}{a} e^{-ax}, \tag{4.20}$$

As compared with (4.19) we have received temperature change as result of friction

$$\Delta T = T - T_1 = b(1 - e^{-ax}). \tag{4.21}$$

Taking into consideration Equations (4.16) and (4.17) and actual data of the oil well operating: $\bar{v} = 0.541\text{M/s}$; $l = 3000\text{M}$; $D_{\varpi} = 0.036\text{M}$; $i = 0.055\text{M/KM}$; $Q\gamma = 0.58\text{Kq/s}$; $C = 0.75\text{Kkal}/(Kq℃)$; $K = 0.00256\text{Kkal}/(m_2 \cdot \text{S} \cdot ℃)$ in result of calculation we have: $a = 6.7 \cdot 10^{-4}$ (1/M); $b = 2.4℃$.

According to the mentioned above, it may be concluded that Equations (4.12) $\sim$ (4.21) and our estimates are allowing on the temperature distribution in the WB account oil well debit.

We are considered now physical meaning the coefficients a, b of Equations (4.19) $\sim$ (4.21). Coefficient a has length inversely value (1/M); coefficient b has temperature degree value (℃).

If introduce outlay equation:

$$Q = \frac{\pi D^2 v}{4}. \tag{4.22}$$

Then with:

$$\gamma = \rho g,$$

according to (4.13) from (4.17) we have:

$$b = \frac{\rho \lambda_f v^2}{8KE}. \tag{4.23}$$

As following from Equation (4.23) hat maximal outlet flow temperature increasing has quadratiq proportionality from OM flow rate. And besides in such case increasing OM flow rate and decreasing heat transmission the b value increased. Therefore, measuring well outlet flow characterizied well debit value. Thus with increasing OM outlay not only increased the a, b coefficients values, also decreased OM time stay in WB and consequently decreased heat losing at the time.

As shown from Equations (4.16) and (4.17) for estimation a and b coefficients values requireds determining λ_f and K values.

For smooth tube λ_f value may be more accuracy determined using the Equation [9]:

$$\lambda_f = 0.3164 Re^{-\frac{1}{4}} = 0.3164[(v \cdot D \cdot \rho)/\mu]^{-\frac{1}{4}}, \tag{4.24}$$

where μ is the dinamycal viscocyty $(Pa \cdot s)$

For determining K values may be using the Equation:

$$K = \left(\frac{1}{\alpha_1 D_1} + \frac{1}{2\lambda h_1} ln \frac{D_2}{D_1} + \frac{1}{\alpha_2 D_2} + \frac{1}{2\lambda h_2} ln \frac{D_3}{D_2} + \frac{1}{\lambda_3 D_3} \right)^{-1}, \tag{4.25}$$

where $\alpha_1, \alpha_2, \alpha_3$ is the relative heat return coefficients from OM flow to the WB Wall; from WB Wall to the casing annulus; from casing annulus to the surrounding rocks; λ_{h_1} and λ_{h_2} is the relative thermal conductivity coefficients WB Wall and casing annulus (see Fig. 4.2). $1, 2, 3$ is the relative WB, casing and rock; $3, 4$ is the relative WB and casing walls; χ is the adsorption layer with great viscosity; $r_1 + \chi, r_3$ is the relative WB and casing radiuses; C_1, C_g is the relative liquid and gaseus columns; $\lambda_{h_1}, \lambda_{h_2}$ and λ_{h_1} is the relative thermal conductivity coefficient of WB Wall, casing annulus and rock.

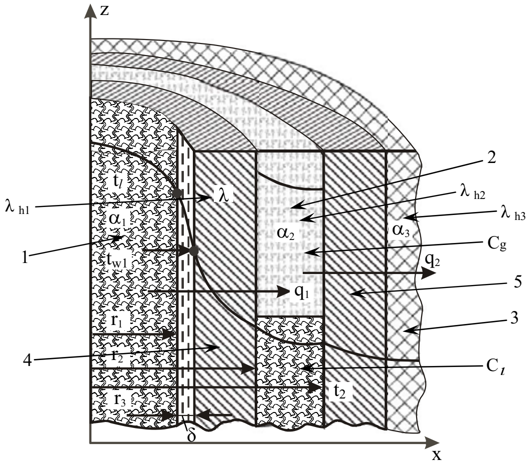


Fig. 4.2 Scheme heat exchange through cylindrical walls and casing annulus

As shown in Fig. 4.2, heat transmission processes take place in several stages:

1. From the flow nucleus to the adsorption layer (ϕ);
2. From the border (ϕ) to the inner surface WB Wall (r_1);
3. From the inner surface to the outward WB Wall surface (r_2);
4. From the outward WB Wall surface through casing annulus to the inner casing surface (r_3);
5. From the inner surface to the outward casing surface (r_4);
6. From the outward surface to the rock.

In the first stage taking place connective heat return, where heat transmission process from the OM flow nucleus to the WT Wall carry complicated character and depends first of all from motion regime of OM flow. Main drop temperature in the case turbulence motion regime taking place in liquid border (ϕ). It is mean that thermical resistance adsorption layer plays decisive role in heat return process.

Therefore increasing turbulence degree decreased adsorption layer thickness, promoted more heat return intensity. In thus case heat return value calculated using the Nyuton Equation (4.14).

In the laminar thermal motion in direction perpendicular to the direction OM flow, that is taking place heat conductivity.

According to the mentioned above, it may be concluded that main resistance in the heat transmission from nucleus OM flow in WB to the rocks is casing annulus, where OM and gaseous columns almost are stationary (in motion) and heat transmission realized only with thermal conductivity.

The $\alpha_1, \alpha_2, \alpha_3$ coefficients values are determining using known Equation:

$$\alpha_i = Nu \frac{\lambda_{h_i}}{d} = 0,$$

where Nu is the Nusselt criterion, which for connective exchanger is determined through Reynolds Re, Grasgofs Gr and Prandtls Pr criterion:

$$Nu = f(Re, Gr, Pr), \quad Re = \frac{vd}{v}, \quad Pr = \frac{vCp}{\lambda_h}, \quad Gr = \frac{d^3 g}{v^2} \beta \Delta T,$$

where β-the volume expansion coefficient $(1/℃)$.

For laminar flow any fluids proposed following empirical Equation:

$$Nu = 0.15 Rl_f^{0.33} Pr_f^{0.43} Gr^{0,1} \frac{Pr_f}{Pr}.$$

For turbulent flow:

$$Nu = 0.021 Re_f^{0.8} Pr_f^{0.43} \left(\frac{Pr_f}{Pr} \right),$$

where λ_{h_3}-he rocks thermal conductivity. And values λ_h for water and oil can determining using N.B.Vargaftiks Equation:

$$\lambda h_i^0 = \varepsilon C \rho \gamma^3 \sqrt{\frac{\gamma}{M}},$$

where M is the molecular weight of fluid.

Since λ_{h_i} depends from temperature for oil and water the dependence described approximate linear Qrets Equation [9],

$$\lambda h_i = \lambda h_i^0 (1 + \varsigma T) \approx 3.11 \cdot 10^{-4} (1 + 0.11 T),$$

where ς is temperature coefficient

Values $\lambda h_i^0 = f(T)$ for gazes separation space in casing may be determining using approximates Equation:

$$\lambda_{hg} = \lambda_{h_g}^0 \left(\frac{273 + C}{T + C} \right) \left(\frac{1}{273} \right)^{3/2}.$$

4.4 Conclusion

This paper presents a proposed new indirect method determining instantly oil well debit using developed mathematical models. As a result of integrated analysis using the models it has been revealed correlation between oil well debit and well throw out flow temperature. Therefore putting purpose was obtained.

References

1. Chekalyuk E (1965) Thermodynamics of oil stratum. Nedra, Moscow
2. Qematudinov S (1971) Physics of oil and gas stratum. Nedra, Moscow
3. Areshev E (2000) The nature of oil wells thermohydrodynamic investigation abnormal data. Oil Economics 3:41–47
4. Lee J (2007) Modeling of hydrodynamics end off intervals of well with developed logic. Oil and Gas Technologies 925–930
5. Klyukin S, Jkhsanov M, Tsiku Y (2010) Assessment of the well bottom zone state on the base of comprehensive research by methods of thermo-and hydrodynamics. Oil Economics 11:94–96
6. Zaytsev M (2011) Influence of thermal colmatation of near bore zones of well production. Oil Economies 2:83–85
7. Simkin E (2010) Thermodynamic analysis of the wetting and temperature effect on the relative permeability. Oil Economics 10:136–139
8. Pnesku S (2011) The latest achievement in the sphere well carottage and estimation parameters of stratum. Oil and Gas Technologies 10:31–41
9. Leybenzon L (1955) Work collection, oil trade mechanics. Academic Science of USSR, Moscow

Chapter 5
The Establishment of Rough-ANN Model for Dynamic Risk Measure of Enterprise Technological Innovation and Its Application

Xiaofeng Li and Li Wang

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 Technological innovation · Risk measure · Rough set · BP artificial neural network

5.1 Introduction

Technological innovation is the main source of modern economic growth, also improves the competitiveness of enterprises, promotes the sustainable development of enterprises. However, since the uncertainty of the objective environment and peo-

---

X. Li (✉) · L. Wang
Business School, Sichuan University, Chengdu 610064, P. R. China
e-mail: lixiaofeng@scu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_5,

ple to know the limitations of this uncertainty, enterprises in technological innovation process will inevitably encounter various risks, causing financial loss, or business failure. Therefore, in the enterprise technology innovation activities using the method of system science to measure the risks is very necessary.

Over the years, research on technological innovation risk measure is highly concerned by scholars and enterprise management workers. Comprehensive analysis of relevant literature, we can see the initial study of risk measurement in technological innovation, mainly based on investment decisions point of view, formed four ideas [8]: one is the probability method, and the second is variance method, the third is average-all variance method, and the fourth is mean square deviation-loss method. The main representative of the research in this area is from Sharp [24], Pearson [21], Mohamed [23], Davis [7], etc. These studies emphasis on the financial aspects of consider, ignore the technology, market and other aspects of the uncertainty, thus lack guidance on the risk management of technological innovation. With the rapid development of innovation activities, technology innovation and risk assessment studies began to consider other factors as technology, marketing, management, formed the other evaluation method, such as risk assessment model based on the utility function [3, 15], project risk evaluation model based on the t fuzzy mathematics theory [14], risk assessment model based on multi-objective decision-making and fuzzy comprehensive evaluation method [1, 9, 10, 19], quantitative risk assessment model based on the analytic hierarchy process established by value of statistical theory of fuzzy mathematics [5, 13], risk assessment methods based on gray system theory of technological innovation [12, 17], risk estimation models based on the unascertained measure [11], and combination the D-S theory with Fuzzy sets to assess risks for product development projects [28], etc. From the existing evaluation methods, most scholars all regard the technology innovation activities as a static thing to deal with, without making dynamic analysis, which contradicts the law of the technological innovation activities, inevitably bring shortage to the accurate assessment of risk, affect the correctness of the decision-making of business technology innovation and risk management measures to some extent. Therefore, we must build a dynamic measure theory and method for the risk of technological innovation to solve this problem.

With the Rough Set and ANN (artificial neural network) theory, the dynamic measure of technological innovation risk has become a possible and developing trend. This paper combines Rough sets and ANN theory, construct Rough-ANN model for dynamic risk measure of enterprise technological innovation, proves the feasibility and effectiveness of this model with examples.

5.2 Indicator System of Enterprises' Technological Innovation Risk Factors

There are many complex factors influencing enterprise technology innovation risk, which need to build the index system of risk factors by the following principles:

systematic principle, concise scientific principle, coherence principle, comparability principle. Divide the factors which affect the risk of technology innovation according to these principles into six major categories: policy factors, technical factors, production factors, market factors, financial factors, management factors. First constructed risk factors index according to the six risk factors, then through expert research, statistical analysis and other methods, referring to many domestic and foreign literature [2, 4, 6, 27], refining indicators framework, supply and delete, and ultimately establish the index system of enterprises' technological innovation risk factors. The risk factor index system consists of 48 risk factors indicators, which are shown in Table 5.1.

5.3 Rough-ANN Model for Dynamic Risk Measure

5.3.1 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 [20]. 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 [25]. 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 PR, $P \neq \phi$, $P = \{r_{i1}, \cdots, r_{ik}\}$, all equivalence relation of P is $\bigcap P = \bigcap_{j=1}^{k} r_{ij}$, then 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 [16].

Table 5.1 Indicator system of enterprises' technological innovation risk factors

Risk factor	Risk factor indicator	Risk factor	Risk factor indicator
Policy factor	Changes in the macro-economic situation The degree of sectoral constraints or authorities The impact of industrial policy or the law Intellectual property protection The impact of the imported products	Market factor	Industry boom degree Potential market capacity Competition strength The number of competitors Competitor's unfair competition The requirements of the users of the products Changes in consumer demand New product life cycle The price of new products Corporate reputation and visibility The enterprise marketing ability
Technical factor	Technological maturity Technology advanced degree Technical complexity and difficulty Technical measure The difficulty of the intermediate test Technology accumulation degree Technological substitutability Technical collaboration Technology personnel strength	Financial factor	The ease of credit funding sources Demand for innovative financing Corporate financial strength Timeliness of funds supplying Operational capacity of the enterprise funds
Production Factor	The scale of production Raw material requirements The difficult degree of parts supply Adjustment of existing equipment and technology The difficulty in introducing of new equipment Quality performance of new products The cost of new products The production cycle of new products	Management factor	The management capacity The accuracy of market information Scientific decision-making level Feasibility studies and planning The project team's overall ability Ability of the person in charge of the project Project management capacity The project schedule control capabilities Treatment of technology developers The degree of leadership support

5.3.2 Overview of Artificial Neural Network Theory

The artificial neural network is on the basis of the results of modern neuroscience research, according to the characteristics of the basic functions of the human brain, trying to mimic the biological nervous system function or structure to develop a new information processing system or computing system [29]. Such a system has its unique features in dealing with vague, random, large, low-precision information

[18]: one is to carefully study assess results by a large number of experts , quantified embody the assessment methodology in experts' minds, and apply it to the actual assessment, to reduce the impact of man-made irrational factors; The other is to constantly learn new samples, and continue to improve their assessment methods, with the dynamic adaptive technology and the economy continues development, to adjust the impact of the assessment object. BP neural network model is one of the important models for artificial neural network, which consists of input layer, hidden layer and output layer. A standard back propagation neural network is shown in Fig. 5.1. Traditional BP neural network model make a set of sample input/output problem into a nonlinear optimization problem, the use of the optimization of the most common gradient descent algorithm has a strong function for the identification problem, thus the error can be arbitrarily small degree for complex nonlinear model simulation in theory. Although it has many advantages, but there are still some shortcomings [22]. In the literature [26], we improved the identification and selection of learning rate and other aspects of the traditional BP neural network structure parameters, put forward the improved BP algorithm, which makes the BP neural network has good fault tolerance, memory capacity, the classification ability and dynamic reasoning performance.

5.3.3 The Basic Principles of Rough-ANN Model Construction

Many factors affect the risk of technology innovation indicators, such as changes in the macroeconomic situation, technologically advanced degrees, competitor strength (see Table 5.1). Correlation may exist between the data of these indicators, if regard all of them as artificial neural network input variables will obviously increase the complexity of the network, reducing 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, to simplify the neural network training set, reduce the complexity and training time of neural network system by Rough set theory. First with the

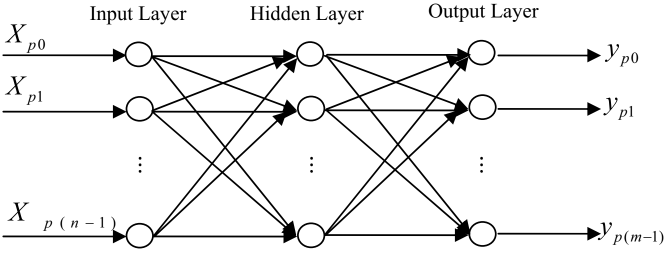


Fig. 5.1 A standard BP neural network

knowledge of reduction in the Rough Set Theory, compress enterprises' technological innovation risk factors indicators, use the simplified 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 good at extracting rules and information from large amounts of data, and has a good dynamic prediction function. Therefore, learn from each other, will organically combine the two methods, thus improve capabilities of artificial neural network to deal with complex issues like technological innovation risk measure this kind of unstructured, non-linear problems.

5.3.4 Rough-ANN Model Structure

According to the traditional BP neural network structure, divide Rough-ANN model for enterprises' technological innovation dynamic risk measure into three layers:

(1) Input layer: According to the index system of enterprises' technological innovation risk factors, use the knowledge reduction method in Rough Set Theory to remove redundant indicators, take the remaining indicators as input variables of neural network.

(2) Hidden layer: Dynamically adjusted learning algorithms in accordance with the improved BP neural network [26], first to set up hidden layer nodes large, let network self-regulated learning, and finally get the right size of hidden layer nodes.

(3) Output layer: Measuring the risk of technology innovation is a from the qualitative to the quantitative to the qualitative process, convert the qualitative into quantitative output by the neural network model, then combined the evaluation set with output results to measure the risk of technology innovation again. The risk of technology innovation level is divided into five levels: low risk, lower risk, general risk, higher risk, high risk. In artificial neural networks, respectively, using the output vector $(0,0,0,0,1)$ $(0,0,0,1,0)$, $(0,0,1,0,0)$, $(0,1,0,0,0)$, $(1,0,0,0,0)$. Therefore, the neural network's output layer nodes are 5.

5.3.5 Rough-ANN Model Basic Algorithm

Based on the above model structure design, forms the enterprise technology innovation risk dynamic measurement Rough-ANN model, the basic algorithm procedure is as follows:

Step 1. According to the indicator system of enterprises' technological innovation risk factors, data collection, use knowledge reduction method in Rough Set Theory to remove redundant indicators, take the remaining indicators as input variables of the neural network.

Step 2. Set neural network for 5 output layer node, and initialized other parameters of network (including a given study accuracy ε, the provisions of the iterative step number M, hidden nodes limit r, learning parameters b, momentum coefficients a. The initial hidden nodes should be appropriate to take a large number).

Step 3. Enter the learning sample, the sample parameter values into the $[0,1]$.

Step 4. Random values between $[-1,1]$, assigned to the initial weight matrix.

Step 5. According to the improved BP method to train the network.

Step 6. Judge whether the number of iterations exceed the prescribed number of steps or meet the learning accuracy requirements or not. Yes, termination algorithm; No, return to Step5, keep learning.

Step 7. Collect the value of test for evaluation of risk factors of enterprises' technological innovation projects, and processes the data to make data into $[0,1]$.

Step 8. Input processed data to the trained BP neural network to calculate the output.

Step 9. According to the output results, combined with enterprise technology innovation level of risk evaluation set, to make the evaluation of the risk of technology innovation.

5.4 Empirical Study

Chengdu Striker Electronics Company is currently the striker ranked in the top three gas-fired water heater manufacturer, the Chengdu High-tech enterprises and the industrial pillar enterprises, has the right of import and export business. Since 1982, Chengdu striker Electronics Co., Ltd. has developed a series of gas water heater products. Select typical technical innovation projects of Chengdu striker electronics companies in gas water heater during the past 15 years, and use the established Rough-ANN model in this paper to measure the risk of enterprise technology innovation project afterwards. Choice of technology innovation project are: project 1 (QFM0601YD type), project 2 (QFM0807YQ type), project 3 (QFM1061D type), project 4 (QF0971D type), project 5 (QFM1062TQ type), project 6 (QFM1601Q type), project 7 (QF1051Q type), project 8 (QF1011 type), project 9 (QF119 type), project 10 (QFM1021D type), project 11 (QFM1051D type), project 12 (QF139 type), project 13 (QFM1262TQ type), project 14 (QF0951Q type), project 15 (QFM1601W), project 16 (QFM1098D type). Previous 12 projects are taken as a training sample of the Rough-ANN model, and the after 4 projects as a risk measure forecast sample.

5.4.1 Enterprise's Technology Innovation Indicators of Risk Factors for Knowledge Reduction

(1) Risk factors indicators evaluation value

Divided Enterprises' technological innovation risk factors indicators into five risk levels: low risk, lower risk, general risk, higher risk, high risk. When a risk factors of enterprises' technological innovation indicators $x_i\,(i = 1,2,\cdots,48)$ is in low-risk, the evaluation value of 1; at a lower risk, the evaluation taking 2; so, when xi is high-risk evaluation to take 5.

Use expert evaluation method to score for Chengdu striker electronic company's technical innovation project 1 to 12 of 48 project risk factors index score, get the assessed value of the index. (Due to space limitations, the specific calculation process and the value of indicators assessment omitted in this).

(2) Knowledge reduction of risk factors indicators

According to the knowledge Reduction in Algorithm in Rough set theory to remove redundant indicators in the evaluation. Here, in two steps: first, remain only one indicator between the risk factors which have the same value; then calculate the risk factors indicators nuclear, delete redundant indicators according to risk factors indicators nuclear, find the smallest simplification of the indicators. From the final reduction results can be seen, the original 48 risk factors index, be reduction for 25 risk factors index. The index of the 25 risk factors are: Changes in the macroeconomic situation, The impact of the imported products, Technological maturity, Technology advanced degree, Technical complexity and difficulty, Technology accumulation degree, Technological substitutability, Technology personnel strength, Technical performance requirements, The difficult degree of the raw materials supply, The difficulty in introducing of new equipment, Quality performance of new products, The cost of new products, Competition strength, Competitor's unfair competition, The requirements of the users of the products, Changes in consumer demand, Corporate reputation and visibility, The ease of credit funding sources, Demand for innovative financing, Corporate financial strength, The management capacity, Feasibility studies and planning, Ability of the person in charge of the project, The degree of leadership support.

5.4.2 Rough-ANN Model

According to risk factors index knowledge reduction of result, neural network use 25 input variables (i.e. input layer take 25 node), and the middle hidden layer take bigger some, here take 60 node, the output layer for five node, the network structure is 25-60-5. Initialize the network (take the error limit $\varepsilon = 0.0002$, learning rate $\eta = 0.5$, the inertia parameters $a = 0.1$), convert 25 risk factor indicators of the 12 technological innovation projects (the remaining risk factors indicators after knowledge reduction) to $[0,1]$ (each evaluation values was divided by 10). 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 25-32-5 after training (25 input layer nodes, 32 hidden layer nodes, 5 output layer nodes), at the same time get optimize network weights matrix. The inference results (output) of the network study sample are shown in Table 5.2. It can be seen from the table, network inference results of the study sample and the actual results are exactly the same, this indicates the feasibility and effectiveness of the Rough-ANN model for dynamic risk measurement of enterprise technological innovation.

Table 5.2 Network inference output

Project	The actual status of project risk	Sample output	Network inference output	Network evaluation result
Project 1	High-risk	(1,0,0,0,0)	(0.9998,0.0215,0.0932,0.0751,0.0068)	High-risk
Project 2	Higher risk	(0,1,0,0,0,)	(0.0017,0.9859,0.0051,0.0043,0.0032)	Higher risk
Project 3	General risk	(0,0,1,0,0)	(0.0021,-0.0023,0.9786,1.0015,0.0078)	General risk
Project 4	General risk	(0,0,1,0,0)	(0.0094,0.2101,0.93156,0.0845,0.0567)	General risk
Project 5	Lower risk	(0,0,0,1,0)	(-0.0031,0.0025,0.0021,0.9978,0.1475)	Lower risk
Project 6	Lower risk	(0,0,0,1,0)	(0.0093,0.0098,0.0987,0.9075,0.0061)	Lower risk
Project 7	Lower risk	(0,0,0,1,0)	(0.089,0.3481,0.0258,1.0560,0.0054)	Lower risk
Project 8	Lower risk	(0,0,0,1,0)	(0.0421,0.0687,0.0541,0.9385,0.0723)	Lower risk
Project 9	Low-risk	(0,0,0,0,1)	(0.0089,0.0521,0.0006,0.0745,1.1258)	Low-risk
Project 10	Low-risk	(0,0,0,0,1)	(0.0147,0.0235,0.0796,0.1239,0.9999)	Low-risk
Project 11	Low-risk	(0,0,0,0,1)	(0.3698,0.2694,0.0046,0.0034,1.0007)	Low-risk
Project 12	Low-risk	(0,0,0,0,1)	(0.0364,0.0017,0.0037,0.0094,1.0013)	Low-risk
Project 13	Measuring degree		(0.9987,0.0016,0.0021,0.0085,0.0029)	High-risk
Project 14	Measuring degree		(0.0014,0.0227,0.0036,0.0089,1.0012)	Low-risk
Project 15	Measuring degree		(0.0008,0.0321,0.9937,0.0195,0.0015)	General risk
Project 16	Measuring degree		(0.0279,0.0016,1.0035,0.0085,0.0213)	General risk

5.4.3 *Risk Measure of the Enterprises' Technological Innovation Projects*

Use the trained neural network to measure the risk of Chengdu striker electronic company's technical innovation project. Score for 25 risk factors index (the remaining risk factors indicators after knowledge reduction) in Project 13, 14, 15, 16 of Chengdu striker electronic company's technical innovation project by the use of expert evaluation method. Then, convert the risk assessment values of these four projects to $[0, 1]$ (each evaluation values was divided by 10), put the processed data into neural network calculating, the output of each project were shown in last 3 lines of Table 5.2. According to the maximum membership degree principle, we can see the risk level of Project 13 is high-risk, the risk level of Project 14 is low-risk, the risk level of Project 15, 16 is general risk. This is consistent with the actual risk profile of the four technical innovation projects, Technological Innovation Project 13 failed in research and development, Technology Innovation Project 14, Project 15 and Project 16 have achieved success. Projects 14 obtain better benefits than Project 15 and 16.

5.5 Conclusion

Technological innovation is a high risk activities, and how to measure and manage the risk of technological innovation projects is a problem long plagued the development of enterprises. This paper established a Rough-ANN Model for dynamic risk measure of enterprise technological innovation, which based on Rough Set Theory and ANN (artificial neural network) method, not only able to extract the of the main features properties of the technology innovation risk, delete redundant information to reduce cost of the risk measure in information collecting, but also reduced the complexity and training time of neural networks, improved neural network learning ability, inferential ability and classification ability to achieve a dynamic measure for overall level of enterprise technology innovation risk. The model has better ability of practice operation than existing methods. In the end, an example is given to show the application of the Rough-ANN Model for dynamic risk measure of enterprise technological innovation. 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.

References

1. Bergman A, Fuss M, Regev H (1989) Tech firm in Israel industry. Environmental Science and Technology 3:225–226
2. Rubenstein AH, Chakrabarti AK (1976) Factors influencing innovation success at the project level. Research Management 19:15–20
3. Belev GC (1989) Minimizing risk in high-tech programs. Cost Engineering 31:11–14
4. Benaroch M (2001) Option-based management of technology investment risk. IEEE Transactions on Engineering Management 48:428–444
5. Zhang C, Jiang D (2001) Venture capital project assessment of quantitative models. Science of Science and Technology Management 10:44–46 (In Chinese)
6. Cooper RG (1979) Identifying industrial new product success: Project newprod. Industrial Marketing Management 8:124–135
7. Davis CR (2002) Calculated risk: A framework for evaluating product development. MIT Sloan Management Review 43:71–77
8. Fan X (1994) Comprehensive theory of industrial and technological innovation risk. Science Technology and Dialectics 11:52–58 (In Chinese)
9. Blau G, Methta B, Bose S (2002) Risk management in the development of new products in highly regulated industries. Computers Chemical Engineering 24:659–664

10. Zhou H, Song W, Liu C (2008) Construction project risk evaluation based on multi-attribute group decision making. Southwest Jiao Tong University (Social Science Edition) 3:124–128 (In Chinese)
11. Mao J, Huo B (2002) Risks and assessment of technological innovation. Quantitative & Technical Economics 28–31 (In Chinese)
12. Zhang J, Ye Y (2001) Technological innovation theories and methods of risk assessment and decision-making. Quantitative & Technical Economics 4:65–68 (In Chinese)
13. Ke K, Huang J (2005) The application of gathering statistics in high-tech project risk assessment. Science and Technology Progress and Policy 10:83–85 (In Chinese)
14. Kuchta D (2001) Use of fuzzy numbers in project risk criticalityassessment. International Journal of Project Management 19:305–310
15. Ekenberg L, Boman M, Joanne L (1997) Catastrophic risk evaluation. Working Papers 2–4
16. Li L, Cheng H, Lu B (2002) Convex rough set-based data reduction and rule discovery research. Southeast University 32:201–206 (In Chinese)
17. Wang L, Yong L, Ren R (2006) Enterprise technology innovation risk assessment based on the grey multi-level method. Systems Engineering Theory and Practice 26:98–104 (In Chinese)
18. Zhang N, Yan P (1998) Neural networks and fuzzy control. Tsinghua University Press, Beijing (In Chinese)
19. Pilar G, Guillermo P (2006) Technological innovation and environmental practices in the auxiliary automotive industry. International Journal of Business Environment 1:177–189
20. Pawlak, Z. (1998) Rough set theory and its applications to data analysis. Cybernetics Systems 29:661–688
21. Pearson AD, Newton RN (2001) Managing uncertainty in research and development. Technovation 21:79–90
22. Ergezinger S, Tomsen E (2001) An accelerated algorithm for multiplayer perceptions optimization layer by lays. IEEE Transactions Neural Networks 31–42
23. Sherif M, Alison KM (2001) Modelling project investment decisions under uncertainty using possibility theory. International Journal of Project Management 19:231–241
24. Sharp G (1994) Venture capital. Euromoney Publication PLC. 2nd edn
25. Zhang W, Wu W, Ye L (2001) Rough set theory and method. Science Press, Beijing (In Chinese)
26. Li X, Xu J (2004) Dynamic parameter self-tuning improvements of BP neural network model. Chinese Journal of Management Science 12:68–72 (In Chinese)
27. Wang Z, Ping Y (2008) Enterprises' independent innovation risk factors influencing. Technical and Economic 27:1–6 (In Chinese)
28. Zhang C (2008) Product development project risk assessment based on ds theory and fuzzy sets. Technology Management Research 39–41 (In Chinese)
29. Zhang L (1993) Artificial neural network model and its application. Fudan University Press, Shanghai (In Chinese)

Chapter 6
Secure Optimized Link State Routing in Mobile Social Networks

Rizwan Akhtar and Irfan Shahid

Abstract Mobile social network MSN is comprised of autonomous and self-organizing mobile computing devices which do not have a fixed infrastructure but rather they use ad-hoc routing protocols for data transmission and reception. Due to the continuous mobility of the user and working with the internet through the cellular operators on the mobility there is a need of efficient mobile social network services (MSNs) where user of similar interest in specific area under the connectivity of telecom operation can exchange contents like news, pictures, voice and video chatting and much more by accessing the internet. Optimized Link State (OLSR) is an IP reactive routing protocol which is optimized for MANET that is part of mobile social network and it can also be used for other wireless ad-hoc networks. Nodes in mobile social network network cannot perform route discovery or maintenance functions itself. This problem is resolved by using OLSR as it computes the routing distance from sending node to receiving node at preset intervals.

This research paper proposed Secure Routing Protocol (SRP) OLSR Message for Mobile social network and its implementation. Performance of proposed SRP is compared to ordinary OLSR. The simulation results reveal that proposed SRP is more efficient and secure than ordinary OLSR. SRP OLSR can be used for further research towards development of a commercial demand for the MSNs routing protocol using Blowfish cryptosystem for encryption and decryption for secure routing in a given MSN.

Keywords SRP · OLSR · MSN · Reactive routing · Network simulator

---

R. Akhtar (✉) · I. Shahid
ICT PTCL Acadmy. NWFP University of Engineering and Technology, Peshawar 25000, Pakistan
University of Electronic Science and Technology of China, Chengdu 610054, P. R. China
e-mail: rizwanakhtarpk@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_6, © Springer-Verlag London 2013

6.1 Introduction

Mobile Social Network MSN are of big importance without any ambiguity, in the running era, because of the fact that Social networks is source of presenting a collection of ties among the people and also the strength for those ties [1]. In MSN one user authenticate itself from the internet through telecom operators and get the contents from the internet server and then it can make ad hoc network with existing all other mobile user to share the contents with each other and thus on users side that they don't have any fixed infrastructure for support. MSN can easily be used to set up collaborative computing and communications wireless network in smaller areas (buildings, organizations, etc.).

Fig. 6.1 shows the generation of MSN. There is no access point in the MSN so nodes are connected directly with each other and each node act as a router which then itself receives information and transfers it to other node like a router in infrastructure mode [7]. However one node should be connected to content provider and thus share with all other mobile users. In this way all the nodes make their own ad hoc network in order to share their ideas, pictures and other social ties between them.

As node in mobile social network is free to move and can send information through direct radio communication. Therefore it is essential to provide better security in mobile social networks. Researchers around the world have explored a variety of mechanisms to attain security of data while considering the whole network at the same time. Moreover, due to increasingly security threats to the wired networks and growing demand of mobile networks, OLSR is now becoming a hot area of research for wireless LAN and Bluetooth Devices. The most common concept used in a mobile ad hoc network and other type of network is Packet forwarding, which contains block of logically addressed packets propagating from a source to the destination through nodes [6].

The proposed work aims to provide security using message of OLSR Routing Protocol. In this work routing Protocol is made secure for transmission in MSN. Routing protocols determine the path on which the routers communicate with each

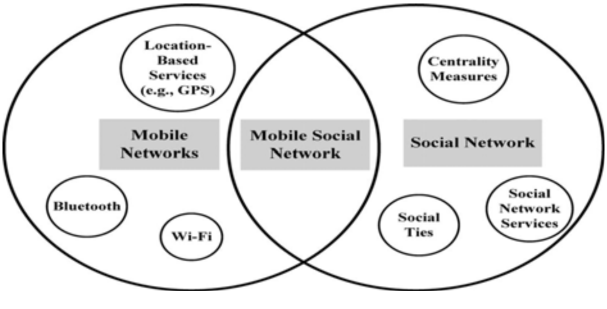


Fig. 6.1 Mobile social network is the intersection part of social network and mobile network

other using different routing algorithms. This information is instantly shared with the immediate neighbors, and then throughout the network. The behavior and characteristics of the routing protocols and their selection depend on the type of topology being used in the network. For MSN, OLSR is best for the short range communication network which do not have fixed dedicated infrastructure, any type of routing protocols may be used. The basic idea is that a new node may announce its presence and may listen for announcements broadcast by its neighbors. Each node has information about nodes nearby and also how to reach them. The mechanism of routing protocol is based on the procedure through which the nodes select preferred routes using information about the hop count (also known as hop cost) and the amount of the time required for communication between the source and destination. Some common examples of the routing protocols are OLSR, AODV [3], DSR, IS-IS, RIP.

Regardless of what type of routing algorithm is used, data security is another ever growing demand especially within Mobile social network. contents security is the only means of ensuring that contents are safely transferred between the communicating devices and is kept safe from corruption and that access to it is suitably controlled. Thus data security helps to maintain privacy, no doubt, which is an ocean of hackers and attackers. Some of the security mechanisms deployed today mainly captures hardware based security while others may deal with more software based approaches. Data Masking, Data Erasure and backups help to provide data security to some extent; Data Encryption has been identified as the best of all options for the security. The work presented in this paper mainly deals with the encryption of all sent messages and decryption of all received messages while communicating within a mobile social network using OLSR routing protocol.

The remainder of this paper is organized as follows: The proposed model for secure routing protocol is introduced in Sect. 6.2. In Sect. 6.3, simulation results are illustrated and performance analysis is made in comparison with other models. Conclusion is made in Sect. 6.4.

6.2 Proposed Model

Mobile social networks do not provide security for a dedicated infrastructure. The issue of secure routing is very critical in ad hoc networks and some basic protocols (AODV, OLSR etc) need to offer more reliable security features.

6.2.1 System Function

The proposed research work deals with a very basic implementation of Secure OLSR message for MSN using Blowfish cryptosystem for encryption and decryption for secure routing in a given mobile ad hoc network. Encryption at Source node and decryption at the destination node is performed using the following proposed model as show in the Figs 6.1 and 6.2.

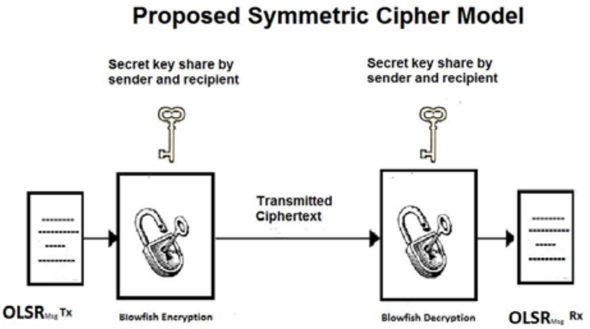


Fig. 6.2 Encryption and decryption using Blowfish algorithm in MSN

Here we can see that:
Message of OLSR = Mi;
Blowfish Encryption = ENB;
Now at transmitting node TX;
Cipher text = [Message of OLSR] [Blowfish Encryption];
$\rightarrow C =$ [Mi][ENB];
Similarly at receiving node RX;
Message of OLSR = Mi;
Blowfish Decryption = DCNB;
Plain Text = [Message of OLSR] [Blowfish Decryption];
$\rightarrow P =$ [Mi][DCNB].

A mobile Social network is one kind of ad hoc network so node in this network is an autonomous system that contain mobile routers (and associated nodes) connected by wireless links. The routers can free to move randomly as a part of network and organize nodes themselves arbitrarily; thus, the network's topology of wireless network may change quickly and unpredictably [4].

The behavior and characteristics of the routing protocols and their selection depends upon the type of topology being used in the network. For Mobile Ad hoc networks, which do not have fixed dedicated infrastructure [5], Ad hoc routing protocols that can be used for establishment of MSN. Our work mainly deals with the encryption of all messages sent and decryption of all messages received while communicating in a MSN using OLSR. As mentioned earlier, Blowfish encryption and decryption algorithm is kind of a tool used to make sure that all the messages transmitted on the network remain unreadable to any type of interfering entity providing fool proof security over the network. Furthermore, any sent message can only be read at a node if the destination node is also using the same protocol, so this is a part of the given network. Additionally if a node has been identified as a malicious node, newly developed protocol is capable of blacklisting it and thus informing the whole network about the node which has just been blocked so that the whole network is protected against any threat from the malfunctioning node. Usually there are other security schemes proposed to defense against more sophisticated attacks such as black hole, wormhole, rushing and similarly replay attacks in ad hoc networks [2].

6.2.2 Experiment Analysis

In this research paper we are interesting to deploy cryptography. Blowfish is keyed symmetric algorithm that can provide best encryption and decryption technique. It was introduce to world by a famous researcher Bruce Schneier in the area of data security over the any kind of network. To generate a cipher suit this algorithm is used for the encryption of the plain text now a day. The performance of the encryption rate is very high and due to popularity of this performance this algorithm is also designed in much latest software. It is general purpose mostly used algorithm and we can it is replacement of popular algorithm like AES, DES and many others.

According to Indian researcher worked in the field of data security over wireless sensor network Blowfish is best encryption algorithm which requires only 1 KB of the memory space and it only requires 400 Byte for the set up the symmetric key. So according to him this algorithm need low computational cost and provide high performance. He gives the practical graph of the Blowfish algorithm camper with other famous algorithm used for encryption. This is the graph for the performance

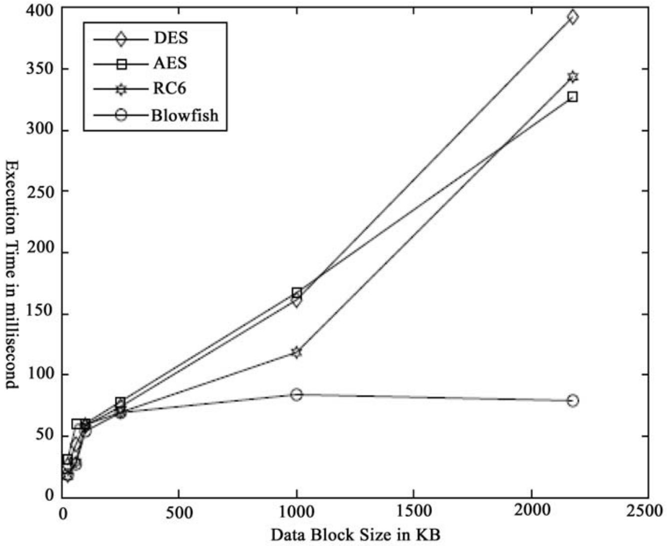


Fig. 6.3 The working of Blowfish

analysis which shows that results of Blowfish algorithms can be helpful for both energy and also the storage limitation. Another advantage of this algorithm is that it based upon open source mechanism so public can easily use this algorithm. Currently it used by many countries for getting the high performance security in their newly developed routing protocols. Common features of such algorithm involves key dependent and other is S-boxes which consist of highly complex key schedule.

6.2.3 The Algorithm

Blowfish is called as a keyed, block symmetric cipher that was designed by Bruce Schneier in 1993. It included in a large number of cipher suites and encryption products. Blowfish provides a good encryption rate in software and no such effective cryptanalysis of it has been found to date. Blowfish algorithm is similar like two-fish cryptographic Algorithm. It is a symmetric Cipher currently using in many commercial products. It is highly fast as compared to DES and AES because of using small key size of 128 KB. For securing small amount of data this cipher is consider to the best for providing security. The main limitation of Blowfish algorithm is cannot use in Hardware like chips of smart card because it take 4 KB of memory size. However this problem was solved by two-fish but in our research both of these cipher are applicable [12].

Blowfish consist of a 64-bit block size and having a variable key length from 32 up to 448 bits. It is composed of 16-round Feistel cipher and thus uses large key-dependent S-boxes. It is similar of the structure to CAST-128, which utilizes fixed S-boxes. Fig. 6.3 shows the working of Blowfish. Each line is representing 32 bits. The algorithm contains two sub key arrays one is 18-entry P-array and other is four 256-entry S-boxes. The S-boxes accept 8-bit input and generate 32-bit output. One entry of the P-array is utilize for every round, and after the final round, each half of the data block performed XORed with one of the two remain in unused P-entries. Fig. 6.4 presents Blowfish's F-function. The work of function is to splits the 32-bit input into four eight-bit quarters, and then uses the quarters as input to the S-boxes. The outputs are added modulo 232 and then XORed to generate the Final 32-bit output. Decryption is performed exactly the same as encryption, except that of P_1, P_2, $\cdots$ P_{18} are used the reverse order. This is not so obvious because XOR function is commutative and associative. A common mistake that occur is to use inverse order of encryption as decryption algorithm (i.e., first XORing P_{17} and P_{18} to the cipher text block, then using the P-entries in reverse order). Blowfish's key schedule starts by Algorithm initiate the P-array and S-boxes with values that derived from the hexadecimal digits of pi, which contain no obvious pattern.

The secret key is then XORed with the P-entries in required order (cycling the key if necessary). A 64-bit all-zero blocks is then ready to be encrypted with the algorithm as it stands. The resultant cipher text replaces P_1 and P_2. The cipher text is then encrypted again with the newly sub keys, P_3 and P_4 are replaced by the new cipher text. This will continue, till replacing the entire P-array and all the S-box entries. In all, the Blowfish encryption algorithm will run 521 times to produce all the sub keys about 4KB of data it is processed. In this work the Blowfish algorithm has been embedded in OLSR and the resulting new protocol has been tested using network simulator 2. In order to achieve secure routing, some functions have been added in the OLSR message which is explained in detail below.

6.2.4 Optimized Link State Routing(OLSR)

OLSR is the protocol used in MANETs. Since in MSN their exist a partial ad hoc network so we are using OLSR for route building in MSN This protocol fall in category of proactive protocols that is used for routing. This protocol is also needed to establish a route between the two communicating nodes in network. This protocol work on the mechanism that route established by it is always available. The routing table by the nodes are exchange with one and other each time, It find the best routing path through continuous exchange of routing table. OLSR select routing path through MPR called multipoint relay. So every node broadcast its information to other node through MPR [10]. By using the multipoint array OLSR can minimize the overhead and thus can reduce the delay time by controlling the packets. The node in selected MPR only can then communicate with each other [11]. OLSR does not need any duplicate transmission however security features are required to identify malicious node in the network.

6.3 Results and Comparison

This research paper mainly deals with the encryption of all sent contents and decryption of all received while communicating in a mobile Social network. In order

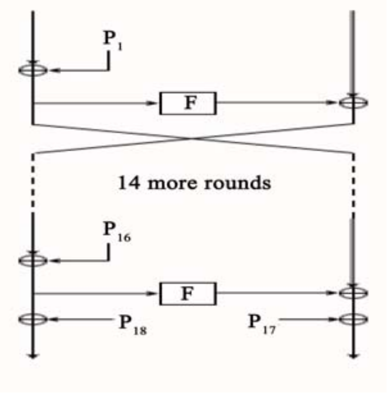


Fig. 6.4 Working procedure of Blowfish

to achieve our target variables, structures and functions have been added to the original OLSR message. A Blowfish Algorithm is used for cryptosystem using OLSR deals with the simulation scenario that is implemented in Network Simulator. NS-2 (Network Simulator - 2) is known to be a discrete event that is a simulator targeted at networking research. NS-2 can provides substantial support for simulation of TCP, routing, and multicast protocols over both wired and wireless The results shown are the successful implementation of secure routing protocol for MSN . The simulation results of implemented newly secure OLSR also show that Blowfish algorithm does not add unbearable overhead to the network traffic and hence the delay and drop rate both for packets is not affected, when compared to original OLSR.

The graph in section II-A shows the total throughput for the Blowfish algorithm after the T seconds time mark, the time when actual data starts transferring. So if we add security features in the message of OLSR it does not affect the overall delay system as compared to the original OLSR due to the fact that an extra encryption and decryption is utilizing place for all the contents sent or received. The resulting OLSR protocol has successfully been tested and is shown to be efficient and more secure when it is compared to ordinary OLSR. These results obtained by the simulation in NS-2 shows that it can be used for further research towards development of a commercial demand for the MSN routing protocol. An example of such a progress is development of an intrusion detection module and its integration with the existing system in order to provide fool proof security to the MSN nodes when it is depending on reactive protocols.

6.4 Conclusion

The results generated from the comparison based on the scenario discussed above show that the newly developed protocol is well efficient and no continuous network disconnection is experienced with longer delays which has mostly caused due to route non-availability. SRP OLSR can be used for further research towards development of a commercial demand for the MSN routing protocol using Blowfish cryptosystem for encryption and decryption for secure routing in a given mobile social network.

References

1. Chang YJ, Liu HH, Li C (2007) A general architecture of mobile social network services. In: Proceedings of 2007 International Conference on Convergence Information Technology
2. Ramanathan R, Redi J (2002) A brief overview of ad hoc networks: challenges and directions. IEEE Communications 40:20–22
3. Perkins CE, Belding-Royer EM, Das SR (2003) Ad hoc on-demand distance vector (AODV) routing. IETF Internet Draft, draft-ietf-manet-aodv-13.txt

4. Shrader B (2002) A proposed definition of ad hoc network. Royal Institute of Technology (KTH), Stockholm
5. Perkins, CE (2001) Ad hoc networking: An introduction. Ad Hoc Networking 40:20–22
6. Deng H, Li W, Agrawal D (2002) Routing security in wireless ad hoc networks. IEEE Communications 40:70–75
7. Karp B, Kung HT (2000) GPSR: greedy perimeter stateless routing for wireless networks. In: Proceedings of 6th Annual International Conference on Mobile Computing and Networking
8. Perkins CE, Royer EM (1999) Ad hoc on-demand distance vector routing. In: Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications
9. Zapata MG, Asokan N (2002) Secure ad hoc on-demand distance vector routing. ACM Mobile Computing and Communications Review 3:106–107
10. Adjih C (2003) Optimized link state routing protocol. IETF Internet Draft, draft-ietf-manet-olsr-08
11. Jacquet P, Mühlethaler P, Clausen T et al (2001) Optimized link state protocol for ad hoc networks. IEEE INMIC Pakistan
12. Dahna MC (2007) Bruce almighty: Schneier preaches security to Linux faithful. Computer World

Chapter 7
Psychological Rehabilitation of Sport Injury of High Level Athletes

Ying He and Ming Xu

Abstract With the methods of using document literature, logical analysis, system analysis and so and forth, mental model, psycho diagnosis index, and mental intervene model of sport injury happened on high-level athletes are discussed. As a result, it is concluded that the rehabilitation of their sport injure is a systematic process, and joint efforts from the coach, medical personnel, sports psychology workers as well as athletes themselves are needed. Only do they cooperate well with each other can the athletes recover and go back to the race course sooner.

Keywords High-level athletes · Sport injury · Mental model · Diagnosis · Rehabilitation

7.1 Introduction

With the gradually increasing intensity of competitive sports, ever more participated high-level athletes have got injured. Injure is commonly seen in sport competition. Due to the high -rate of mortality in modern athletic sport, sport injure has been treated as a widely accepted way of screening, in order to weed out the disqualified. Since modern athletic race is added with more utilitarian, commercial permeation and the further exposure of the media, ever more audiences are attracted to, at the same time, a comparatively more complicated social-psychological mood is reflected. In the past, such study was carried out from following subjects, say, physiology, medical science, the subject of training, etc. However, this essay focuses on rehabilitation mode of their sport injure psychologically, which is supposed to

---

Y. He (✉)
Sports Department, Chengdu Sport University, Chengdu 610041, P. R. China
e-mail: Heying7439@yahoo.com.cn

M. Xu
PE Department, Chengdu University, Chengdu 610106, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_7, © Springer-Verlag London 2013

serve as psycho-assistance for thorough recovering and finally returning back to the course.

7.2 The Mental Model of Sport Injure on High-level Athletes

On the early stage, study about the relationship between psychological factor and sport injure of high-level athletes is mostly carried on by coaches as well as relevant medical workers who are responsible for the curing stuff. While at present, more and more study is deepened on psychological factor and its potential mechanism, thus several stress theoretical models are gradually developed. It is important to get an idea of stress theoretical models of such sport injure as to prevent from such injure and, besides, to speed up rehabilitation practically and theoretically.

7.2.1 The Stress of Andersen and Williams-Sports Injury Model

Andersen and Williams referred to the stress-disease model [1] and put forward a stress-sports injury model [2] which based on the existing stress theoretical basis. In this model, high-level athletes regard stress as cognition of stress environment. When those high-level athletes find it hard to cope with the environmental requirements, their stresses are stimulated and the change of corresponded physiology and attention would make muscle tension, vision narrowing. In addition, at the same time, their danger of being hurt would increase and producing sports injury. Cognition, physiology and attention influence each other. Therefore, as the cognition can influence attention and physiology, attention can also reflect cognition. According to this model, the stress reaction of those high-level athletes will decide the happening of sports injury. What is more, their stress reaction can be adjusted by series psychological factors and intervention indirectly and directly. The psychological factors influence those high level athletes' sports injury including their personalities, the source of stress history, coping resources and intervention measurements, etc. However, with the development of research, those researchers find out that this model overemphasizes the linear relation between sports injury and psychological factors but neglects the relations among these factors and their interaction to influence high-level athletes' sports injury [3].

7.2.2 The Modified Stress of Andersen and Williams-Sports Injury Model

Aiming at the insufficient of sports injury model, Williams and Andersen made some modifications [4]. The new model makes some easy comparison between the high level athletes of hurt and unhurt to find out those influenced psychological factors and emphasizing the relations among these factors and their interaction to influence sports injury. Many scholars have done a lot of empirical study of this new model-stress sports injury model to find out the interaction of coping tactics, contest characteristics anxiety and the changing sides in daily life and contest. They would influence high-level athletes' sports injury [5–7]. A recent study also proof that, personality variable has an influence on acute motional trauma in two ways, from the motion damage by the impact on the cognition of high-level sports athletes in the context of the reaction in the stress response, namely direct influence. Another one is from the stress experiences and the assessments on coping resources of the high-level athletes and the individual's response to the stress reaction to impact the occurrence of the sports injury, which is intermediary variable having the mutual influence [8]. However, movement damage model still has the weakness that is the inadequate understanding of psychological intervention measures to the high-level athletes [9].

7.2.3 The Interactive Theoretical Model of Astrid Junge

Aim at correcting the deficiencies of the stress—movement damage model of Andersen and Williams, Astrid proposed a interactive theoretical model based on summing up of latest research [10]. According to him, whether a sportsman of high level will be injured during exercise is decided by his alarm reaction to the bad environment. Some influencing factors are listed as follows: psychosocial stress (especially daily events), coping with resource as well as emotional state [5, 11, 12]. In addition, he believes that these psychological factors work interactively instead of alone to cause the injury of sportsman of high level.

In summary, today, the model of three sports injury psychology theory plays an important role in comprehensive understanding of high level athletes' sports injuries. However, from the above analysis, we can also find some defects in the theoretical models more or less;

The theoretical model of psychological research is focus on single psychological factors to the influence of high-level athletes' injury. While there are few studies about the relationship and reciprocity between all kinds of psychological factors which have an effect on high-level athletes' injuries;

A high level of sport injury psychology research theoretical model does not consider self-concept, social impact, emotional response, motivation and self-regulation from high level athletes of different ages. Those factors may have an impact on the occurrence of their sports injuries, psychological response and recovery.

In addition, the theoretical model of sports injury psychology which studies intervention and prevention of high-level athletes' sports injuries is not enough in the breadth and depth.

These should be talked by researchers all over the world and be improved in future studies.

7.3 Psychological Diagnosis of High-level Athletes' Sports Injuries

7.3.1 The Different Stages of Psychological Reactions of the High-level Athletes' Sports Injuries

The psychological reaction to the high-level athletes who were injured can be foreseen in a large degree. This reaction contains five continuous stages.

The first stage is denial. This is a well known means of defense. When High-level athletes are facing difficulties and worries, they may produce a partial or complete misinterpretation to reality. After injured, they often initially refused to admit their bodies have gone wrong. But, long time deny is depart from reality and not conducive to rehabilitation. It seems that it is an unconscious act in some degree. However, some high-level athletes showed a tenacious struggle and strong will, and consciously deny or cover up their situation of sports injuries.

The second stage is anger. For the injury has become a reality, high-level athletes' attitude shift from questioned to scolding attitude while firstly they are thinking about "not me" then to the "how". Under that they are often in angry emotion, and accompanied by panic. This is a response that high-level athletes can not continue to participate in the competition.

The third stage is pain. After injured, their bodies naturally in a recovery process with pain, and even influence the actions of daily life. In rehabilitation process, the high-level athletes can not take part in team training and competition. This will produce a sense of loneliness and loss, and feel their own value and position is declining in the sports teams. If the period rehabilitation not yet reached the ideal rehabilitation status, the high-level athletes' emotion would return to the anger or into the more obvious depression.

The fourth stage is depression. When the high-level athletes finally realize that can not immediately solve the problem of pain or muscle, bone and joint injuries, they will become withdrawn, self-pity. They often evade their coaches and teammates under a depression and frustration emotion.

The fifth stage is the spirit of restructuring. When the high-level athletes recognize and accept the fact that he had injured, they begin to plan how to return to the competition successfully. At the same time, their psychological recovery process begins. But this process is complex, and sometimes even produces some new psychological conflicts. Such as high-level athletes will worry about if they are still the kingpin in the team or weather they can restore to pre-injury.

Each high-level athletes deal with sports injuries on its own unique way. The rehabilitation process does not necessarily go through all of the above stages. But the injured moments of the game time, the period of the entire season and the time of rehabilitation decide the mental endurance of high level athletes.

7.3.2 Psychological Diagnosis Standard for High-level Athletes' Sports Injury

It's necessary to conduct a psychological diagnosis on the high-level athlete who suffered an athletic injury. The key point lies in applying the psychological method and technique to assessing the psychological states, psychological difference and behavioral expression of injured high-level athlete so as to ensure its properties and degree [13]. In athletic injure psychology, the most common psychological diagnosis includes personality inventory, clinical neuropsychological inspection and various symptom estimate forms. In certain ways, psychological diagnosis, which is more sensitive than physical diagnosis, is conducive to identifying and estimating the psychological difference among individualities or the psychological states and reaction under different circumstances. It can improve athletic injury the diagnosis quality of high-level athlete and provide theory guide for the rehabilitation.

The athletic injury rehabilitation of high-level athlete is closely associated with its degree of injury. To a great extent, the degree of injured athletes' injury determines the degree of psychological rehabilitation. Retrospective investigation used to be the widely-accepted method in researches. The simple select in outcome variable may enlarge or conceal the relationship between the athletic injuries and psychological factors of high-level athlete. In abroad, experts usually take the quantity of athletes' absence from games or training as the criteria to mark off the athletic injury degree of high-level athlete. The degrees are defined as follows, mild degree (with absence of one to seven days), medium degree (with absence of eight to twenty-one days) and severe degree (with absence of over twenty-one days). In addition, the athletic injury degree of high-level athlete can be estimated in accordance with the medical estimation or diagnosis. This estimation method can dominate the influence of several potential irrelevant variable so as to achieve a more accurate and objective research process.

7.4 Psychological Intervention Model for High Level Athletes' Sports Injury

7.4.1 Rehabilitation Model for High Level Athletes' Sports Injury

Grove and Gordon put forward the rehabilitation model for high level athletes' sports injury based on Anderson's and Williams' stress — rehabilitation model for sports injury [14]. According to the rehabilitation model for high level athletes' sports injury, whether high level athletes can come back to competition with their injury rehabilitated is decided by both treatment factors, individual injury factors, individual stressor history, coping resources, personality and other psychological factors as well as psychological intervention. The rehabilitation processes of high level athletes are the interaction of their psychic reaction, cognitive appraisal and behavior.

7.4.2 Psychological Intervention Methods for High Level Athletes' Sports Injury

Overall recovery method should be applied in the rehabilitation for high level athletes' sports injury. It will help athlete recover from injury if we use psychological therapy as a supplement to medicine, physiology and training therapy. Although psychological therapy origins from high level athletes' understanding to injury, it's not enough to only understand reaction process after being injured. The working process of psychology and technology can promote high level athletes' rehabilitation process. The following are included: firstly, developing close relationship with injured high-level athletes; secondly, teaching them some knowledge about injury and rehabilitation process; thirdly, teaching them special psychological skills of dealing with injuries; fourthly, making them prepared for recurrence of injuries; fifthly, building social supportive system and guiding them to learn from other injured high-level athletes [15].

7.5 Conclusion

It's a process for high-level athletes to rehabilitate. During this period, coaches, team physicians and other sports psychology workers are responsible to learn and teach high-level athletes to acquire and to apply the above psychological rehabilitation skills. High-level athletes should improve self-management skills especially self-regulation ability. Only by persisting in practicing can they recover from injury comprehensively as soon as possible and come back to competition.

References

1. Smith RE (1983) A cognitive affective approach to stress management for athletics. Psychology of motor behavior and sport 54–72
2. Andersen MB, Willams JM (1988) A model of stress and athletic injury: Prediction and prevention. Journal of Sport Exercise Psychology 10:294–306
3. Taimela S, Osterman L (1990) Motor ability and personality with reference to soccer injuries. Journal of Sports Medicine Physical Fitness 30:194–201
4. Williams JM, Andersen MB (1998) Psychological antecedents of sport injury: Review and critique of the stress and injury model. Journal of Applied Sport Psychology 10:5–25
5. Petrie TA (1993) Coping skills competitive trait anxiety and playing status: Moderating effects on the life stress-injury relationship. Journal of Sport Exercise Psychology 15:261–274

6. Deng RH, Yan J, Li NC et al (2000) The thougt of evaluating coping model and effect about sport injury. Sports & Science 5:29–31 (In Chinese)
7. Rider SP, Hicks RA (1995) Stress coping and injuries in male and female high school basketball players. Perceptual Motor Skills, 81:499-503
8. Dai Q, Ji CS, Li ZH (2005) The influence of personality on sports injuries among baseball athletes. Journal of Tianjin Institute of Physical Education 20:11–13 (In Chinese)
9. Gunnoe AJ, Horodyski MB, Tennant LK et al (2001) The effect of life events on incidence of injury in high school football players. Journal of Athletic Training 36:150–155
10. Junge A (2000) The influence of psychological factors on sports injuries: Review of the literature. American Orthopedic Society for Sports Medicine 28:10–15
11. Hanson SJ, McCullagh P, Tonymon P (1992) The relationship of personality characteristics, life stress and coping resources to athletic injury. Journal of Sport Exercise Psychology 14:262–272
12. Kolt GS, Kirkby RJ (1994) Injury anxiety and mood in competitive gymnasts. Perceptual Motor Skills 78:955–962
13. Wang XD (1993) Mental health evaluation manual. China's Psychological Health Magazine, Beijing (In Chinese)
14. Grove JR, Gordon S (1991) The psychological aspects of injury in sport. Textbook of science and medicine in sport. Blackwell, London 176–186
15. Weinberg RS, Gould D (2003) Foundation of sport & exercise psychology. Human Kinetics Publishers

Chapter 8
Study on the Skilled Talents Evaluation Model based on Variable Weight Theory

Kesen Chen, Feng Tang, Yuanfeng Xie, Chenjing Ling and Zhenfen Gao

Abstract This paper presented a multi-layer talents evaluation model based on the post requirements and features for skilled talents, which is consisted of 4 primary indexes and 13 secondary indexes. It is structured based on variable weight theory and the variable weight vector is imported in the model. In this model, the index's weight value change with the variation of index's value, this agrees with the emphasis on talents' comprehensive qualities and specialty. This model has been applied in practice, and 2 samples introduced in this paper proved it's practical, reasonable and scientific.

Keywords Variable weight · Skilled talents · Evaluation model · Index system

---

K. Chen (✉)
Department of Environmental Engineering, Shandong Water Polytechnic, Rizhao 276826, P. R. China
School of Civil Engineering, Shandong University, Jinan 250061, P. R. China
e-mail: cks111@126.com

F. Tang
Department of Environmental Engineering, Shandong Water Polytechnic, Rizhao 276826, P. R. China
School of Economics and Management, Shandong University of Science and Technology, Qingdao 266590, P. R. China

Y. Xie · C. Ling
Department of Environmental Engineering, Shandong Water Polytechnic, Rizhao 276826, P. R. China

Z. Gao
Department of Environmental Engineering, Shandong Water Polytechnic, Rizhao 276826, P. R. China
School of Environmental and Municipal Engineering, Qingdao Technological University, Qingdao 266033, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_8,

8.1 Introduction

The research on talents evaluation model is practical and useful for selecting and employing talents, and a scientific, reasonable and practical talents evaluation method can make positive influence on talents training. The following methods are commonly used in talents evaluation: the fuzzy comprehensive evaluation method, the grey clustering method, the 3E evaluation method, the analytic hierarchy process, the bench marking management method and the balanced scorecard method [1–10], etc. In these methods, the indexes weight are constant, but in the skilled talents evaluation model, the weight of these indexes should be varied with the variation of index's value. Because a skilled talent should has excellent comprehensive qualities as well as specialties. Therefore, the skilled talents evaluation method should completely reflect the talent's comprehensive quality and specialty. The share of one index in the evaluation system should increase when the index's value is especially high or low, and the reward value and the punishment value can be reflected by this way. This paper presented the theory that the index weight in the evaluation model changes with the index's value. By increasing the special high or low index's proportion in the evaluation system to realize the reward or punishment. The variant vector related to the index value is an important factor to the theory, and the reasonable construction process of it is the key to realize this model.

8.2 Evaluation Index System

8.2.1 Construction of Evaluation Index System

The selection of indexes is the key to a evaluation method. According to the social requirements and position features, a qualified skilled talent's basic qualities include the ideological and ethical standards, the professional qualities, the aesthetic abilities and the psychological qualities. The scientific evaluation model is founded on the proper selection of index. The selected indexes should be operable and practical, and reflect the vocational features. In this paper, the multi-layer model is consisted of 4 primary indexes and 13 secondary indexes (Fig. 8.1).

8.2.2 Obtainment of Indexes Value

The 13 secondary indexes can be valued separately according to their features. Generally, we can directly get the quantized values of Marks C_5, Certificates Obtainment C_8, Operating Ability C_9, Specialty in Sports and Arts C_{11}. Political Quality C_1, Ethic Quality C_2, Psychological Quality C_3, Discipline C_4, Knowledge Obtainment C_6, Knowledge Application C_7, Responsibility C_{10}, Interpersonal skills C_{12}, Administration Ability C_{13} can be valued on test results or the testers' daily behaviors. The results we get are original values, after dividing it by 100, we'll get the index evaluation standard value.

8.3 Evaluation Model

8.3.1 Variable Weight Principle

Generally, the constant weight evaluation model is: $A = \sum_{i=1}^{n} w_i x_i$, where x_i is the index vector, w_i is the constant weight vector, and $\sum_{i=1}^{n} w_i = 1$, w_i is a constant number, and we get W_i by the experts' advice and usage of AHP, it is extraneous with x_i. (The constant weight in the talents evaluation model has been marked in Table 8.1)

But the talents evaluation model based on constant weight can not completely reflect the reward and the punishment to the talent who has obvious excellencies and

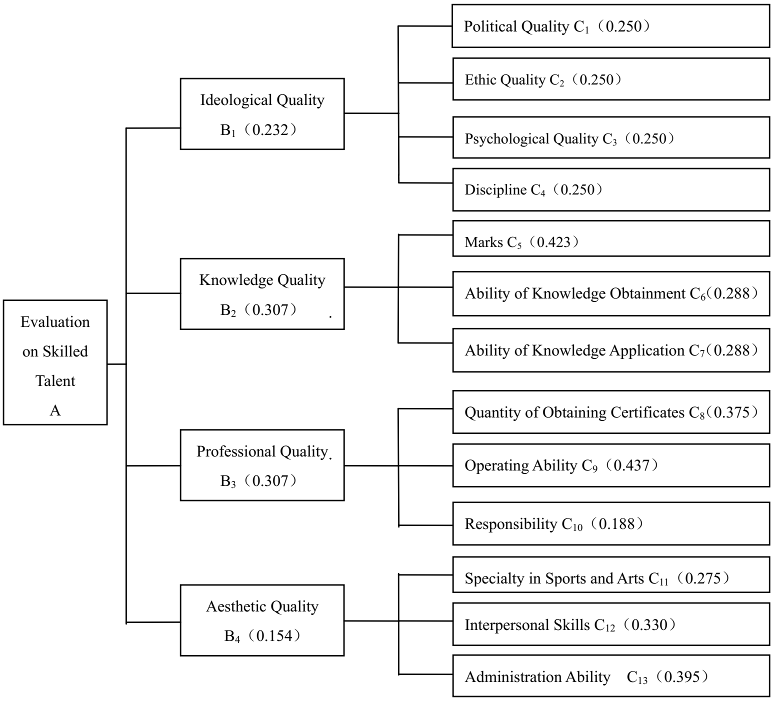


Fig. 8.1 The evaluation index system on skilled talents

defects. The talents evaluation should reflect the talents' comprehensive quality and specialty. In this paper, we lead the variable weight principle in the talents evaluation model, and the indexes weight varies with the change of indexes valuation.

The variable weight used in this evaluation model is constructed on the foundation of constant weight.

Set mapping $S : [0,1]^m \to [0,1]^m$, $S(X) = (S_1(X), S_2(X), \ldots, S_m(X))$, if any j gets its corresponding $\alpha_j, \beta_j \in (0,1)$, $\alpha_j < \beta_j$, and makes the $S(X)$ satisfy the $S_j(x)$ monotonically decreases in, meanwhile it monotonically increases in $[\beta_j, 1]$; X_j of $\sum_{k \neq j} W_k^0 S_j(X)$ monotonically increases in $[0, \alpha_j]$, and monotonically decreases in $[\beta_j, 1]$. The constant weight vector $W_0 = w_1^0, w_2^0, \ldots, w_m^0$ and are $S(X)$ operated according to the Hadamard, and the result is:

$$W(X) = (w_1(X), w_2(X), \ldots, w_m(X)) = \frac{W_0 S(X)}{\sum\limits_{j=1}^{m} w_j^0 s_j(X)}$$

$$= \left[\frac{w_1^0 S_1(X)}{\sum\limits_{j=1}^{m} w_j^0 S_j(X)}, \frac{w_2^0 S_2(X)}{\sum\limits_{j=1}^{m} w_j^0 S_j(X)}, \ldots, \frac{w_m^0 S_m(X)}{\sum\limits_{j=1}^{m} w_j^0 S_j(X)} \right]. \tag{8.1}$$

It is the m manifolds partial variable weight vector, $S(X)$ is the state variable weight vector.

8.3.2 State Variable Weight Vectors

This paper presents the following state variable weight $S(X)$ model based on the skilled talents evaluation system:

$$S_j(X) = \begin{cases} 1, & x_j \in [0, \alpha] \\ \frac{C-1}{\beta-\alpha} x_j + \left[1 - \frac{C-1}{\beta-\alpha} \alpha\right], & x_j \in (\alpha, \beta] \\ C, & x_j \in (\beta, \gamma] \\ \frac{1-C}{1-\gamma} x_j + \left[1 - \frac{1-C}{1-\gamma}\right], & x_j \in (\gamma, 1], \end{cases} \tag{8.2}$$

where$j = (1,2,3,4)$, and α, β, γ, C are separate parameters in $[0,1]$, α is the negative level, β is the qualified level, γ is the encouraging level, C is the adjusting level.

Generally, when $0 < x_j \leq \alpha$, the result is at the punishing level; when $\alpha < x_j \leq \beta$, the punishing values decreases with the increase of x_j ; when $\beta < x_j \leq \gamma$, the index j gets its normal value; when $\gamma < x_j \leq 1$, the encouraging level increases with the increase of x_j; as for the adjusting level C, C is inversely proportional with the punishing and the encouraging level.

In this paper, we take the parameters' value as following: $\alpha = 0.4, \beta = 0.6, \gamma = 0.9, C = 0.2$.

Therefore, the Equation (8.3) is:

$$S_j(X) = \begin{cases} 1, & x_j \in [0, 0.4] \\ 2.6 - 4x_j, & x_j \in (0.4, 0.6] \\ 0.2, & x_j \in (0.6, 0.9] \\ 8x_j - 7, & x_j \in (0.9, 1], \end{cases} \tag{8.3}$$

8.3.3 Variable Weight Evaluation Model

The skilled talents variable weight evaluation model:

$$A = \sum_{j=1}^{n} w_j(X) x_j, \tag{8.4}$$

where $W_j(X) = (w_1(X), w_2(X), \ldots, w_m(X))$.

8.3.4 Illustrations

The skilled talents evaluation model presented in this paper has been tested in practice. By leading actual cases into this model, we can get the test results which comprehensively and scientifically reflect the tester's qualities. The following 2 samples are introduced to illustrate the usage of this model.

Sample 1

Lead the original value of Sample 1 into Table 8.1, and evaluation process and results of Sample 1 can be seen in Table 8.1.

Table 8.1 shows that the tester has many index values above the encouraging level, no index value below the negative level. Therefore, the tester's variable weight comprehensive evaluation value is higher than the constant weight comprehensive evaluation value, it well reflects the reward effect.

Sample 2

Lead the original value of Sample 2 into Table 8.2, and evaluation process and results of Sample 2 can be seen in Table 8.2.

Table 8.2 shows that the tester has many index values below the negative level and other index values at the normal level. The evaluation result on him by the constant weight method is 0.617, which means he is at the passing level; but the evaluation result by the variable weight model is 0.577, which means the tester's valuation is at the failing level, it reflects the punishment effect.

Table 8.1 The evaluation process and results of sample 1

ω_j^0	B1 (0.232)				B2 (0.307)			B3 (0.307)			B4 (0.154)		
ω_{ji}^0	C_1 0.250	C_2 0.250	C_3 0.250	C_4 0.250	C_5 0.424	C_6 0.288	C_7 0.288	C_8 0.375	C_9 0.437	C_{10} 0.188	C_{11} 0.275	C_{12} 0.330	C_{13} 0.395
x_{ji}	78	80	70	65	88	87	76	84	89	76	92	94	94
X_j^0	73.25				84.26			84.68			93.45		
X_j	0.7325				0.8426			0.8468			0.9345		
A^0	0.8324												
$S_j(x)$	0.2				0.2			0.2			0.4760		
$\omega_j^0 S_j(x)$	0.0464				0.0614			0.0614			0.0733		
$\omega_j(x)$	0.1913				0.2532			0.2532			0.3023		
A	0.8504												

Note: where ω_j^0 is the constant weight value of the primary index, ω_{ji}^0 is the constant weight value of the secondary index; x_{ji} is the state value of the secondary index; X_j^0 is the standard value of the primary index, $X_j = X_j^0/100A^0$ is the comprehensive evaluation value of the constant weight, $A^0 = \sum_{j=1}^4 \omega_j^0 x_j$; $\omega_j(x)$ is the variable weight value of the primary index, $W_j(X) = \frac{W_j^0 S_j^X}{\sum_{j=1}^4 w_j^0 s_j^X}$; A is the comprehensive evaluation value of the variable weight.

Table 8.2 The evaluation process and results of sample 2

ω_j^0	B1 (0.232)				B2 (0.307)			B3 (0.307)			B4 (0.154)		
ω_{ji}^0	C_1 0.250	C_2 0.250	C_3 0.250	C_4 0.250	C_5 0.424	C_6 0.288	C_7 0.288	C_8 0.375	C_9 0.437	C_{10} 0.188	C_{11} 0.275	C_{12} 0.330	C_{13} 0.395
x_{ji}	60	62	70	65	39	76	37	74	70	76	72	76	78
X_j^0	64.250				49.080			72.628			75.690		
X_j	0.6425				0.4908			0.7263			0.7569		
A^0	0.6392												
$S_j(x)$	0.2				0.2			0.2			0.4760		
$\omega_j^0 S_j(x)$	0.2				0.6368			0.2			0.2		
$\omega_j(x)$	0.1389				0.5852			0.1838			0.0921		
A	0.5797												

Note: See Table 8.1.

8.4 Concluding Remarks

This paper presents a multi-layer talents evaluation model based on the post requirements and features for skilled talents, and this evaluation system is consisted of 4 primary indexes and 13 secondary indexes. The model is structured on variable weight theory and the variable weight vector is imported in the model. In this model, the index's weight values change with the variation of index's value, this agrees with the emphasis on talents' comprehensive quality and specialty. It is proved by illustrations that this model is scientific and practical.

The affirmance of state variable weight vector is the key to the evaluation model. The values of 4 parameters in variable weight vector(α,β,γ,C) should completely reflect the rewards and punishment effect, and their values depends on the evaluation indexes. We may get more precise results if we take different variable weight vectors according to different indexes.

This evaluation model is operable and can be operated by the software.

Acknowledgements Supported by a grant from Shandong Provincial Education Department for Science and Technology Program of 2011 (J11WF12).

References

1. Liu X, Huang H (2011) Discussion on the evaluation system for innovative talent cultivation of industrial engineering. Vocational and Technical Education 35:56–60 (In Chinese)
2. Pan C, Fan Z, Wu Y (2009) Study on the framework and evaluation of quality requirements for international talents. Shanghai Management Science 4:67–69 (In Chinese)
3. Sheng L, Zhang H, Xiao H (2009) A class of probability-based fuzzy analytic hierarchy process method. In: Proceedings of the Third International Conference on Management Science and Engineering Management
4. Sheng X, She Y (2011) The evaluation method of innovative talents quality based on interval-valued fuzzy sets. Mathematics in Practice and Theory 20:35–42 (In Chinese)
5. Shi S, Cui Y, Xu S et al (2010) Grey synthetic evaluation for rainwater collecting irrigation project planning. In: Proceedings of the 4th International Conference on Management Science and Engineering Management
6. Sun C, Liu Y, Qiang X et al (2008) The research on method measuring quality of staff in medical research institutes based on OWA aggregation operator. Chinese Journal of Health Statistics 2:42–45 (In Chinese)
7. Wang Y (2011) Forming a dynamic system of quality assessment for vocational personnel. Journal of Huangshi Institute of Technology (Humanities and Social Sciences) 5:62–65 (In Chinese)
8. Wu D, Yao W (2010) A study of assessment model for the cultivation of applied talents based on AHP. Journal of Changchun Normal University (Natural Science) 8:28–31 (In Chinese)
9. Yang W (2008) Study on evaluation of talent quality based on set pair theory and varying weight mechanism. Science & Technology Progress and Policy 7:190–192 (In Chinese)
10. Zhang X, Wen Y (2011) The study on evaluation index model based on core quality of new generation of marketing talent. Journal of Ocean University of China (Social Sciences) 6:57–62 (In Chinese)

Chapter 9

A State Enhancement or Reduction Model of Maintenance Effect and Application to Maintenance Decision

Xiaokai Ge, Jianbo Hu, Bofeng Zhang and Wei Yang

Abstract The aim of this paper is to investigate the mathematical modelling of maintenance effects in optimal maintenance model. Motivated by the Arithmetic Reduction of Intensity model with memory (ARI), our goal is to build a model, which can be used to unveil the quality of the maintenance performed according to current state or condition of equipments rather than its virtual age. By analyzing influence of maintenance actions on decision making, a state enhancement or reduction model (SERM) is presented in which maintenance effects are interprets as a random variable of real state and maintenance times. SERM models with and without human factors are constructed respectively. Then, the goodness character such as convergence and stability of it is proved by deducing formulation. And fit methods are given to estimate the parameters and human factors of model through historical maintenance information, which is easy to get from actual maintenance practice. Finally maintenance decision model simulation is used to analyzing the efficiency of it.

Keywords Maintenance effect · Human factors · Maintenance decision · Parameters estimation

---

X. Ge (✉)
Graduate Student Management Department 11, Engineering College, Air Force University of Engineering, Xi'an 710038, P. R. China
e-mail: wjzaixian1984@163.com

J. Hu
Engineering College, Air Force University of Engineering, Xi'an 710038, P. R. China
School of Computer Engineering and Science, Shanghai University, Shanghai 200072, P. R. China

B. Zhang
School of Computer Engineering and Science, Shanghai University, Shanghai 200072, P. R. China

W. Yang
Engineering College, Air Force University of Engineering, Xi'an 710038, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_9,

9.1 Introduction

Maintenance effects, which usually can be divide into imperfect and perfect maintenance, is the key factor during maintenance decision model. Research and practice has already shown that imperfect maintenance is accord with fact better, maintenance may not be "as new" or "as old" in simple, usually the state or condition of system after maintenance is "better than old, bad than new", so much as "bad than old" or "better than new".

Pham and Wang surveyed the imperfect maintenance model specifically [6], currently there are three type of it: (1) Brown- Proschan model, (2) ARA model, (3) ARI model [12]. The B-P model think maintenance makes the system as good as new with probability , and maintains the condition as before with the probability $1-p$ [1]. This model is simple, and fit to kind of decision model, but it is independent of maintenance history, and lack of practicality. The other two models assume the effect of maintenance is reduction to the virtual age or failure intensity. In fact the virtual age and failure intensity is related, and can be transformed to each other. According to the memory intensity of maintenance history, ARI model can divided to ARI_1, ARI_m and ARI_∞ models (accordingly there are ARI_1, ARI_m and ARI_∞) [2]. These models have played importance role in maintenance effect model, but they did not solve the imperfect maintenance problem statistically, and the maintenance effect or probability is not estimated from real maintenance information. In addition, these models are aim at virtual age or failure intensity, and can not be used in decision model based on condition degradation [3, 9, 10]. There are also any other models, such as PAR, failure rate adjusting model, geometrical distribution model [7, 8] and some combined models, all of which are extended form these two models above. Furthermore, current models neither take the human factors into account. Therefore, in this paper, we present the state enhancement or reduction model with the intention to describe real maintenance actions and real situation better, and make decisions based on system state or condition more exactly.

The rest of this paper is outlined as follows: In Sect. 9.2, we start with the problem description of maintenance effects model in preventive maintenance by analyze maintenance action and practice. Then, SERM with and without human factors are given out in Sect. 9.3 and 9.4 separately based on system assumptions. And fit methods are used to estimate model parameters, synthesis evaluate method is used to estimate human influence factor. Sect. 9.5 describes the character of SERM. Sect. 9.6 provides numerical examples of s-shape deteriorating system to illustrate the implementation of the proposed model. Finally, Sect. 9.7 gives a brief conclusion.

9.2 Problem Description and Model Assumption

Generally, maintenance policy for deteriorating systems includes corrective maintenance and preventive maintenance, corrective policy usually is replacement which makes system return to the condition as new. So this paper mainly studies maintenance effect modeling of preventive maintenance.

Maintenance effect varies with the maintenance intensity [13], which is decided by the current condition, times of maintenance while maintenance action is performed, as well as capability of maintenance crew [4, 5]. On one hand, preventive threshold indicates the difficulty in maintenance. The higher the threshold, the closer to failure, and the harder to be repaired, thus maintenance effect will be worse. On the other hand, difficulty in maintenance is influenced by times of maintenance activity performed. Maintenance too much times will age the system, weaken system state, thereby it will be in disrepair, and maintenance effect will be bad.

The SERM model researched latter is based on following assumptions.

Hypothesis 1. A single-unit deteriorating system consisting of one component or one group of associated components is considered.

Hypothesis 2. States of deteriorating system can be described by a continuous stochastic process , and initial state $Y(0) = 0$.

Hypothesis 3. Each maintenance activities can improve the condition of deterioration, and the quantity of improvement rests with failure history of the system.

Hypothesis 4. the deterioration process after maintenance is as it is before, which means the failure or deteriorating mechanism is inherent, and can not be changed by other outside actions.

For the good traits of geometric process [8], this paper using the adjusted geometric distribution to model and analysis maintenance effect, SERM with and without human influence factors are constructed separately.

9.3 Maintenance Effect Model Without Human Factor

In this section, the problem of maintenance effect model without human factor is illustrated, with basic character is verified. We referred to it as the SERM1.

9.3.1 SERM1

Let Y_i denote the system state after the ith maintenance action, which reflect the maintenance effect directly. And define the maintenance state enhancement factor $\phi(i)$ as follow:

$$\phi(i) = \frac{M - Y_i}{M}, \tag{9.1}$$

where M is the preventive maintenance (PM) threshold. The meaning of it is the ratio quantity to be improved after maintenance activity. So after preventive maintenance the system state will be as follow:

$$Y_i = (1 - \phi(i))M. \tag{9.2}$$

This formulation is similar with B-P model, but has factual interpretation, $\phi(i)$ is the improvement percentage after maintenance.

The function of $\phi(i)$ assumed to be in the form of geometric process as follow:

$$\phi(i) = (1 - \exp(-a^i - b)),\ i = 1, 2, \cdots N,\ a < 1,\ b < 1, \tag{9.3}$$

where *i* is the numbers of maintenance actions be performed (maintenance times), *a* and *b* is two unknown parameters to be estimated to fit the factual maintenance practice.

It is common sense that maintenance effect is the function of maintenance times. With increasing maintenance be performed, the effect of it will be weaker, until that the maintenance no longer make visible impact. According to Equations (9.2) and (9.3), the state enhancement factor should be positive function of maintenance times.

Proposition 9.1. *$\phi(i)$ is a positive function of maintenance times.*

For any two adjoining maintenance times i and $i+1$, we have:

$$\begin{aligned}\phi(i+1) - \phi(i) &= (1 - \exp(-a^{i+1} - b)) - (1 - \exp(-a^i - b)) \\ &= e^{-b}(\exp(-a^i) - \exp(-a^{i+1})) = e^{-b}e^{-a^i}(1 - e^{-a}) > 0.\end{aligned} \tag{9.4}$$

Of which is positive, so the $\Phi(i)$ is a positive function.

Proposition 9.2. *When $i \to \infty$, $\Phi(i)$ tends to a stability value (maintenance effect of the worst situation) It is easy to get that:*

$$\lim_{i\to\infty} \phi(i) = \lim_{i\to\infty}(1 - \exp(-a^i - b)) = 1 - e^{-b} \lim_{i\to\infty} \exp(-a^i) = 1 - e^{-b}. \tag{9.5}$$

Its meaning is that with the numbers of maintenance increasing, the maintenance effect becomes a constant. At the same time we can get that the parameter a reflects the speed of decreasing maintenance effect, while the parameter b reflects the stability level.

Proposition 9.3. *For a given PM threshold M, and the least improvement value δ, exist a max maintenance times.*

Least improvement value can be described by adjoining $\phi(i)$, that is:

$$\phi(i+1) - \phi(i) = e^{-b}e^{-a^i}(1 - e^{-a}) \geq \delta. \tag{9.6}$$

So we have the max maintenance times as follow:

$$\max(i) = \log_a(b - \ln(\delta/(1 - e^{-a}))). \tag{9.7}$$

The above model is very general, since we have not imposed any restriction on the function other than positive, hence the parameters can be estimated according to actual situation and maintenance history record, to represent the maintenance effect of particular system.

9.3.2 Parameters Estimation of SERM1

For the model above, we need the maintenance effect series to estimate its parameters, which is easy to build according to system state changing dataset $\hat{Y}_i$ gotten from the history maintenance record information. Then we can calculate the ith actual state enhancement factor $\hat{\phi}(i) = \frac{M-\hat{Y}_i}{M}$, by now, the two parameters could be estimated by the least squares fitting method, and get the maintenance effect model as follow:

$$Y_i = (1-\phi(i))M = e^{(-\hat{a}^i-\hat{b})}M,\ i = 1,2,\cdots,N. \tag{9.8}$$

Example 9.1. This part using some real control system as an example to illustrate the parameters estimated process by fitting (the actual maintenance record information is omitted).

Fig. 9.1 is the plot of parameters fitting, from which we can see when maintenance times near 16, the effect of maintenance is inconspicuous, so we can fixed the max maintenance times as 16 for this object system, and get the optimized parameters

$$\hat{a} = 0.8096,\quad \hat{b} = 0.2329.$$

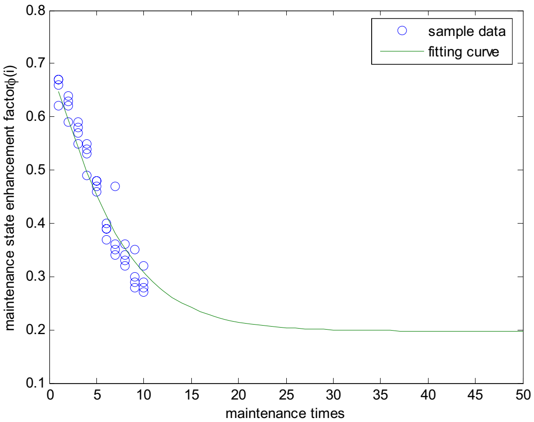


Fig. 9.1 Parameters fitting of maintenance effect model without human factors

9.4 Maintenance Effect Model with Human Factor

In this section, human factor is taken into account, and SERM1 is renewed to SERM2. Also character of the model with influence of human factor is verified.

9.4.1 SERM2

The SERM1 can be considered to be the maintenance effect under ideal situation, which is usually difficult to reach $(1-\phi(i))M$ in practice. Influenced by techno-capability, psychology factors of maintenance crews et al, there are useless maintenance, even maintenance that make the system malfunction (ill-maintenance in [13]), that is mean the system will go to failure state F directly.

In this part, we define the state reduction factor σ_0 (without regard to redesign, thus $0 \le \sigma_0 \le 1$) to illustrate the influence of human factors. For $\sigma_0 = 1$ maintenance effect is ideal, and $\sigma_0 = 0$, system will be failure. We using the linear model to express the relation of human factor and maintenance effect, then get:

$$\frac{Y_i - F}{\sigma_0} = \frac{(1-\Phi(i))M - F}{1-0}. \tag{9.9}$$

Transform the above expression, we get:

$$Y_i = ((1-\Phi(i))M - F)\sigma_0 + F. \tag{9.10}$$

Introducing the ideal model (9.3), we get the maintenance effect model with human factors SERM2:

$$Y_i = \left(e^{(} - \hat{a}^i - \hat{b})M - F\right)\sigma_0 + F. \tag{9.11}$$

Also we can find the stability value when the maintenance times tend to infinity.

$$\lim_{i\to\infty} Y_i = (e^{-b}M - F)\sigma_0 + F = \sigma_0 e^{-b}M + (1-\sigma_0)F. \tag{9.12}$$

From the Equation (9.12), we can find that the stability value is composed by two parts, one is the maintenance effect of ideal situation being modified by human factors, another is harmful maintenance item. When human influence is ignorable, that is σ_o near to 1, the second item is similar to 0. When the human influence is great, the stability level will be close to failure state.

In SERM2, the enhancement factor Φ_r can be calculated as follow:

$$\begin{aligned}\phi_r &= \frac{M - Y_i}{M} \\ &= \frac{M - \sigma_0 M(1-\phi(i)) - (1-\sigma_0)F}{M} \\ &= (1-\sigma_0)\frac{M-F}{M} + \sigma_0\phi(i).\end{aligned} \tag{9.13}$$

When human influence is ignorable, Φ_r mainly decided by second item, and $\Phi_r \approx \Phi(i)$. When the human influence is great, it is mainly decided by the first item, which means the system tends to be failure after maintenance.

Proposition 9.4. *When the human influence is ignorable, max maintenance times is independent of state reduction factor* σ_0.

We assume the maximum maintenance times for Equation (9.6) is $i_{\max}$, *then the least improvement value of SERM2 is:*

$$\phi_r(i_{\max}+1)-\phi_r(i_{\max})=\sigma_0(\phi(i_{\max}+1)-\phi(i_{\max})). \tag{9.14}$$

Apparently there exist a σ_0 *as follow:*

$$\sigma_0=\frac{\delta}{\Phi(i_{\max}-1)-\Phi(i_{\max})}\leq 1. \tag{9.15}$$

Make the follow equation come into existence.

$$\phi_r(i_{\max}+1)-\phi_r(i_{\max})=\delta. \tag{9.16}$$

At the same time we can get:

$$\begin{aligned}\phi_r(i_{\max})-\phi_r(i_{\max}-1)&=\sigma_0(\phi(i_{\max})-\phi(i_{\max}-1))\\&=\frac{(\phi(i_{\max})-\phi(i_{\max}-1))}{\phi(i_{\max}+1)-\phi(i_{\max})}\delta\\&=\frac{e^{-a^{i_{\max}-1}}}{e^{-a^{i_{\max}}}}\delta=e^{-1/a}\delta.\end{aligned} \tag{9.17}$$

Because $0<a<1$, *so we have:*

$$\phi_r(i_{\max})-\phi_r(i_{\max}-1)<\delta. \tag{9.18}$$

From Equations (9.16) and (9.18), we can get the conclusion that, for a single given δ, *SERM1 and SERM2 reach the maximum at the same maintenance times.*

For the SERM1, we have: $\Phi(i_{\max}-1)-\Phi(i_{\max})\rightarrow\delta$, *so there is a tiny state reduction factor* $\sigma_0=\frac{\delta}{\Phi(i_{\max}-1)-\Phi(i_{\max})}$, *which have neglectable influence on maximum maintenance times for SERM2.*

9.4.2 Parameters Estimation of SERM2

In what follows we provide a simple and convenient procedure of parameters estimation for maintenance effect model with human factor.

1. Establish crew capability evaluating index system (include techno-capability, knowledge, practice capability and accident ratio et al). Score the index and evaluate the weight of every item of it by expert, then calculate the state reduction factor σ_0 by Comprehensive Evaluation method.
2. System state data after maintenance can be used to estimate parameters of Equation (9.11) by fitting methods; Or firstly calculate the b according to Equation (9.13) by experience and the stability value of system state after maintenance, then estimate a by fitting method. The latter is of better efficiency.

Example 9.2. This part using the same control system as a example, and suppose that failure state value is $F = 80$, and threshold is $M = 58$. Fig. 9.2 is the curve of system state after PM under different human factors. That is the maintenance effect curve.

9.4.3 Results and Analysis

In Fig. 9.2 we plotted eight typical maintenance effect curves, from which we can draw the conclusion as follow:

1. When the human factor is between 0.9-0.98 (the normal level), the system after maintenance is in the operational state, and the effect go to stability after a fixed maintenance times (15 or 16). The difference is that for crew with lower maintenance technology, the maintenance effect is worse, which put the system under the inefficient operation performance in the long run.
2. When the human factor grows bigger (roughly around 0.5, that is to say there is half chance to make the system down), the system state after maintenance will be close to or exceed the preventive threshold, and the actual maintenance times will decrease, such as 6 for the human factor of 0.5 and 3 for 0.4.
3. In the extreme situation (about 0.2), system will be failure after the first time PM. Next, normal level (such as the human factor is 0.98) under different preventive maintenance threshold is studied. Fig. 9.3 is the relation between system state after maintenance and maintenance times under different threshold. Fig. 9.4 is the three-dimensional relation of them.

From the plots above, we can get follow conclusion. The stability maintenance times is almost the same for different PM thresholds, just for that the lower thresholds be set ,the earlier PM action will be taken, so maintenance will be frequently, which is

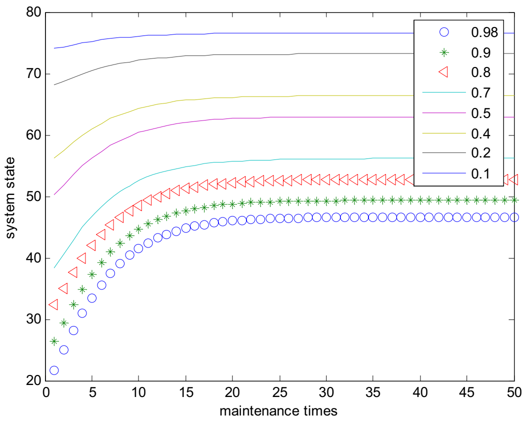


Fig. 9.2 Maintenance effect against maintenance times under different state reduction factor

harmful to system operation, and lead to over maintenance. At the same time, system will be work under the weak state in the long term, and have a low availability. Oppositely, if be set too high, it may lead to the inadequate maintenance. So the question is how to find the optimal threshold among the allowable region, under the restriction of cost and availability of object system.

9.5 Character Summary of SERM

Through the model analysis process and conclusion of example simulation, we can see that the presented model coverage almost all the maintenance type in actual maintenance practice, such as, harmful maintenance, basic maintenance, moderate

Fig. 9.3 System state against maintenance times under different PM threshold

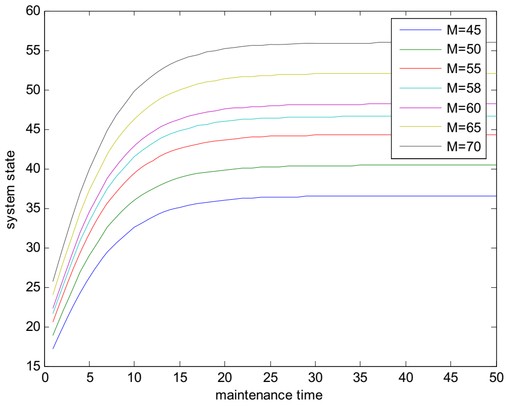
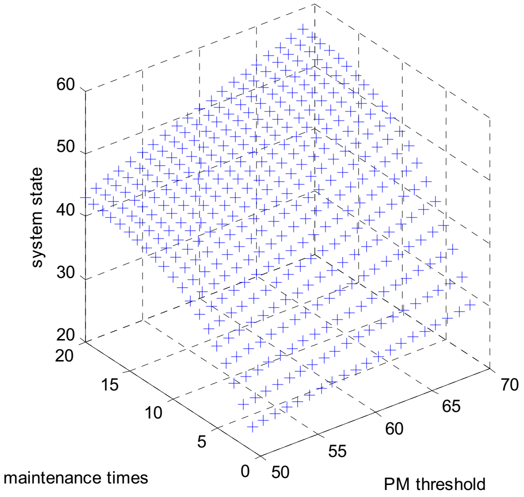


Fig. 9.4 Relation among system state-PM threshold and maintenance times



maintenance, perfect maintenance and even improvement maintenance [13]. State enhancement factor and reduction factor can be used together to describe kinds of maintenance situation. The properties of the constructed models can be summarized as follows.

SERM1 without human influence

1. When $\Phi(i) = 0$, the model refers to useless maintenance (as bad as old).
2. When $\Phi(i) = 1$, the model refers to optimal maintenance (as good as new).
3. When $\Phi(i) = p$, where p is a constant, then the model turn into the B-P model.
4. When $0 < \Phi(i) < 1$, the model refers to effective maintenance.
5. The model takes full advantage of Maintenance history information, and possesses good memory.

Besides, SERM2 with human influence also include other features.

1. Human influence factor is considered, and model is better approaching the maintenance practice.
2. When $\sigma_0 = 0$, it is worst maintenance (that is failure after maintenance).
3. When $\sigma_0 = 1$, it refers to harmless maintenance (without artificial breakage).
4. When $0 < \sigma_0 < 1$, it refers to harmful maintenance (the general situation in practice).
5. When normal maintenance is performed, the max maintenance times is decided by difficult intensity of system itself, and is independent of human influence (this can be gotten from proposition 4).

9.6 Numerical Simulation Study

An average maintenance cost model of literature is considered to test the SERM presented above, for the decision-making of optimal PM threshold [4]. In this model two maintenance actions are considered, replacement upon failure and PM. The best threshold to do PM is the one which minimizes the expression:

$$EC = \frac{E\left(\sum_{i=1}^{N} C_{ti} + C_{tf}\right)}{E\left(\sum_{i=1}^{N} T_i + T_f\right)}, \tag{9.19}$$

where EC is the average maintenance cost, C_{ti} is the PM cost at ith PM action, C_{tf} is failure replacement cost, T_i is the operation time from the $i-1$th PM to ith PM, we term it the ith degraded time, T_f is the operation time from the last PM to failure replacement we term it failure replacement degraded time. For convenience we do not concern the distributions of maintenance time and maintenance cost, also neglect the inspection cost. Set PM cost of every time be $C_{ti} = 200$, failure replacement cost be $C_{tf} = 850$. Using the fitting technique and results introduced in Sect. 9.3, the estimates are $\hat{a} = 0.8096$, $\hat{b} = 0.2329$.

Randomized logistic degradation path function $Y(t) = We^{Bt}/(B+e^{At})$, as an S-shaped curve, for example, describes well the degradation process and it matches the path of the cumulative degradation of many systems in practice [11]. Thus we use it to illustrate the decision procedure in this paper. Let the parameter values be: $W = 80$, $A = 50$, $B = 0.1$. Substituting these parameters into the function, we can obtain the degraded time and failure replacement degraded time as Equations (9.20), (9.21) and (9.22) respectively.

$$T_1 = \frac{\ln(AM/(W-M))}{B}, \tag{9.20}$$

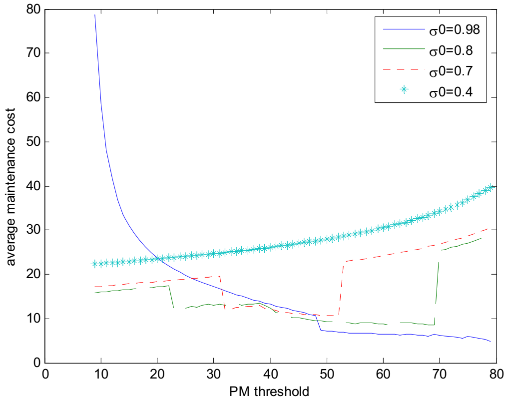
$$T_i = \frac{\ln(AM/(W-M))}{B} - \frac{\ln(AY_{i-1}/(W-Y_{i-1}))}{B}, \; i > 1, \tag{9.21}$$

$$T_f = \frac{\ln(AF/(W-F))}{B} - \frac{\ln(AY_{16}/(W-Y_{16}))}{B}. \tag{9.22}$$

Substituting maintenance effect Y_i gets from SERM model into Equations (9.20), (9.21) and (9.22), and minimizes Equation (9.19), we can obtain some results presented in Fig. 9.5 and Fig. 9.6. Fig. 9.5 is the relationship chart between the average maintenance cost and PM thresholds, of which the σ_0 are 0.98, 0.8, 0.7 and 0.4 separately. And we can get the optimal result as follow:

1. When the state reduction factor is near to ideal state (0.98), average maintenance cost tends to a stability value with the PM thresholds increasing. In order to ensure the system is operating in good state, the optimal PM threshold can be set as the lowest value among stability value (that is 50 here).
2. For bigger human influence (such as 0.8 or 0.7), the average maintenance cost descends first and ascends later with the PM thresholds increasing. The reason for this is that the maintenance effect after PM is very close to the PM thresholds, thus the operation time after PM be reduced. At this situation, more PM action will just multiply the maintenance preparation cost, and cause the leap of average maintenance cost.

Fig. 9.5 The plot of average maintenance cost against PM threshold under different σ_0



Under this situation, the influence of maintenance crews' capability is to shorten the length of the stability region, and accelerate the increasing region arrival (such as 52 for $\sigma_0 = 0.8$, and 70 for $\sigma = 0.7$).

3. Under the extreme situation (for example 0.4), system state is worsened by PM action at the beginning. The higher the threshold, the harder to do PM actions, and the average maintenance cost is increasing.

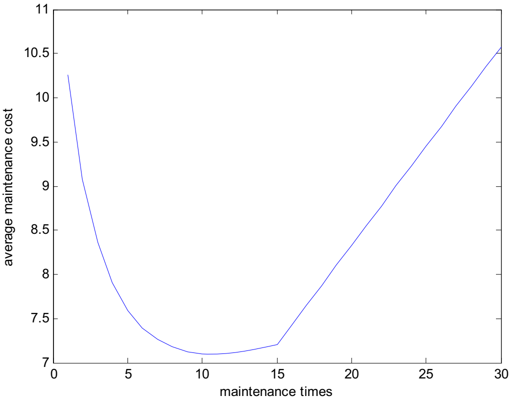
Fig. 9.5 is the relationship chart between average maintenance cost and maintenance times at . We can obtain the best maintenance times 13, which is similar to the conclusion in Sect. 9.3. The left side is inadequately maintenance, and the right side is over maintenance, both of which will increase the average maintenance cost.

9.7 Conclusions

In this work, we research the influence of maintenance action to decision-making; have presented the state enhancement or reduction maintenance model (SERM), which is fit to the maintenance decision of deteriorating system very well. We constructed models with human influence (SERM1) and without it (SERM2) respectively. By analyzing and formulization deduction, the properties relevant to the proposed model are also addressed. Based on our analyses and simulation above, we have the following remarks:

This paper assumes that the system after maintenance could be as good as new, as bad as old or some other middle situation, and maintenance effect is used to illustrate these problems in practice. We assume that the maintenance effect is a geometric process, which is the function of current system state and maintenance times. And maintenance history information is used to estimate the parameters of it. Obviously, the model is more realistic than the model based on virtual age, and those which do not use the actual maintenance history information.

Fig. 9.6 The plot of average maintenance cost against maintenance times



Also human factor is considered in SERM2. According to the example analysed, we find that the model with human factors describe the maintenance process more accurate than those do not considered it.

According to the numerical simulation example, we find that with the model presented in this paper, the decision is more accurate, and we can calculate different optimal PM threshold when we set different human influence factors. Therefore, we can get different decision result under different maintenance environment demand. It is convenient to adjust the parameters to describe different circumstance, and help to make appropriate maintenance determination.

We can also find the appropriate maintenance times for particular system from Fig. 9.6. What's more, we have found from experiments that average maintenance cost always go to a stability value when the influence of human factor is in the ideal or extreme situation, or else, it will descends first and ascends later in the general. Thus the optimal PM threshold can always be found at the minimum stability value or the turning point.

Acknowledgements The authors would like to thank the reviewers for pointing out a number of issues that help improve the quality of the paper significantly. This work was supported by the shanghai Leading Academic Discipline Project (Grant No. J50103); and Scientific Research Innovation Funds for the Air Force University of Engineering (Grant No. XS1101020).

References

1. Brown M, Proschan F (1983) Imperfect repair. Journal of Applied Probability 20:851–859
2. Doyen L, Gaudoin O (2004) Classes of imperfect repair models based on reduction of failure intensity or virtual age. Reliability Engineering and System Safety 84:45–56
3. Hirmer C, Rboulet G, Sourget F et al (2009) Maintenance optimization for a system with a gamma deterioration process and intervention delay: Application to track maintenance. Journal of Risk and Reliability 223:189–198
4. Hu J, Ge X, Yang Y et al (2011) Study of synthetical condition-based maintenance framework of aviation materiel. Journal of Air Force Engineering University 12:1–6
5. Kinnison H (2004) Aviation maintenance management. McGraw Hill Professional Press
6. Pham H, Wang H (1996) Imperfect maintenance. European Journal of Operational Research 94:425–438
7. Shahannaghi K, Babaei H, Bakhsha A et al (2008) A new condition based maintenance model with random improvements on the system after maintenance actions: Optimizing by Monte Carlo simulation. World Journal of Modeling and Simulation 4:230–236
8. Tai A, Chan L (2010) Maintenance models for a continuously degrading system. Computers & Industrial Engineering 58:578–583
9. van Noortwijk J (2009) A survey of the application of gamma processes in maintenance. Reliability Engineering & System Safety 94:2–21
10. van Noortwijk J, van der Weide J, Kallen MJ et al (2007) Gamma processes and peaks-over-threshold distributions for time-dependent reliability. Reliability Engineering and System Safety 92:1651–1658
11. Wang H, Pham H (2006) Reliability and optimal maintenance. In: Springer series in reliability engineering series 171–203, Springer-Verlag, London

12. Wang L, Hu H, Wang Y et al (2011) The availability model and parameters estimation method for the delay time model with imperfect maintenance at inspection. Applied Mathematical Modelling 35:2855–2863
13. Zuo H, Cai J, Wang H (2008) Maintenance decision theory and method. Aviation Industry Press, Beijing (In Chinese)

Chapter 10

Numerical Computation Studies between a New Algorithm, Power, and QR Iterative Algorithms for Solution of Eigenvalue of Essentially Positive Matrices

Tedja Santanoe Oepomo

Abstract The aim of this manuscript is to study and to compare several iterative procedures based on Oepomo, Power, and QR methods for solving dominant eigenvalues of essentially positive matrices. Ascending and descending techniques lead to a new iterative method, new algorithm. The new technique was compared to the Power and QR methods in term of speed of convergence, number of required mathematical operations, and effectiveness to numerically calculate dominant eigenvalues of essentially positive matrices. Numerical examples illustrate the purpose.

Keywords Collatz's theorem · Perron-Frobernius' theorem · Eigenvalue

10.1 Introduction

For solving the system of eigenvalues, we consider any convergent methods using the power and QR iterative methods. Quite often the convergence is too slow and it has to be accelerated. There exist many processes for that purpose whose references can be easily found. The aim of this manuscript is to understand the Oepomo's, QR, and Power methods.

10.2 Eigenvalue Computation

The second fundamental problem in linear algebra is to compute the eigenvalues and eigenvectors of a square matrix. In other words, to diagonalize a square matrix.

T. Oepomo (✉)
Science, Technology, Engineering, and Mathenmatics Division West LA/LA Harbor Colleges, School of Business California International University, 1301 Las Riendas Drive, La Habra CA 90631, USA
e-mail: oepomots@wlac.edu; oepomots@lahc.edu

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_10, © Springer-Verlag London 2013

In theory we know what to do. We have to compute the characteristic polynomial $P(\lambda)$, find the roots λ_i, then for each i, we have the equation $(A-\lambda_i)x = 0$ for the eigenvectors. However, this procedure is not satisfactory.

Newtown's method give a very fast way to compute roots of polynomial $P(\lambda)$, it can also easily be extended to complex roots. But remember, that Newton's method usually works very well once you are reasonably "close" to the root, but it may diverge if you start far away. Still you need ad hoc method to get "close" to the root. To reduce the chance element in this "hit or miss" strategy, another numerical computations were invented, i.e. power, QR iterative, and Oepomo's methods. Moreover, we also have to care about the stability of the method, as the eigenvalue problem can be quite ill conditioned, so we do not want to make it much worse by an unstable algorithm.

Example 10.1. Consider the $n \times n$ matrix:

$$A = \begin{bmatrix} 0 & & & & & & & & \varepsilon \\ 1 & 0 & & & & & & & \\ & 1 & 0 & & & & & & \\ & & 1 & 0 & & & & & \\ & & & 1 & 0 & & & & \\ & & & & \cdot & \cdot & & & \\ & & & & & \cdot & \cdot & & \\ & & & & & & \cdot & \cdot & \\ & & & & & & & 1 & 0 \end{bmatrix}, \tag{10.1}$$

where ε is a tiny number with all entries are zero. The characteristic polynomial of A is $P(\lambda) = \lambda^n - \varepsilon$. Clearly all eigenvalues are 0 if $\varepsilon = 0$. However for $\varepsilon \neq 0$ there are n complex eigenvalues, the n-th roots of unity. Even if we focus on the real eigenvalue $\varepsilon^{1/n}$, it is clear that the problem is very ill conditioned. Let $n = 40$ and choose $\varepsilon = 10^{-40}$ which is an extremely tiny relative error of order $\frac{10^{-40}}{1} = 10^{-40}$. However, one of the eigenvalue is $\lambda = 10^{-1} = 0.1$ which is at a distance of 10^{-1} from the "unperturbed" eigenvalue of 0. Hence the change in the eigenvalues is equal to the change in the perturbation parameter ε multiplied by 10^{39}. There is another disquieting aspect of this phenomenon. The number $\varepsilon = 10^{-40}$ is automatically replaced by 0 in the computer, and this rounding introduces an error of order 10^{-1} in the result.

Fortunately the eigenvalue problem is not so ill conditioned for "most" matrices, this example was particularly nasty one. However, it shows that we should aim at stable algorithms, which at least do not make "bad things much worse", since the problem itself can be quite "bad".

10.3 Power Method

This method is extremely simple. Let A be a square matrix. Pick any vector x_0 and start successively multiplying it with A. We can claim, that unless you are extremely unlucky with the choice of x_0, we can easily find the eigenvalue with the largest modulus.

Theorem 10.1. *Suppose that the square matrix A has n distinct eigenvalues* $\lambda_1, \lambda_2, \lambda_3, \cdots, \lambda_n$ *and that they are ordered in decreasing magnitude; that is* $|\lambda_1| > |\lambda_2| \geq |\lambda_3| \geq \cdots \geq |\lambda_n|$. *If* x_0 *is chosen appropriately, then the sequences* $\{x_k = \left(x_1^k, x_2^k, \cdots, x_n^k\right)^T\}$ *and* $\{c_k\}$ *generated recursively by* $y_k = Ax_k$ *and* $x_{k+1} = \frac{1}{c_{k+1}} y_k$ *where* $c_{k+1} = x_j^{(k)}$ *and* $x_j^{(k)} = \max\limits_{1 \leq i \leq n} x_j^{(k)} = \max\limits_{1 \leq i \leq n}$, *will converge to the dominant eigenvector* v_1*and eigenvalue* λ_1, *respectively. That is* $\lim\limits_{k \to \infty} x_k = v_1$, *and* $\lim\limits_{k \to \infty} c_k = \lambda_1$.

Remark 10.1. If x_0 is an eigenvector and $x_0 \neq v$, then some other starting vector must be chosen. It is easy to normalize an eigenvector $[v_1, v_2, \cdots, v_n]^T$ by forming a new vector $V = \frac{1}{c}[v_1, v_2, \cdots, v_n]^T$ where $c = v_j$ and $v_j = \max\limits_{1 \leq i \leq n} \{|v_i|\}$.

Table 10.1 Hilbert matrix H_{40} power method

Operations	$\Delta(x)$	$\log \Delta(x)$
1640	1.423	0.3528
4921	$1.41x10^{-1}$	-1.958
8200	$1.39x10^{-2}$	-4.275
11490	$1.3441x10^{-3}$	-6.611
14764	$1.296x10^{-4}$	-8.949
18040	$1.25x10^{-5}$	-11.288
21322	$1.208x10^{-6}$	-13.626
24600	$1.116x10^{-7}$	-15.965
27880	$1.123x10^{-8}$	-18.304

Table 10.2 Hilbert matrix H_{40} oepomo method

Operations	$\Delta(x)$	$\log \Delta(x)$
4800	$1.016x10^{-1}$	-2.288
9600	3.71×10^{-3}	-5.597
14400	8.549×10^{-5}	-9.368
19200	3.068×10^{-6}	-12.6934
24000	7.061×10^{8}	-16.467
28800	2.536×10^{-9}	-19.289
29700	9.977×10^{-10}	-20.628

Proof (see [8]).

This method gave only the eigenvalue of largest modulus. With a little trick, one can get all other eigenvalues,

Theorem 10.2. *Suppose that the square matrix A has an eigenvalue λ_p, which is closer to p than all other eigenvalues. Run the*

$$x_{n+1} = (A - pI)^{-1} x_x,$$

iteration with some initial vector x_0. If the vectors x_0 and ω are chosen randomly, then $\lim_{n\to\infty} \frac{w^t \cdot x_{n+1}}{w^t \cdot x_n} = \frac{1}{\lambda_p - p}$ "almost surely". Hence λ_p is obtained as $\lambda_p = \lim_{n\to\infty} \frac{w^t \cdot x_n}{w^t \cdot x_{n+1}} + p(if\lambda_p \neq p)$. Moreover, again, the normalized vectors $\tilde{x}_n := \frac{x_n}{\|x_n\|}$ converge to the eigenvector belonging to λ_p.

Table 10.3 Hilbert matrix H_{40} QR method

Operations	$\Delta(x)$	$\log\Delta(x)$
17400	2.423×10^{-2}	-3.21
23400	1.007×10^{-4}	-9.202
26600	8.263×10^{-9}	-18.614
332000	2.422×10^{-2}	-3.722
442000	1.0096×10^{-4}	-9.212
506000	8.239×10^{-9}	-18.615

Table 10.4 Almost cyclic matrix C_{40} power method

Operations	$\Delta(x)$	$\log\Delta(x)$
3780	$3.091x10^{-1}$	-1.174
7980	2.089×10^{-1}	-1.566
1188	1.421×10^{-1}	-1.950
16390	9.706×10^{-2}	-2.334
20580	6.6381×10^{-2}	-2.714
24780	4.5461×10^{-2}	-3.092
28990	3.111×10^{-2}	-3.478
33190	2.1341×10^{-2}	-3.848
37380	1.4651×10^{-2}	-4.228

Proof. Simply that the eigenvalues of $B := (A - pI)^{-1}$ are $(\lambda_1 - p)^{-1}, (\lambda_2 - p)^{-1}, \cdots$, where λ_i are the eigenvalues of A. Hint: this statement does not require being symmetric, so spectral theorem cannot be used. From the condition, it follows that $(\lambda_1 - p)^{-1}$ is the largest in modulus among them, so we can apply Theorem 10.1. The statement on the eigenvector is straightforward from Theorem 10.1.

Remark 10.2. The power method looks very simple and elegant. However, notice it is powerful only for the eigenvalue largest in modulus. Applying Theorem 10.2 already requires inverting a matrix, and more importantly, it requires knowing a point p "near" the eigenvalue. Hence, we run into similar difficulties when we applied

Newtown's iteration for finding the roots of the characteristics polynomial. In fact, there is essentially a Newtown's iteration behind Theorem 10.2.

Discussions: The power method converges very slowly if the separation between λ_{k+1} and λ_1 is poor; in such cases, it may be feasible to speed up the convergence as follows. Consider the matrix $A-qI$, where q is a number and I is the identity matrix. The matrix $A-qI$ has eigenvalues $\lambda_i - q$, and if q is chosen properly, convergence to an eigenvector may be sped up. If, for example, $\lambda_1 > \lambda_2 \geq \cdots \geq \lambda_n > 0$, then the optimum value of q for the maximum rate of convergence is $\left(\frac{\lambda_2+\lambda_n}{2}\right)$. Of course, we need some knowledge of the eigenvalues to apply this method, but if the eigenvalues are known to be positive, then trial values of q can be easily chosen to find the value yielding the best rate of convergence. This is the shift of origin technique and has proven to be effective for some eigenvalue distribution [14].

If λ is an eigenvalue of A then A^{-1} is an eigenvalue of. According to a variant of the power method that may be called the inverse power algorithm, sequences $\{x^m\}\{y^m\}$ are formed by the following recursion:

$$(1)\, x^{m+1} = A^{-1}y^m, \quad (2)\, y^{m+1} = \frac{x^{m+1}}{\max\limits_i \left|x_i^{m+1}\right|}. \tag{10.2}$$

Each step here requires the solution of the linear system:

$$Ax^{m+1} = y^m. \tag{10.3}$$

Using the inverse power method, we can find the absolutely smallest eigenvalue and the corresponding eigenvector of the matrix.

The inverse power method can be considerably accelerated by the shift of origin technique, if A is a Stieltjes matrix. A real (n,n) matrix $A=(a_{ij})$ with $a_{ij} \leq 0$ for all $i \neq j$ is a Stieltjes matrix if A is symmetric and positive definite. Let the eigenvalue of A be given by $0 < \lambda_1 \leq \lambda_2 \leq \cdots \leq \lambda_n$. If A is irreducible Stieltjes matrix it can be proven [12] that for all $0 < \sigma_m < \lambda_1$ (for $m = 0, 1, \cdots$).

$$(A - \sigma_m I)^{-1} > 0. \tag{10.4}$$

A^{-1} has the same eigenvectors as $(A-\sigma_m I)^{-1}$, therefore we replace in (i) A^{-1} by $(A-\sigma_m I)^{-1}$ and we get the recursive relation:

$$\text{(i)}\, x^{m+1} = (A - \sigma_{mI})^{-1}y^m, \quad \text{(ii)}\, y^{m+1} = \frac{x^{m+1}}{\max\limits_i \left|x_i^{m+1}\right|}, \tag{10.5}$$

where $\sigma_0 = 0$ and $y^0 > 0$ is the initial value of starting vector. Using Collatz's theorem to the last relation it can be shown [1] that:

$$\underline{\lambda}_1^{(m)} \equiv \sigma_m + \min_{1\leq i\leq n}\left(\frac{y_i^m}{x_i^{m+1}}\right) \leq \lambda_1 \leq \sigma_m + \max_{1\leq i\leq n}\left(\frac{y_i^m}{x_i^{m+1}}\right) \equiv \bar{\lambda}_1^{(m)}, \tag{10.6}$$

where the first and the last terms are lower and upper bounds for λ_1 If equality holds in the above equation than $\underline{\lambda}_1^{(m)} = \bar{\lambda}_1^{(m)} = \lambda_1$, and the procedure terminates. On the other hand, if these bounds are unequal we define the following relationship $\sigma_{m+1} = \underline{\lambda}_1^{(m)}$ and continue the iterative process.

Table 10.5 Almost cyclic matrix C_{40} oepomo method

Operations	$\Delta(x)$	$\log\Delta(x)$
1400	2.76×10^{-2}	-3.589
2800	7.607×10^{-4}	-7.187
4200	2.293×10^{-5}	-10.699
5600	6.3492×10^{-7}	-14.277
7000	1.9246×10^{-8}	-17.774
8400	5.3279×10^{-10}	-21.358

Table 10.6 Almost cyclic matrix C_{40} QR

Operations	$\Delta(x)$	$\log\Delta(x)$
2400	3.091×10^{-1}	-6.6224
3260	2.089×10^{-1}	-8.308
4000	1.421×10^{-1}	-14.178
44680	9.706×10^{-2}	-21.798
21340	6.6381×10^{-2}	-6.620
29340	4.5461×10^{-2}	-8.30892
37300	3.111×10^{-2}	-14.178
41340	2.1341×10^{-2}	-21.798

10.3.1 Speed of Convergence

In the iteration in the theorem uses equation

$$x_k = \frac{(\lambda_1)^k}{c_1 c_2, \cdots, c_k} \left(b_1 v_1 + b_2 \left(\frac{\lambda_2}{\lambda_1} \right)^{k-1} v_2 +, \cdots, b_n \left(\frac{\lambda_n}{\lambda_1} \right)^{k-1} v_n \right) \tag{10.7}$$

and the coefficient of v_j that is used to form x_k goes to zero in proportion to $\left(\lambda_j/\lambda_1\right)^k$ Hence, the speed of convergence of $\{x_k\}$ to v_1 is governed by the terms $\left(\lambda_2/\lambda_1\right)^k$. Consequently, the rate of convergence is linear. Similarly, the convergence of the sequence of constant $\{c_k\}$ to λ_1 is linear. The Aitken Δ^2 method can be used for any linearly convergent sequence $\{p_k\}$ to form a new sequence,

$$\hat{p}_k = p_k - \frac{(\Delta p_k)^2}{\Delta^2 p_k} = p_k - \frac{(p_{k+1} - p_k)}{p_{k+2} - 2p_{k+1} + p_k}, \tag{10.8}$$

that converges faster.

10.3.2 QR Iteration for Eigenvalues

We will discuss the QR algorithm, which is the most frequently used for calculation of the set of eigenvalues of a general matrix. However, it does not compute eigenvectors unless the matrix is symmetric. The QR method seeks the reduction of e general matrix to a triangular from with the aid of unitary transformation. Instead of the triangular decomposition, as in LR method, the QR method uses the factors of the type:

$$RQ = Q^t(QR)Q = Q^tAQ, \tag{10.9}$$

where Q is a unitary matrix, R an upper triangular matrix, RQ and matrix is actually conjugated to the original matrix A, hence RQ has the same set of eigenvalues as A. So we compute $A_1 = RQ$ and run the same steps again: compute the QR factorization of $A_1 = Q_1R_1$ (of course $Q_1 \neq Q$ and $R_1 \neq R$ since Q, R do not commute), then compute $A_2 = R_1Q_1$ and repeat the process of factorization.

Table 10.7 Matrix Q_{40} power method

Operations	$\Delta(x)$	$\log\Delta(x)$
4200	6.506×10^3	8.788
3780	1.0023×10^2	4.608
7990	6.196	1.824
12190	1.065	0.0609
16390	2.1967×10^{-1}	−1.518
20580	4.985×10^{-2}	−2.988
24790	1.160×10^{-2}	−4.458
28990	2.703×10^{-3}	−5.916
33190	6.294×10^{-4}	−7.372

In the general in n^{th} step, we consider the QR-factorization $A_n = Q_nR_n$ of A_n, then we let $A_{n+1} = R_nQ_n$.

It is clear that the set of eigenvalues of all the A_n matrices are the same. It is not true that A_n converges to a diagonal matrix, in fact the upper off-diagonal matrix elements may not converge at all. However, the sequence becomes increasingly upper tridiagonal, i.e., the lower of-diagonal elements go to zero, and more importantly, its diagonal elements converge to the eigenvalues. The precise theorem goes as follows, which we state without proof.

Theorem 10.3. *Suppose that the real valued square matrix A is invertible and all eigenvalues $\lambda_1, \lambda_2, \cdots$ are distinct in modules. Then $\lim\limits_{n\to\infty}(A_n)_{ii} = \lambda_i$ for $i = j$ and $\lim\limits_{n\to\infty}(A_n)_{ij} = 0$ for $i > j$.*

If we start with a symmetric matrix A, then clearly the sequence A_n consists of symmetric matrices as well. From the theorem we know that is almost upper triangular, but A_n is also symmetric, hence it is almost diagonal. We obtain

$$A_n = Q_n^t Q_{n-1}^t \cdots Q_1^t A Q_1 Q_2 \cdots Q_n = Q^t A Q, \tag{10.10}$$

with the choice $Q = Q_1 Q_2, \cdots, Q_n$, i.e., $A = Q A_n Q^t$ is almost the spectral decomposition of A since A_n is almost diagonal.

Remark 10.3. Notice that the QR-iteration uses only real numbers; every step of the procedure we never see any genuine complex number. Hence, it is unable to find complex eigenvalues. This is not in contradiction to the theorem, since for a real matrix the complex eigenvalues come in conjugate pairs and conjugate pairs have the same modulus. If λ_1 is a solution to $p(\lambda) = 0$ characteristic equation, then so is $\lambda_2 = \bar{\lambda}_1$, its complex conjugate. To see this, simply take the complex conjugate of the characteristics equation and use that all coefficients are real. There are improvements of the QR-method, which finds eigenvalues as well, but we did not discuss them here.

Table 10.8 Matrix Q_{40} oepomo method

Operations	$\Delta(x)$	$\log \Delta(x)$
2400	3.105	1.134
3260	2.089×10^{-4}	−8.472
4000	4.778×10^{-7}	−14.558
44680	3.124×10^{-10}	−21.879

10.3.3 Algorithm

Each step of the QR algorithm requires the QR factoring of $A_k (k = 1, 2, 3, \cdots)$. For theoretical purposes it was convenient to think of this in terms of the Schmidt or tho-normalization of the column of A_k. In practice, due to round off error, this commonly gives rise to a Q_k which is by no means orthogonal [13, 14]. The first step is to let $A = Q_0 R_0$ be a QR factorization of to create$A_1 = R_0 Q_0$. The second step is to let $A_1 = Q_1 R_1$ be a QR factorization of A_1 to create $A_2 = R_1 Q_1$. The third step is to continue this process. Once A_m has been created, let $A_m = Q_m R_m$ be a QR factorization of A_m and create $A_{m+1} = R_m Q_m$. Then stop the process when the entries below the main diagonal of A_m are sufficiently small, or stop the process if it appears that convergence will not happen. The QR method can fail to converge, and it also can be extremely slow. The algorithm can be modified to converge both faster and for more matrices. One modification is called *shifting*: at each step a scalar c_i then the QR factorization is performed not on A_i but $A_i - c_i I$. The matrix $c_i I$ is added back when A_{i+1} is defined. If the scalars c_i are chosen such that they get closer and closer to an eigenvalue of the matrix, this will dramatically speed up convergence. Another improvement to the method is called *deflating*. The process will allow us to remove the last row and column of the matrix when he last row looks like $[000,\cdots,0x]$. The modified QR method is as follows: The first step is to choose c to be the last diagonal entry in A. Let $A-cI=Q_0R_0$ be a QR factorization of $A-cI$; then create $A_1=R_0Q_0+cI$. The second step is to choose to be the last diagonal entry in A_1 Let $A_1-c_1I=Q_1R_1$ be a QR factorization of $A-cI$; then create $A_2=R_1Q_1+c_1I$. In step 3, we continue the process; once A_m has been obtained, choose c_m to be the last diagonal entry in A_m, let $A_m-c_mI=Q_mR_m$ be a QR factorization of A_m-c_mI and create $A_{m+1}=R_mQ_m+c_mI$ Step 4 will follow when the entries in the final row of A_m (except for the final entry) are zero (to machine accuracy), deflate A_m by removing the final row and column. The final entry in the row just removed is an eigenvalue. The final step is to repeat steps 1 through 4 on the deflated matrix until all the eigenvalues have been found or until it appears that convergence to a triangular limit matrix will not occur.

Table 10.9 Matrix Q_{40} QR method

Operations	$\Delta(x)$	$\log\Delta(x)$
4260	1.429×10^{1}	2.6591
5260	1.322×10^{-2}	−4.329
5870	4.664×10^{-5}	−9.9722
41300	1.4294×10	2.6588
51300	1.324×10^{-2}	−4.3262
55300	4.668×10^{-5}	−9.9722

In practice the matrix Q_k^H is determined such that

$$Q_k^H A_k = R_k. \tag{10.11}$$

The matrix Q_k^H is determined as the product of plane rotations by Given's method [7], or by the use of unitary matrices using Householders method. Here only Householder's triangularization will be used.

Rate of Convergence: In the QR method, the sub-diagonal elements (i,j) of A_k $(k=1,2,3,\cdots)$ converge to zero as fast as $\left(\lambda_i/\lambda_j\right)^k$. The convergence could be slow if the separation of the eigenvalues is poor.

10.3.4 Application and Limitations

The decomposition of A into QR is too laborious (requiring 0 (n^3) operations) for full matrices. For this reason, the matrix is first transformed into Hessenberg form.

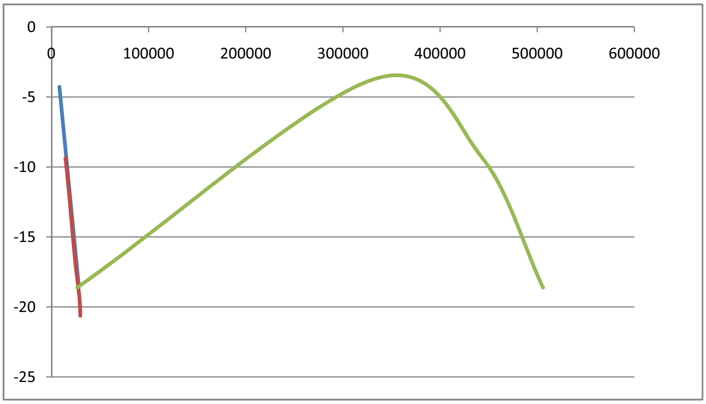
It can be shown that the Hessenberg form is invariant with respect to the QR transformation [13, 14].

The great benefit the *QR* with respect to *LR* transformation is that, because of the use of unitary transformation it is very stable numerically.

A considerable economy in the total number of computation can be obtained by using the following technique. If during the course of the iteration, the magnitude of any sub-diagonal element in position $(i,i+1)$ does not exceed a tolerance ε, the eigenvalue problem of A is reduced in approximation to that of matrix A_{11}, A_{22} of order $i, n-i$, respectively, as shown for a matrix A_k.

$$A_k = \begin{pmatrix} A_{11} & & A_{12}\}r \\ 0 & \varepsilon & \\ \underbrace{0}_{r-1} & \underbrace{0}_{1} & \underbrace{A_{22}}_{n-r}\}n-r \end{pmatrix}. \tag{10.12}$$

The eigenvalues of A_k are approximated by the eigenvalues of A_{11}, A_{22}. If the sub-diagonal element (not exceeding ε happens to be in the position $(n,n-1)$, then $(A_k)_{nn}$ may be regarded as an eigenvelue and deflation to a Hessenberg matrix of order $(n-1)$ may be achieved by dropping the last row and column. If it is in the $(n-1,n-2)$ position, then the eigenvalue of the $(2,2)$ matrix in the lower right hand corner may be regarded as the eigenvalues of the original matrix, and deflation to a Hessenberg matrix of order $(n-2)$ may be achieved [14].



Note: Blue H-40- Power Method, Red H-40 Oepomo Method, and Green H-40 QR Method

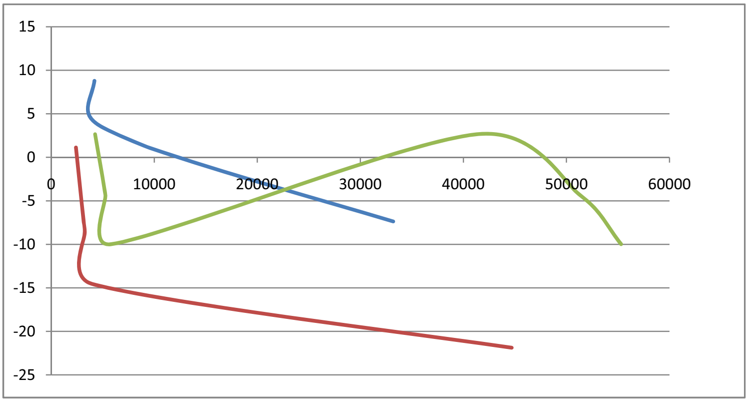
Fig. 10.1 H-40

The rate of convergence of the *QR* method is better by shifting the origin at each iteration, as discussed in connection with the power method. Arithmetic throughout the process can be maintained in real numbers by combining two origin shifts or a pair of complex conjugate origin shifts. An algorithm treating the *QR* process can be found in [5, 11].

10.3.5 Closing Remarks

The following statements are true about *QR* method.

1. The above section applies only to matrices, which have all real eigenvalues. If the matrix happens to have complex eigenvalues, then the *QR* method may generate a sequence of matrices which converges, but the limit matrix will not upper triangular.
2. If the eigenvalues of *A* all have different magnitudes, then the *QR* method will converge to an upper triangular matrix.
3. In practice, software performs a modified *QR* method in two steps. First, the software finds a matrix, which is similar to *A* and is an upper Hessenberg matrix: it has all zeroes below its first sub diagonal. Then *QR* method is applied to this new matrix. The *QR* method produces an upper Hessenberg matrix when given an upper Hessenberg matrix to work on, so the method will produce a sequence of upper Hessenberg matrices. In fact, this sequence will converge to a block upper triangular matrix.



Note: Blue Q-40- Power Method, Red Q-40 Oepomo Method, and Green Q-40 QR Method

Fig. 10.2 Almost cyclic matrix

10.4 Oepomo's Iteration for Eigenvalues

Let A be an $n \times x \times n$ essentially positive matrix. The algorithm can be used to numerically determine the eigenvalue λ_A with the largest real part and the corresponding positive eigenvector $x[A]$ for essentially positive matrices. This algorithm is based on previous manuscript [9, 10]. A matrix $A = (a_{ij})$ is an essentially positive matrix if $a_{ij} \geq 0$ for all $i \neq j,\ 1 \leq i,\ j \leq n$, and A is irreducible. Let $x > 0$ be any positive n components vector [9]. Let

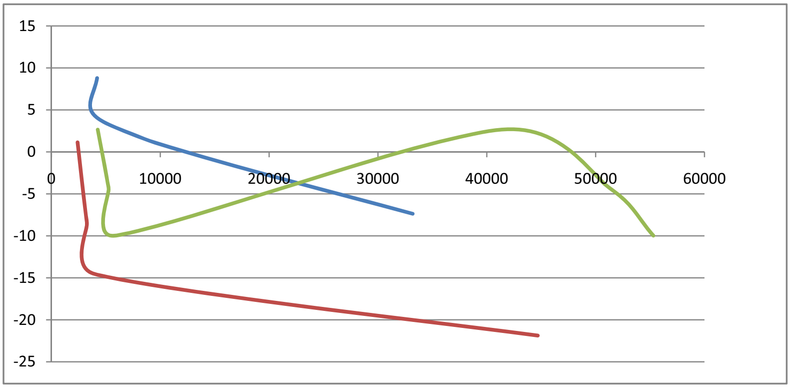
$$z_i(x) = \sum_{\substack{r=1 \\ r\neq i}} a_{ir} x_r, \tag{10.13}$$

$$f_i(x) = \frac{(Ax)_i}{x_i} \equiv \sum_{j=1}^{n} \frac{a_{i,j} x_j}{X_i} \, (i \in N), \tag{10.14}$$

$$\begin{aligned} m(x) &= \min_{i \in N} f_i(x), \\ M(x) &= \max_{i \in N} f_i(x), \end{aligned} \text{[2, 9, 10]} \tag{10.15}$$

$$\Delta(x) = M(x) - m(x), \tag{10.16}$$

$$\|x\| = \sum_{i=1}^{n} x_i. \tag{10.17}$$



Note: Blue H-40- Power Method, and Red H-40 Oepomo Method

Fig. 10.3 Q-matrix

The following theorem is an application of Corollary 2.3 from [9] to the design of algorithms using the Perron-Frobenius-Collatz minimax principle for the calculation $x[A]$. Let $\{x^p\}$ $(p = 0, 1, 2, \cdots)$ be a sequence of positive vectors and $x^p = \left[x_1^p, x_2^p, \cdots, x_n^p\right]^T$.

Theorem 10.4. *If the sequence* x^p $(p = 0, 1, 2, \cdots)$ *of positive unit vectors is such that either* $m(x^p) \to \Lambda[A] \equiv \lambda_A$ *or* $M(x^p) \to \Lambda[A] \equiv \lambda_A$ *as* $p \to \infty$ *then* $x^p \to x[A] \equiv \xi$ *Moreover, the sequence* $\left\{m\left(x^i\right)\right\}, \left\{x^i\right\}$ *are equi-convergent in the sense that an index* υ *and a constant* $K > 0$ *exist such that* $\left\|x^i - \xi\right\| < K\left[\lambda - m\left(x^i\right)\right]$ *if* $i \geq \upsilon$. *Similar statements can be expressed if* $M\left(x^i\right) \to \Lambda[A] \equiv \lambda_A$ *is known.*

Proof. See [9, 10].

10.4.1 Numerical Implication of Theorem 10.4

We will now define a group of sequences, the "decreasing-sequence" which will defined later.

Decreasing-sequence: Let $Y^r(x)(r = 1, 2, \cdots, n)$ be an n component vector valued function such that the following equation is valid:

$$Y_i^r(x) = \begin{cases} x_i, & \text{if } i \neq r, \\ \Omega_r(x), & \text{if } i = r. \end{cases} \tag{10.18}$$

Here $\Omega_r(x)$ $(r = 1, 2, \cdots, n)$ are scalar valued functions which are having properties as described in [10].

Then n-component vector valued function $Y^r(x)$ defined in (10.6) will be referred to as the Decreasing-functions. A sequence $\left\{x^p\right\}$ $(p = 1, 2, \cdots, n)$ of positive n-vectors is constructed which satisfy the conditions of Theorem 10.1. The terms of the sequence $\left\{x^p\right\}$ are generated by the following recursive formula:

$$x^{p+1} = Y^{p+1}(x^p), \tag{10.19}$$

where $Y^k(x) = Y^{k+n}(x)$ $(k = 1, 2, \cdots, n)$. If x^0 is given the sequence $\left\{x^p\right\}$ is completely defined. x^{p+1} and x^p differ only in the r^{th} component where

$$r \equiv p + 1(\text{mode } n). \tag{10.20}$$

Such a sequence will be called a decreasing maximum ratio sequence or briefly decreasing-sequence.

Corollary 10.1. *Any decreasing-sequence converges to* x_A.

Proof. see [10].

We will now define a second group of sequences, the "Increasing-sequence".

10.4.2 Increasing-sequence

Let $Y^r(x)$ $(r = 1,2,\cdots,n)$ be an n component vector valued function such that the following equation is valid:

$$y_i^r(x) = \begin{cases} x_i, & \text{if } i \neq r \\ \omega_r(x), & \text{if } i = r. \end{cases} \tag{10.21}$$

Here $\omega_r(x)$ $(r = 1,2,\cdots,n)$ are scalar valued functions which are having properties as defined in [10].

Then n-component vector valued function $Y^r(x)$ defined in Equation (10.9) will be referred to as the Decreasing-functions. A sequence $\{x^p\}(p = 1,2,\cdots,n)$ of positive n-vectors is constructed which satisfy the conditions of Theorem 10.1. The terms of the sequence $\{x^p\}$ are generated by the following recursive equation:

$$x^{p+1} = y^{p+1}(x^p), \tag{10.22}$$

where $y^k(x) = y^{k+n}(x)$ and $y(x)$ is as defined in Equation (10.9) ($k = 1,2,3,\cdots$). If x^0 is given the sequence $\{x^p\}$ is completely defined. Such a sequence will be called an increasing minimum ratio sequence or briefly increasing-sequence.

Corollary 10.2. *Any Increasing-sequence converges to x_A.*

Proof. see proof in [10].

Numerical tests indicate that a simultaneous application of the decreasing and increasing sequences will converge faster than either the decreasing or increasing sequence separately. Therefore, we will define a sequence of vectors $\{x^p\}$ which are constructed by alternating methods of the decreasing or increasing type functions.

We will describe a sequence of n steps which generate $x^{j+1},\cdots,x^{j+n}$ $(j = 0,n,2n,\cdots)$ in an iteration. If the decreasing functions $\left(y^r(x),\ r = 1,2,\cdots,n\right)$ are used to generate the n terms of the sequence $\{x^p\}$ during iteration as defined in Equation (10.8) then we will say that the iteration is in decreasing mode. Similarly the iteration is in the increasing mode if increasing functions are used as defined in Equation (10.12). Successive terms of the sequence $\{x^p\}$ can be defined recursively in the following respects:

$$x^{k+1} = Y^{k+1}\left(x^k\right) \text{ for } k = 0,1,2,\cdots, \tag{10.23}$$

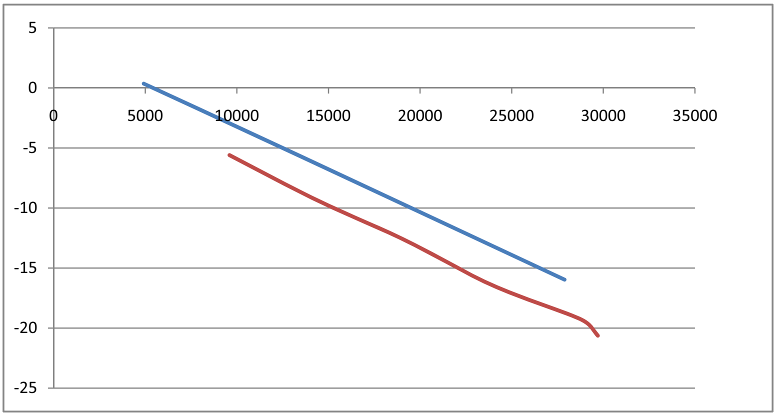
or

$$x^{k+1} = y^{k+1}\left(x^k\right) \text{ for } k = 0,1,2,\cdots, \tag{10.24}$$

where $k = 0$ corresponds to the input vector. The first iteration could be either in the increasing or in the decreasing mode.

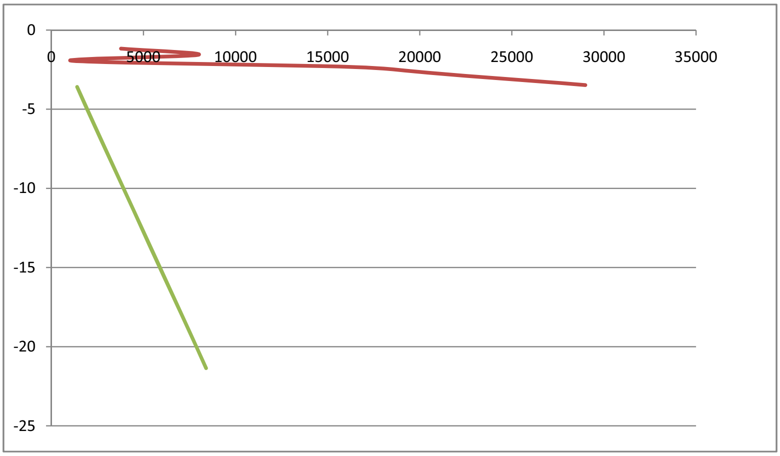
We also define the sequence of real number $\{t_\ell\}$, $\{T_\ell\}$ as follows:

$$t_0 = m\left(x^0\right), \quad T_0 = M\left(x^0\right).$$



Note: Red C-40 Oepomo Method, and Green C-40 QR Method

Fig. 10.4 H-40



Note: Red C-40 Oepomo Method, and Green C-40 QR Method

Fig. 10.5 Almost cyclic matrix

At the end of each iteration we consider the following inequalities:

$$m\left(x^{n\cdot\ell}\right) \geq t_{\ell-1}, \tag{10.25}$$

and

$$M\left(x^{n\cdot\ell}\right) \leq T_{\ell-1}, \tag{10.26}$$

where $(\ell = 1, 2, 3 \cdots)$ are indexes of the iteration. If inequalities (10.25) and (10.26) are met, we may set

$$t_\ell = m\big(x^{n \cdot \ell}\big), \quad T_\ell = M\big(x^{n \cdot \ell}\big), \tag{10.27}$$

and the mode of the next $(\ell + 1)^{st}$ iteration will be different from the ℓ^{st} iteration, i.e., if the ℓ^{st} iteration is an increasing sequence then the $(\ell + 1)^{st}$ iteration is a decreasing sequence or vice versa. If either inequality (10.25) or (10.26) is not satisfied then the mode or direction of the $(\ell + 1)^{st}$ iteration is the same as that of the ℓ^{st} iteration and we set:

$$t_\ell = t_{\ell-1}, \quad T_\ell = T_{\ell-1}.$$

A sequence having the above-mentioned properties will be called Oepomo's alternating sequence iteration.

Corollary 10.3. *Any Oepomo's alternating sequence iteration converges to* x_A.

Proof. See [10].

Corollary 10.1, 10.2, and 10.3 described above lay the foundation of the procedure of an iterative algorithm for the determination of the positive eigenvector of essentially positive matrices. The choices of the functions $\Omega_r(x)$, $\omega_r(x)$ is open but are subject to the restrictions specified in connection with the decreasing and increasing sequences. In Theorem 10.5 and Theorem 10.6 which follow, a possible choice for $\Omega_r(x)$ and $\omega_r(x)$ is given.

Theorem 10.5. *Let* $H_r(x)$ $(r = 1, 2, \cdots, n)$ *denote continuous, positive valued functions which map the set of positive vectors* V_+ *into a set of real number* R *such that*

$$m(x) \leq H_r(x) \leq M(x) \tag{10.28}$$

and equality may hold on either side of (10.16) only if $m(x) = M(x) = \lambda_A$.

For $r \in N$ $(N = 1, 2, \cdots, n)$, *let*

$$\Omega_r(x) = \begin{cases} x_r, & \text{if } f_r \geq H_r \\ \frac{z_r}{H_r - a_{rr}}, & \text{if } f_r < H_r, \end{cases} \tag{10.29}$$

where $H_r \equiv H_r(x)$, $f_r \equiv f_r(x)$ *and all notations are defined in (1, 2, 3, 4, and 5). Then the functions* $\Omega_r(x)$ *(together with a starting vector* x^0*) define a decreasing sequence.*

Proof. see [10].

Theorem 10.6. *Let* $h_r(r = 1, 2, \cdots, n)$ *denotes a continuous bounded function mapping*

$$\sum_r \to R, \text{ such that } m(x) \leq h_r(x) \leq M(x) \tag{10.30}$$

and equality may hold on either side of (10.22) only if $m(x) = h_r(x) = \lambda_A$*,* $x = x_A$*,* $\sum_r$ *has been introduced in Equation (10.20). We further define*

$$w_r(x) = \begin{cases} x_r, & \text{if } f_r \le h_r \\ \frac{z_r}{h_r - a_{rr}}, & \text{if } f_r > h_r > \frac{z_r}{\|x\|} + a_{rr} \\ \|x\|, & \text{otherwise.} \end{cases}$$

Then the function w_r *(together with an* $x^0 > 0$ *define an increasing sequence.*

Proof. See [10].

10.4.3 The Requirements of Functions $H_r(x)$, and $h_r(x)$

The functions $H_r(x)$, and $h_r(x)$ can be selected in many means. The following are a few of the possible choices:

1. $h_r(x) = \frac{1}{2}\left[M(x) + m(x)\right] = \mu(x)$; $H_r(x) = \frac{1}{2}\left[M^*(x) + m(x)\right] = \mu^*(x)$ where $r \in N(N = 1, 2, \cdots, n)$ and $M^*(x) = \min(m(x), M_1)$ and M_1 is an upper estimate of the eigenvalue λ_A, e.g., $M_1 = M(x^0)$. In [3], $m(x)$ is defined as $\min\limits_{i \in k} R_k(x)$ and $M(x)$ is defined as $\max\limits_{i \in k} R_k(x)$.
2. For full matrices a reasonable choice for $H_r(x)$, and $h_r(x)$ are derived from the arithmetic mean of the $f_i' s$.

   $$H_r(x) = \sigma(x) = \frac{1}{n}\sum_{i=1}^{n} f_i(x) \text{ and } h_r(x) = \sigma^*(x) = \frac{1}{n}\sum_{i=1}^{n} f_i^*(x),$$

   where $f_i^*(x) = \min(f_i(x), M_1)$.
3. Another simple choice for $h_r(x)$; $H_r(x)$ is a weighted arithmetic mean of $f_i' s$:

   $$h_r(x) = H_r(x) = \frac{\sum\limits_{i=1}^{n} f_i(x) x_i}{\|x\|} = \upsilon(x).$$

   $\upsilon(x)$ can also be defined in the following mean:

   $$\upsilon(x) = \frac{\sum\limits_{i=1}^{n} b_i x_i}{\|x\|}, \tag{10.31}$$

   where $b_i = \sum\limits_{j=1}^{n} a_{ji}$.

10.4.4 Algorithm

A step of the alternating sequence iteration algorithm consists in modifying a single component x_r of x. As a result $z_i, f_i, \|x\|, \upsilon(x)$ will have to be calculated at each iteration. Calculating $z_i, \|x\|$ from their definition in Equations (10.13) and (10.17) will be referred as recalculating. A considerable reduction of calculation can be accomplished if instead of recalculating these terms are merely updated according to the following steps:

$$\begin{aligned} \|x^{p+1}\| &= \|x^p\| + \left(x_r^{p+1} - x_r^p\right), \\ z_i^{p+1} &= z_i^p + a_{ir}\left(x_r^{p+1} - x_r^p\right), \\ \upsilon(x^{p+1}) &= \upsilon(x^p) + b_r\left(x_r^{p+1} - x_r^p\right), \quad I = 1, 2, \cdots, n. \end{aligned} \tag{10.32}$$

These steps will be referred to as the updating iteration. The updating equations can be obtained easily from Equations (10.13) through (10.17). To prevent the accumulation of round off errors, after a number of iterations the variables will have to be recalculated instead of updating. If we are working in a double precision, our previous experiences indicate that it is more than sufficient to recalculate after every twenty five iterations.

10.5 Over-relaxation Method

From various choices for functions $H_r(x)$, $h_r(x)$ and $\upsilon(x)$ as indicated in Equation (10.34) seems to give a rapid convergence at least for full matrices. The purpose of this section is to present a variant of Equation (10.34) by introducing the over-relaxation technique. We consider the following equation

$$h_r(x) = (1-\gamma)\, f_r(x) + (\gamma)\, \upsilon(x). \tag{10.33}$$

As it well known, for several suitable values for γ is the over-relaxation factor, and $1 \leq \gamma < 2$. Equation (10.34) may be useful in case of banded matrices. The over-relaxation method contains the following cases:

1. $\gamma = 1$ for simultaneous over-relaxation method, and
2. $1 \leq \gamma < 2$ for over-relaxation method.

Error Vector: In all methods the quantity $\Delta(x) = M(x) - m(x)$ as indicated in Equation (10.4) is used as a measure of accuracy.

Discussions: Before we go any further the following issues should be understood. Are both eigenvalues and eigenvectors required to be calculated, or are eigenvalues by itself enough? Is only the absolute largest eigenvalue of interest? Does the matrix have special characteristics, such as real symmetric, essentially positive and so on? If all eigenvalues and eigenvectors are required then this algorithm can not be used;

If a matrix (A) is essentially positive and the positive eigenvector (x_A) and the corresponding eigenvalue (λ_A) are of particular interest, then the algorithm can be used. Each step of the algorithm requires $n^2 + 0(n)$ computations, if the parameters are chosen for the best rate of convergence. It is possible to assume that in half the steps practically no computations are needed, resulting thereby in $\frac{n^2}{2} + 0(n)$ computations for each iteration. As previously stated, after some iteration the variables will have to be recalculated instead of updating. Recalculations need $n^2 + 0(n)$ additional computations. If the computations are performed in double precision, recalculation will not have to be performed so often. As a result recalculations do not increase the total number of computation significantly. For our numerical comparisons all three algorithms, Power, Oepomo, and QR methods, were tried to solve eigenvalue of the following matrices:

1. All three algorithms were used to estimate the eigenvalue of Hilbert matrices of various orders. Let H_n be a Hilbert matrix of order n. The elements of Hilbert matrix are defined according to the following relation:

   $$a_{ij} = \frac{1}{(i+j-1)}, \quad 1 \leq i,\ j \leq n.$$

   The results of the 3 methods can be seen in Tables 10.1, 10.2, and 10.3.
2. We would like to find the efficiency of the three algorithms, when a matrix had eigenvalues of nearly the same modulus. So it was decided to pick a matrix of order n that was almost cyclic (c_n). Consider the below mentioned matrix

   $$\begin{bmatrix} A_{1,1} & A_{1,2} \\ A_{2,1} & A_{2,2} \end{bmatrix}.$$

   The elements of $A_{1,2}$ and $A_{2,1}$ were defined as follows

   $$a_{i,j} = \frac{1}{(i+j-1)},$$

   $A_{1,2}$ is a (8,12) matrix, and $A_{2,1}$ is a (12,8) matrix. The elements of $A_{1,2}$ and $A_{2,1}$ were defined in the following respects

   $$a_{i,j} = \frac{10^{-2}}{(i+j-1)},$$

   $A_{1,1}$ is a (12,12) matrix, and $A_{2,2}$ is a (8,8) matrix. If the elements of $A_{1,1}$ and $A_{2,2}$ were replaced by zero then the matrix would be nearly cyclic. For comparisons, the results of those 3 methods can be seen in Tables 10.4, 10.5, and 10.6.
3. Introducing a proper shift of origin could speed up the convergence of power algorithm [4, 8]. So it was decided to try to that kind of matrix such that by introducing a shift of origin would not help the speed of convergence. Such a matrix of order $n(Q_n)$ can be given by the following relations

$$a_{i,j} = \max\left[\frac{n-i}{n}, \frac{n-j}{n}\right], \text{ for } 1 \leq i,\ j \leq n$$

and

$$a_{i,i} = \left(\frac{n-i}{n}\right) - \left(\frac{50\left(i - \frac{n+1}{2}\right)}{n}\right) \text{ for } 1 \leq i \leq n.$$

The results of our tests are indicated in Tables 10.7, 10.8 and 10.9. We will here assume that we are interested in the positive eigenvector and the corresponding eigenvalue of the essentially positive matrix. From our trials, it is obvious that in all three cases the rate of convergence of our new algorithm is better or at least as fast as the power [4]. The *QR* [12, 14] algorithm converges very slowly in the last two cases, when the separation between the eigenvalues is poor. Let us consider the results of case b, when the matrix is nearly cyclic. For a cyclic matrix there are some eigenvalues of equal modulus, and so for a matrix that is "near cyclic" it is plausible to assume the separation between the modules is very poor. The new algorithm takes about 5700 multiplication and divisions to reach an accuracy of 8 digits; which is about 5 times the computations of the power algorithm and the *QR* algorithm reach an accuracy of 2 digits and 4 digits respectively. We should remember that the *QR* algorithm is not specifically designed to calculate just one eigenvalue; therefore, a comparable efficiency cannot be expected. Thus from our recent experience we can conclude that the new method shows a good speed of convergence even when the separation of the eigenvalues is poor. However in the case of banded matrices the new algorithm converges slowly. The new algorithm was tried on various banded matrices arising from finite difference approximation to boundary value problems of ordinary differential equations. A computer code was written specially for banded matrices, to take advantage of the large number of zero elements in a banded matrix. We will here summarize the results of our computer runs with the following (20,20) matrix:

$$\begin{aligned} &a_{ii} = -2, && \text{if } 1 \leq i \leq n, \\ &a_{i+1,i} = a_{i,i+1} = 1, && \text{if } 1 \leq i \leq n-1, \\ &a_{i,j} = 0, && \text{otherwise.} \end{aligned} \tag{10.34}$$

The over relaxation method as described in Equation (10.33), was tried on the above-mentioned matrix with values of γ ranging from 1 to 1.99. The speed convergence did not show a remarkable dependence of γ. An 8 digit of accuracy was obtained in 168 iterations for $\gamma = 1.73$ whereas for full matrices the new algorithm gave a 9 digit of accuracy in 21 steps. We will now return our attention to full matrices. Let R_n be a matrix (of order n) with pseudo-random entries. The new algorithm and the power algorithm were tried on each family of matrices (R_n, C_n, H_n) of order $n = 20, 40, 80$. The speed of convergence is almost the same for the two algorithms remembering that each iteration step of the power algorithm requires about twice as many computations. Within one algorithm it is somewhat surprising that the number of iteration steps required for as given accuracy hardly depend on the order of the Hilbert matrix at all.

Acknowledgements The author wishes to thank Prof. Schneider, Mathematics Department at the University of Wisconsin in Madison, for his suggestions during the writing of the author's earlier manuscripts [8, 9] and criticism during the writing. His criticism and suggestions yield the development of this survey. The author acknowledges indebtedness to referees, and to their stimulating comments during the review of the earlier articles [8, 9].

References

1. Carnahan B, Luther HA, Wilkes JO (1969) Applied numerical methods. John Wiley, New York
2. Collatz L (1942-43) Einschliessungssatz fuer die charakteristischen Zahlen von Matrizen. Math. Zeits. 48:221–226
3. Elsner L (1972) Verfahren zur berechnung des spektralradius nichtnegativer irreducibler Matrizen II. Computing 9:69–73
4. Faddeev DK, Faddeeva VN (1973) Computational methods of linear algebra. Zapiski Nauchnykh Seminarov POMI 54:3–228
5. Francis JGF (1961) The QR transformation. The Computer Journal 4:265-271
6. Froberg CE, Frhoberg CE (1969) Introduction to numerical analysis, Addison-Wesley, Massachusetts
7. Givens W (1958) Computation of plane unitary rotations transforming a general matrix to triangular form. Journal of the Society for Industrial and Applied Mathematics 9:26–50
8. Mathews JH, Fink KK (2004) Numerical methods using Matlab. 4th Edn, Prentice-Hall, Upper Saddle River, New Jersey
9. Oepomo TS (2003) A contribution to Collatz's eigenvalue inclusion theorem for nonnegative irreducible matrices. Electronic Journal of Linear Algebra 10:31–45
10. Oepomo TS (2011) Oepomo's algorithm for computing largest real part eigenvalues of essentially positive matrices: Collatz & Perron-Frobernius approach. Acta Mathematica Scientia 31:1189–1202
11. Ruhe A (1966) Eigenvalue of a complex matrix by the QR method. BIT 6:350–358
12. Varga RS (1962) Matrix iterative analysis. Prentice-Hall, Englewood Cliffs
13. Watkins D (1982) Understanding the QR algorithm. SIAM Review 24:427–440
14. Wilkinson JH (1965) The algebraic eigenvalue problem. Claredon Press, Oxford
15. Wilkinson JH (1966) Convergence of LR, QR and related algorithms. The Computer Journal 8:77–84

Chapter 11
Solutions of Modified Equal Width Equation by Means of the Auxiliary Equation with a Sixth-Degree Nonlinear Term

Zehra Pinar and Turgut Öziş

Abstract 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 modified equal width equation. By the aid of the solutions of the original auxiliary equation; some other physically important nonlinear equations can be solved to construct novel exact solutions.

Keywords Nonlinear equations · Symbolic computation · Auxiliary equation method · Modified equal width equation · Wave solutions

11.1 Introduction

In Fluid mechanics, if a long wave of elevation travels in shallow water it steepens and forms a bore. The bore is undular if the change in surface elevation of the wave is less than 028 of the original depth of water. The growth of an undular bore from a long wave which forms a gentle transition between a uniform flow and still water. Mathematically, a physical account of its development is followed by nonlinear systems and the equal width (EW) equation was to use as a model. Because many mathematical models alike are described by nonlinear differential equations. Hence, searching and constructing exact solutions for nonlinear differential equations is a popular research area. In recent times, there have been many effective and convenient methods for solving nonlinear equations in the literature. These are generalized Riccati expansion method [1], F-expansion method [2, 3], mapping method [4], elliptic function method [5], exp-function method [6], The (G'/G)-expansion method [7, 8], sub-equation method [9, 10], auxiliary equation methods [11–16], and so on.

Z. Pinar · T. Öziş (✉)
Science Faculty, Department of Mathematics, Ege University, Bornova-İzmir 35100, Turkey
e-mail: turgut.ozis@ege.edu.tr

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_11,

The methods-Exp-function method, The (G'/G)-expansion method, Sub-equation method and Auxiliary equation methods-mentioned, in broad-spectrum, belong to a class of method called subsidiary ordinary differential equation methods. In this letter, we apply direct algebraic method so called Auxiliary equation method to seek more types of new exact solutions of nonlinear differential equations which satisfy a first-order nonlinear ordinary differential equation with a sixth-degree nonlinear term to the modified equal width equation.

11.2 Auxiliary Equation Technique and Some Remarks

We assume that the given nonlinear partial differential equation for $u(x,t)$ to be in the form:

$$P(u, u_x, u_t, u_{xx}, uxt, u_{tt}, \cdots) = 0, \tag{11.1}$$

where P is a polynomial in its arguments, which includes nonlinear terms and the highest order derivatives.

Then, using the transformation $u(x,t) = u(\xi)$, $\xi = \mu(x - ct)$ we reduce Equation (11.1) to the ordinary differential equation:

$$Q(u, u_\xi, u_{\xi\xi}, u_{\xi\xi\xi}, \cdots) = 0. \tag{11.2}$$

Now, we seek the exact traveling wave solutions of Equation (11.2) by means of direct algebraic method so called auxiliary equation method.

As it is well known, most exact traveling wave solutions [1–22] were obtained on the assumption that the exact solution can be expressed as a finite expansion of a function. Hence, for the solution of Equation (11.2), let us assume that the exact solution can be expressed as simple expansion in the form of

$$u(\xi) = \sum_{i=0}^{N} a_i z^i(\xi), \tag{11.3}$$

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 traveling 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 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 (11.3) in general.

In most auxiliary equation methods; the function $z(\xi)$ is defined as the solution of an auxiliary ordinary differential equations. Even if it is possible to construct more complex types of exact solutions for many auxiliary ordinary differential equations, one also encounters some difficulties.

In this paper, we seek for the solution of Equation (11.2) in terms of ansatz Equation (11.3) with $z(\xi)$ satisfying the following new auxiliary equation with a sixth-degree nonlinear term i.e.:

$$\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi), \tag{11.4}$$

where a_i $(i = 0, 2, 4, 6)$ are real constants. Table 11.1 reports the new solutions of the auxiliary Equation (11.4) under 8 distinct cases which include solutions including Bessel function and Lambert function and one can use these new solutions to seek exact traveling wave solutions for nonlinear equations.

Hence, in ansatz Equation (11.3), the parameter N is a positive integer and can determined by balancing the higher order derivative term and highest power nonlinear terms in Equation (11.2). The highest degree of $\partial^p u/\partial \xi^p$can be calculated by:

$$\begin{cases} \mathcal{O}\left[\frac{\partial^p u}{\partial \xi^p}\right] = N + p, \quad p = 0, 1, 2, \cdots \\ \mathcal{O}\left[u^q \frac{\partial^p u}{\partial \xi^p}\right] = qN + p, \quad p = 0, 1, 2, \cdots. \end{cases} \tag{11.5}$$

Consequently substituting Equation (11.3) and Equation (11.4) into Equation (11.2) 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 (11.3) and the auxiliary Equation (11.4), we can get the exact solutions for Equation (11.1).

11.3 Model Problem

The generalized EW equation was first put forward as a model for small-amplitude long waves on the surface of water in a channel by Peregrine [25, 26], by Benjamin et al [27] and the equal width (EW) equation was to use as a model partial differential equation for the simulation of one-dimensional wave propagation in nonlinear media with dispersion processes $u_t + buu_x - au_{xxt} = 0$, by Morrison [24]. When the EW equation is used to model waves generated in a shallow water channel the variables are normalized so that distance x and water elevation u are scaled to the water depth h and time t is scaled to $\sqrt{(h/g)}$, where g is the acceleration due to gravity. In physical phenomenon such as unidirectional waves propagating in a water channel, long-crested waves in near-shore zones, and many others, the generalized

Table 11.1 The solutions of auxiliary Equation (11.4) with a sixth-degree nonlinear term

Cases	$z(\xi)$
Case 1 $\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_6 z^6(\xi)$	$Bessel\,J\left(\frac{1}{6}, 2Z^6\right) Z\pi + 3\xi\Gamma\left(\frac{5}{6}\right)$
Case 2 $\left(\frac{dz}{d\xi}\right)^2 = a_4 z^4(\xi) + a_6 z^6(\xi)$	$\frac{\sqrt{(-a^6+a_4^2\xi^2-2a_4^2\xi c_1+a_4^2c_1^2)a_4}}{-a^6+a_4^2\xi^2-2a_4^2\xi c_1+a_4^2c_1^2}$
Case 3 $\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_2 z^2(\xi) + a_6 z^6(\xi)$	$\frac{\left(\left(-\frac{3}{8}\xi\left(\frac{\sqrt{-10a_6a_2}a_2}{a_6}\right)^{\frac{3}{2}}+\frac{3}{8}\xi\left(\frac{\sqrt{-10a_6a_2}a_2}{a_6}\right)^{\frac{3}{2}}c_1+\frac{a_0\sqrt{\frac{a_0(-8+9a_2\xi^2-18a_2\xi c_1+9a_2c_1^2)}{a_2}}}{8a_6}\right)a_2^2\right)^{\frac{1}{2}}}{a_2} + \frac{\sqrt{-10a_6a_2}a_2}{\left(\left(-\frac{3}{8}\xi\left(\frac{\sqrt{-10a_6a_2}a_2}{a_6}\right)^{\frac{3}{2}}+\frac{3}{8}\xi\left(\frac{\sqrt{-10a_6a_2}a_2}{a_6}\right)^{\frac{3}{2}}c_1+\frac{a_0\sqrt{\frac{a_0(-8+9a_2\xi^2-18a_2\xi c_1+9a_2c_1^2)}{a_2}}}{8a_6}\right)a_2^2\right)^{\frac{1}{2}}}$
Case 4 $\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_4 z^4(\xi) + a_6 z^6(\xi)$	$\frac{e^{\sqrt{a_2}(-2\xi+c_1)}\sqrt{2}}{2\left(-\frac{a_6e^{\sqrt{a_2}(-2\xi+c_1)}}{a_4\,Lambert\,W\left(-\frac{2a_6e^{\sqrt{a_2}(-2\xi+c_1)}}{3a_4}\right)}\right)^{\frac{1}{2}}}$
Case 5 $\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_4 z^4(\xi) + a_6 z^6(\xi)$	$\xi - \int^{z(\xi)} \frac{da}{\sqrt{a_0+a_4a^4+a_6a^6}} - c_1 = 0$
Case 6 $\left(\frac{dz}{d\xi}\right)^2 = a_2 z^2(\xi) + a_6 z^6(\xi)$	$\frac{e^{\sqrt{a_2}(-\xi+c_1)}2^{\frac{1}{4}}}{\left(\frac{a_6e^{4\sqrt{a_2}(-\xi+c_1)}}{a_2\,Lambert\,W\left(\frac{-a_6e^{4\sqrt{a_2}(-\xi+c_1)}}{2a_2}\right)}\right)^{\frac{1}{4}}}$
Case 7 $\left(\frac{dz}{d\xi}\right)^2 = a_6 z^6(\xi)$	$\frac{1}{\sqrt{-2\xi\sqrt{a_6}+2c_1\sqrt{a_6}}}$
Case 8 $\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi)$	$\frac{a_6 81^{\frac{2}{3}}\left(\frac{\left(-\frac{3}{8}\xi a_0^{\frac{2}{3}}+\frac{3}{8}a_0^{\frac{3}{2}}c_1+\frac{3\sqrt{8}a_0}{8}\sqrt{\frac{a_0(-8a_6+9a_4^2\xi^2-18a_4^2\xi c_1+9a_4^2c_1^2)}{a_4^2}}\right)a_4^4}{a_6^2}\right)^{\frac{1}{3}}}{18a_4^2} + \frac{a_0 81^{\frac{1}{3}}}{2\left(\frac{\left(-\frac{3}{8}\xi a_0^{\frac{2}{3}}+\frac{3}{8}a_0^{\frac{3}{2}}c_1+\frac{3\sqrt{8}a_0}{8}\sqrt{\frac{a_0(-8a_6+9a_4^2\xi^2-18a_4^2\xi c_1+9a_4^2c_1^2)}{a_4^2}}\right)a_4^4}{a_6^2}\right)^{\frac{1}{3}}}$

EW equation serves as an alternative model to the generalized RLW equation and GKdV equation [28–31]. The modified equal width (MEW) equation, which is related to the regularized long wave (RLW) equation, has solitary waves with both positive and negative amplitudes, all of which have the same width. The modified equal width equation is given by:

$$u_t + 3u^2 u_x - a u_x xt = 0, \tag{11.6}$$

where a is real constant. To find the traveling wave solutions for Equation (11.6), we use the wave variable $\xi = (x - ct)$, where $c \neq 0$ and $\mu \neq 0$. The wave variable n carries Equation (11.6) into the ordinary differential equation:

$$cu' + 3\mu u^2 u' - a\mu^2 cu''' = 0. \tag{11.7}$$

From Equation (11.3), and using Equation (11.5), we have $N = 3$. Therefore, the ansatz yields:

$$u(\xi) = g_0 + g_1 z(\xi) + g_2 z^2(\xi) + g_3 z^3(\xi), \tag{11.8}$$

where $z(\xi)$ may be determined from one of the cases in Table 11.1. 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 11.1. We consider the auxiliary equation with six-degree nonlinearity, Case 2 in Table 11.1. Substituting Equation (11.8) and the auxiliary equation in Case 2 into Equation (11.7) and letting each coefficient of $z^i(\xi)\sqrt{a_2 z^2(\xi) + a_6 z^6(\xi)}$, $(0 \leq i \leq 8)$ to be zero, we obtain system of algebraic equations. Solving the system by the aid of Maple 13, we can determine the coefficients:

$$\begin{aligned}
c &= -\frac{75 g_3^2}{a_4^2 a^2 \mu^4}, \quad g_0 = \pm\frac{\sqrt{-3c}}{3}, \quad g_1 = 0, \quad g_2 = \frac{2ac\mu^2 a_4 \sqrt{3}}{6\sqrt{-c}},\\
g_3 &= \frac{-39375 a_6^3 - 46225 a_4 a_6^2 - 7956 a_6 a_4^2 + 144 a_4^3}{25 a_4(-325 a_6^2 + 489 a_6 a_4 + 84 a_4^2)},\\
a &= \frac{2(-300 a_6^2 - 419 a_6 a_4 + 6 a_4^2)}{a_4^2 \mu^2 (41 a_4 + 25 a_6)}.
\end{aligned}$$

Substituting the above coefficients into ansatz (11.8) with the solution Equation, we obtain another new solution of the modified equal width equation as following:

$$\begin{aligned}
u(x,t) :=\ & \frac{1}{7500}\sqrt{225}\sqrt{625}\Bigg(\Bigg(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k} - 39375 a_6^3 + \frac{1989}{2}\frac{a_6^2 a}{k}\\
&+ \frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\Bigg)^2 \frac{(25a_6 + \frac{41}{4}\frac{\sqrt{-2kaa_6}}{k})^2}{\left(-325 a_6^2 + \frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k} - \frac{21}{2}\frac{aa_6}{k}\right)^2}
\end{aligned}$$

$$\frac{1}{\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)^{\frac{1}{2}}\Bigg(-\frac{1}{3750}\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)$$

$$\frac{\left(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\right)^2\sqrt{3}\sqrt{75}\sqrt{625}}{\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2}$$

$$\Bigg(\Bigg(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\Bigg)^2$$

$$\frac{\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)^2}{\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)^{\frac{1}{2}}$$

$$\Bigg(-a_6-\frac{1}{8}aa_6\mu^2\Bigg(x-\frac{3}{400}\Bigg(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}$$

$$+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\Bigg)^2\frac{\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)^2t}{\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2}$$

$$\frac{1}{\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)^2/k+\frac{1}{4}-C_1aa_6\mu\Bigg(x-\frac{3}{400}$$

$$\Bigg(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\Bigg)^2$$

$$\frac{\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)^2t}{\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)$$

$$/k-\frac{1}{8}\frac{aa_6-C_1^2}{k}\Bigg)\Bigg)-\frac{1}{100}\Bigg(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}$$

$$+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\Bigg)k\sqrt{4}\Bigg(\Bigg(-a_6-\frac{1}{8}aa_6\mu^2\Bigg(x-\frac{3}{400}\Bigg(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}$$

$$-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\Bigg)^2\frac{\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)^2t}{\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2}$$

$$\frac{1}{\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)^2/k+\frac{1}{4}-C_1aa_6\mu x-\frac{3}{400}$$

$$\left(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\right)^2$$

$$\frac{\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)^2t}{\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)$$

$$/k-\frac{1}{8}\frac{aa_6-C_1^2}{k}\frac{\sqrt{-2kaa_6}}{k}\Bigg)^{\frac{3}{2}}\Big/\Bigg(\sqrt{-2kaa_6}\Bigg(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}$$

$$-\frac{21}{2}\frac{aa_6}{k}\Bigg)\Bigg(-a_6-\frac{1}{8}aa_6\mu^2\Bigg(x-\frac{3}{400}\Bigg(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3$$

$$+\frac{1989}{2}\frac{a_6^2a}{k}+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\Bigg)^2\frac{\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)^2t}{\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2}$$

$$\frac{1}{\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)^2/k+\frac{1}{4}-C_1aa_6\mu x-\frac{3}{400}$$

$$\left(\frac{46225}{4}\frac{a_6^2\sqrt{-2kaa_6}}{k}-39375a_6^3+\frac{1989}{2}\frac{a_6^2a}{k}+\frac{9}{4}\frac{(-2kaa_6)^{\frac{3}{2}}}{k^3}\right)^2$$

$$\frac{\left(25a_6+\frac{41}{4}\frac{\sqrt{-2kaa_6}}{k}\right)^2t}{\left(-325a_6^2+\frac{489}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-\frac{21}{2}\frac{aa_6}{k}\right)^2\left(-\frac{419}{4}\frac{a_6\sqrt{-2kaa_6}}{k}-300a_6^2-\frac{3}{4}\frac{aa_6}{k}\right)^2}\Bigg)$$

$$/k-\frac{1}{8}\frac{aa_6-C_1^2}{k}\Bigg)^3.$$

Fig. 11.1 Graph of the solution for the case 2 in Table 11.1

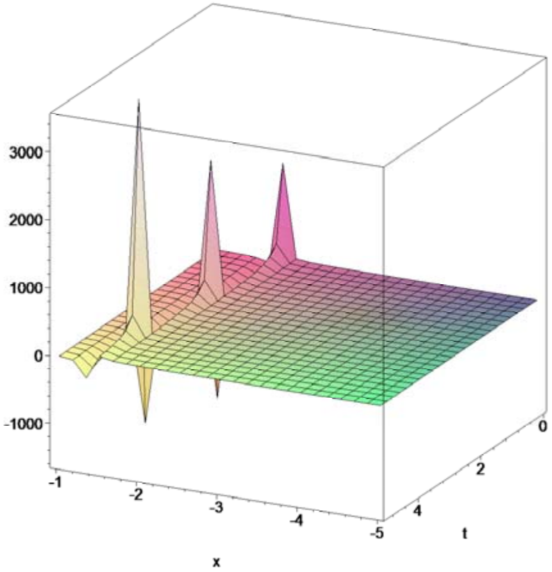


Fig. 11.1 illustrates the graph of the solution for selected values of parameters and our solution coincides with the solution in [23].

11.4 Conclusion

As it is seen, the key idea of obtaining new traveling 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 (11.4)):

$$\left(\frac{dz}{d\xi}\right)^2 = a_0 + a_2 z^2(\xi) + a_4 z^4(\xi) + a_6 z^6(\xi), \tag{11.9}$$

where a_i, $(i = 0,2,4,6)$ are real constants, is used to construct the solutions of the modified equal width equation. Using these solutions, we have successfully obtained some new exact periodic solutions of the modified equal width equation.

References

1. Yong C, Biao L, Hong-Quing Z (2003) Generalized Riccati equation expansion method and its application to Bogoyaylenskii's generalized breaking soliton equation. Chinese Physics

12:940–946

2. Zhou Y, Wang M, Wang Y (2003) Periodic wave solutions to a coupled KdV equations with variable coefficient. Physics Letters A 308:31–36
3. Cai G, Wang Q, Huang J (2006) A modified F-expansion method for solving breaking soliton equation. International Journal of Nonlinear science 2:122–128
4. Zeng X, Yong X (2008) A new mapping method and its applications to nonlinear partial differential equations. Physics Letters A 372:6602–6607
5. Yong X, Zeng X, Zhang Z et al (2009) Symbolic computation of Jacobi elliptic function solutions to nonlinear differential-difference equations. Computers & Mathematics with Applications 57:1107–1114
6. Özis T, Aslan I (2008) Exact and explicit solutions to the (3+1)-dimensional Jimbo-Miwa equation via the Exp-function method. Physics Letters A 372:7011–7015
7. Ozis T, Koroglu C (2008) A novel approach for solving the Fisher equation using Exp-function method. Physics Letters A 372:3836–3840
8. Yildirim A, Pinar Z (2010) Application of the exp-function method for solving nonlinear reaction diffusion equations arising in mathematical biology. Computers & Mathematics with Applications 60:1873–1880
9. Ma WX, Huang T, Zhang Y (2010) A multiple Exp-function method for nonlinear differential equations and its applications. Physica Scripta 82(065003)8–8
10. Ozis T, Aslan I (2010) Application of the G’/G-expansion method to Kawahara type equations using symbolic computation. Applied Mathematics and Computation 216:2360–2365
11. Ozis T, Aslan I (2009) Symbolic computation and construction of new exact traveling wave solutions to Fitzhugh-Nagumo and Klein Gordon equation. Zeitschrift für Naturforschung-A 64:15–20
12. Aslan I, Ozis T (2009) an analytical study on nonlinear evolution equations by using the (G’/G)-expansion method. Applied Mathematics and Computation 209:425–429
13. Ozis T, Aslan I (2009) Symbolic computations and exact and explicit solutions of some nonlinear evolution equations in mathematical physics. Communications in Theoretical Physics 51:577–580
14. Zhang H (2009) A note on some sub-equation methods and new types of exact travelling wave solutions for two nonlinear partial differential equations. Acta Applicandae Mathematicae 106:241–249
15. Lia B, Chena Y, Lia YQ (2008) A generalized sub-equation expansion method and some analytical solutions to the inhomogeneous higher-order nonlinear schrödinger equation. Zeitschrift für Naturforschung 63:763–777
16. Yomba E (2006) The modified extended Fan sub-equation method and its application to the (2+1)-dimensional Broer-Kaup-Kupershmidt equation. Chaos Solitons Fractals 27:187–196
17. Wu GJ, Han JH, Wen-Liang Z et al (2007) New periodic wave solutions to generalized Klein Gordon and Benjamin equations. Communications in Theoretical Physics 48:815–818
18. Sirendaoreji S (2007) Auxiliary equation method and new solutions of Klein-Gordon equations. Chaos, Solitons and Fractals 31:943–950
19. Jang B (2009) New exact travelling wave solutions of nonlinear Klein-Gordon equations. Chaos, Solitons and Fractals 41:646–654
20. Lv X, Lai S, Wu YH (2009) An auxiliary equation technique and exact solutions for a nonlinear Klein-Gordon equation. Chaos, Solitons and Fractals 41:82–90
21. Yomba E (2008) A generalized auxiliary equation method and its application to nonlinear Klein-Gordon and generalized nonlinear Camassa-Holm equations. Physics Letters A 372:1048–1060
22. Wazwaz AM (2006) The tanh and the sine-cosine methods for a reliable treatment of the modified equal width equation and its variants. Communications in Nonlinear Science and Numerical Simulation 11:148–160
23. Zaki SI (2000) A least-squares Finite element scheme for the EW equation. Computer Methods in Applied Mechanics and Engineering 189:587–594

24. Morrison PJ, Meiss JD, Carey JR (1981) Scattering of RLW solitary waves. Physica 11:324-336
25. Peregrine DH (1966) Calculations of the development of an undular bore. Journal of Fluid Mechanics 25:321–330
26. Peregrine DH (1967) Long waves on a beach. Journal of Fluid Mechanics 27:815–827
27. Benjamin TB, Bona JL, Mahony JJ (1972) Model equations for waves in nonlinear dispersive systems. Philosophical Transactions of the Royal Society of London 227:47–48
28. Kaya D (2004) A numerical simulation of solitary-wave solutions of the generalized long-wave equation. Applied Mathematics and Computation 149:833–841
29. Kaya D, El-Sayed SM (2003) An application of the decomposition method for the generalized KdV and RLW equations. Chaos, Solitons and Fractals 17:869–877
30. Bona JL, Pritchard WG, Scott LR (1983) A comparison of solutions of two model equations for long waves. NASA STI/Recon Technical Report N 83:34–38
31. Bona JL, Pritchard WG, Scott LR (1981) An evaluation for water waves. Philosophical Transactions of the Royal Society of London 302:457–510

Chapter 12
A Study on Application of “Pal Map” Function Module in Social Network Site

Xiang Huang, Jinghui Hao and Liang Zhao

Abstract “Pal map” is an application module designed to meet people’s social needs, with which users can obtain information on friends’ real-time address and travel schedule. “Pal map” application module enables users to schedule gathering place and travel route in a scientific manner, make reasonable allocation of time and achieve their social and business goals in the fastest and quickest way. With a relative shortage of such applications in the Chinese mainland, the design of “pal map” has filled the gap of existing social networks and software, realizing an organic combination of pals and maps.

Keywords Social network sites · Friend-map · Push technology · Address information · Travel information · Personal privacy · Positioning function

12.1 Introduction

What we usually call “social network” or “social net” is generally referred to as “Social Networking Site” or “Social Network Sites (SNS)”. In the mainland of China, representatives of social network site/software include Tencent (QQ), Sina Weibo (twitter-like micro-blog), Happy Net, Renren (Facebook-like social network), Jiayuan com and Mi chat. Foreign applications include Facebook, MySpace, Twitter, Mixi, and Wretch, etc.

According to the Statistic Report of 27th Survey on China Internet Development, by December 2010, the number of Chinese social network site users had scaled up to 235 million with an annual increase of 59.18 million and an annual increase rate of 33.7% [2]. Social network site visiting of netizens reached 51.4%, 5.6% higher than 2009.

X. Huang (✉) · J. Hao · L. Zhao
Faculty of Management, City University of Macau, Macau 999078, P. R. China
e-mail: 79081800@qq.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_12, © Springer-Verlag London 2013

Social network site is an interpersonal network based on social network relation system ideas, belonging to social network sites (SNS). The author of this paper and most readers may have used social network site/software and some may even be "fans" of social network site/software.

There have been abundant studies on the competition between social network site /software in the mainland such as Tencent (QQ) and Sina (Blog) and on whether social network sites should imitate Facebook ("lianpu" in the mainland) or Twitter ("tuite" in the mainland), which are not the focus of this paper [3]. This paper studies a function module that can be expanded by social network site/software, which the author is delighted to call "pal map". This function module is specifically designed for social network site/software like QQ, Sina micro-blog and Mi chat.

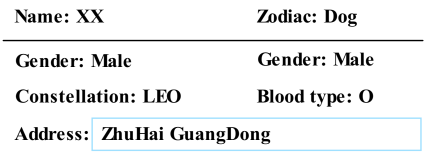
12.2 Research Objectives

Those who often visit social network site/software should know individuals are the basic "components" of social network site/software, who we also call "pals" that serve as the basic "element" of social network site/software. A social network website/software is constituted by numerous "individual-pal". One of the important reasons that we visit or use social network sites/software is to keep in touch with our pals, achieve interactions and maintain a social life [4]. According to Maslow's hierarchy of needs (Abraham Harold Maslow, 1908-1970), when physiological and safety needs are satisfied, people look forward to social needs, esteem and self-actualization. Nowadays, with highly developed economy, when our fundamental demands on physiological and safety needs are achieved, we long for social needs and esteem. But hustling city life and fast pace have made social intercourse a luxury. It has become a craving for people as to how to quickly achieve social intercourse besides the busywork. Social network site/software emerges as the times require as a timely solution. Users of any gender, age, status, can find a place at anytime and anywhere in social network site/software and conduct social inter courses in a fast, efficient manner [5]. This is exactly the charm of social network site/software.

As a social network website/software, it should be featured with social intercourse. At present, social network sites/software develop intercourse activities mainly in two modes, namely online mode and offline mode. The time and space of "pals" may not overlap with each other all the time, so online mode is required for interactions. Major online interactive applications include instant communication, micro message, email, (micro) blog, bulletin board system/BBS, online games and website online activities, etc [6]. When online mode cannot satisfy "pals"' demands for social intercourse or when there is possible overlapping for them in terms of time and space, offline mode becomes prevailing for interactions primarily in forms of spontaneous gathering/party and website offline activities.

Among all kinds of social intercourses and social interactive methods, the contact with our pals is a must. Pals on social network sites are categorized as classmate, colleague, relative, friend, stranger, celebrity and organization, etc [10]. In addition to these categories listed above, typically, we can set, add and delete categories on websites at will so that our pals can be divided into a corresponding category.

Through social network sites, we can not only communicate and interact with pals, but also be updated about recent change and situation of each other, such as micro blog and Shuoshuo, etc. Other public information of pals can be also available, such as telephone number, E-mail, address and job, etc [7]. For pals in the same city, offline activities are necessarily more appealing. How to know if pals are of the same city? Now social network sites generally have an “address” column in pal information item where users are supposed to fill in. For existing pals, address information can be obtained by checking their address column.



Name: XX
Zodiac: Dog
Gender: Male
Gender: Male
Constellation: LEO
Blood type: O
Address: ZhuHai GuangDong

Fig. 12.1 Address information

Now there has come into being a novel friend making mode, namely making friends with strangers of the same city. There are many ways to achieve this, basically website recommendation or personal search for those whose address is in the same city. There are mobile phones or mobile devices having GPS or other positioning modes for help. When strangers from the same social network site/software appear in adjacent geographical positions, it will be indicated that strangers are around so that pals can be made and then contact can be maintained [8]. By far a lot of social network sites have had such function. Some have questioned this in view of personal information release. But in fact this function is generally optionally open or closed.

For existing pals in social network site/software, information on their geographical positions can be obtained in the address column of personal information. But there is great limitation for real-time mobile people [9]. For example, the author of the paper plans to go on a business trip from Zhuhai to Nanchang and stop by to visit friends there. The commonly used method is to look through friends’ address one by one to find those who live in Nanchang. So the process of looking through is a big trouble in that he does not know who are in Nanchang and who are in other cities and memory is the only reference. In addition, even the address column indicates Nanchang it does not necessarily mean friends will be in Nanchang when we get there. Maybe the date is filled in before or friends are going out on business. A more effective method is to post a message in the group that says “I am coming to Nanchang. Who is there?” This original method has many defects. For example, some who have not visited the group for long would not see the message. Some have not joined the group. Some are shy and do not know if he should contact you. And the shout-out in the group is so short that pals do not know about detailed schedule of the business trip. Then how to inform pals of the schedule so that you can contact each other in a convenient and real-time manner? This is the focus of the present paper.

12.3 Research Process and Methods

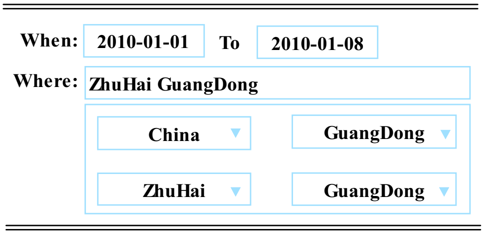
The present pal map function is designed to be added to social network sites/software, a click on which pops up a simulation map that can be global or nationwide according to specific scope with zoom capability to zoom in and out geographical position. Users fill in the name of the city where they are, which can be realized via a drop-down menu or clicks on the map. Then location information of all friends who have filled in their addresses can be presented on the map. In view of address information, users don't necessarily fill out to keep their own information confidential for privacy consideration or make relevant setting after that, making that visible to designated friends, be it a group or individuals. A blacklist function is available in case users do not want to be known by a certain group. Of course, those who do not like manual operation of address information filling in can achieve this in a positioning mode such as GPS, base station and IP address.

Through the pal map one can see the location or the city of their friends, or specifically, those who make their address information visible to us. Social network sites/software can also provide detailed city information such as temperature, weather, city overview, history, culture, tourism and transportation when users click the city where their friends are located.

Fig. 12.2 Where is your pal

When users or user’s friends make real-time move, two methods can be taken to obtain real-time location information.

1. Artificial selection mode. Users enter the pal map and select destination and time in the “I am going out” option or select the city where they will travel or go on a business trip on the map and tick time duration in the drop-down menu such as: January 01, 2010- January 08, 2010. Of course this is not necessary for privacy consideration. Users can make settings at will. It is also possible for users to leave the friend a message in the ”remark” that pops up later.
2. Positioning mode. Social network sites/software position a user through various methods such as GPS, base station and IP address, etc. It must be noted that in view of privacy and relevant legal regulations, it is the user’s option as to use this function under the condition that the mode does not violate relevant laws and regulations.



When: 2010-01-01 To 2010-01-08

Where: ZhuHai GuangDong

China ▼ GuangDong ▼

ZhuHai ▼ GuangDong ▼

Fig. 12.3 When and where

In the artificial selection mode, when the user finishes “travel/on business” friends (to whom the user has agreed to publicize his address information) in the target city will receive a letter, indicating who is arriving with a dwell time duration. A dwell time duration will not be shown in the letter if it is not selected by the user. A message can be shown in the letter if the user has left one.

In the positioning mode, when a social network site/software obtains user address information through positioning, a letter will be sent to friends of the city where the user stays currently indicating that a pal is coming. Of course the receiver must be one of those to whom the user has agreed to publicize his address information.

Users who have missed the letter can obtain friend address information via the pal map. When the pal map module is opened, there will be new message for indication of friends coming to the city, having left and having been in the city. Users can add the module of “pal focused on” to track traveling situations of the friends. Or you can click on any friend to see his recent traveling situation. Of course users have the option to decide if they allow pals access to their traveling information to protect their privacy. The most convenience of the pal map is that current location, information on friends coming to the city and friends in any city can be seen directly on the map. Pal names are available in the map or can be obtained through “pal name display” next to the map after clicking on the city, or both display modes are available, all of which are straightforward. Different colors can be used to classify friends permanent in the local city, traveling in a different city and coming to the local city, those having left and focused on for intuitive observation and understanding of friend traveling situations. If users require, a report can be generated with items of long-term local, traveling information within one week, traveling information within a month and pal favorite places, etc. Report items can be decided by users themselves.

For social network site/software focusing on stranger friend making functions, a stranger friend making function can be added to the above function. Through settings, users can choose to inform a specific group when arriving at a city and select options like interest & hobby, age, gender, purpose of friend making, the same school, the same professional, the same city and 200 meters scope and so on, all of which can be set by users. For notification, artificial selection mode can be used to determine a target city before a letter or the positioning mode can be used to position before a letter.

In order to make an applicable analysis on the pal map module, we conduct a questionnaire survey on related users for research and analysis.

According to the Research Report on 2010 Chinese netizens Use of Social Network Site Application issued in March 2011 by China Internet Network Information Center [1], young group aged under 30 features social network site users with 20-29 years old accounting for the highest of 37.4%, followed by those aged under 19 years old that accounting for 31.6%. And 30-39 years old accounts for 20.8%. These three age groups already account for about 90% of the total and none of the rest age groups reached 10%. Compared with all netizens, social network site users are younger in the age structure with young population taking a high proportion.

In view of user's vocational structure, students take the biggest proportion of 37.5%, users of other professions taking a proportion of no more than 20%.

For this reason we set research subjects at the age: under 19, 20-29 and 30-39.

Research object: age groups under 19, 20-29 and 30-39.

Research objective: analysis on applicability of the pal map function module on users.

Research focus: detailed study and analysis on applicability of the pal map function module on users of different age groups mainly in aspects of what methods users adopt for address confirmation and offline contact and if the pal map is adopted, does it help and what the defects are.

See Appendix for the questionnaire.

We use stratified sampling and simple random sampling in the questionnaire. Considering time, funds and other objective difficulties, we believe there must be flaws in our questionnaire and welcome your correction for defects. The sample we select is college students, high school students and teaching faculty of a university and its affiliated high school. 240 questionnaires in total are sent, 240 replied, a replied rate of 100 percent. When replied questionnaires are coded, the results are as follows:

The sampling contains 240 people, 137 men accounting for 57.1% and 103 women, accounting for 42.9% with the ratio of men and women of 1.33 : 1.

Table 12.1 Gender

		Frequency	Percentage	Valid percentage	Accumulative percentage
Valid	1.00 men	137	57.1	57.1	57.1
	2.00 women	103	42.9	42.9	100.0
	Total	240	100.0	100.0	

Table 12.2 Age

		Frequency	Percentage	Valid percentage	Accumulative percentage
Valid	Under 19	115	47.9	47.9	47.9
	20-29	77	32.1	32.1	80.0
	30-39	48	20.0	20.0	100.0
	Total	240	100.0	100.0	

Table 12.3 Education level

		Frequency	Percentage	Valid frequency	Accumulative percentage
Valid	Senior high school and under	120	50.0	50.0	50.0
	College	95	39.6	39.6	89.6
	Graduate and above	25	10.4	10.4	100.0
	Total	240	100.0	100.0	

The total sampling contains 115 aged under 19 years old, accounting for 47.9% of the total sampling, 77 aged between 20 and 29, accounting for 32.1% of the total sampling and 48 aged between 30 and 39, accounting for 20% of the total sampling.

The total sampling contains 120 people with education level of senior high school and under, accounting for 50%, 95 of college degree, accounting for 39.6% and 25 of graduate degree and, accounting for 10.4%.

Table 12.4 Do you want to obtain pal location information via social network sites

		Frequency	Percentage	Valid percentage	Accumulative percentage
Valid	No	14	5.8	5.8	5.8
	Does not matter	75	31.3	31.3	37.1
	Yes	131	54.6	54.6	91.7
	Quite yes	20	8.3	8.3	100.0
	Total	240	100.0	100.0	

For the question on whether he or she wants to obtain pal location information through social network sites, over 60% interviewees say they do or they quite do, 30% say it does not matter, and only less than 6% say they do not. None says "not at all". It can be seen that most people want social network site/software to provide pal location information.

Table 12.5 Do you want to contact pals when traveling in a different place

		Frequency	Percentage	Valid percentage	Accumulative percentage
Valid	No	9	3.8	3.8	3.8
	Does not matter	38	15.8	15.8	19.6
	Yes	151	62.9	62.9	82.5
	Quite yes	42	17.5	17.5	100.0
	Total	240	100.0	100.0	

For the question as to whether the interviewee wants to contact pals when traveling in a different place, over 80% interviewees say yes and quite yes, no less than 16% saying does not matter, less than 4% saying no, none saying quite no. it can be learnt that most people want to contact their pals when traveling in a different city, so social network sites and software must attach great importance to this function.

Table 12.6 Is it convenient to obtain pal location information on currently social network sites

		Frequency	Percentage	Valid percentage	Accumulative percentage
Valid	Quite unpractical	22	9.2	9.2	9.2
	Unpractical	96	40.0	40.0	49.2
	So-so	69	28.8	28.8	77.9
	Practical	46	19.2	19.2	97.1
	Quite practical	7	2.9	2.9	100.0
	Total	240	100.0	100.0	

For if it is convenient to obtain pal location information on currently social network sites, half think it is unpractical and quite unpractical, 30% saying so-so, only 20% saying practical and quite practical. It can be concluded that current social network sites and software need to improve in terms of helping customers obtain pal location information.

Through the survey on the use of social network sites and software, we get the statistics that in the past 12 months, 142 have used emails, accounting for 59.2% of the total sampling, 86 using the blog accounting for 35.8%, 101 using BBS accounting for 42.1%, 195 using instant communication software accounting for 81.2%, 115 using the micro blog accounting for 47.9% and 20 using other social intercourse applications accounting for 8.3% of the total sampling.

Instant communication software has the most users with the absolute advantage. In the sample, most people used instant communication software, so we can see instant communication software still dominates in social network website/software. It is followed by email users. Nearly 60% of the sample used email. Although there

Table 12.7 Use of social network sites and software

		Response		Case percentage
		N	Percentage	
A4	Use of email in the past 12 months	142	21.5%	59.2%
	Use of blog in the past 12 months	86	13.1%	35.8%
	Use of BBS in the past 12 months	101	15.3%	42.1%
	Use of instant communication software in the past 12 months	195	29.6%	81.2%
	Use of micro blog in the past 12 months	115	17.5%	47.9%
	Use of other social intercourse applications in the past 12 months	20	3.0%	8.3%
Total	659	100.0%	274.6%	

is a gap between instant communication software, email way exceeded the one in the third place. The third and fourth in the ranking are micro blog and BBS, the two having a narrow gap. Blog ranked the fifth. The extremely popular blog in the past has gradually been replaced by its twin brother – micro blog while the traditional BBS has maintained its popularity.

Table 12.8 Pal information provided by social network sites

		Response		Case percentage
		N	Percentage	
B1	Does current social network sites provide pal’s constellation	153	15.3%	63.8%
	Does current social network sites provide pal’s Chinese Zodiac	161	16.1%	67.1%
	Does current social network sites provide pal’s age	200	19.9%	83.3%
	Does current social network sites provide pal’s blood type	148	14.8%	61.7%
	Use of other social intercourse applications in the past 12			
	Does current social network sites provide pal’s address	134	13.4%	55.8%
	Does current social network sites provide pal’s gender	197	19.6%	82.1%
	Does current social network sites provide pal’s other information	10	1.0%	4.2%
Total		1003	100.0%	417.9%

Based on statistics on pal information provided by social network sites,over 80% of the sample say social network sites provide their pals’age and gender and over 60% say these sites provide pals’constellation, Chinese Zodiac and blood type. Only a half say current social network sites provide their pals’ address information, accounting the least among the list. Therefore current social network site/software has not received recognition from customer in terms of address information provision.

Table 12.9 Methods of obtaining pal's location information

		Response		Case percentage
		N	Percentage	
B4	Obtain pal location info by asking a pal himself	168	33.2%	70.0%
	Obtain pal location info by asking others	108	21.3%	45.0%
	Obtain pal location info through address book	123	24.3%	51.2%
	Obtain pal location info through social network sites	85	16.8%	35.4%
Total		506	100.0%	210.8%

Based on the survey about methods of obtaining pal's location information, we are very surprised to see 70% of the interviewees adopt the most traditional and troublesome method–asking a pal himself and only a half by asking others and through the original address book. Only 30% had used the most convenient computer network system-social network sites and software. This shows that social network sites and software are ineffective in terms of pal address information function and find it difficult to meet the demands of customers. Customers have to turn to those traditional methods to obtain pal address information.

Table 12.10 Calculation of gender group

	Gender	N	Mean	Standard deviation	Mean standarderror
Want to obtain pal location info through social network sites	Men	137	3.6642	.73040	.06240
	Women	103	3.6408	.69810	.06879
Want to contact pals when traveling in a different city	Men	137	3.9270	.70330	.06009
	Women	103	3.9612	.68488	.06748
It is convenient to obtain pal location info on current social network sites	Men	137	2.7737	1.06407	.09091
	Women	103	2.5243	.84997	.08375
Does the pal map function increase your social intercourses	Men	137	4.0146	.79507	.06793
	Women	103	4.0097	.67874	.06688

Through the inspection, we can see significant difference between men and women's opinions on if it is convenient to obtain pal location info on current social network sites. Women hold current social network sites are unpractical in obtaining pal location info than men do.

Through the inspection, we can see in terms of if the pal map can enhance your social activities, there is significance among the 30-39 and 20-29. 30-39 users significantly think the pal map function is practical, followed by the 19 and under, and then the 20-29.

Table 12.11 Gender independent sample inspection

		Variance equation Levene test		Mean equation *t* test						
		F	Sig.	t	df	Sig. (bilateral)	Mean difference	Standard difference	Difference 95% confidence interval	
									Lower limit	Upper limit
A	Equal variances assumed	.055	.815	.251	238	.802	.02346	.09347	−.16068	.20760
	Unequal variances assumed			.253	224.789	.801	.02346	.09287	−.15956	.20647
B	Equal variances assumed	.554	.457	−.377	238	.707	−.03416	.09070	−.21283	.14452
	Unequal variances assumed			−.378	222.810	.706	−.03416	.09036	−.21222	.14391
C	Equal variances assumed	7.330	.007	1.956	238	.052	.24945	.12755	−.00183	.50073
	Unequal variances assumed			2.018	237.099	.045	.24945	.12361	.00594	.49296
D	Equal variances assumed	2.985	.085	.050	238	.960	.00489	.09748	−.18714	.19692
	Unequal variances assumed			.051	234.127	.959	.00489	.09533	−.18291	.19269

A: Want to obtain pal location info through social network sites.
B: Want to contact pals when traveling in a different city.
C: Is it convenient to obtain pal location info on current social network sites?
D: Does the pal map function increase your social inter courses?

Through the comparison we find that in terms of whether it is convenient to obtain pal location info on current social network sites, there is significance between interviewees with education level of college degree and of senior high school and under. Interviewees with education level of senior high school and under hold more significantly that current social network site/software are unpractical in obtaining pal address information than those of college degree. It is interesting that people of lower education level are more likely to think current network sites are not practical in information obtaining.

Table 12.12 Multiple comparison of ages

Dependent variable	(I) a2age	(J) a2age	Mean difference (I-J)	Standard error	Significance	95% confidence interval	
						Lower limit	Upper limit
A	19 and under	20 – 29	−.13145	.10497	.635	−.3845	.1216
		30 – 39	.11395	.12250	1.000	−.1814	.4093
	20 – 29	19 and under	.13145	.10497	.635	−.1216	.3845
		30 – 39	.24540	.13110	.187	−.0707	.5615
	30 – 39	19 and under	−.11395	.12250	1.000	−.4093	.1814
		20 – 29	−.24540	.13110	.187	−.5615	.0707
B	19 and under	20 – 29	.06494	.10212	1.000	−.1813	.3112
		30 – 39	.18750	.11917	.351	−.0998	.4748
	20 – 29	19 and under	−.06494	.10212	1.000	−.3112	.1813
		30 – 39	.12256	.12754	1.000	−.1849	.4301
	30 – 39	19 and under	−.18750	.11917	.351	−.4748	.0998
		20 – 29	−.12256	.12754	1.000	−.4301	.1849
C	19 and under	20 – 29	−.28775	.14414	.141	−.6353	.0598
		30 – 39	−.21957	.16821	.579	−.6251	.1860
	20 – 29	19 and under	.28775	.14414	.141	−.0598	.6353
		30 – 39	.06818	.18002	1.000	−.3659	.5022
	30 – 39	19 and under	.21957	.16821	.579	−.1860	.6251
		20 – 29	−.06818	.18002	1.000	−.5022	.3659
D	19 and under	20 – 29	.15596	.10886	.460	−.1065	.4184
		30 – 39	−.18225	.12704	.458	−.4886	.1241
	20 – 29	19 and under	−.15596	.10886	.460	−.4184	.1065
		30 – 39	−.33820*	.13596	.041	−.6660	−.0104
	30 – 39	19 and under	.18225	.12704	.458	−.1241	.4886
		20 – 29	.33820*	.13596	.041	.0104	.6660

* Significance level of mean difference is 0.05.

A: Want to obtain pal location info through social network sites.

B: Want to contact pals when traveling in a different city.

C: Is it convenient to obtain pal location info on current social network sites?

D: Does the pal map function increase your social inter courses?

In terms of if the pal map function increases social inter courses, there is significant difference between interviewees with education level of senior high school and under and of college degree.There also exists significant difference between those of college degree and of graduate and above degree. Students of graduate degree and above significantly think the pal map function is practical, followed by those of senior high school and under, and the last is interviewees of college degree. This complies with the results of multiple comparison in Table 12.12 that older interviewees with high education levels significantly hold the pal map is practical, followed by the 19 and under of low education level, and the last is the young of college degree. For social network sites, older interviewees of high education level use them for business and life purpose while the low education level of 19 and under use them

Table 12.13 Multiple comparison of education level

Dependent variable	(I) a2age	(J) a2age	Mean difference (I-J)	Standard error	Significance	95% confidence interval	
						Lower limit	Upper limit
A	(3)	(1)	.04781	.09836	1.000	−.1894	.2850
		(2)	−.14167	.15746	1.000	−.5213	.2380
	(1)	(3)	−.04781	.09836	1.000	−.2850	.1894
		(2)	−.18947	.16100	.721	−.5777	.1987
	(2)	(3)	.14167	.15746	1.000	−.2380	.5213
		(1)	.18947	.16100	.721	−.1987	.5777
B	(3)	(1)	.12018	.09531	.626	−.1096	.3500
		(2)	−.05667	.15257	1.000	−.4245	.3112
	(1)	(3)	−.12018	.09531	.626	−.3500	.1096
		(2)	−.17684	.15600	.774	−.5530	.1993
	(2)	(3)	.05667	.15257	1.000	−.3112	.4245
		(1)	.17684	.15600	.774	−.1993	.5530
C	(3)	(1)	−.37544*	.13275	.015	−.6955	−.0554
		(2)	−.49333	.21252	.063	−1.0057	.0191
	(1)	(3)	.37544*	.13275	.015	.0554	.6955
		(2)	−.11789	.21729	1.000	−.6418	.4060
	(2)	(3)	.49333	.21252	.063	−.0191	1.0057
		(1)	.11789	.21729	1.000	−.4060	.6418
D	(3)	(1)	.33553*	.09948	.003	.0957	.5754
		(2)	−.19500	.15925	.666	−.5790	.1890
	(1)	(3)	−.33553*	.09948	.003	−.5754	−.0957
		(2)	−.53053*	.16282	.004	−.9231	−.1379
	(2)	(3)	.19500	.15925	.666	−.1890	.5790
		(1)	.53053*	.16282	.004	.1379	.9231

* Significance level of mean difference is 0.05.

A: Want to obtain pal location info through social network sites.

B: Want to contact pals when traveling in a different city.

C: Is it convenient to obtain pal location info on current social network sites?

D: Does the pal map function increase your social inter courses?

(1): College; (2): Graduate and above; (3): Senior high school and under.

more for entertainment and making friends. The young of college degree linger in between with fuzzy boundaries.

12.4 Research Conclusion and Suggestions

Through the investigation and study we can conclude that interviewees generally want to obtain pal location/ city information through social network site/software and make contacts with friends in the city where they are traveling. But it is difficult to determine what places have what friends.Traditional methods are generally used, such as phone calls or SMS are used for confirmation. Relatively speaking, these are all troublesome. However, current social networksites/software is not convenient in confirmation of pal's location/city and the main reason is the lack of timeliness, not updated address and poor operability. At present, users are still using traditional methods to obtain friends' address information.

For the "pal map" functions, interviewees generally hold it is more intuitive, convenient and easy to operate. Users can choose between two modes according to individual needs so as to obtain pals' or publicize his own real-time location information in a time lier manner. It shall be noted that first, the target shall be of wide range with considerable users and uses' habit of application shall be developed. Second, social commerciality can be enlarged according to specific conditions and user demands and friends making modes can be more open. Third, users' personal privacy must be protected. The above is just a preliminary study on the "pal map" function module. Readers who are interested in the "pal map" or similar modules are welcome to contact the author the paper by emailing to hx838383@yahoo.com.cn. According to properties of social network site/software and requirements of customers, the "pal map" function module can be changed in forms and extended and long-term detailed researches shall be continued.

Table 12.14 Suggestions

Criticism	2 copies	Pal map functions are not perfect.
Praise	12 copies	Pal map functions are practical.
Suggestion	8 copies	1. Privacy needs improvement. 2. It would be the best if the map is accurate on street level. 3. Operations shall not be too complicated.
Of no significance	1 copy	Irrelevant to the survey.

Appendix

Respected Madame/Sir,

This is an academic research questionnaire with the main purpose to discuss the application of the "pal map" in "social network site (software)". From the angle of applicability, this study aims to understand how users shall search and contact pals living in a different city while using social network sites (software) in a convenient manner.

Based on literature study, this study has sorted out several questions on “address information”. You are supposed to give independent solutions to questions in the questionnaire from your personal point of view.

Thank you very much for your warm-hearted assistance. Your information is of great help to this study. Questions are designed to understand actual situation with no standards of good and bad answers. We are looking forward to your personal viewpoints. All materials are for academic research use only.Questionnaires are anonymously finished and your personal information will not be publicized. Please take ease to finish this questionnaire.

We thank you for your support and cooperation. Sincerely wish your health and happiness!

I. Personal information

1. Gender

A male B female

2. Age

A 19 and under B 20-29 C 30-39

3. Education level

A senior high school and under B college C graduate and above

4. Which social interactive application (s) have you used in the past 12 months? (can be more than one)

A email B blog C BBS D instant communications

E micro blog F others

II. Questionnaire on “address information”

1. What information of pals do current social network sites (software) provide? (can be more than one)

A constellation B Chinese zodiac C age D blood type

E address F gender G others

2. Do you want to know pals’ location/city information through social network sites (software)?

A quite no B no C does not matter D yes E quite yes

3. Do you want to make contacts with local friends (classmates and colleges) when traveling (going on a business trip)?

A quite no B no C does not matter D yes E quite yes

4. What methods do you typically use to obtain pals’ location information? (can be more than one)

A asking a pal himself B asking others C address books

D social network sites (software) E others

5. Do you think it is practical and convenient to obtain pals’ address (location) information through current social network sites (software)?

A quite unpractical B unpractical C so-so D practical

E quite practical

Based on current social network sites (software) the author of the present paper has developed the “pal map” function.

The "pal map" function refer to display users' geographical location on the simulation map and update the information according to users' situations so that friends can know each other's real-time location information which makes contact convenient. Take Tencent QQ for example. The geographical position in your information column will be automatically added to the "simulation map". Likewise, geographical locations of all your pals in your QQ will be displayed in the "simulation map". You just need to click the "pal map" icon after you log on QQ, you will see the geographical distribution of all your friends and get detailed information of the city where your pals are. When you are going to travel or go on a business trip in a city where your pals live you need to leave relevant information on the target city on the map and your friends will instantly receive the remind that you are coming and obtain your real-time position information. Of course for privacy consideration we provide privacy protection authority so that you can choose specific pals to publicize your travel information and decide whether to display your real-time position.

6. Do you think the "pal map" function has increased your social inter courses to some extent?

A quite unpractical B unpractical C so-so D practical E quite practical

7. Do you have any suggestion on the "pal map" functions?

References

1. The research report on 2010 Chinese netizens use of social network site application. China Internet Network Information Center (2011)
2. Statistic report of 27th survey on China internet development (2011) China Internet Network Information Center
3. Xie P (2011) Social network site of China: Where to go? Southern Weekend
4. Xu T, Wu Y (2009) A study on API of social network site in China. In: Proceedings of 2009 International Symposium on Application of Information Technology in China
5. Hao R (2010) Motivations of facebook use of college students in the US. Northwest University Press
6. Wu J (2010) Development and prospect of research on SNS. Hunan University Press
7. Clara C (2009) The facebook era: Tapping online social networks to build better products, reach new audiences, and well more stuff. Prentice Hall Press
8. Matthew F, Soumitra D (2008) Throwing sheep in the boardroom: How online social networking will transform your life, work and world. John Wiley & Sons
9. Starr H, Chad R (2009) Get connected: The social networking toolkit for business. Entrepreneur Press
10. Tara H (2010) The power of social networking: Using the whuffie factor to build your business. Three Rivers Press

Part II
Information Technology

Chapter 13
Status and Prospects of Technology Diffusion Research based on Patent Information

Lucheng Huang and Ning Wang

Abstract The current research and achievements of technology diffusion using patent data and patent analysis methods were described, and then the deficiencies in current analysis methods were presented, which could help to quickly grasp the status and deficiency of technology diffusion research based on patents. On the basis of current research, a research frame of technology diffusion based on patent information was presented, through which we hoped to offer a preliminary idea to mine the intelligence of the spread of technology comprehensively and deeply. Finally, the improvements should be made in the further work were illustrated.

Keywords Technology diffusion · Technological knowledge flows · Patent citation analysis · Research frame

13.1 Introduction

Diffusion is a process in which an innovation is spread through some specific paths in a social system [16]. There are many channels for technology diffusion in practice, including: product exhibitions or expositions; technology conferences; technology licensing and transfers [8]; the hiring of employees of the innovation firms and so on. However, the diffusion effect of the above methods cannot be observed or measured clearly. In addition to above channels, a more meaningful way to diffuse technologies is patent citation behavior. This is related to the nature and characters of patent system as follows. Firstly, technical information of one design or invention must be published firstly in the patent literature, other reports exist a lag time. Scherer [17] pointed out, although promoting inventions was the main goal

---

L. Huang (✉) · N. Wang
Beijing University of Technology, School of Economics & Management, Beijing 100022, P. R. China
e-mail: hlch@bjut.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_13,

of patent system, it also promoted the development and commercialization of inventions, which enlarged the application of technological information. Secondly, patents as medium of the disclosure of technology, the detailed technical information are documented in patent literatures, according to WIPO statistics, more than 90% of each year's inventions in the world are patented, which are able to get through the retrieval of patent information. Schumpeter [18] divided technological innovation into three processes: invention, innovation, diffusion. However, all these three processes have always been inseparable from patent information flow. Thirdly, in the content of a patent, the "prior art" illustration is a key element; it clearly lists the former patents or previous literature this patent have cited or referenced [13]. In other words, it represents prior existing knowledge upon which this invention builds. Not only does the inventor write the citations, but also a firm's lawyer of a patent examiner might seriously add citations that the inventor does not know about [22]. So the "prior art" is of strictness and explains the development trace of the technology. A patent citation connects one prior invention technology to another later, in which technology is delivered and spread, technical knowledge flow and spillover. For example, if patent A is cited by patent B, this implies that the first patent represents a piece of prior existing knowledge upon which patent B is based, some technological knowledge in A are diffused into B, we can say technology A is applied by technology B, technology A is thus diffused. Thus, just as many researchers have pointed out: among many technology forecasting indicators, patents and patent citation is a mature and objective indicator [3]. Generally, the more frequently a certain patent is cited by subsequent patents, the more the related technology can be said to be diffused, implying that the technology is more widely applied and thus more valuable [3]. By patent citation metrics, the diffusion pattern of a certain technology domain can be quantitatively explored, combining with current popular network analysis, spread track and context of technology can be visually traced.

Firstly, a comprehensive literature review of technology diffusion was provided in the second section. Then the deficiencies in current analysis methods were presented in the third section. The following was a preliminarily proposed research frame of technology diffusion based on patent information. In the fifth part, the improvements should be made in the further work were illustrated. And finally was the acknowledgement of this paper.

13.2 Technology Diffusion Literature Review based on Patent Information

Research on technology diffusion based on patent data, means considering "technology diffusion" as a knowledge spillover and flow process, which is caused by patent citation. In such studies, a patent is used as a proxy for technology or knowledge itself, and patent citation is regarded as a spillover or diffusion of technology. So patented technology diffusion, in essence, is the transfer and diffusion of technical information contained in patent documents and it has directions. A patent cited previous patents, implying technologies diffuse from the cited to citing. Via such citation relationship, R&D sector can make innovations on the basis of previous revealed research. Over a long time, patents citations may lead to a new technology disseminate from one technology field to another field related or very different; be applied from one industry to another industry; spread from one country to another country. Even within the same technology field, which is the most common, the patents citations can make this field grow in strength. Since simple statistics of patent information cannot interpret technology diffusion, only by patent citation relations, technologies can be applied and spread, so the existing research are all using patent citation data and paten citation analysis. Tracing the process of technology diffusion and the technological knowledge flows among different countries is a research hotspot for current patent citation analysis.

13.2.1 Knowledge Flow and Spillover in Technology Diffusion Process between Countries by Paten Citation

Most of past studies used patent citation statistic analysis to explore knowledge spillovers and diffusion among countries. Trajtenberg and Henderson [10] supposed patent citation was accompanied by the patent knowledge diffusion, by comparing the similarities and differences of geographic location of the cited patents and citing patent, the patterns of knowledge diffusion were measured; through calculating time scope between the cited patent application dates and citing patent application dates, the rate of knowledge diffusion of different countries was measured.

By patent citation metrics, Jaffe and Trajtenberg [11] found: knowledge flows between G5 countries appeared to be two-way flow; countries were more likely to cite domestic patents than to cite patents in foreign countries, this phenomenon was called geographic concentration; if the probability of U.S. patents cited by Japan was larger than cited by German, then the probability of Japan patents cited by U.S. would correspondingly larger than Germany. Through above phenomenon they created a patent citation probability function. Hu and Jaffe [9] examined patterns of knowledge diffusion from the U.S. and Japan to Korea and Taiwan using patent citations as an indicator of knowledge flow. They estimated a knowledge diffusion model using a data set of all patents granted in the U.S. to inventors residing in these four countries, explicitly modelling the roles of technology proximity and knowledge decay and diffusion over time. They found that it was much more likely for Korean patents to cite Japanese patents than U.S. patents, whereas Taiwanese inventors tended to learn evenly from both. But they didn't analyze the diffusion of one specific technology, only statistical analysis of diffusion between countries in the macro level. Tijssen [20] measured a single patent citation, highly cited patents and other citation indexes to investigate the detail of the domestic or cross-border technology linkages and knowledge flows. Zheng and Zhang [23] applied patent citation probability model proposed by Jaffe and Trajtenberg to consider the phenomenon of knowledge spillovers caused by patent citations. Different from previous, in their paper, IT industry was taken as empirical case and knowledge spillovers in IT industry between six countries: United States, Japan, Taiwan et al. were investigated.

Until recent years, the research of flows and spread of technological knowledge based on patent citation has still been active, but no longer a simple statistical metrics of patent citation such as citation amount and higher frequency cited patents, more and more are adopting the view of network analysis to construct visual patent citation network or knowledge diffusion networks between countries, combining with social network analysis to measure the quantitative network properties on behalf of technology diffusion. The researches of technology diffusion between countries based on patent citation network are mainly empirical studies of one specific technology.

13.2.2 The Impact of Patented Technology's Diffusion

Some scholars have studied the effect of patented technology's dissemination and diffusion to productivity and national R&D output. These studies proved that patents had brought the diffusion of technology in some degree.

Evenson and Puttnam [24] used patents to estimate technological knowledge flows and their impact on productivity. In the empirical study of patent applications in 19 OECD countries, Eaton and Kortum [4] showed: in most OECD countries, the international patented technology flows had led to substantial growth in productivity, the growth rate negatively correlated with the level of productivity; countries except U.S. received by more than 50% of productivity growth via foreign patents. Branstetter [2] found that Japan would benefit from patented technology knowledge spillovers of the United States. Anderson and VanWincoop [1] indicated that compared to international trade, technological knowledge flows brought about by the international patent application is broader.

13.2.3 Technology Diffusion in the Same Industry or between Different Industries by Patent Citations Information

Fung and Chow [6] innovatively applied patent citation to analyze technology diffusion in the same industry and between different industries. Using patent citation data, indicators were established to detect knowledge flows among enterprises within the same industry and external knowledge flows between different industries. Meanwhile, they calculated the frequency one specific industry cited by other industries to measure the density of external knowledge spillovers. But their study did not target one technology to illustrate how it was diffused between industries.

Lai et al [14], mainly based on Fung's method, illustrated the technology diffusion in business methods domain. They quantitatively examined that diffusion between different industries through patents, providing a beneficial reference about development of this technology for related R&D institutions. Verspagen [21] examined knowledge flows and diffusion between six sectors. It was from a macro point of view, to find which industries are closely linked, and which are not closely linked, and may support policy development. But the study of Verspagen needs to handle with a large amount of patent documents, and the process of data analysis and sorting is very complex.

13.2.4 Combining Patent Citation with Network Analysis

Yoon and Park [22] pointed out that the simply patent citation analysis had some drawbacks; they proposed a network-based patent analysis method. The comparative advantages of network analysis are obvious, for instance, network analysis can more vividly display overall relationship of all patents. In recent years, more and more scholars have combined the patent citation and network analysis methods together, such as social network analysis, to study technical knowledge flow, dissemination and diffusion in patent citation network. The majority of such researches are empirical analysis, based on patent citation networks of different technologies to study the actual process of technology diffusion.

Li and Chen [15] examined the knowledge transfer of nanotechnology in different technical fields, institutions and countries. Based on original raw patents citation relation three networks were constructed: technology field diffusion networks, institutions diffusion network, and country diffusion network, nodes in these three networks respectively represented related technology fields (IPC or UPC number), different institutions, and different related nations; links represented citation relation generated from row patent data. The patent citation networks were described taking advantage of critical node, core network, and network topological analysis. This included identifying key players and fields, the knowledge transfer patterns among them, and the overall knowledge transfer efficiency. Hsueh and Wang [8] also used the similar research methods to study the LCD field in different institutions and diffusion of knowledge among countries.

Shih and Chang [7] defined the structural configuration of each country within the international diffusion network by measuring its degree, closeness, and betweeness centralities. In addition, they distinguished between embodied technology diffusion, measured by multilateral trade, and disembodied technology diffusion, measured by patent citations. A sample dataset of international technology diffusion taken from 48 countries was tested; the empirical results showed that the structural configuration of countries exhibits similar patterns in disembodied diffusion networks. Their study in macro level investigated the position and roles of selected 48 countries in the big diffusion network.

Su and Lee [19] through the network structure view and patents citation analysis to dynamic and quantitative explore the dynamic changes in technology and the evolution process of technology. In Degree centrality, which was the number of times that a patent was cited, was defined as an indicator to measure momentum of technology diffusion; it can be used as an indicator to measure knowledge flow from one target patent to later patents. They calculated the annual average in Degree centrality over time to reflect the diffusion status and its dynamic change over time.

13.2.5 Technology Diffusion Curve using Patent Data

In Fallah's research [5], forward patent citations curve was seen as technology diffusion curve, by extracting the number of forward citations issued each year for each patent through 2008. On the initial proposition that forward citations should follow a classic S-curve distribution, if this proposition can be examined, then forward patent citations can be used as predictive measures for diffusion of emerging technologies. Chang and Lai [3], firstly measured the relationship of these basic patents of business method technology, and classified the basic patents by hierarchical cluster analysis into eight groups, then drew a curve of each group according to issued date and corresponding patents numbers in each group, calling this as diffusion curve of technology represented by each group.

13.2.6 Forecasting of Technology Diffusion by Diffusion Model

In this respect, Lai and Chang [13] made innovative research, in their research, the Bass diffusion model was firstly introduced into patented technology diffusion, and also empirical analysis about business methods technology was done. The result testified patent citation behaviour in technology diffusion was consistent with Bass diffusion model; direct patents citations were like innovation adopters, indirect patents citations were like imitation adopters, and diffusion into other technology fields was mainly due to direct patents citations.

Similar to Lai's methods, Kim and Shin [12] used Bass diffusion model to predict the spread of IPTV technology which was a quantitative method of technology forecasting. Bass model has been traditionally used to predict the adoption of new products or services in general market; as a patent can represent each technology in technology market, so they applied this model at technology market and patent data was seen as input data for Bass model. In their research, experiment results suggested new possibility that patent data can be applied in Bass model. Moreover, utilizing Bass diffusion model, the cumulative number and annual number of patents of IPTV technology can be predicted in the future.

13.3 Limitations in Current Research

How to use patent information for analyzing technological diffusion, many scholars have already made a lot of work, and developed a series of methods of patent analysis. However, after the survey of the relevant academic literature, we find that the amount of literatures about technology diffusion research using patent data are relatively few, probably related to that patent documents are not easy to people that are not professionals, and also due to the implicit role of patent to technology diffusion. In summary, the following are some characteristics of current technology diffusion research base on patents.

1. The researches are all exploiting patent citation data and patent citation analysis method. Patent citation relations are employed to analyze technology diffusion, either by simple patents citation statistical analysis in the past or by patent citation network analysis at present. This is a major characteristic of technology diffusion research using patent information.
2. At present, many literatures which are related to technical knowledge spillovers occurring in technology diffusion process among the same industry, different industries, the same technology field, different technologies fields and countries are also few. The existing literatures, mostly from single perspective, researches measuring specific technology domain from multiple aspects as how technology diffuse in fields, enterprises industries or countries are in need, because through these diverse singles, diffusion process about specific technology can be thoroughly and deeply investigated.
3. Lacking of empirical research, that is to say, investigation into the detailed diffusion process of one technology domain is not enough. Many studies of technology diffusion between countries are not aimed at a specific technology, but in macro layer statistic and classify all the patents in the patent database applied by countries, and sort out citation relationship between countries. Although it may be helpful to the national strategy development and related research institutions. However, it is unusually large amount of work, the implementation is very difficult, and do not have a particular meaning for specific technology. Diffusion of technology in industries or technology fields are not penetrated deeply, research methods are not diversified, single way such as patent citations networks analysis or patent number statistics are used in most studies, in which dynamics in the diffusion process cannot be well shown.
4. Many researches only examined the technology diffusion patterns and features, but failed to effectively explore the inspiration from analysis results about technology diffusion, that is, lack of integration between process analysis and forecasting of diffusion, which may provide support for the R&D services to make decision.
5. Forecasting of diffusion trend of technology is scare, only two or three scholars have used Bass model to estimate the number of annual and cumulative citing patents of main technology filed and other technology fields forecasting in fu-

ture. There isn't any research on forecasting diffusion of technology in potential application fields or industries. However, research in this area is valuable.

6. Current theories and methods are not systematic, lack of an integrated analysis framework for technological diffusion from patent perspective.

13.4 Research Frame Proposed

In the conclusion, on the basis of summarizing the current research methods and making some improvements, we proposed a preliminary research frame of technology diffusion based on patent information. It is shown in Fig. 13.1.

It is expected that this frame can provide a reference and summary of how to study in the technology diffusion of the selected technology. We wished this framework could take a utility of mining the information and intelligence of the spread of technology comprehensively and deeply, showing the changing pattern and the track of technology diffusion clearly and visually and quantitatively forecasting the diffusion of technology to support decision-making.

However, it is only a preliminary framework, some contents such as the research methods in the frame need to be further improved and verified by experiments. This framework consists of three parts. It was interpreted in the following.

13.4.1 The First Part

The first part is choosing one particular technology domain, extracting and flittering patents, then sorting out the patent-to-patent citation information.

13.4.2 The Second Part

The second is to comprehensively illustrate the diffusion process and status of selected technology from the three angles: diffusion in technology fields, diffusion in R&D entities (countries and institutions) and diffusion in industries. Among so many patents about the empirical technology, if a certain patent is at a critical position in its field of technology, and most technologies following need to cite that certain technology, then the patent can be called as a basic patent. We can say that basic patents play an important role in its technology diffusion process; they may be cited by many patents which belong to different technical fields, different countries and institutions, and even different cited by different industries.

(1) Technology Diffusion in Technology Fields

The angle of diffusion in technology fields can study from two aspects: diffusion of basic patents in technology fields which is statistical analysis and technology

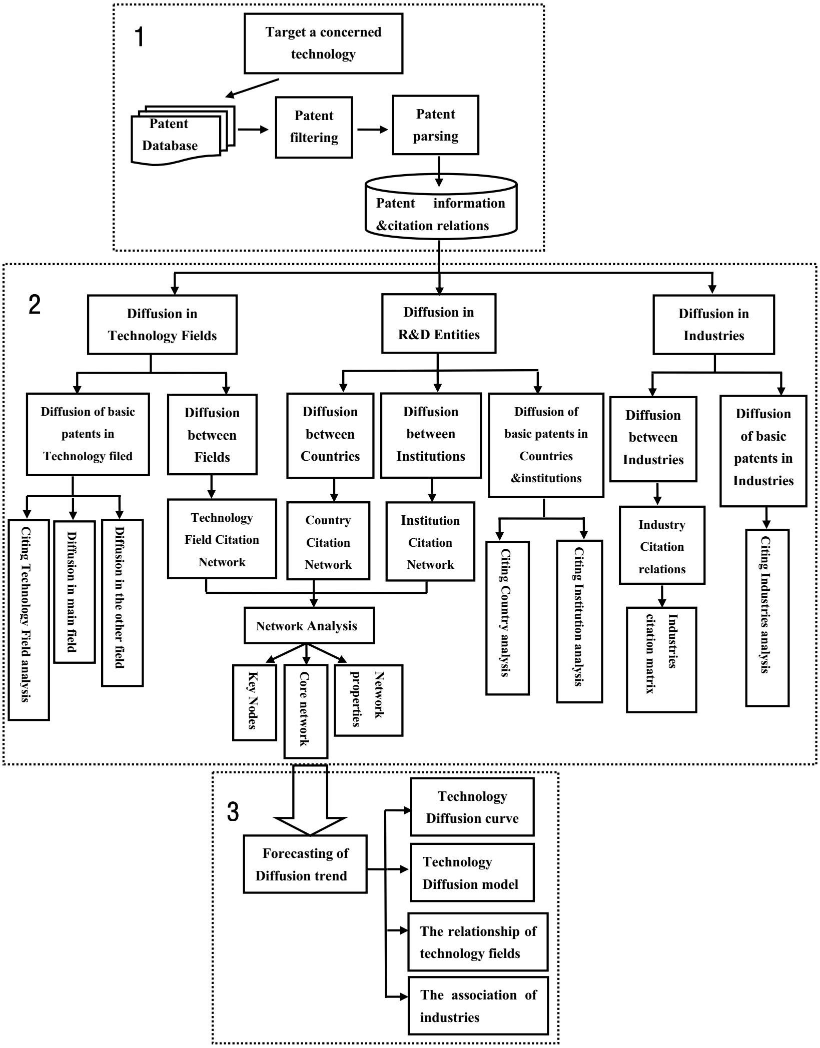


Fig. 13.1 The research frame of technology diffusion based on patent information

diffusion among different technology fields by analyzing technology fields' citation ties. In general research, technology fields can be represented by corresponding IPC or UPC classification patents belong to.

(a) Diffusion of basic patents in technology fields:

From analyzing technology fields citing basic patents we can see which fields basic patents are applied into. As there will be one or two main fields one specific technology affiliated to, by statistics of patents number in main field and non-main field citing basic patents over the years, we can see the dynamic diffusion process of basic patents in main field and in other field.

(b) Technology diffusion between fields:

A network view of technology field citation relations provides a better global understanding of the technology diffusion process. Technology fields' citation ties can be obtained by sorting out the patent-to-citation information, then by visualization of these citation ties, to develop technology field citation network. A technical field is seen as a node in the network. Links represent citation relations between the patents that belong to the neighbour two technical field. Next, the technology field citation networks are described using critical node, core network, and network topological analysis. Critical node analysis helps to identify the key technical field. The visualization of the core network provides information on the technology knowledge diffusion patterns among the key technical field. In addition, the network measures are used to analyze the global structure of the technology field citation networks.

(2) Technology Diffusion in R&D Entities

R&D entities refer to related counties and institutions associated with each patent. And they can be extracted from each patent document.

(a) Diffusion of basic patents in technology fields:

From analyzing countries and institutions citing basic patents we can explore which countries and institutions have applied this technology. In addition, by the time series analysis, we can get the dynamic change of amount of entity, the new joining entities which reflect the adoption of the technology.

(b) Technology diffusion between countries:

The main objective is to understand the technology knowledge diffusion processes between different countries. Since patent citation relations can be aggregated into the patent assignee country citation relations, by visualization methods, to construct countries citation network which could provide insight into the knowledge diffusion processes between countries. In this network, a node is a county which is an analytical unit. Links represent citation relations between the patents that belong to the two neighbour countries. The weight of the link represents the number of citations between the neighbour countries. Directions of the links represent the direction of the technological knowledge flow. Next, to study key node, core network, network properties utilizing network analysis methods. This includes identifying key influential countries in the network, the technology diffusion patterns among them.

(c) Technology diffusion between institutions:

Patent citation relations also can be aggregated into the patent assignee institution citation relations. Institution citation relations can be developed to the institution citation network using visualization methods. In this network, a node is representing an institution. Links represent citation relations between the patents that belong to the two neighbour institutions. The weight of the link represents the number of citations between the neighbour institutions. Directions of the links represent the direction of the technological knowledge flow. Then, to describe institutions citation networks utilizing key node, core network, network properties analysis, Critical node analysis helps to identify the key institutions. The visualization of the core network provides information on the technology knowledge diffusion patterns among the key institutions. In addition, the network measures provide insight into the global structure of the institution citation networks.

(3) Technology Diffusion in Industries

(a) Diffusion of basic patents in industries:

We can reference the international standard industry classification (ISIC) to classify the empirical technology patents into different industries. Also, we can classify the technology related industries according to the company types. From analyzing industries citing basic patents we can obtain the information about which industries had involved into the empirical technology domain or applied this technology.

(b) Technology diffusion between industries:

After classifying the empirical technology patents into different industries, citation relations between different industries can be achieved by patent-to-patent citation information. Further we can adopt industries citation matrixes to quantitatively show the technology diffusion and the technology knowledge flow between industries.

13.4.3 The Third Part

The last part is on the foundation of above analysis result to forecast the diffusion trend quantitatively and qualitatively.

(1) Technology diffusion curve and technology diffusion model

Based on the statistic data about patents citing basic patents, and the time series analysis, we can draw technology diffusion curve. In this curve, the patents citing basic patents are seen as adopters of the technology, we can see the accumulative adoption of the technology annually and the overall diffusion trend. Combining with the diffusion model, such as the Bass model, we may be able to forecast the amount of future patents citing basic patents in the main field or in the other fields, thus we can forecast the quantitatively development trend of technology fields.

(2) The relation of technology fields and the association of industries

By analyzing the relationship between technology fields, or the association between industries, we will find sparse or close relations, and although the relationship of some technology fields or industries is sparse at present, but they may indicate the new direction of technology development, potential technology application field and technology application industries.

13.5 Future Work

According to the drawbacks and defects of the current researches, it will be interesting to conduct some further research with several directions described as below.

13.5.1 Diversification and Innovation of Research Methods

The current approaches, either patent citation statistics or the patent citation network analysis, are all based on patent citation relation data, which are somewhat monotonous. To consider if there are other possible methods of using patent data that can be used to study the spread and flow of technologies is necessary, such as now popular modelling and simulation methods, to display the dynamic diffusion process of patented technology. But this suggestion need to be further tested.

13.5.2 Expand the Scope of Empirical Research

Now the range of empirical technologies involved in literatures is not broad. Nevertheless, good comprehensive research on how the selected technology is diffused is valuable because it can assist related research institutions or companies to develop strategies. So pay attention to the actual micro-level analysis of sample technology, especially now potential and well developed technology, is important.

13.5.3 Emphasize on Multi-angle Analysis, Comprehensiveness and Integrity

In order to get enough useful information about the diffusion history and current status, it is difficult to comprehensively analyze the diffusion of one specific technology by simply using only one perspective. Therefore, for an empirical technology, it is better to describe diffusion of that technology from various aspects as diffusion in technology fields, in industries, in countries or organization. At last, based on investigation into these aspects, qualitative exploration and quantitative forecasting of diffusion are needed to be done, to provide beneficial references to related R&D organizations about the selected technology.

13.5.4 Build a Hierarchic Research Frame or an Systematic Analysis Process

A multi-angle and more effective analysis framework is needed to build for analyzing diffusion of one specific technology deeply and comprehensively and thus to support decision-making. The frame is required to contain the detailed analysis process and point out the methods used to analyze the various parts.

Acknowledgements The authors would like to acknowledge the colleagues of Technology Management Lab of BJUT, the financial support of National Soft Science Research Program 2010GXS-3K083, Beijing Academic Human Resources Development Project PHR-IHLB, and National Natural Science Foundation of China under Grant No. 70639002, National Social Science Foundation of China under Grant No. 11&ZD140.

References

1. Anderson J, Wincoop EV (2001) Cravity with gravitas: A solution to the border puzzle. American Economic Review 93:170–192
2. Branstetter LG (2001) Are konwledge spillovers international or intranational in scope? Microecnometric evidence from the U.S. and Japan. Jounal of International Economics 53:53–79
3. Chang SB, Lai KK, Chang SM (2009) Exploring technology diffusion and classification of business methods: Using the patent citationnetwork. Technological Forecasting and Social Change 76:107–117
4. Eaton J, Kortum S (1996) Trade in idees: Patenting and productivity in the OECD. Jounal of International Economics 40:251–278
5. Fallah MH, Fishman E, Reilly RR (2009) Forward patent citations as predictive measures for diffusion of emerging technologies. In: Proceedings of Portland International Conference on Management of Engineering & Technology 420–427
6. Fung MM, Chow WW (2002) Measuring intensity of knowledge flow with patent statistics. Econimic Letter 74:353–358
7. Shih HY, Chang TLS (2009) International diffusion of embodied and disembodied technology: A network analysis approach. Technological Forecasting and Social Change 76:821–834
8. Chih HC, Wang CC (2009) The use of social network analysis in knowledge diffusion research from patent data. Advances in Social Network Analysis and Mining 393–398
9. Hu AG, Jaffe AB (2003) Patent citation and international knowledge flow: The cases of Korea and Taiwan. International Journal of Industrial Organization 21:849–880
10. Jaffe AB, Trajtenberg M, Henderson R (1993) Geographic localization of knowledge spillovers as evidenced by patent citations. The Quarterly Journal of Economics 108:577–598
11. Jaffe AB, Trajtenberg M (1999) International knowledge flows: Evidence from patent citations. Economics of Innovation and New Technology 8:105–136
12. Kim DH, Shin YG, Park SS et al (2008) Forecasting diffusion of technology by using Bass Model, computational methods in science and engineering. Advances in Computational Science 1148:149–152
13. Lai KK, Chang SB (2004) Establishing technology diffusion model of business method: A study integrating patent citation and Bass model. Journal of Technolonogy Management 9:1–34 (In Chinese)
14. Lai KK, Chang SM, Chang SB (2007) Using patent citation to explore knowledge flow between different industries. In: Proceedings of Portland International Conference on Management of Engineering & Technology 1777–1783
15. Li X, Chen HC, Huang Z, Roco MC (2007) Patent citation network in nanotechnology. Journal of Nanoparticle Research 9:337–352
16. Rogers EM (1983) Diffusion of innovations. The Free Press, New York
17. Scherer FM (1980) Industrial market, structure and economic performance. Rand Meally, Chicago
18. Schumpeter JA (1934) The theory of economic develoment, an inquiry into profits, capital, credit, interest and business cycle Cambridge. Harcard University Press, MA

19. Su HN, Lee PC (2009) Dynamic and quantitative exploration on technology evolution mechanism: The case of electrical conducting polymer nanocomposite. In: Proceedings of Portland International Conference on Management of Engineering & Technology 2433–2440
20. Tijssen RJW (2001) Global and domestic utilization of industrial relevant science: Patent citation analysis of science-technology interactions and knowledge flows. Research Policy 30:35–54
21. Verspagen B, Loo ID (1999) Technology spillovers between sectors and over time. Technological Forecasting and Social Change 60:215–235
22. Yoon BY, Park YT (2004) A text-mining-based patent network: Analytical tool for high-technology trend. Journal of High Technology Management Research 15:37–50
23. Zheng XL, Zhang SQ (2005) Patent citation and international knowledge spillovers: Evidence from IT industry. Journal of Technology Management 8:103–140 (In Chinese)
24. Evenson R, Puttnam J (1988) The Yale-Canada patent flow concordance. Yale University, Economic Growth Centre Working Paper

Chapter 14
The Research on Wal-Mart in China's E-commerce

Jinghui Hao, Xiang Huang, Min Yu and Chang Lin

Abstract Increasing the e-commerce channel is thought to be an important breakthrough point of business growth for Wal-Mart in China. For better adapt to the market in China, Wal-Mart increase the input electronic commerce in Chinese mainland market. At present, Wal-Mart launched the Wal-Mart Sam member online stores in Shenzhen and Beijing, and then became the shareholder in the no. 1 store. But during the process of pushing electronic business, Wal-Mart also had some problems, including the market environment of localization, strong competitors and new logistics distribution environment, etc. Therefore, if Wal-Mart wants to enter into China's e-commerce market, it must give full consideration to China's national conditions, and combine its own characteristics and advantages, then promote "localization" process in order to look for greater market penetration and open up their second battlefield.

Keywords Electronic commerce · Wal-Mart · Logistics information system · Logistics distribution · The second battlefield

14.1 Introduction

(1) Research Backgrounds

With the development of modern information technology, network and computer technology increasing rapidly, electronic commerce is playing more and more im-

---

J. Hao (✉)
Faculty of Management, Xuzhou Institute of Technology, Xuzhou 221000, P. R. China
e-mail: 39430409@qq.com

X. Huang · C. Lin
Faculty of Management, City University of Macau, Macau 999078, P. R. China

M. Yu
Department of Economy and Trade, Yangzhou Business School of Higher Occupation, Yangzhou 225000, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_14, © Springer-Verlag London 2013

portant role in business model now. With its operation mode flexibility and rapid response on consumers' personalized needs, electronic commerce wins the wide concern of consumers and enterprises. The electronic commerce has been changing the ways of trade and consumption, and affecting every corner of the world.

In recent years, the electronic commerce has been developed rapidly in our country, and its users are keeping rising, continually, the market trading is also expanding .According to the information center – ≪29th issued by the China Internet network development condition investigation statistics report≫, it shows that the scale of Chinese Internet users has reached to 513 million by the end of December, 2011, and the number of new Internet users is 55.8 million throughout the year. Internet penetration rate in value rises by 4% and reaches to 38.3%. In the way of internet application in practice for Internet users, the electronic commerce application has been developed steadily, utilization rate is keeping rising. The user scale, such as online shopping, online payment, internet banking and online travel booking application, is growing comprehensively. Compared with 2010, the number of online payment users has increased to 33.44 million, growth rate reached to 20.8%, The usage rates of online payment and internet banking are also increasing to 21.6% and 19.2%. Meanwhile, ≪In the year of 2011 China's e-commerce market data monitoring report≫ shows that, China's e-commerce market transactions amount to 6 trillion yuan by the end of December ,2011, a year-on-year increase of 33%. Among them, the B2B e-commerce amounts to 4.9 trillion, an increase of 29%. Overall it maintains stable development situation. The retail market for trading network scale is 349.2 billion yuan, and by the end of December, network retail market trade scale hit the 800 billion, reached to 801.9 billion yuan, a year-on-year increase of 56%. At the same time, China's e-commerce research center forecasts, China's e-commerce service industry will have its golden age in the next few years. (Fig. 14.1)

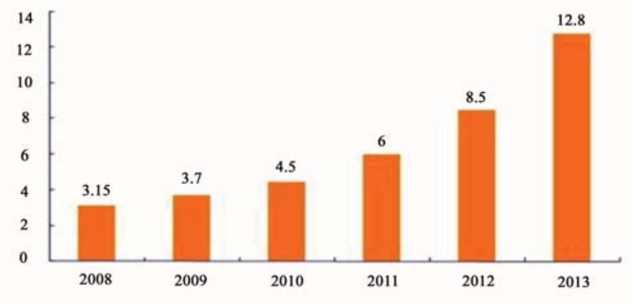


Fig. 14.1 Trading scale of China's e-commerce market in 2008-2013 (Date was adopted from CECRC)

Those who once carve out by the traditional channel of entity shop are fascinated with electronic business entity. As a global retail giant, although entity shop is still the major source of revenue for Wal-Mart, with global e-commerce wind, and investment attitude of Carrefour, Amazon traditional rivals in the field, Wal-Mart will put a banner in the market according to the situation. In 2009, Wal-Mart's e-commerce business income has reached to 3.5 billion in the United States. Although compared with offline business, the income gap is very huge, however, Wal-Mart has become one of the most influential players after Amazon in the e-commerce market of the United States, and it has an obvious rising momentum [1].

(2) The Purpose and Meaning of the Research

Along with the rapid development of China's e-commerce, Wal-Mart has gradually increased input in China's e-commerce market. Because of special conditions in China's retail market, Wal-Mart is difficult to cover all, and one of usages of the electronic commerce in our country market is an add for sells. Through the Internet coverage and opening up the second battlefield, Wal-Mart scores the territory that Wal-Mart can't occupy and seeks for the larger market breakthrough.

At present, Wal-Mart China sales performance accounted for nearly 10% of the proportion in international business. Increasing electronic business channel is thought to be an important breakthrough. In the future, the keys to the retail industry competition are the combination of the traditional retail and online shop, integrate online offline resource and perfect logistics system.

14.2 The Current Development Status

By the end of 2010, Wal-Mart Shenzhen Sam member online store (http://www.samsclub.cn) quietly online; In May 2011, Wal-Mart announced formally shares 20% of the no. 1 store that called "online Wal-Mart"; In June, Wal-Mart and Shanghai business committee in Shanghai signing ≪About promoting the development of Wal-Mart electronic business cooperation framework memorandum in Shanghai≫, officially established in Shanghai Wal-Mart global e-commerce Chinese headquarters that develop China's e-commerce business.

14.2.1 Sam's Club

In November 2010, Wal-Mart (China) in Shenzhen quietly testing B2C mall, for Sam's club stores member open online shopping channel .it managed by the China of the headquarters of the electronic ministry In the early stage of testing, relying on Sam's club stores, Sam's Club provides storage service for online business, both sides share Sam member store storehouse, the service scope were only allowed in Shenzhen, distribution for the common express way. At present the Sam's Club crossed to Beijing market after tested in Shenzhen.

14.2.2 Invest No. 1 Store

As the world's largest retailer, it has the important strategy meaning for Wal-Mart to invest No. 1 store to in the Chinese market.

At present No. 1 store have Beijing, Shanghai, Guangzhou, Wuhan, and Chengdu 5 storage center across the country and have built more than 130 the mixed center in the national 34 cities. As for Wal-Mart, The biggest attraction of No. 1 store is the way that warehousing system. Investing No. 1 store can accelerate the development of Wal-Mart e-commerce channel, realizing the combination of online and offline closely.

14.2.3 About Promoting the Development of Wal-Mart Electronic Business Cooperation Framework Memorandum in Shanghai

Wal-Mart and Shanghai business committee in Shanghai signing ≪About promoting the development of Wal-Mart electronic business cooperation framework memorandum in Shanghai≫, officially established in Shanghai Wal-Mart global e-commerce Chinese headquarters that develop China's e-commerce business. The headquarters will be responsible for operation and management of Wal-Mart e-commerce in the Chinese market. This marks that Wal-Mart have launched electronic business trip in the Chinese market.

According to the memo, Wal-Mart global electronic commerce will actively introduced accumulated advanced manage experience of the traditional retail and e-commerce field in China, and introduce the electronic commerce high-end talents who have international background and rich experience.

14.3 Existing Problems

From past experience, in Chinese Internet domain, none of foreign giants made brilliant success, whether Yahoo, eBay, Google or Amazon, MSN, these foreign great businesses in China are mediocre. Carrefour also has tried to "online shopping" in several years ago, with a few cities as a pilot to carry out online shopping business. But now, Carrefour retained the electronic commerce only in Beijing and Shanghai, the two international metropolises, other city is stopped [2]. From some reasons, when these enterprises stationed in the Chinese markets, all of them confront with certain "unsuit to the climate" problem, namely the combine "localization" deficiency. While in the "localization" of this issue, Wal-Mart also faced with many challenges.

14.3.1 Market Environment

First of all, due to China's broad area, leading to providers are more dispersed, and almost in every area, the supplier has its ”bibcock enterprise”, in almost every regional market, Wal-Mart had faced strong resistance of local enterprises. Moreover, several major domestic e-commerce sites have started a price war [3]. It lets the “consumer parity“ phenomenon seriously. It is truly a question that whether Wal-Mart can bear Chinese constant pursuit of “not the cheapest, only cheaper”.

Secondly, compared with the foreigners one week one buying patterns, Chinese consumers/ category for online shopping supermarket is “repeated small”. In this shopping habit, Wal-Mart supermarket's later distribution is likely to be a severe test.

14.3.2 Strong Competitors

For developing the Chinese electronic commerce, many people think that its biggest competitor will be Alibaba's Taobao: according to 2010 official data showed that Taobao has 180 million users (Chinese netizens for a total are 340 million), the first half of 2009, only the sales of mobile phones, laptops and digital cameras the three digital products are as high as 20 billion yuan. In January 13, 2010, Taobao launched the Electric City, not only moved national warranty, authentic licensed, formal invoice, guaranteed after-sales service safeguards from the offline to the online, and wantonly creating a ”cheap” atmosphere [4].

In addition, the domestic traditional channel business almost all start their B2C business, after Wal-Mart has opened the second front online, its opponent is not just a Taobao: First, China's top electricity provider, such as JINGDONG, VANCL, RedBaby. Secondly, the local traditional retail enterprises like Ginza shares and Yi-INTAI Group put such effort to build e-commerce platform; In addition, Carrefour online store, online store of GOME and SUNING Tesco are all online. Among them, GOME and SUNING stores tend to develop themselves into a daily provisions distributor. This means that the positive “collision” will occur to Wal-Mart with more local businesses in the near future.

14.3.3 It Is Difficult for Logistics System to Reduce Costs

The former Wal-Mart CEO David Glass said “a Distribution facility is one of the key to Wal-Mart's success, if we have done something better than others that is the distribution center.” Wal-Mart's developed distribution system makes it occupy a great advantage in logistics and distribution costs and expenses, making Wal-Mart in a good position during the competition and ensuring that its business strategy “everyday low prices” [5]. In the U.S., Wal-Mart's strengths are the logistics, but the biggest bottleneck Wal-Mart's business suffered in China is precisely the logistics system that using the proud distribution center as the core [6]. But in China, Wal-Mart has bottlenecks in this regard, resulting in difficulty to reduce logistics costs. The main reasons are as follows:

(1) The constraints of the road environment

Our level of development in highway is still very low; we still need to wait until 2035 in order to achieve United States in the early 1950's level of 89,000 km. And due to the imbalance of economic development of our country districts, resulting in differences of traffic conditions, reducing the efficiency of Wal-Mart distribution center.

(2) Distribution centers set unreasonable

Wal-Mart's logistics and distribution centers are typically built in the center position of more than 100 branches, trying to ensure that the distribution within a radius of 320 km or less, to ensure the maximization of economies of scale. In China, Wal-Mart build three large logistics distribution center in Shenzhen, Tianjin, and Jiaxing (see Fig. 14.2).

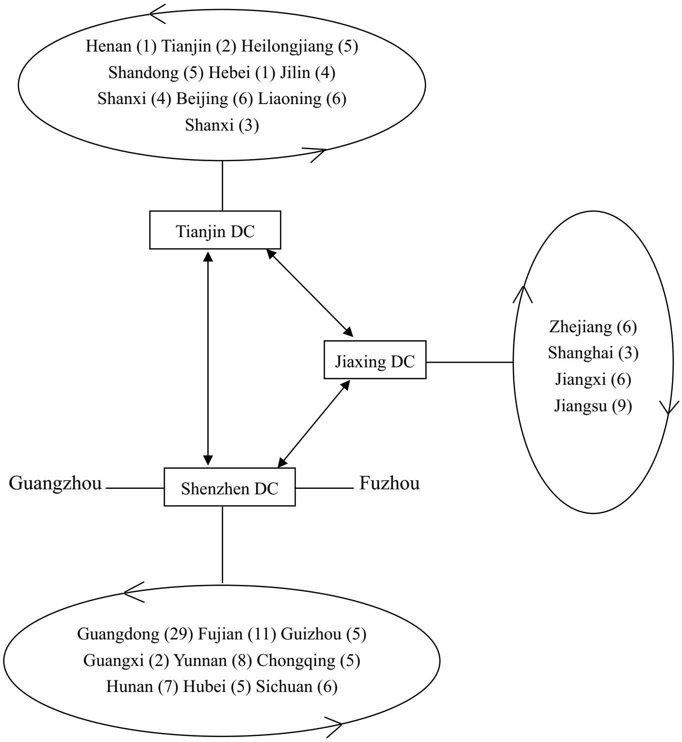


Fig. 14.2 Geographical coverage of Wal-Mart China distribution center

From the figure, we can see that Wal-Mart in Tianjin, Jiaxing and Shenzhen has its own logistics and distribution center, but China has a vast distribution, only three is not enough; While Tianjin distribution center and Jiaxing distribution center is surrounded by only 20 or 30 stores, which can't meet the condition for Wal-Mart to maximize economies of scale. At this stage, the distributions of goods rely on Wal-Mart's three distribution centers, with third-party logistics and transport cooperation. Irrational shop distribution, it is difficult to show the scale effect, the average transportation cost is much higher than the peer level, has seriously affected the mid-price of commodities, as the obstacle to its ”everyday low prices”. After entering the e-commerce, such a loose configuration will obviously become the Wal-Mart's "weakest link".

(3) The distribution model faces a challenge

Electronic business service object do not restrict from geographical location, and how fast response to customer demand and deliver the goods to the customer with the minimum cost become a very important conditions of electronic business enterprise attracting the customers.

In the United States, customers also can order online then get to the nearest supermarket to take goods, also can accept door-to-door delivery services. As for the distribution costs, Wal-Mart has two advantage that can help the transport costs falling to lowest. One advantage is that the contract price between express companies such as UPS is very low; the other is Wal-Mart cover USA more than 140 distribution center at the same time. At the same time, Wal-Mart continuously launches a variety of free delivery activities to win customers. When Wal-Mart in the U.S. launch free delivery to win customers, at the same time, the Chinese market appears to reverse the situation: due to higher oil prices and too great distribution pressure, private Courier companies raise fares leading to some seller Of Taobao has increased express cost .Wal-Mart's distribution center in China are only three, at the same time, the lack of strong enough logistics partner, so their advantage don't show in the distribution and the way. At the same time, because of China's vast, logistics network is not perfect compared with American and remote area how to distribute, these are the entire subject that Wal-Mart China needs to resolve before.

From the above analysis, we conclude that Wal-Mart should fully consider China's national conditions, can not always keep their "American" experience and should launch "localization" strategy [8].

14.4 Conclusion and Recommendation

14.4.1 Conclusion

Adding e-commerce channel is considered to be an important breakthrough point of the growth of Wal-Mart's business in China. In order to adapt the market demand better, Wal-Mart increased investment in e-commerce market in mainland China.

China headquarters of Wal-Mart's global e-commerce has been set up in Shanghai for the development of e-commerce business in China. In Shenzhen and Beijing it has launched Wal-Mart Sam Member online store, and shared on the 1st shop. But Wal-Mart also encountered a number of issues in China to promote e-commerce process, including the localization characteristics of the market environment, strong competitors and a new logistics and distribution environment. Therefore, Wal-Mart should give full consideration to the situation of China with its own characteristics and advantages to station in the e-commerce market in China and promote the process of "localization". For this conclusion, the main recommendations are from the following aspects.

14.4.2 Recommendation

(1) Create a fully functional self logistics

It is an extremely important condition for e-commerce businesses to attract customers to respond quickly to customer needs and delivery goods to the hands of customers at the lowest cost. Completion depends on the logistics support. The levels of development of logistics always determine the degree of development of electronic commerce. Competition in the e-commerce businesses depends largely on the development of logistics. 'Who own logistics who own the world' is fit in e-commerce market, the advantages of self-built logistics will become more prominent in it.

Currently, Wal-Mart has three distribution centers in Tianjin, Jiaxing and Shenzhen, but its investment in the 1st store has five storage centers in Beijing, Shanghai, Guangzhou, Wuhan, and Chengdu. And in 34 cities with 130 more self-center across the country, greatly expanding the Wal-Mart's e-commerce channels, that contribute to its closely integration of online and offline business.

On the basis of integrated shop storage resources on the 1st, in order to ensure e-commerce business can be rapidly and orderly in full swing, Wal-Mart needs to further increase investment in logistics, and even build a certain powerful, full service logistics and transport lines. After all, opponents, led by Taobao have seized the initiative in this regard, if Wal-Mart doesn't want to be controlled by others, it can only set up a rapid reaction of the distribution chain, logistics and transport by itself.

(2) Diversification of distribution model

The distribution model is generally divided into the following styles: Self-logistics model; supplier logistics distribution model; common logistics model; interoperability logistics model; third-party logistics model [9]. Wal-Mart combine own characteristics and China's market feature, choosing the Self-logistics model oriented, supplemented with other styles.

- First tier cities

We can use self-logistics model and supplier logistics distribution model in the first tier cities. In China, Wal-Mart stores, mostly in the central cities, logistics and the resources are relatively abundant, therefore, the vast suppliers provide specialized services, and the delivery is more convenient and fast.

- 2-4 tier cities

As February 1, 2011, Wal-Mart has opened more than 370 shopping centers in 21 provinces and 4 municipalities over 140 cities, of which 80% of the shopping malls in 2-4 tier cities. Moreover, in China's vast markets of 4-6 tier cities, it's very difficult for Wal-Mart to achieve comprehensive coverage.

As China's vast region, distribution center has not yet achieved full coverage. In 2-4 tier cities, Wal-Mart can implement self-logistics and distribution model, the supplier of logistics model and third-party logistics model.

(3) To integrate online and offline business

It is an inevitable trend for future e-commerce development to combine online and offline business. Now for Wal-Mart, one of the biggest challenges is how to integrate online and offline supply chain effectively. As the online business giant, Wal-Mart already owns a lot of experience in the USA. Many American online business giant such as EBay, Amazon, and Newegg took many detours because of the market condition difference between China and the USA [10]. The bottleneck problem for the way to traditional stores turning into e-commerce is the integration of online and offline business. The degree of coincidence is inconsistent for online and offline consumers. So how to conduct differential marketing of online and offline is the priority for Wal-Mart to consider now.

Although Wal-Mart e-commerce has just started in China, sharing a small piece of its whole turnovers, we can see the bright future of it, and should invest in it.

References

1. Ma G (1998) The success of the Wal-Mart business culture. Domestic and Foreign Economic Management 4:15–17 (In Chinese)
2. Li M (2010) Conform to the trend of the times in China electronic commerce Wal-Mart opened up the first World War II field. IT Time Weekly, May 5th (In Chinese)
3. Kenny S (2005) Against Wal-Mart. Mechanical Industry Press
4. Yao F (2010) The research on logistics distribution in electronic business environment in China. Wuhan University of Science and Technology 19–24 (In Chinese)
5. Wang XQ (2004) The Wal-Mart retail method. Guangdong Economic Press (In Chinese)
6. Aela AV, Patrich E (2008) Murphy: Marketing with integrity-ethics and the service-domingt logic for marketing. Journal of the Academy Marketing Science 36:39–53
7. Ran P (2009) Bussiness Strategy of Wal-Mart China. Zhongshan University 20–31 (In Chinese)
8. Qin YL (2006) The Wal-Mart China localization and their implications for the development of the retail business in China. Masters's degree thesis, University of International Business and Economics
9. Wei W (2010) Regional distribution of e-commerce routing optimization problem. Wuhan University of Science and Technology 13–16 (In Chinese)
10. Miles MP, Munilla L, Darroch J (2009) Stainable corporate. International Entrepreneurship and Management Journal 5:65–76

Chapter 15
Wavelet Transforms for Macro Fiber Composites Transducers

Raúl Ruiz de la Hermosa González-Carrato, Fausto Pedro García Márquez and Vichaar Dimlaye

Abstract This paper presents a novel pattern recognition approach for a Non Destructive Test (NDT) for pipes. NDT is based on Macro Fibre Composites Transducers (MFC). The signals are analysed employing Wavelet Transforms (WT). WT is an optimum methodology for the detection and diagnosis of particular behaviors that is very effective for maintenance management in NDT of pipes. WT analysis is a windowing technique that allows the use of time intervals when more precise information is required. It leads to WT to be a powerful tool that can reveal characteristics of the signals as trends, breakdown points or self-similarities. In this paper a real case study is presented, where all possible combinations between signals are considered in order to find pattern recognitions. To achieve the results, signals are broken down by mathematical software based on wavelets principles. Similarities are found with an associated energy percentage for each decomposed signal exchanging the waveforms, levels of decomposition and border distortions.

Keywords Transforms · Macro fibre composites transducers · Pattern recognition · Maintenance management

15.1 Introduction

A Macro Fibre Composite (MFC) has been used to detect temperature effects in a pipe. An AC voltage signal was used in the MFC transducers. The signal is transferred along the surface of the pipe. The input voltage signal is in high frequency excitation (30 kH). Experiments were done using 4 MFC transducers attached at 3

R. González-Carrato · F. García Márquez (✉)
Ingenium Research Group, Universidad Castilla-La Mancha, Ciudad Real, Spain
e-mail: FaustoPedro.Garcia@uclm.es

V. Dimlaye
NDT Technology Group, TWI-Technology Engineering, United Kingdom

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_15, © Springer-Verlag London 2013

m from the nearest beginning (see Fig. 15.1). The transducers are arranged at 45 degrees around the pipe of 8. The pulse-echo data from each transducer and the sum of them where collected. The sensor and actuator are located at the same place on the pipe. The discontinuities of the structure will lead the change of the wave that is read by the sensor. The signal will represent changes of the structure as geometry (edges of the pipe, extremeness, etc.), faults (corrosion, cracks, defects), environment conditions, etc. The main objective in this paper is to study the environment temperature in the pipe. The authors have not found a previous study about this topic.

Fig. 15.1 shows the allocation of the MFC sensors and the pipe geometry. The pipe has a diameter of 20.32 cm and a length of 9 meters. The MCF sensors are set at 6 m of the end and at 45° between them. Fig. 15.2 presents the sum of the 4 MFC transducers signals. The main shapes of the signal are associated to the geometry of the pipe. The pulses are basically longitudinal wave modes with a velocity $V = 5400 m/s$.

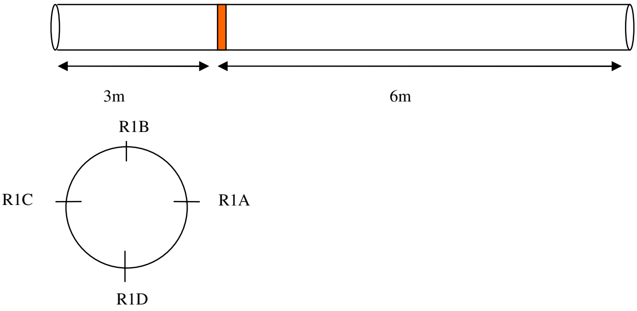


Fig. 15.1 MFC transducers set on a 8 pipe

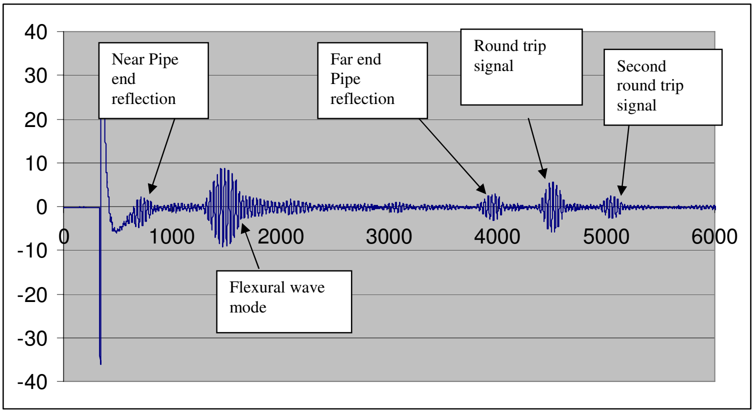


Fig. 15.2 MFC signal (mV) vs. samples

The movement of the pulse-echo from along the surface of the pipe is described in Fig. 15.2. Fig. 15.3 shows the movement from the transducers to the beginning of the pipe and its return to the transducers. The distance covered is denoted by d_1 , being 3 m and the velocity of $V = 5400m/s$, therefore $t_1 = 3/5400 = 555us$. This time corresponds to the near end reflection as shown in Fig. 15.2. Fig. 15.4 shows second part of the pulse-echo movement from the transducers to the end of the pipe (d_2) and vice versa, being $d_2 = 6m$, $V = 5400m/s$, $t_2 = 6/5400 = 111us$. The data from R1A, R1B, R1C and R1D (mV) are plotted in Fig. 15.5.

The correlation coefficients are showed in Table 15.1, where the correlation is calculated between the signal of the column i and row j.

Table 15.1 Correlation coefficients of the signals R1A, R1B, R1C and R1D

	R1A	R1B	R1C	R1D	Total
R1A	1.0000	0.4925	0.2987	0.5094	0.6419
R1B	0.4925	1.0000	0.6393	0.8121	0.9237
R1C	0.2987	0.6393	1.0000	0.4834	0.7835
R1D	0.5094	0.8121	0.4834	1.0000	0.8722
Total	0.6419	0.9237	0.7835	0.8722	1.0000

The correlation coefficients range is from -1 to 1, where values close to 1, e.g. principal diagonal, indicate that there high correlation. Every signals and the sum of them, called "total" except R1A, and R1B-R1D, have a positive linear relationship. Values close to -1 would indicate that the data from an experiment has a negative linear relationship to another (anti-correlation), but there is not any case. Finally values close to 0 would indicate that there is no linear relationship between the signals. In this work has been analyzed the signal given by the sum of the signals (called total).

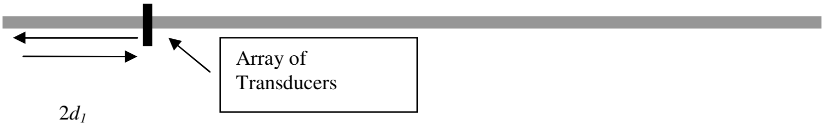


Fig. 15.3 First part of the pulse-echo movement and d_1

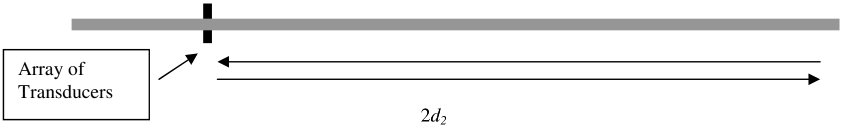


Fig. 15.4 Second part of the pulse-echo movement and d_2

The objective of this project is to detect changes in the structure according to the temperature. The wavelet transform is proposed in order to detect the temperature.

15.2 Signal Processing: Wavelet Transform Approach

The transformation of a signal to the frequency domain by the Fast Fourier Transform (FFT) can lead to lose part of the information in time domain, and it can be difficult to determine when a behavior occurs or a certain frequency appears [1]. Wavelet transforms analysis is an excellent method in order to solve this problem, and it leads to work with high and low frequencies. The principle of the Wavelet decomposition is splitting the original signal into different components, as the sum of all corresponds to the original signal, but at different frequency bands. Usually the most important information appears at low frequencies, while the particular features are found at higher frequencies [2].

This paper presents a novel pattern recognition approach for MFC transducer signals related to 8 conditions of environment temperatures $[t1,\ldots,t8]$. Every signal has 11321 data. The main objective is to develop a pattern recognition method that can identify every pair of signals. The use of the Wavelet transforms stems from the need to find a methodology that suits the type of signal. It is discarded the use of FFT failing to fulfill the expected requirements when working with a data type that does not follow any set pattern [1].

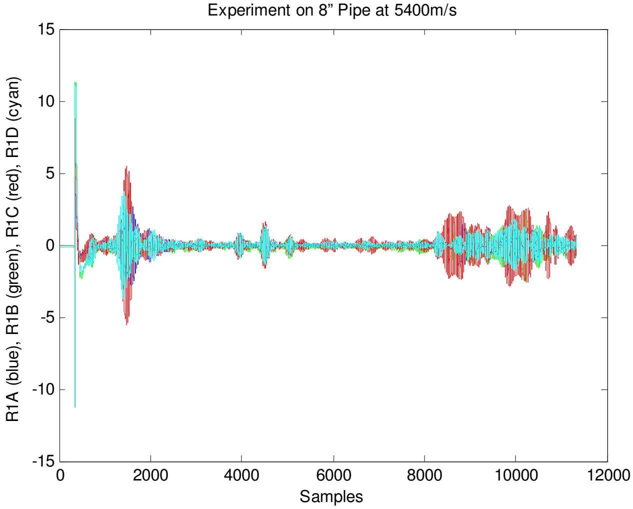


Fig. 15.5 Signals R1A, R1B, R1C and R1D (mV) versus samples

The Wavelet transform is a mathematical approach that has many applications in signal processing, process control and detection of anomalies. It associates every finite energy signal with a particular function that represents the main or mother wavelet. It enables to analyze the signal structures that depend on time and scale, being an useful tool to detect, characterize and identify signals with spectral features, unusual temporary files and other properties related to the lack of stationary.

In general terms, the Wavelet transform of a function $f(t)$ is the decomposition of $f(t)$ in a set of functions and $\psi_{s,\tau}(t)$, forming a base. The Wavelet transform is defined as [4, 5]:

$$\omega_f(s,\tau) = \int f(t)\psi^*_{s,\tau}(t)dt. \tag{15.1}$$

Wavelets transforms are generated from the translation and scale change from a same wavelet function $\psi(t)$, called mother wavelet, which is given by Equation (15.2):

$$\psi^*_{s,\tau}(t) = \frac{1}{\sqrt{s}\psi(\frac{t-\tau}{s})}, \tag{15.2}$$

where s is the scale factor, t is the translational factor and t the time ...

The wavelets $\psi_{s,\tau}(t)$ generated from the same mother wavelet function $\psi(t)$ have different scale s and location t, but the same shape. Scale factors are always $s > 0$. The wavelets are dilated when the scale $s > 1$ and contracted when $s < 1$. Thus, the changing of the value s can cover different ranges of frequencies. Large values for the parameter s correspond to lower frequencies ranges or a large scale for $\psi_{s,\tau}(t)$. Small values of s correspond to lower frequencies ranges or very small scales.

This study will focuses on finding similar patterns for all the possible combinations between every pair of signals.

Every signal has been transformed in 5 new ones named a_4, d_4, d_3, d_2 and d_1, where each of them has an energy rate associated from the original signal. Functions in the time domain can be represented as a linear combination of all frequency components present in a signal where the coefficients are the amount of energy provided by each frequency component to the original signal. The main decomposition is associated with a4 that usually has the highest energy, though not always necessary. It has a similar pattern to the original signal. The first (d_4), second (d_3), third (d_2) and fourth (d_1) transformed signals have decreasing energy rates. Signal s will be the signal to be analyzed. Usually, a_4 is the low frequency component of the original signal while d_i is the high frequency component, having d_1 the biggest value. Fig. 15.6 shows the different signals considered.

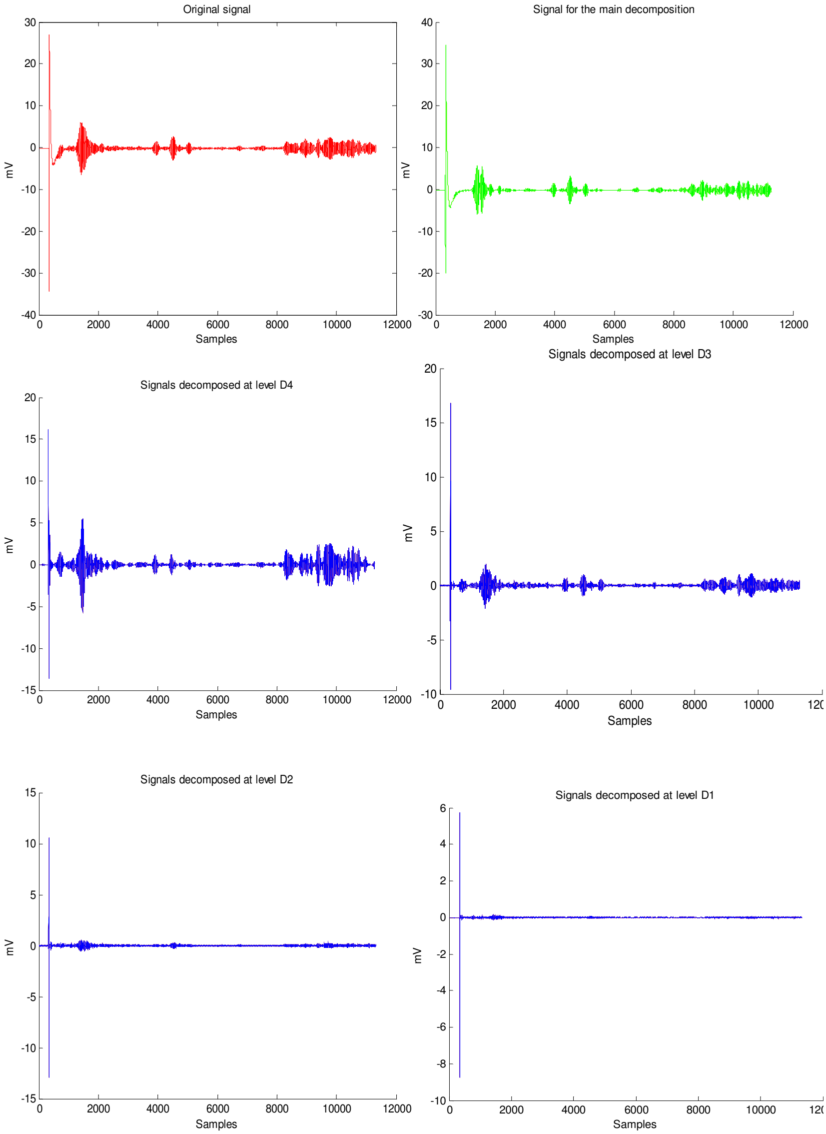


Fig. 15.6 Example of decomposition in 4 levels (t1)

15.3 Pattern Recognition Approach

Table 15.1 shows the decomposition level used. Table 15.2 identifies the pattern recognition nomenclature. There are 3 options: Y means that both signals are similar but one of them with amplitude higher than the other one; N is for cases where pattern recognition does not exist and; E implies that signals overlapping themselves with a high degree of accuracy. Table 15.3 complements the Y option in Table 15.2, stating what the signal with the higher amplitude is. Finally, Table 15.4 explains if the behavior is total or partial in the study section. The signal was analysed in three segments in order to consider the different parts that present the signal (Fig. 15.2). All signals show similar characteristics: an abrupt first phase, a second stabilization phase, where it is supposed to find the conditions of interest, and a third part with a shape irregular. The main conclusion for these experiments was that the pattern recognition for different temperatures was found in the second third.

Table 15.2 Decomposition levels

Energy signal decomposition (4 levels)	a_4	Main decomposition
	d_4	First decomposition
	d_3	Second decomposition
	d_2	Third decomposition
	d_2	Third decomposition

Original signal (s) = main decomposition (a_4) $+d_4+d_3+d_2+d_1$

Table 15.3 Pattern recognition

Pattern recognition	Y	Yes
	N	No
	E	Signals are(nearly) equal

Table 15.4 Amplitude

Signal amplitude	>	Amplitude $i >$ Amplitude j
	<	Amplitude $i <$ Amplitude j

Table 15.5 Pattern recognition, partial or complete

Signal	C	Complete pattern similitude for pair i, j in the section
	P	Partial pattern similitude for pair i, j in the section

15.4 Results

Table 15.6 shows the main conclusions found in the experiment results presented in Fig. 15.7. The nomenclature employed has been:

N means there is no pattern recognition.

- $Y,<,P$ means that there is a partial pattern recognition where signal i is smaller than signal j.
- $Y,>,P$ means that there is a partial pattern recognition where signal i is bigger than signal j.
- $Y,<,C$ means that there is a complete pattern recognition where signal i is smaller than signal j.

			Signals																							
			j																							
			1			2			3			4			5			6			7			8		
			[0, 1/3]	(1/3, 2/3]	(2/3, 1]	[0, 1/3]	(1/3, 2/3]	(2/3, 1]	[0, 1/3]	(1/3, 2/3]	(2/3, 1]	[0, 1/3]	(1/3, 2/3]	(2/3, 1]	[0, 1/3]	(1/3, 2/3]	(2/3, 1]	[0, 1/3]	(1/3, 2/3]	(2/3, 1]	[0, 1/3]	(1/3, 2/3]	(2/3, 1]	[0, 1/3]	(1/3, 2/3]	(2/3, 1]
Signals	i	1				a4 - E, C d4 - E, C d3 - E, C d2 - E, C d1 - E, C	a4 - E, C d4 - E, P d3 - E, C d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C	a4 - E, C d4 - E, C d3 - E, C d2 - E, C d1 - E, C	a4 - E, C d4 - E, C d3 - E, C d2 - E, P d1 - E, C	a4 - E, C d4 - E, C d3 - E, C d2 - E, C d1 - E, C	a4 - E, C d4 - E, P d3 - E, P d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, P d2 - E, P d1 - Y, >, P	a4 - N d4 - N d3 - E, C d2 - E, C d1 - Y, >, P	a4 - E, P d4 - N d3 - E, P d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, P d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, P d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, P d2 - E, P d1 - E, P	a4 - E,P d4 - N d3 - N d2 - Y, >, P d1 - Y, >, P	a4 - N d4 - N d3 - N d2 - N d1 - N	a4 - E, C d4 - E, C d3 - E, C d2 - E, C d1 - E, C	a4 - E, C d4 - E, C d3 - E, P d2 - E, P d1 - E, C	a4 - E, C d4 - E, C d3 - E, C d2 - E, C d1 - E, P	a4 - E, P d4 - E, C d3 - E, C d2 - E, C d1 - E, C	a4 - E, C d4 - E, C d3 - N d2 - N d1 - Y, >, P	a4 - E, P d4 - E, P d3 - E, C d2 - E, C d1 - E, C
		2							a4 - E, C d4 - E, C d3 - E, C d2 - E, C d1 - E, P	a4 - E, P d4 - N d3 - N d2 - N d1 - N	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, P d2 - E, C d1 - E, C	a4 - N d4 - N d3 - N d2 - N d1 - Y, >, P	a4 - N d4 - E, P d3 - E, P d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, P d2 - E, C d1 - E, P	a4 - E, P d4 - N d3 - N d2 - E, C d1 - E, C	a4 - N d4 - E, P d3 - E, P d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - Y, >, P d1 - Y, >, P	a4 - N d4 - N d3 - N d2 - N d1 - N	a4 - E, P d4 - E, P d3 - E, C d2 - E, C d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - Y, >, P	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, C d2 - E, C d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - Y, >, P	a4 - N d4 - E, P d3 - E, C d2 - E, C d1 - E, C
		3										a4 - E, P d4 - E, P d3 - E, P d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, P d2 - E, C d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - Y, <, P	a4 - N d4 - N d3 - E, P d2 - E, C d1 - E, P	a4 - E, P d4 - E, P d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - Y, >, P	a4 - N d4 - N d3 - N d2 - N d1 - N	a4 - E, P d4 - E, P d3 - E, C d2 - E, C d1 - E, C	a4 - N d4 - E, P d3 - N d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, P d2 - E, C d1 - E, C	a4 - E, P d4 - E, C d3 - E, C d2 - E, C d1 - E, C	a4 - E, C d4 - E, C d3 - E, P d2 - E, C d1 - Y, >, P	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C
		4													a4 - N d4 - N d3 - E, P d2 - E, P d1 - Y, <, P	a4 - N d4 - N d3 - N d2 - N d1 - Y, <, P	a4 - N d4 - N d3 - E, P d2 - E, C d1 - Y, <, P	a4 - N d4 - E, P d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - N	a4 - E, P d4 - E, P d3 - E, P d2 - E, C d1 - E, C	a4 - N d4 - N d3 - N d2 - E, P d1 - Y, >, C	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, P d2 - E, C d1 - E, C	a4 - N d4 - N d3 - N d2 - E, P d1 - E, C	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C
		5																a4 - E, P d4 - E, P d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - Y, >, P d1 - Y, >, P	a4 - N d4 - N d3 - N d2 - N d1 - N	a4 - E, P d4 - E, P d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - Y, >, P	a4 - N d4 - N d3 - E, P d2 - E, C d1 - E, C	a4 - E, P d4 - E, P d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - Y, >, P	a4 - N d4 - E, P d3 - E, P d2 - E, P d1 - E, P
		6																			a4 - E, P d4 - N d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - N	a4 - E, P d4 - N d3 - E, P d2 - E, P d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - E, P	a4 - N d4 - N d3 - N d2 - N d1 - N
		7																						a4 - E, P d4 - E, C d3 - E, C d2 - E, C d1 - E, C	a4 - N d4 - N d3 - N d2 - E, C d1 - E, C	a4 - N d4 - N d3 - E, C d2 - E, C d1 - E, C
		8																								

Fig. 15.7 Simplified statistics

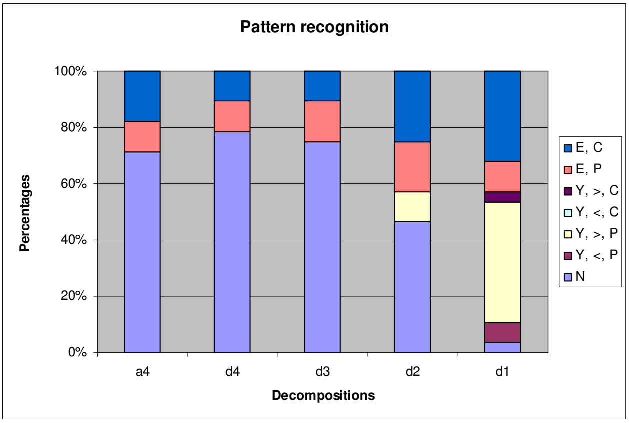


Fig. 15.8 Statistics with all the possibilities studied

- $Y,>,C$ means that there is a complete pattern recognition where signal i is bigger than signal j.
- E,P means that both signals are almost identical but with minor differences.
- E,C means that both signals are identical.

Fig. 15.8 presents the results given in Table 15.5. It can seen that employing d_1 most of the temperatures at the structure, 96,43 %, can be detected, where only 1 case was not detected (Table 15.7). Studying other signals, the percentages of the temperatures detected decreased.

Table 15.6 Statistics with all the possibilities studied

	N		$Y,>,P$		$Y,<,C$		$Y,>,C$		$Y,<,C$		E,P		E,C		Total	
	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%	Cases	%
a_4	20	71,43	0	0,00	0	0,00	0	0,00	0	0,00	3	10,71	5	17,86	28	100
d_4	22	78,57	0	0,00	0	0,00	0	0,00	0	0,00	3	10,71	3	10,71	28	100
d_3	21	75,00	0	0,00	0	0,00	0	0,00	0	0,00	4	14,29	3	10,71	28	100
d_2	13	46,43	0	0,00	3	10,71	0	0,00	0	0,00	5	17,86	7	25,00	28	100
d_1	1	3,57	2	7,14	12	42,86	0	0,00	1	3,57	3	10,71	9	32,14	28	100

15.5 Conclusions

The main conclusions are:

1. The second third, around the sample interval [5500, 8000], is the section of major interest for the environment temperature.

Table 15.7 Simplified statistics

	N		Y		Total	
	Cases	%	Cases	%	Cases	%
a_4	20	71,43	8	28,57	28	100
d_4	22	78,57	6	21,43	28	100
d_3	21	75,00	7	25,00	28	100
d_2	13	46,43	15	53,57	28	100
d_1	1	3,57	27	96,43	28	100

2. The best results have been found using the signal d_1. Signal d_1 has lower percentages of energy. It is the high frequency component and provides more signs of identity.
3. Cases Y,<, P; Y,>,P; Y,<,C and Y,>,C have more interest. They are over 55presented employing d_1.
4. Mathematically, it is impossible to draw conclusions with signals 5 and 6 because they provide several errors, but in visually terms they report good behaviors, especially of the form Y,>,P.

References

1. Nieto N, Marcela, D (2008) The use of the discrete Wavelet transform in the reconstruction of sinusoidal signals. Scientia et Technica 38:381–386
2. Chik Z, Islam T, Rosyidi SA et al (2009) Comparing the performance of Fourier decomposition and Wavelet decomposition for seismic signals analysis. European Journal of Scientific Research 32:314–328
3. Mehmet R (2008) Comparison of Wavelet and short time fourier transform methods in the anayslis of EMG signals. Journal of Medical Systems 34:91–94
4. Wang D, Miao Q, Fan X et al (2009) Rolling element bearing fault detection using an improved combination of Hilbert and Wavelet transform. Journal of Mechanical Science and Technology 23:3292–3301
5. Schmitt E, Idowu P, Morales A (2010) Applications of Wavelets in induction machine fault detection, ingeniare. Revista Chilena de Ingenieria 18: 158–164

Chapter 16

Research on Construction of Sustainable Resolution Mechanism for Urban Flood Disaster based on ISM

Xuemei Wang and Rong Huang

Abstract In recent years, flood disaster happen frequently in the urban areas, which threatens each aspect of the city. Resolution mechanism of urban flood disaster becomes one important approach to safeguard the people's safety of life and asset and to reduce the degree to be damaged. In order to construct the sustainable resolution mechanism of urban flood disaster reasonably and scientifically, this paper adopts the approach of Interpretive Structural Modeling (ISM) in the realm of principle of system engineering. This paper is based on classical cases in the flood disaster of some cities and by means of literature. 13 related factors and influence relationship are found and further and systematic analysis on them is made. Multilayer-transfer Interpretive Structural Modeling(ISM) is established. Reference is providing for construction and improvement of flood disaster solutions and enhancement of capability.

Keywords Interpretive Structural Modeling (ISM) · Urban flood disaster · Sustainable · Resolution mechanism

16.1 Introduction

Flood disasters have always been one of the worst natural disasters in China, flood disasters during 1990 to 2006 caused an economic loss of average 113.67 billion annual, which accounts for 1.7 percent of GDP of the same period and this is much higher than the level of developed Western countries [1]. Along with the climatic change and rapid urbanization progress, as the population density, wealth accumu-

X. Wang
Sichuan University for Nationalities, Kangding 626001, P. R. China

R. Huang (✉)
University of Electronic Science and Technology of China, Chengdu 611731, P. R. China
e-mail: 420552214@qq.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_16,

lation and expanding cities, they get larger and larger influence from flood disasters. The development of social economy didn't decrease the influence degree, but made the urban water-logging become more and more serious. The summer is on the way, the rains will come, and the rainstorms will test the flood control capacity of Chinese cities. The frequent urban rainstorm flood disasters told us that, we should build a serious of sustainable solution mechanism imperatively to avoid the phenomenon of "take stop-gap measures".

Although we human is unable to extirpate the natural disasters, we are able to enhance our flood disaster control capacity. Although against flood disaster has been a major theme of human survival and development, but it was until 1854 that the France Seine established the first flood forecasting and prevention and warning system firstly. Since the beginning of 20th century, foreign studies on urban flood disaster are gradually increasing, but most studies on urban hydrology are based on the perspective of geography. In the following decades, foreign countries carried out lots of research work on reduction of urban flood disasters, and improved the engineering measures and non- engineering measures of flood prevention and control gradually. American White Gilbert, the father of flood management, who has wrote the Human and Adjustment to Flood which became of the based work of American flood plain management and flood insurance from 1960s. He put forward at least eight measures in his book, such as flood control project, emergency response, land use, public relief, and so on [2]. The United States created the national flood insurance management (NFIP) in 1968, and became the first country of build the mandatory flood insurance system in the world. Since from 1960s, Japan has developed analysis model of flood, includes urbanization model, urban hydrology and hydraulics model, flood loss model, and flood research has been a powerful tool of scientific decisions [3]. The "Integrated Urban Water policy" was implemented in Japan in 1977 [4]. After the 1980s, the research object of urban flood control turns to the coastal cities along with the global warming and see-level rise. Flood research in China was start from 1990s, especially after a serious flood of the Yangtze River, the literature increasing rapidly and change from "flood control" to "flood management" was put forward, as well as the relevant laws and regulations, emergence plans was built to guarantee. View the literatures from home to abroad generally, mostly be the flood disaster researches on coastal areas and river basins cities, while researches on water-logging disasters caused by strong and short duration rainstorms in internal area cities are relevant less, especially the sustainability solution mechanism of urban rainstorm flood.

The Interpretative Structural Modeling (ISM) as one of structural modeling methods in system engineering, it is widely used in solving the problems in complex system with research object of social sciences and simple system with research object of nature sciences [5]. The ISM method was intended to use in this paper to discuss the relations between impact structure factors of sustainability solution mechanism of flood disaster, and build the layered structure model of sustainability solution mechanism to offer basis for solving urban flood disasters.

16.2 Connotation of Sustainability Solution Mechanism of Urban Flood Disasters and Influence Factors

16.2.1 Connotation

sustainability solutions is to comply with the development requirements of the city, avoiding instant success and quick profit, and can't take simple attitude to analysis and solve the urban flood disaster problem, in other words, it is to build city according with the requirements of sustainability development, and offer a set of sustainable prevent and solve mechanism for flood disasters. I think the connotation of sustainability solution mechanism includes the following aspects:

1. Urban pipe network system, especially the underground drainage system is sustainable effective for solving urban flood disaster;
2. Urban planning and construction are fit with the urban development, particularly the against flood capacity;
3. Forward-looking standard of flood prevent engineering could resist water disasters in a long period;
4. Sustainability solutions can guarantee the sustainable development of recovery after disaster and society, it has good social benefits.

16.2.2 Influence Factors

Based on a large number of literatures at home and abroad, and combine with the typical urban rainstorm disaster cases in China in recent years, and the flood solution characteristics, the influence factors of sustainable solution mechanism of urban flood are confirmed. S means sustainable solution mechanism of urban flood disaster, S_i means the influence factor, then $S = (S_1, S_2, \cdots, S_n)$.

Therefore, sustainable solution mechanism of urban flood disaster contains the following aspects:

S_0 : Sustainable solutions of urban flood disaster;
S_1 : Prevention and warning system;
S_2 : Emergency plans;
S_3 : Urban underground pipe network construction;
S_4 : City development and planning;
S_5 : Urban flood prevent strategy planning;
S_6 : Urban flood prevent and control projects;
S_7 : Urban flood prevent and control support system;
S_8 : Flood influence evaluation system;
S_9 : Urban flood risks management;
S_{10} : Emergency response capacity and guarantee;
S_{11} : Recovery system after disaster and evaluation;
S_{12} : Citizen consciousness and participation.

16.3 Establishment and Realization of Sustainable Solution Mechanism Model of Urban Flood Disaster by ISM

16.3.1 Build the Adjacency Matrix

Through the above analysis about sustainability solution system of urban flood disaster, and combine with amount of former research results, we can determine the logical relations between different factors, then we get the adjacency matrix R of various factors, which is a 13 order matrix, and its element definition is $(i,j=1,2,\cdots,13)$:

$$r_{ij}=\begin{cases}1, & S_i \text{ influences } S_j \text{ directly}\\ 0, & S_i \text{ does not influence } S_j \text{ directly}\end{cases} \tag{16.1}$$

and

$$R=\begin{array}{c}\\ S_0\\ S_1\\ S_2\\ S_3\\ S_4\\ S_5\\ S_6\\ S_7\\ S_8\\ S_9\\ S_{10}\\ S_{11}\\ S_{12}\end{array}\begin{array}{c}\begin{array}{ccccccccccccc}S_0 & S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 & S_8 & S_9 & S_{10} & S_{11} & S_{12}\end{array}\\ \left[\begin{array}{ccccccccccccc}
0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&0&0&0&1&1&0&0&0&0\\
0&1&0&0&0&0&0&0&0&0&1&0&1\\
1&0&0&0&0&0&0&0&0&0&1&0&0\\
1&0&0&1&0&0&1&0&0&0&0&0&0\\
1&1&1&0&0&0&1&1&1&1&1&1&0\\
1&0&0&0&0&0&0&0&0&0&1&0&0\\
0&0&1&0&0&0&0&0&1&0&1&1&0\\
0&0&1&0&0&0&0&0&0&0&1&0&0\\
1&1&1&0&0&1&1&1&1&0&1&1&1\\
1&0&0&0&0&0&0&0&0&0&0&0&0\\
1&0&0&0&0&0&0&0&0&0&0&0&0\\
1&1&0&0&0&0&0&1&0&1&1&1&0
\end{array}\right]\end{array}. \tag{16.2}$$

16.3.2 Build the Reachability Matrix

The adjacency matrix R describes the pair direct relation of sustainability solution mechanism influence factors on urban flood disaster. We use the Boolean calculation rule to calculate the adjacency matrix, then we get the reachability matrix M, find the direct relation and indirect relation between the factors, the calculate formula is:

$M=(R+I)^n$, which I means the unite matrix with the same order of R.

Then calculate the exponentiation of $R+1$ until $M=(R+I)^(n+1)=(R+I)^(n)\neq\cdots\neq(R+I)^2\neq(R+I)$.

Use the Matlab software, to calculate the exponentiation of $R+1$ in the adjacency matrix of sustainable solution mechanism influenced on urban flood disaster build in Sect. 16.3.1.

When $n = 4$, $M = (R+I)^4 = (R+I)^3 \neq (R+I)^2 \neq (R+I)$.

Then we can got the following reachability matrix M:

$$M = \begin{array}{c|ccccccccccccc}
 & S_0 & S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 & S_8 & S_9 & S_{10} & S_{11} & S_{12} \\
\hline
S_0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
S_1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
S_2 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
S_3 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
S_4 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\
S_5 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
S_6 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
S_7 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
S_8 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
S_9 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
S_{10} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
S_{11} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
S_{12} & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1
\end{array} . \tag{16.3}$$

16.3.3 Build the Reachability Matrix

Division of reachability matrix M, definition of reachability set $p(S_i)$ which represents the reachability factors in the corresponding row in factor S_i in matrix, ie, the matrix elements contain 1 in the lines. The Linear set of $Q(S_i)$ represents the reachability factors of the S_i factor in matrix in the corresponding column, ie, the matrix elements contain 1 in the column. The intersection of the reachability set and liners set, ie, $L_i = P(S_i) \cap Q(S_i)$ $(i = 1, 2, \cdots, n)$, which means the domain decomposition of reachability matrix, the result showed in following Table 16.1.

And partition the corresponding level of the above data, understand the level relations between the factors, the top level represents the final system goal, and the following level respectively represents the reason or relevance factors of the upper level. When meet $L_i = \{S_i | P(S_i) \cap Q(S_i) = P(S_i),\ i = 1, 2 \cdots, n\}$, the factors of each level could be determined. The first level factor is the final goal of the structural model. Only S_0 meet this formula in Table 16.1, from this we can determine that $L_1 = \{S_0\}$. Secondly, pass the first column and first row in reachability matrix and find out the factor of the second level, we can get that $L_2 = \{S_{10}, S_{11}\}$. Similarly, we can get that $L_3 = \{S_3, S_6\}$, $L_4 = \{S_1, S_2, S_4, S_5, S_7, S_8, S_9, S_{12}\}$.

16.3.4 Establishment of Interpretative Structural Modeling (ISM)

Based on the above analysis, the ISM of sustainable solution mechanism of urban flood disaster can be established, show in Fig. 16.1.

Table 16.1 The reachability set and liners set of sustainability solution mechanism influence factors on urban flood disaster

S_i	$P(S_i)$	$Q(S_i)$	$P(S_i)\cap Q(S_i)$
0	0	0,1,2,3,4,5,6,7,8,9,10,11,12	0
1	0,1,2,5,6,7,8,9,10,11,12	1,2,5,7,8,9 12	1,2,5,7,8,9, 12
2	0,1,2,5,6,7,8,9,10,11,12	1,2,5,7,8,9	1,2,5,7,8,9, 12
3	0,3,10	3,4	3
4	0,3,4,6,10	4	4
5	0,1,2,5,6,7,8,9,10,11,12	1,2,5,7,8,9, 12	1,2,5,7,8,9,12
6	0, 6, 10	1,2,4,5,6,7,8,9,12	6
7	0,1,2,5,6,7,8,9,10,11,12	1,2,5,7,8,9, 12	1,2,5,7,8,9,12
8	0,1,2,5,6,7,8,9,10,11,12	1,2,5,7,8,9, 12	1,2,5,7,8,9,12
9	0,1,2,5,6,7,8,9,10,11,12	1,2,5,7,8,9, 12	1,2,5,7,8,9,12
10	0,10	1,2,3,4,5,6,7,8,9,10,11,12	10
11	0,11	1,2,5,7,8,9, 12	11
12	0,1,2,5,6,7,8,9,10,11,12	1,2,5,7,8,9, 12	1,2,5,7,8,9,12

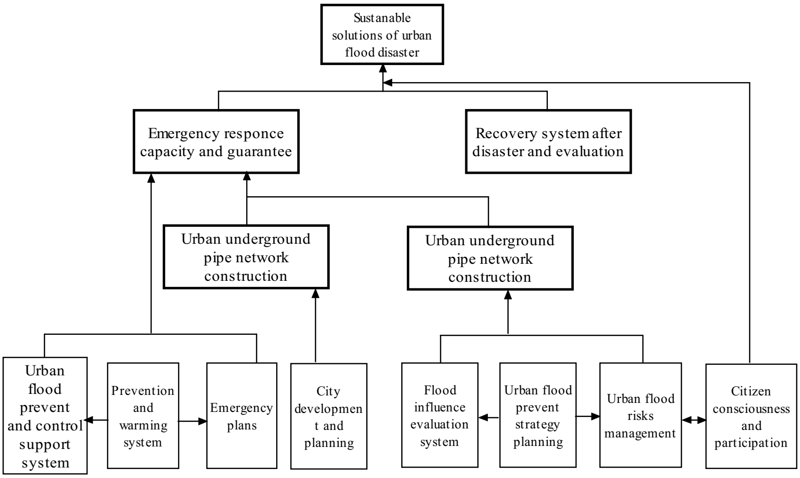


Fig. 16.1 Multi-level structural model of sustainable solution mechanism of urban flood disaster

16.3.5 Model Analysis and Research

From analysis on Fig. 16.1 based on the system analysis view, we can know that the sustainable solution mechanism of urban flood disaster has a multilevel of 4-level structure. It showed that the first-level influence factors conductive to sustainable solution of flood is the emergency response capability and guarantee (S_{10}) and recovery system and assessment after disaster, the second-level influence factors is the urban underground pipe network construction (S_3) and urban flood control project (S_6), the third-level influence factor is the support system of flood control (S_7), prevention and prevention and warning system (S_1), emergency plans (S_2), urban development and planning (S_4), flooding effect assessment system (S_9), strategy planning for urban flood control (S_5), flood risks management (S_9) and citizen awareness and participation (S_{12}). This structure system is the comprehensive thinking and planning of sustainable solution mechanism of solving the urban flood disaster, which reflects the relevance of overall and elements. The visual, vivid and objective level chart could make us master the major contradictions when analysis and solve the flood disaster.

In this system, each factors effect the urban flood disaster solution, and the most basis factors are the prevention and prevention and warning system, emergency plans, urban development and planning, flooding effect assessment system, strategy planning for urban flood control, flood risks management and citizen awareness and participation, although they lay at the fourth-level, they play the significant role in solving the flood disaster. Effective monitoring is beneficial to the implement of support system of urban flood control and other non-engineering measures, rapid prevention and warning system guarantee the emergency plans can executed for the first time, and the urban flood control plan is the special planning for making overall arrangements of various engineering or non-engineering measures for control and decrease the harm of flood disaster on urban, as well as they are parts of the urban overall planning for cities threat by flood [6]. Urban development and planning, especially the reservation of firm ground, green land, wetland and forest which directly affect the smooth urban drainage. In addition, a cooperation mechanism of government, public and market is the effective channel of flood risks management [7]. The citizen's awareness of disaster prevention and participation capacity after disaster, play an important role especially in the urban flood risks management, therefore, it is necessary to enhance the democratic and scientific of decision to reduce the policy conflict. And the urban underground pipe construction especially the drainage system and flood control project play the solid core role in flood disaster prevention, as well as act a significant role for emergency capacity and guarantee. The urban rainstorms directly test the urban drainage system and the flood prevention capacity of flood control project, excellent urban drainage system could resist the heavy rainstorm or flood. And the emergency response capacity and guarantee lay the core position in structure, the rainstorm type of flood disaster mostly solved after the event so that the lower urban resist capacity especially the emergency response capacity and guarantee of the government and relevant units, will directly influence if the flood disaster could be solved effectively or not. And the recovery system and assessment rules after disaster will influence the future strategy plans of urban flood disaster and sustainable solutions. In fact, the sustainable solution mechanism for urban flood disaster is a complete open system, which closely relates to the nature, environment, ecological, society and economy system, so it must be considered over all and arrange scientifically.

16.4 Conclusion

Interpretative Structural Modeling (ISM) lays theoretical foundation for various influence factors build by flood disaster solution mechanism, and we can understand a clear structure through research. To improve the urban flood solving capacity, we not only should pay attention to the emergency response capacity and guarantee, recovery and assessment after disaster, but some influence factors such as urban development, drainage system and risks management should also draw attention to, as well as increase citizen's awareness of flood control and participation ability couldn't be ignored anymore. However, the level structure model build based on the qualitative method analysis didn't reflect the quantification of influence factors, so we need to combine other calculation methods to establish the quantizing assessment of system model to realize the "second development", such as the network analysis, fuzzy mathematics, rough set, neural network and so on.

References

1. Zhang Y, Ren GZ, Xie XM (2007) Water conservancy and national economy. China Water-Power Press, Beijing (In Chinese)
2. Xiang LY (2008) American father of flood management — Gilbert White and human and adjustment to flood. Chinese Flood Control and Drought Resistant 1:55–57 (In Chinese)
3. Qiu JW, Chen H, Liu SK (1998) Shenzhen urbanization and flood disaster. Journal of Natural Disaster 67–73 (In Chinese)
4. Cheng XT, Feng ZY (1994) Urbanization and changes of flood disaster in modern society. Journal of Natural Disaster 3:41–48 (In Chinese)
5. Wang YL (2004) System engineering principles, methods and applications. Higher Education Press, Beijing (In Chinese)
6. Flood Control Law of People's Republic of China (1997) (In Chinese)
7. Hu XH, Wang HM, Ma SJ (2008) Chinese new urban flood risks management methods: Government, market and public cooperation. East China Economic Management 121–125 (In Chinese)

Chapter 17

PHM-based Fault Identification for Electronics-rich Systems under Uncertainty

Lei Xu and Ming Xu

Abstract Electronics are essential to most current systems and equipments especially for electronics-rich systems. Prognostics and health management (PHM) is introduced to cope with the essentiality. Due to the complex structures, numerous parameters as well as various intangible and uncertainty factors, fault diagnosis based on PHM for electronic systems is a highly desirable but also difficult work. There is relatively rare research-concerning applicable and efficient fault identification for electronic systems. This paper proposes a PHM-based diagnostic Bayesian network approach to perform available and efficient fault identification for electronics-rich system. Compare with other methods, it can deal with either single or multiple fault identification with incomplete information and uncertainty. For illustrate purpose, a numerical example is conducted to apply the proposed diagnostics to electronics with uncertain information. The diagnosis results validate that it is accurate in incomplete data conditions even with uncertain fault symptoms. It demonstrates the advantages of the approach to solve the PHM-based fault identification problem for electronics-rich system efficiently.

Keywords Fault identification · Electronics-rich system · Prognostics and health management · Diagnostic Bayesian network · Uncertainty decision making

17.1 Introduction

In recent years, with the fast industrial development and extraordinarily technical competition, system maintenance has been playing an increasing important role in

---

L. Xu (✉)
School of Economics and Trade, Xihua University, Chengdu 610039, P. R. China
e-mail: leihsu@163.com

M. Xu
PE Department, Chengdu University, Chengdu 610106, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_17,

enhancing availability and reducing costs to cope with the high demand for system safety, life cycle cost control, and operational efficiency. Hence, system maintenance including health management has become highly desirable and a very important research field. Besides, most current systems and equipments contain embedded electronics, especially for the electronics-rich systems. Prognostics and health management (PHM) including health monitoring, fault diagnosis, and prognostics is conducted to cope with the essentiality to electronic system. PHM is considered as a system engineering discipline including the processes and technologies used to design, analyze, build, verify, and operate a system to prevent faults, minimize their effects, reduce the life-cycle risk, and avoid unexpected incidents [1, 2].

Meanwhile, fault diagnosis approach containing fault isolation and fault identification has been receiving increasing attention over the last two decades. It is the process of identifying the cause of a failure at various points in a system, so fault identification is the key of diagnostics. PHM-based fault identification helps to proceed with prognostics and avoid incidents, process upsets, performance degradation, major damage to a system or even human health and loss of lives [3]. It is effectively motivated by the demand of improving the reliability and robustness for a system. Current fault diagnosis approaches focus on using model derived from structure and behavior of a system to establish the cause of malfunction. This model-based diagnosis enables more complex inference and achieves more robust diagnosis [4]. In an electronics-rich system, major problems are uncertain, faults may represent either single, multiple or relevant failure forms. Anomalies and faults can be lead to by various factors governed by different failure mechanisms [5]. Modules and subordinate components in an electronics-rich system have inevitable uncertainty that some monitoring sensor data and fault symptoms can be intangible, unobserved, or even missing [6]. Moreover, due to the complex structures, numerous parameters as well as various intangible and uncertainty factors, PHM-based fault identification for electronics-rich systems is a highly desirable but also difficult work [7]. There is relatively rare research-concerning applicable and efficient fault diagnosis for electronic systems. Diagnostic Bayesian network (DBN) proposed by J. Pearl in the 1980s [8] is one of model-based fault diagnosis approaches that often deals with uncertainty and incomplete information [9], and it has been applied as an important diagnostic tool [10–14] for various complex systems. The DBN is a graphical model of uncertain knowledge representation and reasoning based on probability and graph theory. It combines probability theory and graph theory with better representation of uncertainty and better intuitiveness [15]. Under the circumstance that the numbers of external measuring points are decreased in an electronic system, features of faults present more characteristics on uncertainty and incompleteness. This paper proposes a PHM-based DBN diagnostics to perform available and efficient fault diagnosis for electronic system. The remainder of this paper is organized as follows. Sect. 17.2 introduces PHM-based fault identification for electronics-rich system, describes the faults classification and conceptual architecture of PHM-based fault identification. In Sect. 17.3, the proposed DBN diagnostics is discussed in detail and the modeling framework is formalized and presented. An illustrative numerical example is conducted to apply the proposed DBN diagnostics into a set of anomaly electronic modules in Sect. 17.4. The conclusions are finally stated in Sect. 17.5.

17.2 PHM-based Diagnosis for Electronics-rich System

Since electronic systems are becoming increasingly important to provide operational capabilities, PHM as well as PHM-based fault identification for electronics has become highly desirable and critical for the safety, affordability, and performance of electronic system. Table 17.1 shows the standard failure mechanisms in electronic systems.

Table 17.1 Standard failure mechanisms in electronic systems

Failure mechanisms	Failure sites	Relevant loads
Fatigue	Wire-bond/TAB, solder leads, bond pads, traces, vias/PTHs, interfaces	ΔT, Tmean, dT/dt, dwell time, ΔH, ΔV
Corrosion	Metallization	$M, \Delta V, T$
Electro-migration	Metallization	T, J
Conductive filament formation	Between metallization	$M, \nabla V$
Stress-driven diffusion voiding	Metal traces	s, T
Time-dependent dielectric breakdown	Dielectric layers	V, T

where: Δ: Cyclic range; ∇: Gradient; V: Voltage; T: Temperature; M: Moisture; J: Current density; s: Stress; H: Humidity.

Furthermore, under current technical condition, fault diagnosis for electronic system is aimed at the wear-out failures [16] rather than sudden failures. The proposed conceptual architecture of PHM-based fault diagnosis for electronics-rich system based is shown in Fig. 17.1.

Due to the complex structures and some intangible or even missing variables, it is a tough task to perform fault diagnosis for an electronics-rich system on account

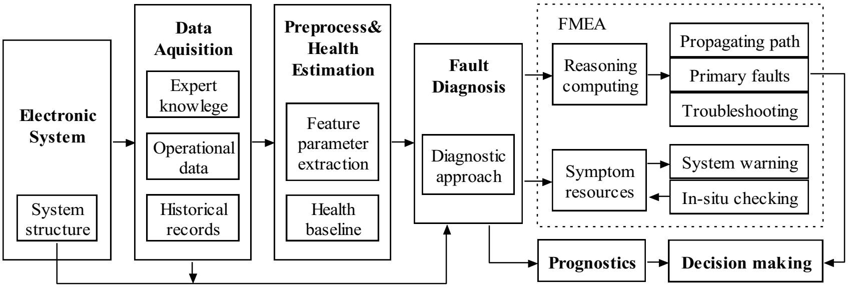


Fig. 17.1 Conceptual architecture of PHM-based fault diagnosis for electronics-rich system

of uncertain environment and limitation of parameters [7]. On the other hand, diagnostic structures can be identified much more available in a certain module-level. The efficient module-level fault diagnosis requires an accurate approach that can handle uncertain information coming with intangible monitoring data and potential unobserved fault symptoms. This paper performs the fault diagnosis for electronic system by conducting DBN that can accurately obtain the diagnostic results, effectively deal with uncertain information by deducing diagnostic reasoning along fault events causalities and probabilistic relations represented in its topological model [9, 17]. It can accept ingoing information for parameter learning. The topological model, parameter learning, and reasoning are the basic problems of DBN [18, 19]. Moreover, the diagnosis results in module-level can be used as the fault diagnostic targets in the component-level. Thus, it can perform fault diagnosis for electronic systems from module-level to component-level by using DBN in a hierarchical way.

17.3 Fault Identification Modeling

17.3.1 Basic Theory

The substance of DBN is applying under-mentioned Bayesian theory in fault causality events. In DBN diagnostics, suppose a countable collection of events $\{B_i, i \in n\}$ represents fault types, another event A represents fault symptoms. The priori fault probability of B_i occurs $= P(B_i)$ and the condition probability of appearing fault symptom A when fault B_i occurs $= P(A|B_i)$ are acquired for each $i \in n$. According to the total probability formula, the priori probability of fault symptom A is expressed as

$$P(A) = \sum_{i=1}^{n} P(B_i) P(A\,|B_i\,). \tag{17.1}$$

Diagnostic reasoning based on the Bayesian formula is performed to calculate the condition probability of occurring fault B_i when fault symptom A appears, it follows that where $i = 1, 2, \cdots, n; j = 1, 2, \cdots, m$. Calculate $P(Bi|Aj)$ through the DBN, the fault diagnosis results can be obtained.

$$P(B_i\,|A_j\,) = \frac{P(A_j B_i)}{P(A_j)} = \frac{P(A_j\,|B_i) P(B_i)}{\sum\limits_{i=1}^{n} P(B_i) P(A_j\,|B_i\,)}. \tag{17.2}$$

17.3.2 Modeling Procedure

Underlying regularities are found out from the learning knowledge base consists of known fault types, operational data, and historical records. Then according to those extracting information to perform fault diagnosis based on the DBN. The framework of PHM-based DBN diagnostics modeling for electronic system is shown in Fig. 17.2. The modeling procedure is represented as following steps.

Step 1. Definition of fault types and symptoms sample set. Various fault types of the diagnosed system are defined according to the abnormal data and historical records. Suppose $F_i = F_1, F_2, \cdots, F_m$ is the fault types set, $1 \le i \le m$. Suppose $S_j = S_1, S_2, \cdots, S_n$ is the fault symptoms sample set, $1 \le j \le n$. Moreover, monitoring data either voltage or current signals are all continuous. To meet the demand of DBN for processing discrete variables, monitoring data of each fault types are discretized and the fault symptoms sample set is constituted.

Step 2. Identification of the diagnostic structure. Build the topology of the DBN by the system's fault tree [20] which comes from the system manual, expert knowledge, and structure learning. The diagnostic structure is a directed acyclic graph which shows the cause-result relationships between fault types and fault symptoms. The nodes in the diagnostic structure represent the system's events or variables. The directed arcs among the variables symbolize the direct causalities or dependencies. Each node has a probability and the priori probabilities of root nodes are learned and obtained.

Step 3. Constitution of learning fault sample set. Constitute the fault sample set according to the fault types and symptoms sample set. Due to some monitoring data can be intangible or missing in an electronic system, incomplete data condition is considered. The more of learning samples, the more rational the obtained conditional probabilities will be [21]. In the incomplete data condition, expectation maximization (EM) algorithm [22] is utilized to obtain priori probabilities of

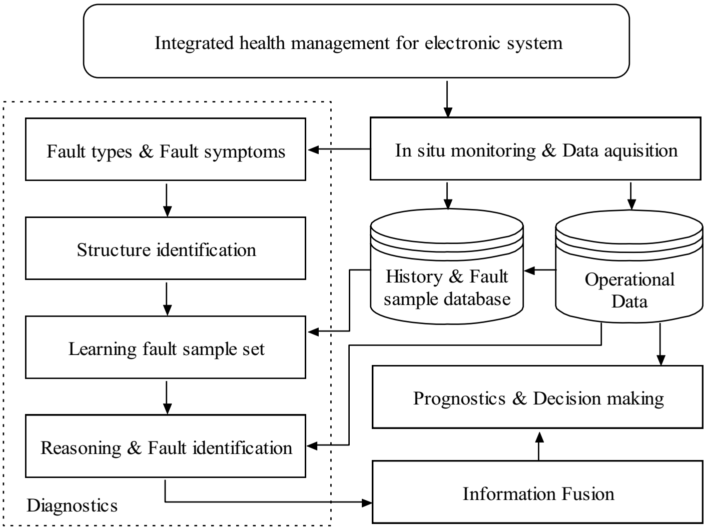


Fig. 17.2 The framework of PHM-based DBN diagnostics modeling

each fault symptom. EM algorithm is the adaptive learning algorithm for calculating the maximum likelihood of a fixed network in uncertain conditions with intangible variables or missing values. The learning is aimed at making the DBN express the knowledge contained in the monitoring data. Then the priori conditional probabilities $P(S_j|F_i)(1 \le i \le m, 1 \le j \le n)$ of each fault symptom nodes in the DBN are learned and obtained.

Step 4. Reasoning and fault diagnosis. Acquire observation symptoms from the current operating data and discretize the current operating data to obtain a diagnostic sample. Diagnostic reasoning based on the diagnostic sample is carried out to obtain the probabilities $P(F_i|S_j)(1 \le i \le m, 1 \le j \le n)$ through the DBN. The fault types corresponding to the maximum probability values are the diagnosis results. The diagnosis results then can be used to proceed with further component-level diagnosis by using the DBN, as well as subsequent PHM-based prognostics.

17.4 A Numerical Example

For illustrative purpose, a numerical example is conducted. According to the PHM architecture, after data acquisition and health estimation, a set of anomaly radar indicators (consist four same pictorial indicators) on avionics system are selected to apply the proposed DBN diagnostics. Get priori parameters of each node, use learning samples to complete parameter learning of the DBN. With the acquired symptoms, according to the DBN diagnostic reasoning we can detect the fault type with the maximal probability max $P(F_i|S_j)$, $1 \le i \le m$, $1 \le j \le n$. The steps together with the diagnosis results are explained as follows.

Step 1. Use equal-width-intervals method to discretize the monitoring data and set as follows: classify the conditions of monitoring data as normal and deviation. According to historical records, given a normal data value v. Monitoring data deviation that is in the $[-5\%, 5\%]$ range of v is regarded as normal and its discretized value is 0, in the range of $[-15\%, -5\%) \cup (5\%, 15\%]$ is deviated and its discretized value is 1. The rest ranges are regarded as damaged. Table 17.2 shows the fault types and symptoms of the diagnosed radar indicators.

Step 2. Suppose the fault types are independent to each other as well as the symptoms nodes are independent to each other. The DBN model [20] of the diagnosed indicator is built and shown in Fig. 17.3.

Step 3. In incomplete data condition, discretize 5000 sets of incomplete historical test data. Suppose the number of iterations is 10, utilize EM algorithm for parameter learning of the DBN. The priori probabilities of each fault symptom nodes are learned and obtained as: $P(S_1) = 0.0072$, $P(S_2) = 0.0051$, $P(S_3) = 0.0043$, $P(S_4) = 0.0032$, $P(S_5) = 0.0029$, $P(S_6) = 0.0020$, and $P(S_7) = 0.0053$. The priori probabilities of each fault types are obtained as: $P(F_1) = 0.0083$, $P(F_2) = 0.0046$, $P(F_3) = 0.0065$. Conditional probabilities $P(S_j = 1|F_i = 1)$ in incomplete data condition are obtained and given in Table 17.3.

Table 17.2 The fault types, symptoms and status values of the radar indicators

	Node events	Symbols	Status values
Top event	Anomaly display on the radar	T	normal (0), anomaly (1)
Fault types	Video circuit fault	F_1	normal (0), fault (1)
	Intermediate frequency circuit fault	F_2	normal (0), fault (1)
	Receiver font-end fault	F_3	normal (0), fault (1)
Fault symptoms	Video amplifier voltage deviation	S_1	normal (0), deviation (1)
	Support power circuit current deviation	S_2	
	Intermediate frequency amplifier voltage deviation	S_3	
	Detection circuit current deviation	S_4	
	High frequency amplifier voltage deviation	S_5	
	Mixer power deviation	S_6	
	Local oscillator frequency deviation	S_7	

Table 17.3 Conditional probabilities of symptom nodes in incomplete data condition

$P(S_j = 1 \mid F_i = 1)$	F_1	F_2	F_3
$P(S_1 = 1 \mid F_i = 1)$	0.7567	0.0072	0.0072
$P(S_2 = 1 \mid F_i = 1)$	0.7545	0.0051	0.0051
$P(S_3 = 1 \mid F_i = 1)$	0.0043	0.7364	0.0043
$P(S_4 = 1 \mid F_i = 1)$	0.0032	0.7346	0.0032
$P(S_5 = 1 \mid F_i = 1)$	0.0029	0.0029	0.6371
$P(S_6 = 1 \mid F_i = 1)$	0.0020	0.0020	0.6368
$P(S_7 = 1 \mid F_i = 1)$	0.0053	0.0053	0.6375

Step 4. Acquire observation symptoms of the four diagnosed radar indicators through current operating data, then it can obtain the diagnostic sample represented as $d_k (1 \leq k \leq 4)$, respectively. For diagnostic reasoning, according to the Bayesian formula and the DBN model shown in Fig. 17.3, Equation (17.2) can be rewritten as

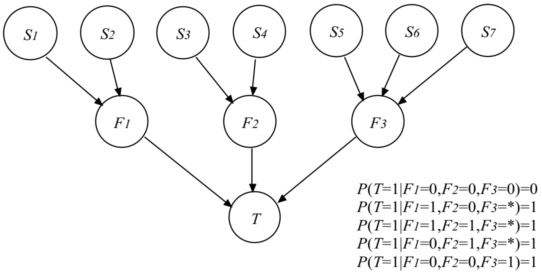


Fig. 17.3 The DBN model of the pictorial indicators

$$P(F_i|S_j) = \frac{P(S_jF_i)}{P(S_j)} = \frac{P(S_j|F_i)P(F_i)}{\sum_{i=1}^{3} P(F_i)P(S_j|F_i)}, \tag{17.3}$$

where $(1 \leq j \leq 7)$, $P(F_i|S_j)$ exceeding 0.5 is diagnosed as fault. According to the DBN diagnostic reasoning based on the diagnostic sample and conditional probabilities $P(S_j|F_i = 1)$, probabilities of the diagnostic sample are reasoned out and the diagnosis results are obtained from the exceeded probabilities. One diagnosed indicator's observation symptom is uncertain, thus, we consider the other three diagnosed indicators in the incomplete data condition.

For the incomplete data condition, the three previous diagnostic samples remain the same. Discretize the fourth observation symptoms as d_4: S_6 uncertain, others = 0. The diagnosis results are obtained according to the diagnostic reasoning from Equation (17.3). Table 17.4 shows the probabilities of the diagnostic sample and the diagnosis results.

Table 17.4 Probabilities of the diagnostic sample in incomplete data condition

Diagnostic sample	F_1	F_2	F_3	Results	Fault facts
$d_1 : S_2 = 1$	0.9910	0.0046	0.0065	$r_1 : F_1 = 1$	$f_1 : F_1 = 1$
$d_2 : S_3 = 1$	0.0083	0.9816	0.0065	$r_2 : F_2 = 1$	$f_2 : F_2 = 1$
$d_3 : S_1 = 1, S_7 = 1$	0.9874	0.0046	0.9838	$r_3 : F_1 = 1, F_3 = 1$	$f_3 : F_1 = 1, F_3 = 1$
$d_4 : S_6$ uncertain	0.4278	0.2255	0.3186	r_4 : fault-free	f_4 : fault-free

In the incomplete data condition, the fault facts are verified as $f_1 : F_1 = 1, F_2 = 0, F_3 = 0.f_2 : F_1 = 0, F_2 = 1, F_3 = 0.f_3 : F_1 = 1, F_2 = 0, F_3 = 1.f_4$: fault-free. As Table 17.4 shows, the diagnosis results are $r_1 : F_1 = 1, F_2 = 0, F_3 = 0.r_2 : F_1 = 0, F_2 = 1, F_3 = 0.r_3 : F_1 = 1, F_2 = 0, F_3 = 1.r_4$: fault-free. Compare with the fault facts, the diagnosis results of DBN are still accurate even with uncertain fault symptom in incomplete data condition. It validates that the DBN has great superiority in dealing with uncertainty and incomplete information with good accuracy. The modules in the diagnosis results then can be used to proceed with further component-level diagnosis and subsequent PHM-based prognostics.

17.5 Conclusion

In this paper, DBN diagnostics based on PHM is proposed to perform available and efficient fault diagnosis for electronic system. PHM-based DBN as well as its diagnostics modeling are presented. Compare to other approaches, the DBN can deal with either single or multiple fault diagnosis even with incomplete information and uncertain fault symptoms. For illustrate purpose, a numerical example is conducted to apply the proposed DBN diagnostics to a set of radar indicators on avionics system considering incomplete data condition with uncertain fault symptoms. EM algorithm is utilized to constitute the learning sample set in incomplete data condition. Corresponding probabilities of event nodes are obtained by the parameter learning, with which is associated diagnostic reasoning and sample of current fault symptoms to perform fault diagnosis. It demonstrated the advantages of the DBN diagnostics to the fault diagnosis for electronic systems with uncertainty and incomplete information. Furthermore, based on the PHM-based DBN diagnostics, it can perform fault diagnosis for electronic systems from module-level to component-level in a hierarchical way. In future work, we shall pay more attention to researches under unknown systematic structure circumstances as well as fusion diagnosis to reduce uncertainty and improve accuracy rate.

References

1. Johnson S (2005) Introduction to system health engineering and management in aerospace. In: Proceedings of the 1st Integrated Systems Health Engineering and Management Forum
2. MacConnell JH (2007) ISHM & eesign: A review of the benefits of the ideal ISHM system. In: Proceedings of IEEE Aerospace Conference 1–18
3. Nan C, Khan F, Iqbal MT (2008) Real-time fault diagnosis using knowledge-based expert system. Process Safety and Environmental Protection 86:55–71
4. Chen J, Patton RJ (1999) Robust model-based fault diagnosis for dynamic systems. Kluwer Academic Publishers, Boston
5. Xu JP, Xu L (2012) Integrated system health management-based condition assessment for manned spacecraft avionics. In: Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering
6. Kane M, Savakis A (2004) Bayesian network structure learning and inference in indoor vs. outdoor image classification. In: Proceedings of 17th International Conference on Pattern Recognition, Cambridge 479–482
7. Verma V, Gordon G, Simmons R et al (2004) Real-time fault diagnosis robot fault diagnosis. IEEE Robotics & Automation 11:56–66
8. Pearl J (1988) Probabilistic reasoning in intelligent systems: Networks of plausible inference. Morgan Kaufmann, San Mateo
9. Loa CH, Wong YK, Rad AB (2011) Bond graph based Bayesian network for fault diagnosis. Applied Soft Computing 11:1208–1212
10. Dey S, Stori JA (2005) A Bayesian network approach to root cause diagnosis of process variations. International Journal of Machine Tools & Manufacture 45:75–91
11. Barua A, Khorasani K (2011) Hierarchical fault diagnosis and fuzzy rule-based reasoning for satellites formation flight. IEEE Transactions on Aerospace and Electronic Systems 47:2435–2456
12. Xu L, Wang H, Long B (2009) Study on fault diagnosis of electronic system using Bayesian network. Computer Engineering and Applications 45:194–197
13. Zhu YL, Limin H, Lu JL (2006) Bayesian networks-based approach for power systems fault diagnosis. IEEE Transactions on Power Delivery 21:634–639
14. Lerner U, Parr R, Koller D et al (2000) Bayesian fault detection and diagnosis in dynamic systems. In: Proceedings of the Seventeenth National Conference on Artificial Intelligence 531–537
15. Ramirez VJC, Piqueras AS (2006) Learning Bayesian networks for systems diagnosis. In: Proceedings od Electronics, Robotics and Automotive Mechanics Conference 125–130
16. Xu JP, Xu L (2011) Health management based on fusion prognostics for avionics system. Journal of Systems Engineering and Electronics 22:428–436

17. Sheppard JW, Kaufman MA (2005) A Bayesian approach to diagnosis and prognosis using built-in test. IEEE Transactions on Instrumentation and Measurement 54:1003–1018
18. Weber P, Medina-Oliva G, Simon C et al (2010) Overview on Bayesian networks applications for dependability, risk analysis and maintenance areas. Engineering Applications of Artificial Intelligence, Doi: 10.1016/j.engappai.2010.06.002.CrossRef
19. Sahin F. Yavuz M, Arnavut Z et al (2007) Fault diagnosis for airplane engines using Bayesian networks and distributed particle swarm optimization. Parallel Computing 33:124–143
20. Bobbio A, Portinale L, Minichino M et al (2001) Improving the analysis of dependable systems by mapping fault trees into Bayesian networks. Reliability Engineering and System Safety 71:249–260
21. Boudali H, Dugan J (2005) A discrete-time Bayesian network reliability modeling and analysis framework. Reliability Engineering & System Safety 87:337–349
22. Friedman N (1997) Learning belief networks in the presence of missing values and hidden variables. In: Proceedings of 14th International Conference on Machine Learning 125–133
23. Dechter R (1999) Bucket elimination: A unifying framework for reasoning. Artificial Intelligence 113:41–85

Chapter 18
The Evaluation Index System for Enterprise IT Service Quality

Zhiliang Liu, Jinlong Zhang and Lingfei Zou

Abstract with the integration of IT and business, IT service quality becomes more and more important. This research on the basis of the situation of the development of enterprise IT management, after systematically analyzed the research of service and IT service quality, develops the index system for IT service quality evaluation. The system is composed of 6 dimensions, which contains 16 indicators of level 2 and 28 indicators of level 3. Use the Delphi and AHP method to determine the index weights. And then apply the index system in the Foshan Power Supply Bureau of Guangdong Power Grid to validate the index system.

Keywords IT service · Service quality · Evaluation index system

18.1 Introduction

With the accelerating of globalization and the intensifying of the market competition, the integration of information technology (IT) and business become closer and closer. The role of IT in the enterprise has been gradually changing. IT in the enterprise is seen as a service, which to support all the business activities and process in the enterprise [1]. IT plays a very important role in the enterprises, it helps enterprises to carry out their business effectively and efficiently, cope with rapid market changes flexibly and rapidly, and improve their competitiveness. Therefore ensure the IT service quality is very important for modern enterprise.

As IT service quality is so important for enterprise, more and more researchers and practitioners take focus on this research area. This research studies the evaluation of enterprise IT service quality. After related literature review and practical work, we establish the evaluation index system for IT service quality. The system is

---

Zhiliang Liu (✉) · J. Zhang · Lingfei Zou
School of Management, Huazhong University of Science and Technology, Wuhan 430074, P. R. China
e-mail: zeallion@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_18,

composed of 6 dimensions, which contains 16 indicators of level 2 and 28 indicators of level 3. And then use the Delphi and AHP method to determine the index weights. Finally, apply the index system in the Foshan Power Supply Bureau of Guangdong Power Grid to validate the index system.

18.2 Related Research

18.2.1 Service Quality and Service Quality Model

The term service quality comes from the traditional product quality. In the early time, service quality was a part of product quality. With the development of service industry, service quality draws more and more researcher‘ attention, separating from product quality, and becomes an independent term. Unlike product quality, which can be measured objectively by such indicators as durability and number of defects, service quality is an abstract and elusive construct because of three features unique to services: intangibility, heterogeneity, and inseparability of production and consumption [2]. As a result, the traditional concept and method of goods cannot apply to service quality. Many researchers make great efforts to carry out the service quality research and get a great achievement: with referring to all service quality definitions, it is a common sense to consider customer perception. As the pioneer Gronroos firstly proposed that the service quality is a kind of customer perception. In his research, the service quality is defined as "perceived by the customer as being the difference between customer expectations and their experience of the services" [3]. Similarly, Parasuraman et al [2] regarded the service quality as the gap between expected and perceived of the services. They indicated "service quality is the result of differences between expectations and the actual performance of the service". In Bitner and Hubbert's research, they defined the service quality as "an overall impression of advantages or disadvantages of organization and its services on consumers" [4].

18.2.2 IT Service Quality

Quality is always the focus in the IT area. In the past researchers and practitioners have made great effort on the research of quality about software or hardware. But most of the quality researches take the 'product' as the object rather than 'service'. With the development of information technology, IT gradually shifts from 'product' to 'service'. On the one hand, with new technology, as cloud computing, SOA and so on sharing infrastructure, connecting huge system pool can easily provide a variety of IT services, which raise its further application to a new level, and make it possible to take the infrastructure, storage, software and applications of IT in the form of services to provide to the user. On the another hand, The embedded technology, such as ios, android, makes IT platform generalization from the PC to other electronic equipment like mobile phones, home appliances, automobiles etc. At the same time, the popularity of wireless communication technology will bring a new trend for other new services. Therefore, the research of IT service quality is significance both to theory and practice.

In the past, researchers mainly use the SERVQUAL model or the modified SERVQUAL model to evaluate IT service quality. Pitt et al [4] applied SERVQUAL model in the IS field, indicated that SERVQUAL model is effective for the evaluation of the IS services quality. Kettinger et al [6] regarded service quality is a measure of information system effectiveness in 1995, and then took empirical research to explain that SERVQUAL cannot completely apply to IS quality in 1997 [7]. Van Dyke et al [8] indicated that SERVQUAL suffer from a number of conceptual and empirical difficulties in the IS context in 1997. In 1999, Kettinger et al [9] proposed a modified SERVQUAL model to evaluate the quality of IS services. Recently, the related researches mainly focus on an IT services, such as web services, e-commerce services, email services. The past research evaluate the IT service quality mostly use a subjective questionnaire, lack of objective evaluation index system, this article will solve this problem.

18.3 The Index System

18.3.1 Research Progress

SERVQUAL has been widely accepted as an effective tool for the evaluation of IT service quality, so the index system is still on the basis of SERVQUAL. We take tangibles, response, reliability, assurance and empty which from SERVQUAL as the dimension of the index system, then optimize it and design the indicators of level 2 and level 3 through interviews and surveys. The interviews include both IT services provider personal depth interviews and IT services customs grouped interviews.

We selected 11 managers from IT service provider to participate in our personal depth interviews. They come from different department of the IT service enterprise (e.g., marketing department, customer service department, and service design department.). In the interviews, the managers in accordance with their respective IT services work were asked to answer the following questions as much detail as possible: (1) what is the IT service quality perceived by their IT service customers they think? (2) What factors are affecting the IT service quality? (3) What measures do they have taken to deliver high quality IT services? We have kept the record of the depth interviews in order to ensure the reliability of the research.

104 IT service customers have taken in our research. According to the type of the IT service they used, we divided them into 5 groups, and organized interview in groups. The 5 types of IT service are IT consulting service, IT design and devel-

opment service, IT integration service, data processing and operation service, and new IT service such as cloud computing. Each group is asked to answer the following questions as much detail as possible: (1) what is the IT service quality their perceived? (2) What factors are affecting the IT service quality in their view? (3) What measures do they wish the IT service provider to take to improve IT services quality? We also have kept the record of the group interviews in order to ensure the reliability of the research.

After finished the interviews, we encoded the interview content by repeated reading the interview record, and then analyzed the code, finally, establish an evaluation index system. The system is composed of 6 dimensions, which contains 16 indicators of level 2 and 28 indicators of level 3.

18.3.2 The Evaluation Index System

The index system consists of five dimensions: security, reliability, responsiveness, tangibles and empathy, which is similar to SERVQUAL model. Only the assurance in SERVQUAL model has been replaced by the security. The security dimension has 3 sub dimensions which are availability, integrity and confidentiality; the reliability dimensions has 5 sub dimensions which are availability, integrity and confidentiality; the responsiveness has 2 sub dimensions which are timeliness and interactivity; the tangibles has 2 sub dimensions which are visibility and profession; the empathy has 3 sub dimensions which are flexibility, proactivity, and courtesy. The specific index system is shown in Table 18.1.

18.3.3 The Design of the Index Weights

In this study, we use Delphi method and AHP method to determine its weights.

First of all, we use Delphi method to investigate the importance of IT service quality indicators. A total of 48 IT experts have joined this investigation. These experts come from IT services companies, IT departments of large enterprises and universities.

And then, we mapped the importance of the indicators measured through the Delphi survey to the 1-7 scale respectively, and built the judgment matrix, we test the judgment matrix consistency in order to ensure the reasonableness of calculated results.

Then, we calculated the largest eigenvalue and corresponding eigenvectors of each judgment matrix, and normalized it to get the final weights, as shown in Table 18.2.

Because there are differences between the different IT services, this study has not set the weights of level 3 indicators.

Table 18.1 The index system

Dimension	Level 2	Level 3
C_1 Security	C_{11} Availability	The audit of information availability
	C_{12} Integrity	The percentage of the terminal joined the AD domain The percentage of the terminal installed desktop management system The percentage of the terminal installed network access monitor
	C_{13} Confidentiality	The audit of information confidentiality The percentage of the terminal installed anti-virus software The percentage of the terminal installed security patch
C_2 Reliability	C_{21} Completeness	The coverage of the IT in the enterprise
	C_{22} Stability	The variance of the percentage of incident resolved The variance of the percentage of response in time The variance of the percentage of call loss
	C_{23} Stability	The percentage of incident resolved in time by service desk The percentage of incident resolved in time by second line The percentage of incident resolved in time by third line The percentage of incident resolved in time by outside service provider
	C_{24} Continuity	MTTR(Mean time to repair downtime)
	C_{25} Traceability	The percentage of documents recorded
C_3 Responses	C_{31} Timeliness	The percentage of response in time
	C_{32} Interactive	The percentage of call loss The percentage of service complaints resolved Interactive platform
C_4 Tangibles	C_{41} Visibility	The audit of visibility by service blueprint
	C_{42} Professional Tangibles	The time of upgrade of hardware The audit of IT human resource
	C_{43} Compliance	The form quality of application
C_5 Empathy	C_{51} Flexibility	The percentage of customer's requirement solved
	C_{52} Proactive	The number of IT train
	C_{53} Courtesy	The audit of courtesy by service blueprint

18.4 The Application

In this research, we apply the evaluation system to the IT center of Foshan Power Supply Bureau of Guangdong Power Grid as a case study to validate it. First of all, we design the weights of level 3 on the basis the specific application, and then, we develop an automatic evaluation system according to the evaluation index system to help evaluate the IT service quality of Foshan Power Supply Bureau. The case study

Table 18.2 The weights of the index system

No.	Dimension	Weights	Level 2	Weights
1	Security	0.1748	Availability	0.0583
2			Integrity	0.0583
3			Confidentiality	0.0583
4	Reliability	0.3450	Completeness	0.0826
5			Stability	0.0826
6			Effectiveness	0.0554
7			Continuity	0.0733
8			Traceability	0.0511
9	Responses	0.2505	Timeliness	0.1728
10			Interactivity	0.0777
11	Tangibles	0.1172	Visibility	0.0393
12			Profession	0.0230
13			Compliance	0.0490
14	Empathy	0.1126	Flexibility	0.0375
15			Proactivity	0.0375
16			Courtesy	0.0375

Fig. 18.1 The screenshot from evaluation system

starts from September 2011. The monitoring data observed by the evaluation system indicate that the evaluation index system can objectively evaluate the IT center IT services quality, and help it to improve the service quality.

18.5 Conclusion and Future Research

This research designs an evaluation index system for the enterprise IT services quality, provides an objective method to evaluate the enterprise IT service quality, it can help enterprises to improve their IT service quality, subsequently improving the effective means of user satisfaction.

However, this is only the beginning of the research,. In the further research, we will evaluate IT services quality on the concern of business and IT service life cycle.

References

1. Zarnekow R, Brenner W, Pilgram U (2006) Integrated information management: Applying successful industrial concepts in IT. Springer, Berlin
2. Parasuraman A, Zeithaml VA, Berry LL (1985) A conceptual model of service quality and its implications for future research. Journal of Marketing 49:41–50
3. Gronoroos C (1984) A service quality model and its maketing implications. European Journal of Marketing 18:36–44
4. Bitner MJ, Hubbert AR (1994) Encounter satisfaction versus overall satisfaction versus quality service quality: New directions in theory and practice. Sage Publications, Thousand Oaks
5. Kettinger WJ, Lee CC, Lee S (1995) Global measures of information service quality: A cross-national study. Decision Sciences 26:569–588
6. Pitt LF, Watson RT, Kavan CB (1995) Service quality: A measure of information systems effectiveness. MIS Quarterly 19:173–187
7. Pitt LF, Watson RT, Kavan CB (1997) Measuring information systems service quality: Concerns for a complete canvas. MIS Quarterly 21:209–221
8. Van Dyke TP, KappeIman LA, Prybutok VR (1997) Measuring information systems quality: Concerns on the use of the SERVQUAL questionnaire. MIS Quarterly 21:195–208
9. Kettinger WJ, Lee CC (1999) Replication of measures in information systems research: The case of IS SERVQUAL. Decision Sciences 30:893–899

Chapter 19
Comparative Study of Market Inefficiency on the Sino-U.S. Stock Markets

Ronghua Yi and Yangbin Zhang

Abstract In this paper, we consider an autocorrelation of stock returns as a good proxy of degree of market inefficiency when we deal with the EMH in the weak sense. We check a time varying structure of autocorrelations of stock returns data based on the Moving Window method and estimate the time varying AR(1) coefficients by using a state space model. We use the monthly returns for the Shanghai A-share Index, B-Share index and S&P500 stock Index from 1992 to early 2012 as a sample. The result shows: the degree of market inefficiency varies through time; on the degree of market inefficiency, the Chinese stock market is greater than the U.S. stock market, A-share market is greater than the B-share market, and the market inefficiency between B-share market and the U.S. market has some linkage. Finally, we calculate the numerical measurement of relative market inefficiency on the Sino-U.S. Stock Markets.

Keywords Efficient market hypothesis · Market inefficiencies · Sino-U.S. stock markets · Time-varying AR model · State space model

19.1 Introduction

Since the concept of fair game has been introduced to financial economics by Samuelson [1], many scholars were supporting the Efficient Market Hypothesis (EMH), but a lot of abnormal phenomena from behavioral finance were reported, so the EMH is still in controversy. The battle about EMH among scholars is still going on, and we believe that it will never end. Neither side can convince the others to accept their points of in built view in this battle. Campbell et al [2] pointed out any effort to verify the EMH by the classical hypothesis testing is in vain and that it

---

R. Yi · Y. Zhang (✉)
College of Economics and Management, China Jiliang University, Hangzhou 310018, P. R. China
e-mail: yimar@qq.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_19,

is productive to establish a measure of relative market inefficiency. In recent years, some scholars try to explore a measure of relative market efficiency from different perspectives. Lo [3] measured the autocorrelation of the stock returns as a degree of market inefficiency, the time-varying structure of which was also examined. Cajueiro and Tabak [4] proposed a useful framework to assess the relative efficiency of the markets, by comparing the total time period, when it has deviated from the efficient market status in the sample period. In this method, scrolling sample method is used to calculate the median of Hurst index, according to which the efficiency of stock markets can be ranked. Ma [5] proposed a method to test relative efficiency of market through the correlations of daily return series, in which a comparative analysis between correlation coefficient of Lag one serial and the percentage of rejected in other studies is used to assess the relative efficiency of the markets. Basing on DEA model, Yi and Da [6] developed a model of measuring market efficiency and non-parameters method testing market efficiency, which not only present apparent measurement about market efficiency, but also offer evidence for investment decision making. Lim et al [7] proposed the use of nonlinear correlation statistical method to assess relative efficiency of stock market, using a double correlation test statistic (H-statistic) to verify the existence of Non-zero BI-related, actually it is a autocorrelation Coefficient between the current rate of return and early. Evans [8] tested for market efficiency of three UK financial futures contracts, and examined the impact of the introduction of electronic trading system on their market efficiency. The analysis is based on the notion of weak-form informational efficiency of the Efficient Market Hypothesis (EMH). Lim [9] calculated H-statistic of each framework in the rolling sample with a fixed length, H-statistic in each period reflects the process of behavior change because of new information or other relevant factors lead to. Hence, H-statistic is not only able to capture the evolution of market efficiency changes over time, but also provides an indicator for stock market efficiency rank. Giglio et al [10] explained the market efficiency with algorithmic complexity theory, with calculations of Lempel-Ziv complexity indicators, Efficiency rating can be ranked based on the relative information quantity which were not be effectively used for converting into securities prices. Ito and Sugiyama [11] estimated a time varying autocorrelation of stock returns as a degree of market inefficiency; the relative inefficiency of the U.S. stock market varies from 1955 to 2006. Giglio et al [12], by using of high frequency data, explained the relative efficiency of the assessment of the stock with algorithmic complexity theory, and made some sensitivity analysis on the Lempel-Ziv index relatively stable area, window size, and margin size. Wang et al [13] analyzed market efficiency for the Shanghai stock market over time using a model-free method known as multi-fractal detrended fluctuation analysis. Through analyzing the change of scale behavior, he found that the price-limited reform improved the efficiency in the long term, but the influence in the short term was very minor. Employing the method of moving window, using three different measures he found that the Shanghai stock market became more and more efficient after the reform. Shive [14] examined the effect of locally informed investors on market efficiency and stock prices using large power outages, which are exogenous events that constrain trading. The evidence suggests that informed investors contribute disproportionately to both liquidity and price discovery, and that these contributions are reflected in valuations and expected returns. Jarrow and Larsson [15] provided a new approach for testing market efficiency that avoid some limitation. He defined a model in which market efficiency can be empirically tested. This definition says that a market (F,S) is efficient with respect to F if there exists an economy whose equilibrium price process is consistent with S. In summary, all the mentioned methods which were proposed to measure the relative efficiency of the markets have advantages and disadvantages. In contrast, the one developed by Ito and Sugiyama [11] can use the time series data from market to complete measuring the degree of time varying market inefficiency, and has more solid theoretical basis. So in this paper, we will try to use the method to study market inefficiency on the Sino-U.S. Stock Markets.

19.2 Methods and Models

We focus on the EMH in the weak form in financial markets; it implies one can never predict returns of an asset by analyzing past data. Inefficiency can be interpreted as implying existence of exploitable opportunities. While some degree of serial correlation implies the predictability, it may not imply inefficiency if the predictability is insufficient to overcome transaction costs. Hence, in case of monthly observations, we consider an autocorrelation of stock returns as a good proxy of market inefficiency when we focus on the EMH in the weak form. Our task is to measure the autocorrelation of the stock returns in each period as a degree of market inefficiency, supposed to be time varying.

Therefore, our first step is to check a time varying structure of autocorrelations of stock return data based on the Moving Window method; second, we will estimate the time varying AR(1) coefficients by using a state space model; furthermore, with the sequence of time varying AR(1) coefficients, we can establish a method of measuring the degree of time varying market inefficiency, by which the degree of market inefficiency in different markets can be compared.

19.2.1 Calculations of First Order Autocorrelations

Let $(x_1,\cdots,x_T)$ be a sequence of the stock returns. When using the Moving Window method, one makes $T-w+1$ sub samples $(x_{t-w+1},\cdots,x_t)$ for $t=w,\cdots,T$ with sub sample size w, called a window width, and then derives the first order autocorrelation to each sub sample. The following statistics will be used:

$$r_k = \frac{\sum\limits_{t=1}^{n-k}(x_t - \bar{x})(x_{t+k} - \bar{x})}{\sum\limits_{t=1}^{n}(x_t - \bar{x})^2}, \; k = 1, 2, \cdots. \tag{19.1}$$

Calculation of $K = 1$, obtaining time varying first order autocorrelation coefficient sequence. Further, checking the existence of a unit root via the Augmented Dickey Fuller (ADF) test, so we can make sure whether the AR coefficients in a time varying AR model follow a random walk process.

19.2.2 Estimations of Time Varying AR Coefficients

Although first order autocorrelation coefficient can measure the correlation of the sequence to a certain extent, it still contains some "noise". Because the first order autocorrelation coefficient is only an empirical analysis on stock return series. It is necessary to seek a more effective filtering and smoothing algorithms to filter out "noise". The simplest method to measure the autocorrelations of stock returns is to apply the AR model to the stock returns data, since the Yule-Walker equation assures sample autocorrelation functions correspond to coefficients of the AR model with each other uniquely. Therefore, Ito and Sugiyama [11] proposed to use a time varying AR model, which its time varying AR coefficient can be estimated, and regards the time varying AR coefficient sequences as a proxy of market Inefficiencies.

Time varying AR model: $x_t = \sum_{i=1} k\beta_{i,t}x_{t-i} + \mu_t$. We here show a state space model representation of the time varying AR model, which allows AR coefficients to vary through time. Actually, the time varying AR model is a specific case of the state space representation of a dynamical system that is composed of an observation equation and a transition equation. The state variables in the model represent the coefficients in the AR model. State matrix in the transition equation is estimated by the ADF test above, that the AR coefficients in a time varying AR model follow a random walk process. This assumption makes our state space model so simple as shown in Equations (19.2) and (19.3).

Observation equation:

$$x_t = (x_{t-1}\; x_{t-2}\; \cdots\; x_{t-k})\left(\beta_{1,t}, \beta_{2,t}, \cdots, \beta_{k,t}\right)^T + u_t \;,\; u_t \sim N(0, \sigma_{u_t}^2). \tag{19.2}$$

Transition equation:

$$\begin{pmatrix} \beta_{1,t} \\ \beta_{2,t} \\ \vdots \\ \beta_{k,t} \end{pmatrix} = \begin{pmatrix} 1\,0 \cdots 0 \\ 0\,1 \cdots 0 \\ \vdots\,\vdots \ddots \vdots \\ 0\,0 \cdots 1 \end{pmatrix} \begin{pmatrix} \beta_{1,t-1} \\ \beta_{2,t-1} \\ \vdots \\ \beta_{k,t-1} \end{pmatrix} + \begin{pmatrix} v_{1,t} \\ v_{2,t} \\ \vdots \\ v_{k,t} \end{pmatrix}, \; v_t \sim N_k(0, \sigma_{v_t}^2 I), \tag{19.3}$$

$$v_t = (v_{1,t}, v_{2,t}, \cdots, v_{k,t}). \tag{19.4}$$

In practice, we use a new calculation technique to realize Kalman smoothing developed by Ito, in which combined with the observation equation and transition equation. Regarding the state variables as estimated parameters, and ultimately to use the least squares algorithm to estimate the state variables in the regression model. Note that Ito's new calculation technique leads to exactly the same estimation result as the traditional Kalman smoothing. It merely cuts down calculation time by doing vast amounts of calculation at a time.

19.3 Empirical Analysis

19.3.1 Sample Selection

This paper uses the monthly returns for Shanghai A-share index, Shanghai B-share index and the S&P500 stock index from Jan 1992 to Feb 2012, taken from DataStream. In practice, we take log first difference of time series of the stock closing index in monthly.

19.3.2 Time Varying Structures of the Autocorrelation of Stock Returns based on Moving Window Method

The period January 1992 to February 2012, Shanghai A-share index, Shanghai B-share index and the S&P500 stock index, each with 242 data points of monthly return. 36 is taked as the width of the window. Thus, we can get the time varying first order autocorrelation coefficient sequences, which are shown below Fig. 19.1, Fig. 19.2, Fig. 19.3. The autocorrelation of monthly return of Shanghai A-share index, Shanghai B-share index and the S&P500 stock index, present a time varying structures of the market inefficiency. To a certain extent, this result itself implies that a degree of market inefficiency varies through time. The autocorrelation of monthly return of Shanghai A-share index has the largest amplitude and frequency. The Shanghai B-share index is both smaller, but great changes have taken place in 2002. This may be related to the opening of B-shares to domestic investors and other large events. Before the 2008 economic crisis, the autocorrelation of monthly return of the S&P500 stock index has relatively smaller in both amplitude and frequency. This shows, the inefficiency of A-share market is the biggest, and S&P500 is the smallest. But this round of economic crisis significantly increased the inefficiency of the U.S. market. It's worth noting that the efficiency of China market has improved. Since the time series shown in these figures are bounded, so may contain a unit root. We apply the Augmented Dickey Fuller (ADF) test to check the existence of a unit root. We assume a model with time trend and a constant and use Schwarz Bayesian Information Criterion (SBIC) as an order selection criterion.

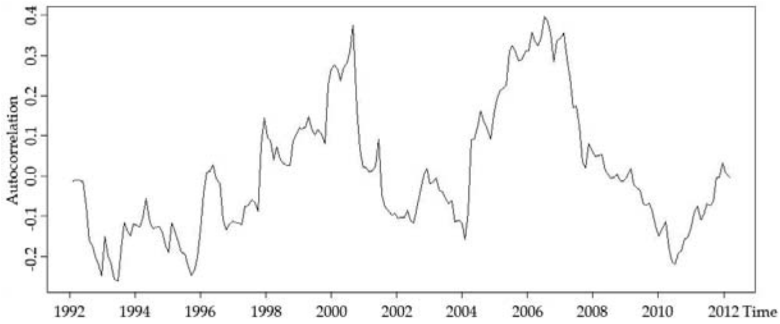


Fig. 19.1 Autocorrelation of monthly return of A-share

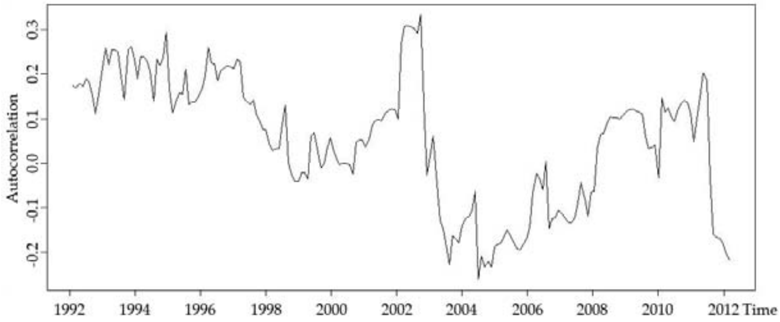


Fig. 19.2 Autocorrelation of monthly return of B-share

Lag 0 is chosen and the test statistics is computed to be -2.41. -2.79. -2.82. The corresponding 5% critical values are both -3.43. So we cannot reject the null that the autocorrelation of monthly return of the three markets all contain a unit root. At the same time, this fact supports our assumption that the AR coefficients in a time varying AR model follow a random walk process.

19.3.3 Time Varying AR(1) Coefficient based on State Space Model

In order to better interpretation of the time varying structures of stock market inefficiency, we draw the time varying AR(1) coefficients of A-share and B-share at the same period in a figure for better comparative analysis, as well as B-share and S&P500. From Fig. 19.1 to Fig. 19.5, we can see that the time varying AR(1) coeffi-

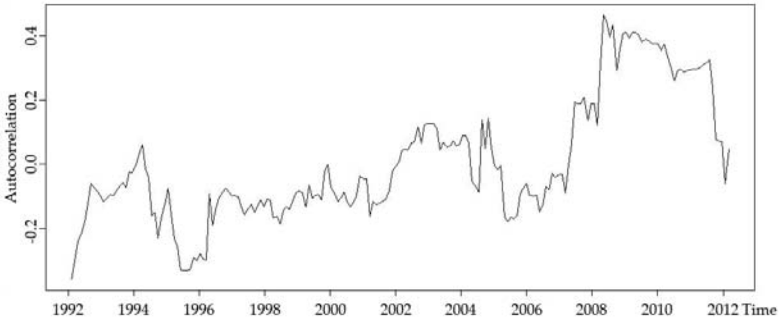


Fig. 19.3 Autocorrelation of monthly return of S&P500

Table 19.1 Measures of relative market inefficiency

Time	A-share	B-share	S&P500	Time	A-share	B-share	S&P500
1992-1993	34.74%	58.05%	7.00%	2004-2005	77.62%	18.93%	29.75%
1994-1995	20.22%	74.15%	12.60%	2006-2007	85.17%	45.25%	44.50%
1996-1997	38.16%	66.97%	11.51%	2008-2009	30.56%	51.27%	50.45%
1998-1999	53.28%	54.17%	6.02%	2010-2011	37.90%	11.71%	27.02%
2000-2001	62.56%	52.49%	6.62%	**1992-2011**	**49.19%**	**47.18%**	**21.55%**
2002-2003	52.63%	38.79%	19.85%				

cients based on state space model have the similar structure with the autocorrelation coefficients based on Moving Window method. It can also reflect that market inefficiency really changes over time, and its trend may be related to the changes of market environment. It can be seen from Fig. 19.4: 1) The time varying AR(1) coefficients of monthly return of Shanghai A-share has a greater amplitude than Shanghai B-share's; 2) The time varying AR(1) coefficients of monthly return of Shanghai A-share and Shanghai B-share are far away from the zero value in the vast majority of time; 3) The time varying AR(1) coefficients of monthly return of Shanghai A-share and Shanghai B-share fluctuate in the opposite direction; 4) Since 2008, the market inefficiency of Shanghai A-share and Shanghai B-share are both tended to decrease. It can be seen from Fig. 19.5: 1) The time varying AR(1) coefficients of monthly return of Shanghai B-share has significantly greater amplitude and frequency than S&P500's; 2) The time varying AR(1) coefficients of monthly return of Shanghai B-share is far away from the zero value in the vast majority of time, with significant market inefficiency, but before the economic crisis, the fluctuation of S&P500 is mainly around zero value ,its market inefficiency is not significant; 3) The time varying AR(1) coefficients of monthly return of Shanghai B-share and S&P500 fluctuate in the same direction; 4) The economic crisis in 2008 produced a significant adverse impact on the U.S. market efficiency. Its market inefficiency

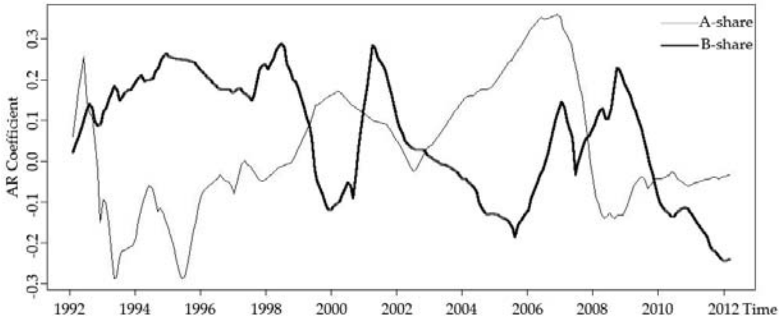


Fig. 19.4 Comparative figure of time varying AR(1) coefficients of monthly return between A-share and B-share

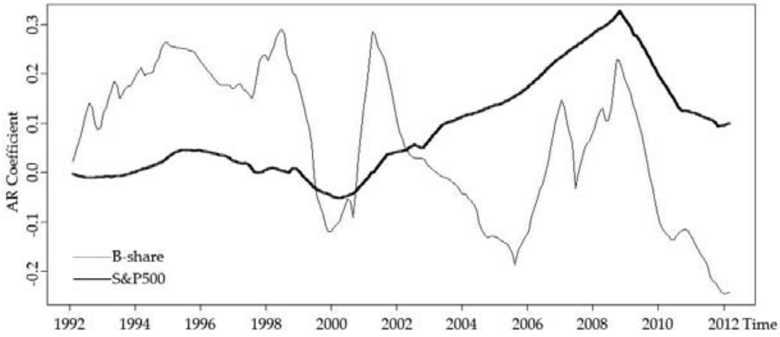


Fig. 19.5 Comparative figure of time varying AR(1) coefficients of monthly return between B-share and S&P500

increased significantly, but has recently tended to decrease. Further, we will assess market inefficiency from the numerical analysis. We divided the time varying AR(1) coefficients of monthly return into 10 sections (2 years for each) by years. In each period, we take the average of these data which have been standardized, then compared with the range of whole markets in order to get the percentages, which we regard as a measure of time varying market inefficiency of the stock markets. At the same time, we also calculated the degrees of market inefficiency of three stock markets in the entire 20 years. $\sum_{t=1} \beta_{1,t} / \phi n$. Results are shown in Table 19.1.

The results show, the measures of relative market inefficiency of the three markets have such a relation, that is A-share>B-share>S&P500. We believe that the value relation reflects the difference degree of market inefficiency among the three markets to a certain extent. The market inefficiencies of Shanghai A-share and Shanghai B-share are both two times more than S&P500's. Generally, there is still a large gap in market efficiency between China's stock markets and America's mature capital markets, so there is a long way for us to improve the market system for a better market efficiency.

19.4 Conclusions

In this paper, we take the time varying autocorrelation coefficients of stock monthly returns as a measure of the degree of market inefficiency, use autocorrelation of monthly returns based on Moving Window method and Time Varying AR model which is a special case of state space model, select Shanghai A-share index, Shanghai B-share index and the S&P500 stock index as samples, empirically analyze the changes of market inefficiency in China's stock markets from 1992 to early 2012, and comparatively study with the U.S. stock markets. Results are shown below:

1. The inefficiency of stock markets has time varying characteristics, and its trend may be related to the changes of market environment.
2. Market inefficiency of China's markets is greater than U.S. stock markets', and A-share is greater than B-share, confirmed the fact that China's market efficiency is lower than the U.S. stock markets'.
3. The market efficiency of U.S. stock markets has the best stability, the next one is Shanghai B-share and Shanghai A-share is the worst.
4. The AR(1) coefficients of Shanghai A-share and Shanghai B-share fluctuate in the opposite direction, but Shanghai B-share and S&P500 have the same direction. This shows that the Shanghai A-share market has more independence; the Shanghai B-share market and U.S. stock market have a certain degree of linkage.
5. Since 2008, the market inefficiencies of Shanghai A-share and Shanghai B-share both significantly shrink and market efficiency has been improved.
6. The economic crisis occurred in 2008 produced a significant adverse impact on the U.S. market efficiency; its market inefficiency increased significantly, but have recently tended to decrease. At the same time, since the economic crisis, the market inefficiency of Shanghai A-share significantly shrank. The "abnormal" phenomenon illustrates not only the independence movements of China's stock market, but also its good economic development momentum and the fact that China's stock market is walking towards maturity.
7. The time varying AR(1) coefficients based on a state space model is better for reflecting the time varying structures of market inefficiency than the autocorrelation coefficients based on Moving Window method.

Acknowledgements National Natural Science Foundation of China (NSFC) under project No. 70873115 and 71173203. The authors appreciate the support from National Natural Science Foundation of China (NSFC) under project No. 70873115 and 71173203. We are also thankful for the funding provided by Key Universities Research Institute of Humanities and Social Sciences in Zhejiang Province, China. Standardization and Intellectual Property Management.

References

1. Samuelson P (1965) Proof that properly anticipated prices fluctuate randomly. Industrial Management Review 6:41–49
2. Campbell J, Lo A, MacKinlay A (1997) Econometrics of financial markets. Princeton University Press, New Jersey
3. Lo A (2004) The adaptive markets hypothesis: Market efficiency from an evolutionary perspective. Portfolio Manager Overview 30:15–29
4. Cajueiro D, Tabak B (2004) Evidence of long range dependence in asian equity markets: The role of liquidity and market restrictions. Physica A 342:656–677
5. Ma S (2004) The efficiency of China's stock market.
   SSRN Working Paper, http://ssrn.com/
6. Yi RH, Da QL (2004) A measuring method of market efficiency and empirical research on market efficiency of chinese security market. China Soft Science 3:144–147
7. Lim K, Hinich M, Brooks R (2006) Events that shook the market: An insight from nonlinear serial dependencies in intraday returns.
   SSRN Working Paper, http://ssrn.com/
8. Evans T (2006) Efficiency tests of the UK financial futures markets and the impact of electronic trading systems. Applied Financial Economics 16:1273–1283
9. Lim K (2007) Ranking of efficiency for stock markets: A nonlinear perspective. Physica A 376:445–454
10. Giglio R, Matsushita R, Silva SD (2008) The relative efficiency of stock markets. Economics Bulletin 7:1–12
11. Ito M, Sugiyama S (2009) Measuring the degree of time varying market inefficiency. Economics Letters 103:62–64
12. Giglio R, Silva SD, Iram G et al (2010) Efficiency of financial markets and algorithmic complexity. Journal of Physics: Conference Series 246:12–32
13. Wang YD, Liu L, Gu R et al (2010) Analysis of market efficiency for the Shanghai stock market over time. Physica A 389:1635–1642
14. Shive S (2012) Local investors, price discovery, and market efficiency. Journal of Financial Economics 104:145–161
15. Jarrow R, Larsson M (2012) The meaning of market efficiency. Mathematical Finance 22:1–30

Chapter 20

A Design of Association Rule Mining System based On the Web Text

Dan Zhang, Hongxia Du and Yue He

Abstract A Web text association rule mining system is designed in the paper. It combines the association rule mining and the Web text. The systematic thinking is proposed, which processes association rule mining directly on the Web text. Obtaining the Web text, word segmentation, data cleansing, feature extraction, text data conversion and association rule mining are integrated into a single system. The system overall function structure, process, database and interface are designed. The system function is achieved. The deficiencies in processing Web text file of the previous association rule mining software are remedied. According to the experimental analysis, by using this system, the Web text association rule mining can be done, and the association rule between the words in the Web text can be found. Therefore, the speed of the search engines, and the recall ratio and precision of search can be promoted. And furthermore, it can be applied to website design and e-commerce site management.

Keywords Web text · Association rule · System design

20.1 Introduction

With the application and popularization of the Internet, the network information becomes plentiful, and shows the explosive growth trend. The information not only provides a plentiful data source for people's search, but also brings a great redundancy. Therefore, how to find the information quickly and effectively, which users are interested in, becomes an important issue to be solved within the modern search engine. With the continuous development of data mining, it is found that, the application of data mining to the Internet is a very effective method to solve the modern

---

D. Zhang (✉) · H. Du · Y. He
Business School, Sichuan University, Chengdu 610064, P. R. China
e-mail: unidatabase@126.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_20,

search engine technology. Therefore, the data mining technology based on the Web is emerged.

The Web data mining is different from the traditional data mining, for which the targets are all the forms of data information on the Web. Furthermore, the technical method for the Web data mining is different from the traditional data mining. A number of branches of the Web data mining have emerged, such as the Web text mining, Web multimedia mining, structure mining, and access log mining, etc. With the emergence of the Web text mining, the corresponding mining techniques are generated [1]. Respectively, they are Web text summarization, Web text retrieval, Web text classification, Web text clustering, Web text association analysis, and Web text distribution analysis and trend forecast. These techniques applied to the Web text mining can help improve the information retrieval technology.

The continuous development of the Internet requires the search engine to improve itself. As an effective method to improve the search engine technology, the research of the Web Text Mining develops and progresses continuously. Among these technologies, the Web text association rule mining is to use the technical to analyze and identify the association relationships between the Web text words. The discovery of these association rules helps to improve the recall ratio and precision of the search engine. Furthermore, it reduces the time of searching and improves the efficiency of the search engine.

Foreign countries research the Web text mining earlier and more maturely than domestic both in the theory and application fields. From the initial theoretical research to the development and application of the mining tools; from the proposing of the automatic word segmentation theory to the emergence of the mail classification, information extraction and information filter technology, the research and application of the Web text mining become wider and wider. Furthermore, it is applied to the business area and search engines. Also, foreign countries research the text mining software relatively early. The existing text mining software is mainly IBM Text Mining, SAS Text Mining, SPSS Text Mining, Autonomy's Concept Agents, and mining products by TelTech Corporation.

Our country researches the text and the Web text mining relatively later. Furthermore, Chinese language is different from the foreign languages in organizations. Thus, in the Chinese text mining, foreign data mining software and technology can not be applied directly. Then, a lot of researches for the Chinese text mining emerged. The Web text mining literature mainly focuses on the research of the Web text classification and clustering. Among them, in the field of the Web text mining theory and technology, Qian [2] researched the classification and clustering of the Web text mining techniques. Besides, Fu [3] researched the method to improve the efficiency of Web text classification by applying association rule mining technology in text classification. Zou et al [4] discussed the major techniques in Web text mining from three aspects: Web text classification, cluster and abstract. As to the research and design of Web text mining system, on the basis of the structure model and Classification Algorithm of text mining system, Tang et al [5] realized the web-based text mining System by combining the background of the application of modern distance education. On the basis of improved clustering algorithm, Guan [6] designed a mining system which was based on Web text clustering. Zhang [7] designed a Web text mining system focusing on classification and clustering. Xue [8] introduced the SOM neural network algorithm in the text mining system and highlighted the effects of knowledge Visualization. These literatures are mainly concentrated in the Web text classification and the research of clustering. By studying these technologies and designs, software for Chinese text mining are developing as well, among which TRS text mining software was the most representative.

Association rule mining is an important research aspect of the Web text mining. But literature on this study is quite little, and we only find three related literatures. Among them, Zou [9] designed and partly realized a text mining system on the basis of improved Apriori Algorithm. Huang [10] improved the efficiency of text by studying and improving the FP-growth Algorithm. Wang [11] combining the XML query language X Query and association rules mining algorithms fulfilled the Apriori algorithm based on X Query and studied on association rules mining to multiple XML documents. Among the three literatures improved the efficiency of mining through improving association rule algorithm and concentrated on the research of flat text association rule mining.

From the literatures mentioned above we can find that most of these researches focusing on Web text classification and clustering. Meanwhile, the studies on Web-based text association rule mining are not only small in amount, but also concentrated on flat text. Furthermore, they didn't have detailed system analysis or design. Therefore, papers design and studies on association rule mining system based on Web text are new research topic.

This paper will combine association rule mining and Web text and integrate text acquiring, text segmentation, data cleansing, text data conversion and association rule mining into one system. Meanwhile, this paper designs the overall system function structure, processing, database and interface, and realizes the function of the system. Thus, the shortages of past association rule mining software in Web text dealing are overcome.

20.2 System Design

This part includes the design of system function, system processing, database, system function interface, and association rule mining method.

20.2.1 System Function

The association rule mining system based on the web text is the one that mines the hidden, potential, useful and interesting relationships between the words from Web text. These relationships can not only reflect the topics and organizations of texts, but also help to improve the search engine and promote the development of the search engine technologies. This system is made up of three parts. They are text acquisition, text feature extraction and association rule mining subsystem. The overall structure of the system is showed in Fig. 20.1.

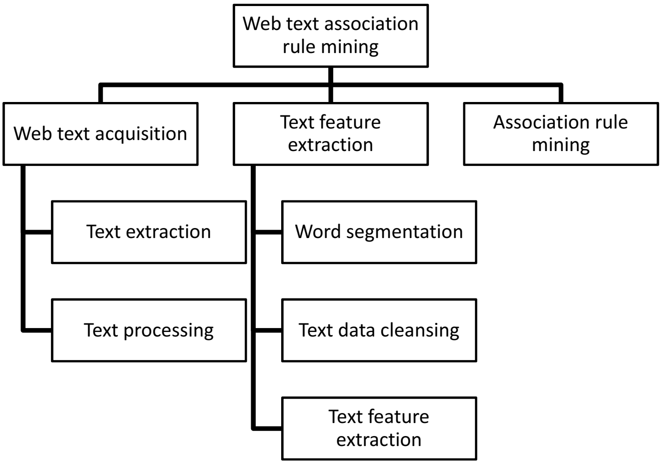


Fig. 20.1 The function and structure of the system

The principle functions of the Web text acquisition subsystem are getting a large number of Web texts from the huge, dynamic Internet through the text extraction module, and transforming the text from Web format to standard format through the text processing module.

The function of association rule mining subsystem is doing association rule mining of the text feature items in the file transaction library by selected association rule mining algorithm, and finding the association relationships among these feature items.

The functions of the three subsystems must be executed in order and none is dispensable.

20.2.2 System Flow

The Web text-based mining system is different from general management information systems, as it does not have any complex features or various roles of users. Each user can use all the features of the system. Furthermore, the system functions are executed in order. Therefore, data from this system can follow the operation sequence flows from one function to another; there are no data distributaries or data convergences. The system's data stream is acquiring Web text from web, processing and saving. Then, segment the processed text information and save. After that, clean the text information and extract the text feature from these word sets. At last, mine the association rules from feature sets and save. The system processing flowchart is shown in Fig. 20.2.

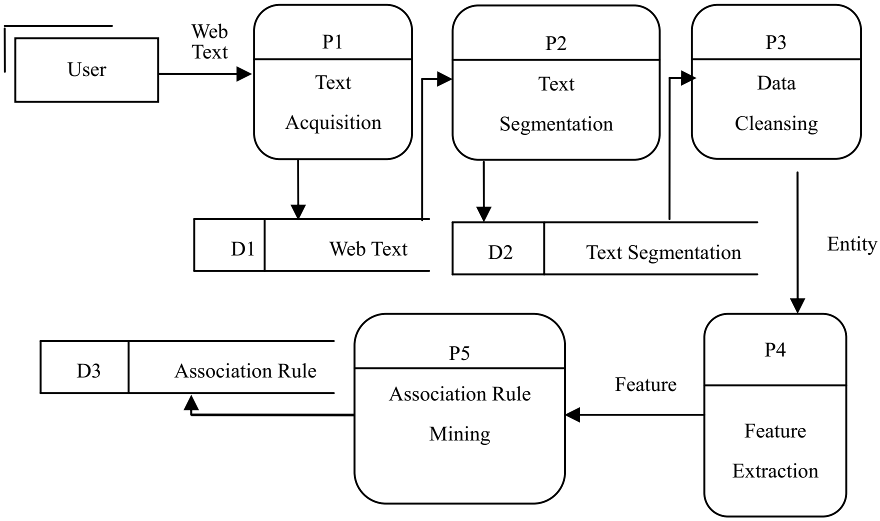


Fig. 20.2 Web text system flow chart

20.2.3 Database Design

The database of the Web text association rule mining system which stores the Web text, text glossary and association rules is the most important foundation of the system. This paper uses the Entity-Relationship Model (E-R model) to design the database. The E-R model of the database is shown in Fig. 20.3.

Based on the E-R model shown in Fig. 20.3, we can get the relational data model corresponding to the E-R model as follows:

1. Web text (Web text number, Web text URL, time, content);
2. Text glossary (text glossary number, text glossary value);
3. Association rule (association rule number, support, confidence, times);
4. Text segmentation (number, text segmentation number, Web text number, mark, feature, times);
5. Association rule item (item number, association rule number, text feature number, item type).

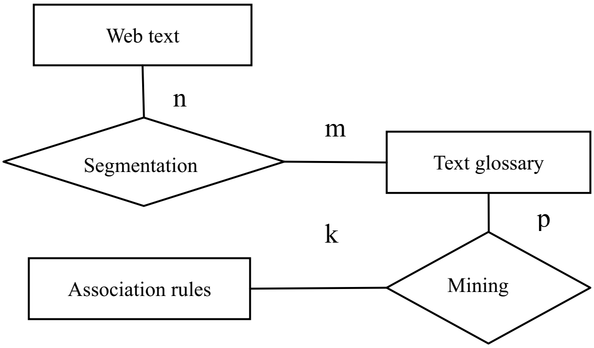


Fig. 20.3 E-R model

20.2.4 The Design of Association Rule Mining Methods

Apriori algorithm [12] is not only the classic algorithm, but also the core ideology of many mining algorithms emerging later. It's a basic algorithm to find frequent itemsets. The basic idea of apriori algorithm is finding frequent itemsets through searching layer by layer. The basic properties of the Apriori algorithm used during the searching are that any non-empty subsets of the frequent itemsets should be a frequent itemsets, and that the supersets of any infrequent itemsets must be infrequent. The algorithm uses these two properties to reduce the space need to search when generating frequent itemsets and generate all the frequent itemsets efficiently. The follows are the main steps:

1. Scan the database D, generating all the candidate item sets of 1-length as candidate item sets C1. Count all the supports of the 1-length item sets and select the all the distinct 1-length itemsets whose support is greater than the minimum support as frequent 1-length itemsets L1;
2. Generate 2-length candidate sets by joining the L1 with itself, and then generate frequent 2-length itemsets L2;
3. Generate candidate 3-length sets and frequent 3-length itemsets iteratively as the methods above until no frequent itemsets can be generated. In this process, we can prune the candidates and reduce the number of candidates, according to the property of Apriori algorithm mentioned above.

For the Apriori algorithm is the basic, simplest and classic association rule mining algorithm that is easy to be achieved by programming, we select it as the specific algorithm for the system design.

20.3 Experiment Analysis

We designed the Web text-based association rule mining system just now. Here we will show the application of this system through an example. The experiment is completed by the following five steps:

1. Acquire 100 Web text files on “DPRK (Democratic People’s Republic of Korea)” from Web. Then use the processing method in the system to transform these files from Web format to common text format;
2. Select the segmentation tools to segment the text files got in the previous step and count the frequencies of the occurring of these words.
3. Process the segmentations of the text files in accordance with the basic meanings of the vocabularies, and get rid of meaningless words. Then based on the relationship between the frequency, vocabulary and “DPRK”, select some words as the feature words of the text files.
4. For the data type the Apriori algorithm processes is Boolean data, before making the next step of mining, the existing data must be converted to Boolean in preparation for further mining.
5. At last, do association rule mining by the function of the association rule mining module. Find and show the association rules. The association rules we get are shown in Table 20.1.

Table 20.1 The example of association rules

Associated vocabulary	Support (%)	Confidence (%)
DPRK, Leader, Kim Jong II	15.50	91.56
DPRK, Korea	14.20	90.95
DPRK, Korea, Jinzhengen	10.40	93.46
DPRK, Satellite	10.30	85.00
DPRK, Korean War	8.10	80.50

By the result of the experiment, we can find out that the co-occur probability of “DPRK” and “LeaderKim Jong II” is 15.50%, which is the highest. The co-occur probability of “DPRK” and “Korea” is comparatively high as well, which is 14.20%. These tell us that “DPRK” and “LeaderKim Jong II”, “DPRK” and “Korea” are high association word sets, as well as other entries. These rules not only reflect the laws of these words’ appearances, but also reflect their importance in the whole experiment text sets. When the words in the rules are the key words of the Web pages, these rules will reflect the association relationships within and between Web pages.

The experiment result shows that the association rules found by the system can increase the recall ratio and precision of the search, and promote the further development of the searching engine technology.

20.4 Conclusions

After analyzing the significant and the current situation of the Web text mining research, this paper puts forth the association rule mining system based on Web. Besides, the association rule mining experiment of 100 texts on DPRK is done. The results indicate that these association rules have practical values for they can help to improve the recall ratio and precision.

The past association rules mining systems based on the Web text must be done by the combination of several application software, and the operations are complex. Aiming at this problem, the paper analyzes and designs an association rule mining system based on the Web text. The application system can mine the huge text information from Web and find the association rules with simple operations. Therefore, the shortages of the past association rule mining systems based on Web text are covered.

We have designed the association rule mining system based on the Web text. Due to the limitations of the study, the following areas still need further study. First of all, segmentation and feature extraction need better methods to meet the increasing requirements in text processing. Second, while having significant improvements, the association rule mining algorithms need further improvement for the sparse feature of the Web text. Finally, how to apply the association rule mining technology into the search engine in a better way is an important and difficult problem in the future studies.

References

1. Wang J, Pan J, Zhang F (2000) Research on web text mining. Journal of Computer Research & Development 37:513–520
2. Qian X (2002) The research and achievement of web text mining technology. Zhejiang University, Hangzhou
3. Fu Y (2006) Research on web text data mining. Tongji University, Shanghai
4. Zou L, Xiao J, Gong X (2007) Research on web text mining technology. Journal of Information 2:53–55
5. Tang J, She J, Yang B (2003) The research and development of text mining system based on web. Computer Science 30:60–62
6. Guan M (2007) Web mining system. Zhejiang Gongshang University, Hangzhou
7. Zhang Y (2008) Based on web text mining system. Shandong University, Jinan
8. Xue H (2010) Research on the web text mining and visualization of its result based on SOM. Nanjing University of Aeronautics and Astronautics, Nanjing
9. Zou Q (2006) Text data mining research based on association rule. Southwest Petroleum University, Chengdu
10. Huang J, Zhang D (2008) An algorithm for mining association rule in textual database. Computer Simulation, 25:96–99
11. Wang Y (2011) Research on web text mining based on XML and association rule mining algorithm. Jiangsu University of Science and Technology, Nanjing
12. Han J, Kamber M (2001) Data mining concepts and techniques. Mechanic industry Press, Beijing

Chapter 21

ITSQM: A Conceptual Model of IT Service Quality

Zhiliang Liu, Jinlong Zhang and Lingfei Zou

Abstract With the development of information technology and the integration of IT and business, IT industry is changing from product-oriented to service-oriented. As a result, IT service management has become more and more important. One of most issues concerned both by researchers and practitioners is IT service quality. Since the shift from product to service, traditional hardware and software have been integrated into service. Thus, traditional quality evaluation methods of software and hardware product cannot meet the requirements of IT service quality evaluation. With this goal, in this paper, we will propose a conceptual IT service quality evaluation model (ITSQM).

Keywords Component · IT service · Service quality · IT management

21.1 Introduction

With the rapid development of information technology (IT), which brings continuous popularization of the network computing, sequential upgrade of the hardware, ongoing change of the application, and in-depth integration of business and IT, a great development. has immerged in the global software and IT service industry.

Global IT service market scale is huge and the industry scale keeps growing at a steady speed. Gartner report shows that, in 2011, IT expenditure of global enterprises will hit 2500 billion dollars, 3.1% higher than that in 2010 (2400 billion dollars). The expenditure in 2014 is expected to hit 2800 billion dollars. In the future, global IT service industry will grow steadily and become the highlight of development of the whole IT industry. As driven by global economic recovery, IT service needs increase rapidly. Countries and organizations will pay more attention to IT

Z. Liu (✉) · J. Zhang · L. Zou
School of Management, Huazhong University of Science and Technology, Wuhan 430074,
P. R. China
e-mail: zeallion@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_21,

service markets and take IT service as the key industry and prepare corresponding development strategies for support and development.

On the other hand, Global IT industry has a new trend which is changing from product-oriented industry to service-oriented industry. The IT service industry becomes a new engine of the IT industry development. The new characteristics of global IT industry are becoming more and more significant. The core competition of industry and market is transformed from "product and technology" to "service". A lot of well-known IT enterprises take IT service as key development direction. Multinational giants represented by IBM and HP have achieved successfully transformation from traditional product provider to IT service provider so as to enhance their competitive capacity and market role.

As a result, IT service has become more and more important [1], meaning while, a series of themes about how to manage IT service are coming One of most concerned both by researchers and practitioners is IT service quality evaluation. Since the shift from product to service, traditional hardware and software have been integrated into service. Thus, traditional quality evaluation methods of software and hardware product cannot meet the requirements of IT service quality evaluation. With this goal, in this paper, we will propose a conceptual IT service quality evaluation model (ITSQM).

21.2 Literature Review

21.2.1 Service Quality and IT Service Quality

Service quality, as a complex structure variable, comes from the marketing research field. Many researchers make great efforts to carry out the service quality research and get a great achievement: with referring to all service quality definitions, it is a common sense to consider customer perception. As this research field pioneer, Gronroos firstly proposed that, the service quality is a kind of customer perception. In his research, the service quality is defined as "perceived by the customer as being the difference between customer expectations and their experience of the services" [2]. Similarly, Parasuraman et al [3] regarded the service quality as the gap between expected and perceived of the services. They indicated "service quality is the result of differences between expectations and the actual performance of the service". In Bitner and Hubbert's research, they defined the service quality as "an overall impression of advantages or disadvantages of organization and its services on consumers" [4].

IT service quality concept is introduced from the service quality of marketing and specially refers to IT-related service quality. According to the research literature, IT service quality still need emphasize the customer perception of IT services. We regard IT service quality as the extent to which the inherent characteristics of IT services satisfy needs.

21.2.2 Service Quality Model

There are various efforts to design conceptual models of service. Quality researchers propose a lot of service quality models based on service quality defination. In this paper, we will introduce three representative models in references:

(1) Gronroos Model

The first model is from the physical product research. Gronroos firstly introduced such model to the field of service quality [4]. In this model service quality is the difference between customer perception and expectations of services, and regards service quality is composed of technical quality and functional quality, as shown in Fig. 21.1.

(2) GAPs Model and SERVQUAL Model

GAPs model and SERVQUAL is the most famous theory in service quality research. Parasuraman et al [3] explored GAPs model through group interviews research. In GAPS model, GAP5 is a function of GAP1, GAP2, GAP3 and GAP4, which reflects the service quality (GAP5 = f (GAP1, GAP2, GAP3, GAP4)). Based on the GAPs model, Parasuraman et al developed 22-items instrument SERVQUAL model (as shown in Fig. 21.2) through qualitative research method for assessing customer perceptions of service quality [3]. In the SERVQUAL model, service quality has five dimensions of 22 items. The five dimensions are reliability, tangibles, responsiveness, empathy and assurance.

(3) Multilevel and Hierarchical Models

Following the criticism of SERVQUL, Dabholkar et al recognized that the SERV QUAL model has been empirical validation in the pure service industry (e.g., banks, telephone service), But does not fit to all service industry. Therefore, he designed a new model called RSQS (Retail Service Quality Scale) by qualitative and quantitative methods [5]. This hierarchical model is that the evaluation of service quality is not simply achieve by the compression of perceived service and expected ser-

Fig. 21.1 Gronroos model

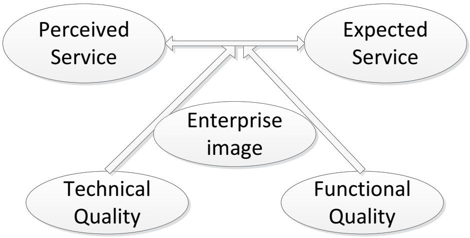
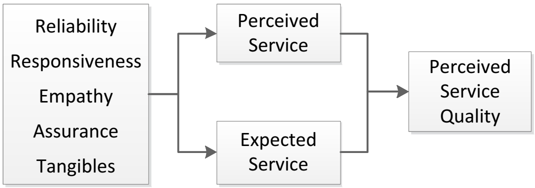


Fig. 21.2 SERQUAL model



vice, but based on three levels: 1) the overall service quality level, 2) the level of the primary dimensions and 3) sub-dimension level as shown in Fig. 21.3. Among them, the service quality as the top level, determined by the five primary dimensions (tangibles, reliability, personal interaction, problem solving and policy), each of the primary dimensions determined by their respective sub-dimensions.

21.3 Research Progress

The nature of service determines the service quality is difficult to be measured, not to mention the IT service quality. The literature reviews indicate that there are arguments about the definition and measurement of service quality among scholars. Although the SERVQUAL and SERVPERF model are widely used to measure the quality of service in different industries, they are built on the basis of traditional services [6], some scholars criticize that there are limitations in these model when applying them to measure some new service quality, such as the e-commerce services quality [7–9], IT service quality. The literature reviews reveals that researchers agree service quality is a multi-dimensional structure variables [10]. For this reason, we will develop IT service quality model based on hierarchical model.

Because of lack of sufficient IT service quality literatures and IT service quality is complex system influenced by various issues. The development of a conceptual model of IT service quality is very difficult. According to the literatures, in this situation, researchers usually use exploratory factor analysis - qualitative research method. Just as Mintzberg said "qualitative research is direct research". Qualitative research method has been widely used in many disciplines, especially in the field of marketing and consumer behavior. Parasuraman et al developed SERVQUAL model through qualitative research method. Dabholkar et al developed RSQS model also through this qualitative research method. We will use the same method to develop IT service quality model.

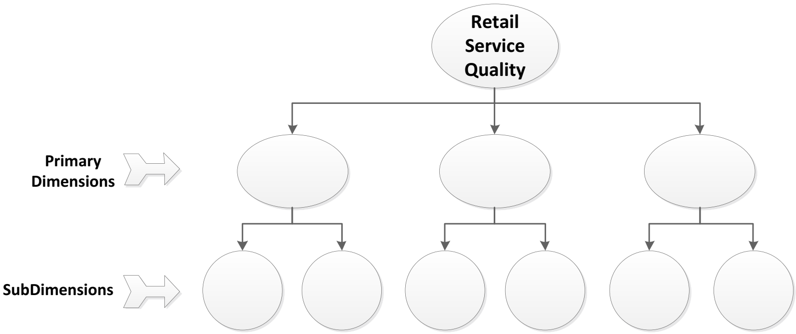


Fig. 21.3 Hierarchical model

In this research, qualitative research is divided into two stages: (1) personal depth interviews with IT service providers and (2) groups interviews with IT service customers. These two stages are guided and implemented by trained student using open interviews and semi-structured questionnaire. The interview and questionnaire is built on the basis of the general concept of service quality defined in the literature in qualitative research.

21.3.1 Personal Depth Interviews with IT Service Providers

We selected 11 managers from IT service provider to participate in our personal depth interviews. They come from different department of the IT service enterprise (e.g. marketing department, customer service department, and service design department). In the interviews, the managers in accordance with their respective IT services work were asked to answer the following questions as much detail as possible:

1. What is the IT service quality perceived by their IT service customers?
2. What are the most important factors affecting the IT service quality in their mind?
3. What measures have they taken to deliver high quality IT services?
4. What problem do they have encountered in the process of providing IT services?

We have kept the record of the depth interviews in order to ensure the reliability of the research.

21.3.2 Groups Interviews with IT Service Customers

104 IT service customs have taken in our research. According to the type of the IT service they used, we divided them into 5 groups, and organized interview in groups. The 5 types of IT service are IT consulting service, IT design and development service, IT integration service, data processing and operation service, and new IT service such as cloud computing. Each group is asked to answer the following questions as much detail as possible:

1. What is the IT service quality they perceived?
2. What factors are affecting the IT service quality in their view?
3. What measures do they wish the IT service provider to take to improve IT services quality?

We also have kept the record of the group interviews in order to ensure the reliability of the research.

21.3.3 Data Analysis

After finish the two-stage interviews, we analyze the interviews record, and get the result of qualitative research. Although the participants were asked to list all factors that affect each of the main dimensions of IT service quality model, we selected the factors which are the literature generally accepted by most scholars. In the initial sequence of the factors, according to Dabholkar, Thorpe, et al. suggestion, we delete the factor - price from the factors sequence. Because they pointed out that the price factor does not belong to the general understanding of the service quality.

We use content analysis method to code the content of the interview record. We code information by the frequency of text content. Firstly, we identify the primary dimensions, and then classify the content code with the same or similar meaning by primary dimensions, in this way, we identify the sub dimensions. When a content code is classified into difference primary dimensions, we need to reestimate the reliability. After interviews data analysis, we get an IT service quality model with 5 primary dimensions and 16 sub dimensions.

21.4 IT Service Quality Model

According to factor analysis results, the final IT service quality model is as shown in Fig. 21.4.

In this model there are 5 primary dimensions which are security, reliability, responsiveness, tangibles and empathy. The security dimension has 3 sub dimensions which are availability, integrity and confidentiality; the reliability dimensions has 5 sub dimensions which are availability, integrity and confidentiality; the responsiveness has 2 sub dimensions which are timeliness and interactivity; the tangibles has 2 sub dimensions which are visibility and profession; the empathy has 3 sub dimensions which are flexibility, proactivity, and courtesy.

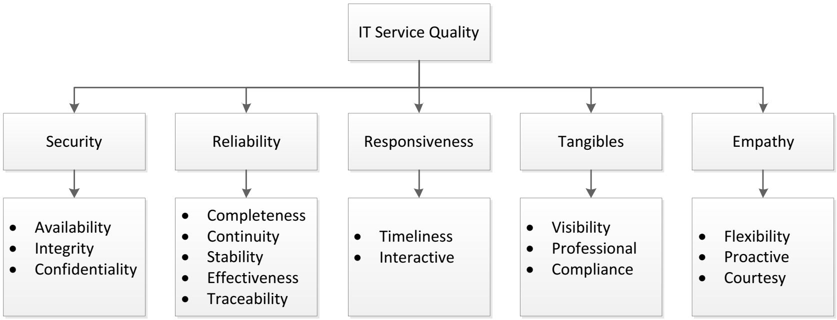


Fig. 21.4 ITSQ model

The primary dimensions and sub dimensions are described in detail as following: (1) Security: The capability of information technology service supplier to guarantee the security of information and relevant resources when providing service.

- Availability: Securing that the normal use of information and relevant resources by authorized users of customer should not be abnormally denied and allowing such users to reliably and timely access and use information and resources when necessary.
- Integrity: Securing that customer's information and resources obtained by supplier during service provision should not be distorted, disrupted or transferred without authorization.
- Confidentiality: The service provided by supplier should secure that customer's information and resources should not be revealed to unauthorized users or entities in the course of use and transmission.

(2) Reliability: The ability of information technology service supplier to perform the service agreement under the provided conditions and within the provided time limit.

- Completeness: The service provided by the IT service supplier should cover all the terms committed in the service agreement.
- Continuity: The ability to secure the fulfillment of the service agreement under all circumstances. It includes two aspects, the commitment to mitigate risks to a reasonable level and to recover business after suspension of the same.
- Stability: The service provided by IT service supplier should continuously and steadily comply with the provisions in the service agreement.
- Effectiveness: The capacity of IT service supplier to effectively settle service requests according to the requirements of the service agreement.
- Traceability: The ability of the supplier to keep complete and documented original record of involved activities in the service process.

(3) Responsiveness: The capability of the IT service supplier to timely responds to the service requests from the customer according to the service agreement.

- Timeliness: The speed at which the IT service supplier responds to the service requests according to the service agreement.
- Interactivity: The ability of the supplier to guarantee the fast and accurate information exchange between the supplier and the customer by establishing the appropriate interaction and communication mechanism.

(4) Tangibles: The ability of supplier to demonstrate its services by tangible evidence.

Note: Such evidences usually include brand, personnel image, service facilities, service process, service tools, etc.

- Visibility: The ability of the supplier to demonstrate its service to the custom in a visible method.

- Profession: The extent of normality, standardization and advancement demonstrated by supplier in the course of service.
  Note: It includes the compliance of perfection degree of the deliverables.
- Compliance: The ability of the IT service to obey standards, agreements or laws and regulations as well as the similar stipulations.

(5) Empathy: The ability of the supplier to sympathize with the customer and to give special attention to the customer.

- Flexibility: The ability for the supplier to provide customized service to the customer according to their personalized needs.
- Proactivity: The ability of the supplier to initiatively perceive the demand of the supplier and actively take measures to ensure the service delivery.
- Courtesy: The capability of the supplier to standardize the service languages, behaviors, and attitudes showed in the process of service provision.

21.5 Conclusion and Further Research

In this research we just develop a conceptual model of IT service quality with 5 primary dimensions and 16 sub dimensions. But this is only the beginning of the research, the model needs to be further purified and validated through exploratory factor analysis by survey study. A confirmatory factor analysis will also be needed to analyze the relationship between the factors.

Acknowledgements This research was supported by the National Natural Science Foundation of China (No. 71101060).

References

1. Roses LK, Hoppen N, Henrique JL (2009) Management of perceptions of information technology service quality. Journal of Business Research 62:876–882
2. Gronoroos C (1984) A service quality model and its maketing implications. European Journal of Marketing 18:36–44
3. Parasuraman A, Zeithaml VA, Berry LL (1985) A conceptual model of service quality and its implications for future research. Journal of Marketing 49:41–50
4. Bitner M, Hubbert A (1994) Encounter satisfaction versus overall satisfaction versus quality service quality: New directions in theory and practice. Sage Publications, Thousand Oaks
5. Dabholkar PA, Thorpe DI, Rentz JO (1996) A measure of service quality for retail stores: Scale development and validation. Journal of the Academy of Marketing Science 24:3–16
6. Cronin J, Taylor S (1992) Measuring service quality: A reexamination and extension. Journal of Marketing 3:55–68
7. Dyke TP, Prybutok VR, Kappelman LA (1999) Cautions on the use of the SERVQUAL measure to assess the quality of information systems services. Decision Sciences 30:877–891
8. James J, Jiang G (2002) Measuring information system service quality: SERVQUAL from the other side. MIS Quarterly 6:145–166

9. Kettinger W, Lee C (1999) Replication of measures in information systems research: The case of IS SERVQUAL. Decision Sciences 30:893–899
10. McDougall G, Levesque T (1994) A revised view of service quality dimensions: An empirical investigation. Journal of Professional Services Marketing 11:189–209

Part III
Decision Support System

Chapter 22
On Solution Method of the Knapsack Problem

Mahammad M. Aliev

Abstract In this paper we give original geometrical interpretation to the domain of definition of integer and combinatorical problems. The solution of the problems concerning NP class has been carried out on the hyperarchs. The existence criterion of the solution on the hyperarchs has been defined. The method for establishing the sequence of approximation to the solution on the hyperarchs was constructed. Calculation experiments were conducted, and the obtained polynomial algorithm, practically solved exactly the (SSP) problem.

Keywords Knapsack problem (KP) · Subset sum problem (SSP) · NP class · Integer programming · n-dimensional cube · Hyperplane · Hypercircle · Hyperarch

22.1 Introduction

The problems in computing mathematics are divided into two classes according to their difficulty: (1) the first class contains the problems in which the number of simple operations for its solution (addition, subtraction, division, comparison, square root) is polynomially expressed by the parameters (by the number of n-variables, the number of m-restriction) of the problem. This class in said to be a polynomial class and in short is called a class. (2) The problems in which the number of simple operations for its solution is proportional to 2^n enter to NP class. This class is called NP hard class. The knapsack problem is one of the classic problems in the linear integer programming problems. Up to present time, it was not possible to solve this problem exactly by a polynomial algorithm.

The knapsack problem can be formulated as a solution of the following linear integer programming formulation:

M. Aliev (✉)
National Academy of Sciences of Azerbaijan, Baku AZ1141, Azerbaijan
e-mail: aliyev.mahammad@yahoo.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_22,

(KP)

$$\max \sum_{j=1}^{n} p_j x_j \tag{22.1}$$

$$\text{s.t.} \begin{cases} \sum_{j=1}^{n} w_j x_j \leq c & (22.2) \\ x_j \in 0;1 \; j = 1,2,\cdots,n. & (22.3) \end{cases}$$

We will denote the optimal solution vector by $X^* = (x_1^*, x_2^*, \cdots, x_n^*)$ and the optimal solution value by Z^*. The set X^* denotes the optimal solution set, corresponding to the optimal solution vector.

Problem (KP) is the simplest non-linear integer programming model with binary variables, only one single constraint and only positive coefficients. Nevertheless, adding the integrality condition (22.3) to the simple linear program (22.1) and (22.2) already puts (KP) into the class of "difficult" problems [1].

The knapsack problem has been studied for centuries as it is the simplest prototype of a maximization problem. Already in 1897 Mathews showed how several constraints may be aggregated into one single knapsack constrain. This is somehow a prototype of a reduction of a general integer program to (KP), thus proving that (KP) is at least as hard to solve as an integer program. It is however unclear how the name "Knapsack Problem" was invented. Dantzig is using the expression in his early work and thus the name could be a kind of folklore [1].

When $p_j = w_j$ in (KP), the resulting optimization problem is known as the subset sum problem (SSP) because we are looking for a subset of the values w_i with the sum being as close as possible to, but not exceeding the given target value c.
(SSP)

$$\max \sum_{j=1}^{n} w_j x_j \tag{22.4}$$

$$\text{s.t.} \begin{cases} \sum_{j=1}^{n} w_j x_j \leq c & (22.5) \\ x_j \in 0;1 \; j = 1,2,\cdots,n. & (22.6) \end{cases}$$

Although (SSP) is a special case of (KP) it is still NP-hard and is NP-complete [1].

The class of NP-complete problems NPC is the set of decision problems Q satisfying the following two properties:

1. $Q \in \text{NP}$.
2. $\forall R \in \text{NP} : R \leq Q$.

To see the latter, one may simply assume that an NP-complete problem Q could be solved in polynomial time, then by transforming R to Q we would also get a polynomial algorithm for R contradicting the assumption.

The theory of NP-completeness gives us a framework for showing that it is very doubtful that a polynomial algorithm for solving e.g. the subset sum problem, then we would also be able to solve numerous famous optimization problems like the traveling salesman problem, general integer programming, and we would even be able to efficiently find mathematical profs of theorems, as stated in Cook [1].

In this paper, a new solution method of knapsack problem is given by an original approach, some problems are solved exactly by a polynomial algorithm. The class of exactly solved problems is shown and a method for version from approximate solution obtained exact solution is given.

22.2 Problem Statement

When constructing the new method we'll take three principles:

1. Definition of existence criterion of the integer point in the considered domain;
2. Construction of the sequence converging to the solution using the found point;
3. Definition of necessary and sufficient conditions for the found solution to be optimal.

22.3 Investigation of n-dimensional Cube

S is the set of vertex points of n-dimensional cube whose rib equals a unit, the vertex is on the origin of coordinate, the ribs originate from the origin of coordinates and are arranged on the coordinate axes. The set is equal to the set $x = 0, 1, j = 1, 2, \cdots, n$ [2].

Let's investigate the structure of n-dimensional cube and mathematical relations between its elements. When a rib of n-dimensional cube equals a unit, the coordinates of its vertex points consists of a unit and zero. The number of these vertices is $S = \sum_{k=0}^{n} C_n^k = 2^n$. For the indicated k the C_n^k number points are such that their K number coordinates consist of a unit, $n-k$ number coordinates consist of zero. The equation of planes holding these points is as follows:

$$x_1 + x_2 + \cdots + x_n = k;\ k = \overline{1, n-1}. \tag{22.7}$$

It is seen from Equation (22.7) that the planes holding the C_n^k number integer points are parallel to each other and these plane equations change only depending on the free term K in the right hand side. Denote these hyper planes by M_{nk}. $R_k = \sqrt{k}$ is the distance of these points from the origin. $d_k = \frac{k}{\sqrt{n}}$ is the distance of hyper planes M_{nk} from the origin, $o_{nkj} = \frac{k}{n}; j = \overline{1, n}$ is the center of a hyper circle located on hyper planes M_{nk} and holding the vertices of n-dimensional cube, contained in M_{nk}. $r_{nk} = \sqrt{\frac{nk-k^2}{n}}$ is a radius of this hyper circle. Denote by K_{nk} a hyper circle of a radius k_{nk} and center at the point O_{nk} located on the hyper plane M_{nk}. On each n-dimensional space we can group the set S being the vertices of n-dimensional cube with a rib equal a unit on parallel hyper planes M_{nk}, we solve problem (KP) on each K_{nk} and find general optimal solution. It is a general geometric principle. By solving the optimization problem considered in any domain we solve the problem in the parts whose unions equal to the domain, and intersections are empty sets, find optimal solution at each part, compare them and then find general optimal solution.

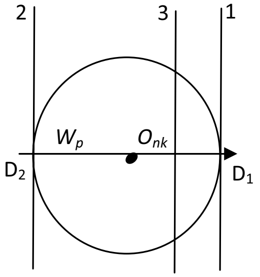


Fig. 22.1 $c > (W,D_1)$

22.4 Correlation of Constraint Hyper Plane and Hyper Circles

Let's study correlations of the constraint plane $M : \left\{\sum_{j=1}^{n} w_j x_j = c\right\}$ and hyper circle K_{nk}. Let's normalize the vector $W(w_1, w_2, \cdots, w_n)$ and denote it by W_n. $|W_n = 1|$ Find the projection of the vector W on the hyper plane M_{nk} and denote it by W_p, $W_p = W_n - (W_n, N_n) * N_n$. $N_n\{1/\sqrt{n}, 1/\sqrt{n}, \cdots, 1/\sqrt{n}\}$ are the normal of the hyper plane M_{nk}. One of the three relations between the hyper plane M and hyper circles K_{nk} is possible:

1. $c > (W, D_1)$ (Fig. 22.1). Here D_2 is the point obtained from the intersection of the straight line passing through the point O_{nk} in the direction W_p and the hyper circle K_{nk} and giving the maximum value to the inner product (W, X) on K_{nk}. In this case, any point lying on K_{nk} satisfies the constraint: $\sum_{j=1}^{n} w_j x_j \leq c$.
2. $c < (W, D_2)$. Here the points D_2 is the point obtained from the intersection of the straight line passing through the point O_{nk} in the direction W_p and giving the minimal value to the inner product (W, X) on the hyper circle K_{nk}. In this case none of the points located on the K_{nk} satisfies the constraint: $\sum_{j=1}^{n} w_j x_j \leq c$.
3. $(W, D_2) \leq c \leq (W, D_1)$. In this case either the hyper plane M intersects the hyper circle K_{nk} or touches it at the points D_1, D_2. In order to solve problem (KP) we solve it on each hyper circle $K_{nk} \subset M_{nk}$ and denote these solutions by X^*_{nk}.

$$\max_S \left(\sum_{j=1}^{n} p_j x_j\right) = \max_k \left(\sum_{j=1}^{n} p_j x^*_{nkj}\right).$$

In the first case the solution of the problem (KP) on the K_{nk} is found as follows. We give unit values to x_j corresponding to K number p_j taking the greatest value. To other $n-k$ number x_j we give zero value.

In the second case the problem has no solution on K_{nk}. In this case we don't look for the solution on K_{nk} and M_{nk}, respectively.

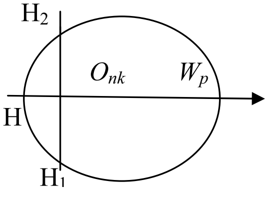
In the third case the solution of problem (KP) on K_{nk} is of special importance. The general solution of the problem reduces to its solution in the third case [3]. In the considered case, the domain for the solutions of the problem is a hyper arch being a part of a hyper circle. We express the hyper arch analytically in the following way

$$\begin{cases} \sum\limits_{j=1}^{n} p_j x_j \leq c \\ \sum\limits_{j=1}^{n} x_j = k \\ \sum\limits_{j=1}^{n} (x_j - o_{nkj})^2 = r_{nk}^2. \end{cases}$$

22.5 Criterion on the Existence of Integer Points on a Hyper Arch

In order to solve the problem we have to define the criterion on the existence of integer points on a hyper arch. By $X(n,k)$ we denote a set of integer points whose k number coordinates contained in the hyper circle K_{nk} equal a unit, $n-k$ number coordinates equal a zero. The hyper plane $M : \left\{\sum_{j=1}^{n} w_j x_j = c\right\}$ intersects the hyper circle lying on M_{nk} and divides it into two parts (Fig. 22.2).

Fig. 22.2 The hyper plane $M : \left\{\sum_{j=1}^{n} w_j x_j = c\right\}$ intersects the hyper circle lying on M_{nk} and divides it into two parts



The hyper arch H_1HH_2 satisfies the constraint $\sum_{j=1}^{n} w_j x_j \leq c$.

Let's give the criterium on the existence of even if one or none of these points on this hyper arch.

For this we find the $k-th$ minimum element among the elements of the vector W and denote it by w_{km}. We give unit value to the x_{1j} corresponding to the k-number w_j satisfying the condition $w_{km} - wj \geq 0$, the zero value to other $n-k$ number x_{1j}. Let's verify if the point $X_1(n,k)$ obtained in such a way satisfies the constraint

$\sum_{j=1}^{n} w_j x_j \leq c$. If the point $X_1(n,k)$ doesn't satisfy the constraint the problem (KP) has no solution in $K(n,k)$ and $M(n,k)$ respectively.

If$X_1(n,k)$ satisfies the constraint of problem (KP) has a solution in $K(n,k)$ and $M(n,k)$, respectively. $X_1(n,k)$ is a point or one of the points contained in $X(n,k)$ and giving the minimum value to the inner product (W,X).

So, we defined the criterium on the existence of integer point on a hyper arch [3].

22.6 The Construction of a Sequence Converging to the Solution on a Hyper Arch

Let's give analytic expression of the problem on a hyper arch:

$$\begin{cases} \sum\limits_{j=1}^{n} p_j x_j \to \max \\ \sum\limits_{j=1}^{n} w_j x_j \leq c \\ \sum\limits_{j=1}^{n} x_j = k \\ \sum\limits_{j=1}^{n} (x_j - o_{nkj})^2 = r_{nk}^2 \\ x_j = 0, 1. \end{cases} \tag{22.8}$$

Assume that the point $X_1(n,k)$ is determined by the existence criterium and is located on the hyperarch K_{nk}. We use this point and construct a sequence converging to the solution of problem (22.8). The terms of the sequence should satisfy the constraint and give strong monotonically increasing values to the functional.

1. Monotonity condition: take the first of the coordinates equal zero of the point $X_1(n,k)$ taking unit values p_i and p_j. $p_i - p_j > 0$.
2. Constraint satisfaction condition. Let's give constraint satisfaction condition for the indices i and j satisfying the monotonity condition. We calculate the difference $d = c - \sum_{j=1}^{n} w_j x_{1j}; d + w_j - w_i \geq 0$ is the constraint satisfaction condition.

$$\begin{cases} p_i - p_j > 0 \\ d + w_j - w_i \geq 0. \end{cases} \tag{22.9}$$

If condition (22.9) is satisfied, we accept $x_{1j} = 0; x_{1i} = 1$. The point $X_2(n,k)$ found in such a way increases the functional and satisfies the constraint and is located on K_{nk}.

We continue this process until the relation (22.9) is not satisfied between the indices i and j.

We conduct the process $k = \overline{1, n-1}$ for all K_{nk} to $k = \overline{1, n-1}$ find the points $X_{q(n,k)^*}$ compare the values that they give to the functional and find the solution of problem (KP). $Z^* = \max\limits_{k} \left(P, X_{q^*(n,k)}\right); k = \overline{1,n}; P(p_1, p_2, \cdots, p_n)$ is object vector.

22.7 Calculation Experiments

We compared the method by the following test problem and verified it.

$$\begin{aligned} Z = {} & 54x_1 + 68x_2 + 789x_3 + 65x_4 + 24x_5 + 35x_6 + 61x_7 + 42x_8 + 786x_9 \\ & + 43x_{10} + 512x_{11} + 424x_{12} + 321x_{13} + 11x_{14} + 4x_{15} + 47x_{16} \\ & + 35x_{17} + 56x_{18} + 12x_{19} + 754x_{20} + 55x_{21} + 457x_{22} + x_{23} + 65x_{24} \\ & + 74x_{25} + 22x_{26} + 4x_{27} + 45x_{28} + 12x_{29} + 5x_{30} + 57x_{31} + 57x_{32} \\ & + 23x_{33} + 54x_{34} + 2x_{35} + 42x_{36} + 77x_{37} + 78x_{38} + 682x_{39} + 142x_{40}. \end{aligned}$$

$$\begin{aligned} & 541x_1 + 786x_2 + 3541x_3 + 75x_4 + x_5 + 652x_6 + 843x_7 + 21x_8 \\ & +10x_9 + 40x_{10} + 46x_{11} + 51x_{12} + 752x_{13} + 810x_{14} + 510x_{15} + 21x_{16} \\ & +42x_{17} + 121x_{18} + 5x_{19} + 4x_{20} + 72x_{21} + 631x_{22} + 720x_{23} + 435x_{24} \\ & +2x_{25} + 820x_{26} + 64x_{27} + 73x_{28} + 770x_{29} + 43x_{30} + 85x_{31} + 912x_{32} \\ & +4x_{33} + 35x_{34} + 14x_{35} + 42x_{36} + 22x_{37} + 54x_{38} + 32x_{39} + 35x_{40} \le c_i; \\ & i = \overline{1,7}. \end{aligned}$$

c_i	999	2000	3000	5000	7000	8000	12000
Exact solution	4190	4749	4983	5330	5826	5899	6081
Obtained result	4172	4717	4983	5318	5826	5899	6081

As is seen from the table the obtained results are exact in the values c_3, c_5, c_6, c_7 and approximate in the values c_1, c_2, c_4. This fact shows that the absence of condition (22.9) between the coefficients p_i, p_j and w_i, w_j is necessary but not sufficient condition for the point to be an optimal solution on the K_{nk}.

Using experimental calculations, we can see that for large values of c_i we get exact solutions.

Denote $\sum_{j=1}^{n} w_j = \overline{S}$. In small values of $d_i = \overline{S} - c_i$ we obtain exact solutions. But for large values of the quantity d_i we get approximate solutions. Now, for $c_i = c_1$ show a method for finding the exact solution using the approximate solution of the obtained problem.

By f_k we denote the largest values of the functional on the hyper circle K_{nk}.

k	1	2	3	4	5	6	7	8	9	10	11	12	13
f_k	786	1540	2222	2734	3191	3615	3757	3835	3912	3986	4051	4105	4126
k	14	15	16	17	18	19	20	21	22	23	24	25	
f_k	3819	3872	3902	3926	3966	3969	4070	4094	4117	4129	4134	4136	

For the value $k = 13$, the functional takes a homogeneous peak value. $f_{13} = 4129$. For $k = 14$, it get the value $f_{14} = 3819$ and for the values $k = \overline{14,15}$ it again increases and becomes $f_{25} = 4136$. For $k > 25$, the restriction in the hyper circle K_{nk} as not satisfied. Majority of the coordinates contained in the peak point and taking a unique value are the coordinates contained in the optimal solution.

Constructing auxiliary problems for j taking a unique value in the peak point and where the quantity $\frac{p_j}{w_j}$ takes small value and for j with coordinates taking zero values in the peak we find other coordinates that participate in the optimal solution and take the values equal a unit.

Pass to the construction of the auxiliary problem.

Step 1. At first we sum the coefficients of variables taking a unit value in the first peak:

$$\sum_{j=1.x_j=1}^{n} w_j = 75+1+10+46+51+4+631+2+35+22+54+32+35 = 998.$$

Subtracting this number from c_1 we denote

$$d = c_1 - 998 = 999 - 998 = 1.$$

Step 2. We construct the following inequality corresponding to the coordinates taking zero values in the first peak:

$$\begin{aligned}&541x_1+786x_2+3541x_3+652x_6+843x_7+21x_8+40x_{10}+752x_{13}\\&+810x_{14}+510x_{15}+21x_{16}+42x_{17}+121x_{18}+5x_{19}+72x_{21}+720x_{23}\\&+435x_{24}+820x_{26}+64x_{27}+73x_{28}+770x_{29}+43x_{30}+85x_{31}\\&+912x_{32}+4x_{33}+14x_{35}+42x_{36}\le 1.\end{aligned} \tag{22.10}$$

Step 3. We calculate the ratio $\frac{p_j}{w_j}$ that corresponds to the coordinates taking a unit value in the peak. We add w_j that corresponds to this ratio to the right hand side of inequality (22.10). Such w_j are w_4 and w_{22}. At first let's construct in auxiliary problem that correspond to the coefficient:

$$\begin{aligned}&541x_1+786x_2+3541x_3+652x_6+843x_7+21x_8+40x_{10}+752x_{13}\\&+810x_{14}+510x_{15}+21x_{16}+42x_{17}+121x_{18}+5x_{19}+72x_{21}+720x_{23}\\&+435x_{24}+820x_{26}+64x_{27}+73x_{28}+770x_{29}+43x_{30}+85x_{31}\\&+912x_{32}+4x_{33}+14x_{35}+42x_{36}\le 76.\end{aligned}$$

It is clear that for this inequality to be satisfied in the zero and a unit value of the variable, in the left hand side, the x_j that correspond to coefficients greater than 76 must take a zero value. Giving zero to these coordinates, we get the following inequality:

$$\begin{aligned}&21x_8+40x_{10}+21x_{16}+42x_{17}+5x_{19}+72x_{21}+64x_{27}+73x_{18}\\&+43x_{30}+4x_{33}+42x_{36}+\le 76.\end{aligned}$$

We compose a functional that corresponds to x_j participating this inequality:

$$\begin{aligned} f = {} & 42x_8 + 43x_{10} + 47x_{16} + 35x_{17} + 12x_{19} + 55x_{21} + 4x_{27} \\ & + 45x_{18} + 5x_{30} + 23x_{33} + 2x_{35} + 42x_{36}. \end{aligned}$$

Subject to appropriate restriction we find the maximum value of this functional by the algorithm mentioned above.

$$f_{\max} = 126.$$

We calculate the increment that the auxiliary problem gives to the problem:

$$\Delta f_4 = 126 - p_4 = 126 - 65 = 61.$$

Thus, $\Delta f_{22} = 461 - 457 = 4$.

For the coordinates taking another unit values in the first peak $\Delta f_k \leq 0$. As Δf_4 gives the greatest increment to the functional we include the x_j taking a unit value to the solution and accept $x_4 = 0$.

The maximum value of the problem is $4129 = 61 = 4190$. The point $Y^* = (0,1,0,1,0,1,0,0,0,0,1,1,0)$ is the optimal solution of the auxiliary problem.

Replacing these coordinates by the coordinates of the initial problem, we get: $x_8 = 1, x_{10} = 0, x_{16} = 1, x_{17} = 0, x_{19} = 1, x_4 = 0, x_{27} = 0, x_{28} = 0, x_{36} = 0, x_{33} = 1, x_{35} = 1, x_{36} = 0$. The point $X^* = (0,0,0,0,1,0,0,0,1,1,0,1,1,0,0,0,1,0,0,1,0,1,0,0,1,0,0,0,0,0,0,0,1,1,1,0,1,1,1,1)$ is a point giving the optimal solution.

Now, express the scheme described above in a general form for the solution of (KP) problem.

1. We solve approximately the (KP) problem by the above mentioned method.
2. Constructing an auxiliary problem for the coordinates taking a unit value in the first peak, calculate Δf_q.
3. x_q satisfying the condition $\Delta f_q \leq 0$ takes a unit value in the optimal solution.
4. We choose $\max \Delta f_q$ among the x_q taking the unit and value $\Delta f_q \geq 0$. We give zero value to the x_q satisfying this condition. Include the coordinates taking a unit value in f_q that gives maximum value to $\Delta f_q \geq 0$ to the solution.

We continue the process until the assumption $\Delta f_q \leq 0$ is satisfied for each of coordinates taking a unit value. The point X^* obtained at the end of the process will be a solution of the problem.

Theorem 22.1. *For the obtained solution to be an optimal solution it is necessary and sufficient that for the coordinates taking a unit value $\Delta f_q \leq 0$.*

Proof of the necessity is obtained from the solution algorithm.

The sufficiency is obtained from $\Delta f_q \leq 0$. If this condition is satisfied, there is no increase of functional value.

The method given above gives more effective results for (SSP). Of exactly solved problems for (SSP) the taken examples is better than the results obtain for (KP) problems.

Example 22.1.

$$W = (41,7,6,35,45,51,71,81,12,13,42,26,37,45,59,60,70,80,87,90,92,127,150,35,18,17,60,64,63,77,66,27,21,83,70,77,140,141,38,39,5,23,29,35,47,57,68,77,83).$$

c_i	1225	1500	2000	2500	2700
Exact solution	1225	1500	2000	2500	2700
Obtained result	1225	1500	2000	2500	2700

22.8 Investigation of Difficulty Order of the Problem

To understand difficulty order we must consider the cycles contained in each other in the algorithm:

$$k = \overline{1,n-1};\ j = \overline{1,n};\ i = \overline{1,n};\ kk = \overline{1,n}.$$

The maximal number of embedded cycles is four.

Hence we proved polynomial property of the method and that its difficulty order a $O(n^4)$.

22.9 Conclusions

1. Geometric interpretation of domain of definition of the solution of combinatorial and discrete problems is given.
2. A method for reducing the solution of any linear integer programming problem to its solution on a hyper arch is given.
3. Existence criterion of this problem on a hyper arch is defined.
4. Using the initial point found on a hyper arch a method for constructing the sequence approximating to the solution is given.
5. Necessary condition for a found point to be an optimal solution on a hyper arch is given. This is an analytic condition. This can be easily checked by calculation. The difficulty order of the algorithm is polynomial.
6. Necessary and sufficient conditions for the found point to be an optimal solution of the found point are given. This condition is analytic.

References

1. Hans K, Ulrich P, David P (2004) Knapsack problems. Spinger-Verlag, Berlin
2. Mnhy M (1990) Mathematical programming. Moskva, Nauka
3. Aliyev M (2005) One approach to the solution of the knapsack problem. Reports NAS of Azerb 3:32–39

Chapter 23
Method based on Consistency Strength and PROMETHEE-II Multi-attribute Group Decision Making

Ge Ma and Jianzhong Chen

Abstract According to problems of multiple attribute of group decision making, it's the first time that we have put forward method based on consistency strength and PROMETHEE-II Multiple attribute of group decision making. First of all, The PROMETHEE algorithm can be used to obtain each decision-making information for each decision maker participating in decision making, and then the sequence vector relationship can be turned into reciprocal judgment matrix for each policy-maker decision-making information. After the details of the algorithm realization aggregate group decision information based on the consistency strength of nonlinear programming model are introduced. Finally, the algorithm is realized and the feasibility and effectiveness of the algorithm is validated through an example.

Keywords Group decision making · PROMETHEE-II · The priority function · Nonlinear programming

23.1 Introduction

Multi-attribute of group decision making problem is an important part in modern decision-making science, which has been widely used in sociology, economics, military science, management science and other fields [1]. The research of group decision making problems mainly focuses on the following three aspects: The first one is the consistency method of group decision making with different forms of preference information, but much research has been done and many meaningful results are reached [2–4] by the existing literature and has been made many significant conclusions; The second is delete the weights of experts in group decision making; The third is the method that aggregates group result from different expert decision-making information in group decision making, whose usual procedure is as follows:

G. Ma · J. Chen (✉)
Statistics School, Guizhou University of Finance and Economics, Guiyang 550004, P. R. China
e-mail: chen560513@yahoo.com.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_23,

Each expert gives a criterion for the judgment of information for individuals, then they synthesize the expert opinions by application of some methods, and they get the final decision information eventually. But in the actual process of group decision making, many scholars consider less the consistency between the group preference data. If others individual decision makers' opinions different from. Probably, the assembled group preference differs very far from the reality condition, no matter whether or not because he gets the information insufficiently, or due to because he thinks too much the subjective component, The recent references was mostly improved and integrated on the basis of he AHP method, fuzzy comprehensive evaluation method and other method of multi objective decision making and these methods also exist consistency of the judgment matrix difficult to meet rephrase which more or less influence evaluation results [5, 6].

With regard to the study of the consistency problem, Herrera et al [7] have studied the consistency problem of the preference structure of group decision making problems, and have proposed using the distance between the individual decision information and group decision making information to measure the degree of consensus. The consistency of the group decision making problems need to return the individual decision information different from the lager group to the specialist, judge them again, until they obtain consistent. Chen et al [8] established a multiple rounds of interaction approximation of satisfactory solution for multiple attribute group decision comprehensive method and use the extended TOPSIS method to evaluation and sort the decision scheme qualitatively in order to solve a class of model and analyses. And multi attribute group decision making problems that is difficult to solve. These methods are accurate and reliable, But they cost too much and need a long time in solving practical group decision-making problem. This is why this paper presents a kind of multi attribute group decision making method based on PROMETHEE. This method is used to get each decision-making information for each decision maker, and turn the decision-making information by the sequence vector relationship into reciprocal judgment matrix, then develop nonlinear programming model based on the consistency strength, and aggregate group decision information.

23.2 The Method and Principle of PROMETHEE-II

Brans proposed the method PROMETHEE based on the method of multiple attribute decision making with "values outranking relations" [9]. The decision makers give priority function, attributive value and attributive weight to determine the alternatives ranking through the precedence relationship.

In the PROMETHEE algorithm, considering t decision-makers $\{E_1, E_2, \cdots, E_t\}$ to evaluate n schemes $\{a_1, a_2, \cdots, a_n\}$ of the solution A under the m properties G_k $(k = 1, 2, m)$ to get each decision-making matrix $X = (x_{ij})$ $(i = 1, 2, \cdots, n;\ j = 1, 2, \cdots, m)$.

Definition 23.1. The prior intensity $F(d_{ij})$ of he scheme a_i and a_j in the properties of $G_k(k = 1, 2, \cdots, m)$ is the prior functions of an attributive value difference, such as formula shown below: $F_k(d_{ij}) = P_k(a_i, a_j) \in [0, 1]$.

The prior intensity of the scheme a_i related to the scheme a_j can range from the $F_k(d) = 0$ (undifferentiated) to the $F_k(d) = 1$ (strict priority). When $d \leq 0, F_k(d) = 0$. Brans provides 6 kinds of preference functioncommon criterion, proposed guidelines, standards with linear precedence relations, grading rules, linear precedence relation criterion with no difference in interval and the Gauss criterion respectively, each kind of preference function has a corresponding meaning and adaptive condition. According to the specific decision problem and decision maker's preference, also make their own prior functions. In six kinds of preference function, the criterion with linear prior relation is the most commonly used. In the criterion with linear prior relation:

$$P(d) = \begin{cases} d/m, & \text{if } d \leq m \\ 1, & \text{if } d > m. \end{cases} \tag{23.1}$$

The guideline allows decision makers' preference to increase linearly with d within m, when $d \geq m$ which is strictly better relations (the value of m can be determined by the maximum gap of the attribute values). According to the above the prior function combined with attributive weights ω^s decision makers agreed, you can define a formula of multiple attributive preference order index:

$$H(a_i, a_j) = \frac{\sum\limits_{k=1}^{m} \omega_k^s p_k(a_i, a_j)}{\sum\limits_{k=1}^{m} \omega_k^s}. \tag{23.2}$$

When aggregating multiple attributes to comprehensively judge, the degree can be defined to which the scheme a_i is superior to other solutions and the degree to which the scheme a_i is inferior to other solutions as outflow $\phi^+(a_i) = \sum_{j=1}^{n} H(a_i, a_j)$ and inflow $\phi^-(a_i) = \sum_{j=1}^{n} H(a_j, a_i)$ respectively through calculating outflow and inflow of every program. More obviously, as outflow is larger, the level of the scheme related to other solutions, and vice versa.

In the PROMETHEE-II, a prior relationship between schemes depends on the difference of the outflow and inflow, namely, net flow $\phi(a_i) = \phi^+(a_i) - \phi^-(a_i)$.

If the $\succ$ stands for superiority and the $\sim$ stands for equality, and the conclusion can be as follows: $a_i \succ a_j \Leftrightarrow \phi(a_i) > \phi(a_j)$ and $a_i \sim a_j \Leftrightarrow \phi(a_i) = \phi(a_j)$. The complete sorting of solution set can be obtained get according to the net size of the scheme.

23.3 Nonlinear Programming Model based on the Consistency Strength

Decision-making views of the various decision makers are obtained from PROME THEE-XX algorithm. As the result of this decision is ordering, therefore it is necessary to turn the order relation vector into reciprocal judgment matrix. the decision-makers order can be set relation vector $\overrightarrow{o_k} = (o_1, o_2, \cdots, o_n)$; $(k = 1, 2, \cdots, t,\ i = 1, 2, \cdots, n)$ is the ranking position of alternatives in all programs, so the reciprocal judgment matrix translated from ordering vector can be calculated by the Equation (23.3).

$$a_{ij}^k = 9^{v_i - v_j}, i, j = 1, 2, \cdots, n. \tag{23.3}$$

In the equation, $v_i = (n - o_i)/(n-1), v_j = (n - o_j)/(n-1)$. Set $\omega^f = (\omega_1^f, \omega_2^f, \cdots, \omega_n^f)$ as weight vector of alternative, in which $\omega_i^f \geq 0, i = 1, 2, \cdots, n$ and $\sum_{i=1}^n \omega^f = 1$. According to the nature of the reciprocal judgment matrix and the principle of decision optimization, the judgment of i and scheme j which from expert E_k should be met $\omega_i^f / \omega_j^f \approx a_{ij}^k, i,\ j = 1, 2, \cdots, n$.

The bias parameter is [10]:

$$b_{ij}^k = (\omega_i^f - a_{ij}^k \omega_j^f)^2. \tag{23.4}$$

According to the meaning of ω_i^f, ω_j^f and a_{ij}^k, the smaller of b_{ij}^k, the group decision result ω_i^f, ω_j^f of and the scheme of i and j from decision maker have closer relative importance degree judgment. Therefore, in the assembly planning ideas, that is in the case of total minimum deviation, we determine ω^f. From above, the objective function can be defined.

$$\min Z = \sum_{k=1}^t c_k \left| \sum_{i=1}^n \sum_{j=1}^n (\omega_i^f - a_{ij}^k \omega_j^f)^2 \right|.$$

Although there is no demand on consistency to individual decision making, the consistency strength requirements is critical in the group decision making. Therefore, after developing total deviation minimum as the target and aggregation of expert opinion, we need constrain the consistency when structure nonlinear programming model. Set the consistency intensity of participation in decision-making expert group is η_{ij}^k, which express expert judgment and final results on the relative importance of the scheme and consistent intensity. The greater of η_{ij}^k, groups' requirements on the consistency of the results are more intense. Under the principle of optimal group decision making.

Set $\eta_{ij}^k = (2t - 1)$, the constraint conditions based on consistency strength can be obtained.

$$\left| 1 - \frac{1}{2(t-1)} \right| a_{ij}^k \leq \frac{\omega_i^f}{\omega_j^f} \leq \left| 1 + \frac{1}{2(t-1)} \right| a_{ij}^k.$$

So nonlinear programming model is established as:

$$\min Z = \sum_{k=1}^{t} c_k \left| \sum_{i=1}^{n} \sum_{j=1}^{n} (\omega_i^f - a_{ij}^k \omega_j^f)^2 \right|$$

$$\text{s.t.} \begin{cases} \sum\limits_{i=1}^{n} \omega_i^f = 1 \\ \omega_i^f \geq 0, i = 1, 2, \cdots, n \\ \left| 1 - \frac{1}{2(t-1)} \right| a_{ij}^k \leq \frac{\omega_i^f}{\omega_j^f} \leq \left| 1 + \frac{1}{2(t-1)} \right| a_{ij}^k \end{cases} \tag{23.5}$$

The model reflects in the group decision-making process, assembly decisions for the gathering of information are based on consistency strength. In which a_{ij}^k express the judgment information of the k expert.

To sum up, the method based on the consistency strength and PROMETHEE-II multiple attribute group decision making includes steps as follows:

Step 1. According to the specific problem of multiple attribute decision-making, we give the decision matrix of decision makers based on evaluate each attribute;

Step 2. Choose the right priority function, and use PROMETHEE-II algorithm to calculate various scheme about “outflow” and “inflow”;

Step 3. Calculate the net flow of each scheme to get the scheme sort of each decision makers;

Step 4. Transform ranking of the various decision makers from sequencing vector to reciprocal judgment matrix;

Step 5. Establish non-linear programming model based on consistency strength;

Step 6. Solve the nonlinear programming model, aggregate group decision making information, and get the scheme final ranking.

23.4 Data Example

Based on literature [11] the proposed judgment of information from 5 alternatives as an example. A city plan is to build a city library, in the process they need to consider what kind of air conditioning system installation. Builder provides 5 options $(a_1, a_2, a_3, a_4, a_5)$, suppose there are 3 experts (E_1, E_2, E_3), the weight of three experts is given as $w^e = (0.2, 0.5, 0.3)^T$. For the air conditioning system considering 8 attributes: G1 (Purchase cost (Yuan)), G2 (Operation cost (Yuan)), G3 (Effect (0-1 Scaling)), G4 (Noise level (DB)), G5 (Convenient maintenance (0-1 Scaling)), G6 (Reliability (Percentage scale)), G7 (Flexibility (0-1 Scaling)), G8 (Security (0-1 Scaling)). The G1, G2, G4 is an attribute of cost, remaining 5 attributes are benefit. Suppose the expert compare these attributes one to one. The weight of attribute obtained by AHP method is $\omega^s = (0.11, 0.09, 0.11, 0.12, 0.18, 0.16, 0.10, 0.13)$ [12].

Evaluate and arrange the 5 alternatives according to the following steps:

(1) Conclude the decision-making matrix by evaluate the attribute of decision prob-

lem;

(2) Standardize each decision maker matrix, get standard decision matrix;

Table 23.1 Table of function with the linear precedence relation criterion

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
$m(E_1)$	2.50	0.40	0.37	1.00	.037	0.21	0.44	0.33
$m(E_2)$	1.00	0.60	0.33	1.00	.058	0.26	0.56	0.44
$m(E_3)$	1.00	0.60	0.40	0.81	.044	0.15	0.47	0.33

Table 23.2 Inflow, outflow and netflow table of makers $E_1 \sim E_3$

		a_1	a_2	a_3	a_4	a_5
E_1	ϕ^+	0.9098	0.6238	0.7839	1.4052	0.9769
	ϕ^-	0.7523	1.9643	0.8962	0.4884	0.6694
	ϕ	0.2285	−1.3405	−0.1123	0.9168	0.3075
E_2	ϕ^+	0.8577	0.6900	0.7664	1.2079	1.1973
	ϕ^-	1.3160	1.2803	0.9763	0.3866	0.7599
	ϕ	−0.4583	−0.5903	−0.2099	0.8213	0.4374
E_3	ϕ^+	1.2024	0.5711	0.8596	1.0285	1.4297
	ϕ^-	0.8762	1.8689	0.9986	0.8399	0.5077
	ϕ	0.3262	−1.2978	−0.1390	0.1886	0.9220

(3) Determine the precedence function and m value of each attribute;

(4) To calculate decision makers $E_1 \sim E_3$ “inflow” and “outflow” of each scheme.

From this table get the sort of scheme, for decision maker $E_1 : a_4 \succ a_5 \succ a_1 \succ a_3 \succ a_2$; for $E_2 : a_4 \succ a_5 \succ a_3 \succ a_1 \succ a_2$; for $E_3 : a_5 \succ a_1 \succ a_4 \succ a_3 \succ a_2$.

(5) Translate various decision makers’ sequencing vector into reciprocal judgment matrix in accordance with the Equation (23.3):

$$A^1 = \begin{bmatrix} 1.0000 & 3.0000 & 1.7321 & 0.3333 & 0.5774 \\ 0.3333 & 1.0000 & 0.5774 & 0.1111 & 0.1925 \\ 0.5774 & 1.7321 & 1.0000 & 0.1925 & 0.3333 \\ 3.0000 & 9.0000 & 5.1962 & 1.0000 & 1.7321 \\ 1.7321 & 5.1962 & 3.0000 & 0.5774 & 1.0000 \end{bmatrix},$$

$$A^2 = \begin{bmatrix} 1.0000 & 1.7321 & 0.5774 & 0.1925 & 0.3333 \\ 0.5774 & 1.0000 & 0.3333 & 0.1111 & 0.1925 \\ 1.7321 & 3.0000 & 1.0000 & 0.3333 & 0.5774 \\ 5.1962 & 9.0000 & 3.0000 & 1.0000 & 1.7321 \\ 3.0000 & 5.1962 & 1.7321 & 0.5774 & 1.0000 \end{bmatrix}.$$

$$A^3 = \begin{bmatrix} 1.0000 & 5.1962 & 3.0000 & 1.7321 & 0.5774 \\ 0.1925 & 1.0000 & 0.5774 & 0.3333 & 0.1111 \\ 0.3333 & 1.7321 & 1.0000 & 0.5774 & 0.1925 \\ 0.5774 & 3.0000 & 1.7321 & 1.0000 & 0.3333 \\ 1.7321 & 9.0000 & 5.1962 & 3.0000 & 1.0000 \end{bmatrix}.$$

(6) Based on the group consistency intensity and the weight of the decision maker, group decision making information by use of the above nonlinear programming model is aggregated according to the following steps, MATLAB is used to solve the nonlinear programming model:

- Define parameters first $A_{eq} = [1,1,1,1,1]; b_{eq} = 1; A = []$;
- Options = optimset('Algorithm', 'interior-point');
- Run interior-point algorithm $b = zeros(150,1); [\omega, \text{fval}] = \text{fmincon}$ $(@(\omega) ff\text{fun}(\omega))$.

According to the MATLAB calculation results obtain the final solution sort of group decision: $G\,a_4 \succ G\,a_5 \succ G\,a_3 \succ G\,a_1 \succ G\,a_2$.

23.5 Conclusion

This paper presents and achieves a kind of group decision making method with multiple attribution. Firstly, establish a assigned value relationship based on the "conventional criterion" by using the PROMETHEE-II method, then calculate the "outflow" and "inflow" and "netflow" of each scheme, then get the sorting of each scheme that each decision-maker makes according to the net flow. Next we can convert each decision-maker's ordered value vector relationship into reciprocal judgment matrix and establish nonlinear programming model based on consistent strength, then assemble a final decision result. We compare the nal results with the unanimous decision results that the application of iterative algorithm achieved in the literature [11], nding the final ranking is consistent, which shows that our algorithm-solving the group decision-making problems with multi attribution based on consistent strength and PROMETHEE algorithm is feasible and valid. At the same time, an approach that this paper proposes is easy to calculate and achieve by computer, then we can develop corresponding strongly operable system that a group decision-making supports. Future study will be in the development and promotion of the system that a group decision-making supports.

Acknowledgements This research are partly supported by the Guizhou Education Natural Science Foundation (No. 2007045) and the national Science Foundation for distinguished Young Scholars (Grant No. 70425005)

References

1. Liu S, Lin Y (1998) An introduction to grey system: Foundations, methodology and applications. IIGSS Academic Publisher, Pennsylvania
2. Guo C, Guo Y (2004) A different kind of preference information to target group decision-making method. Sichuan Institute of Technology Journal 23:54–56 (In Chinese)
3. Guo C, Guo Y (2005) Properties with different forms of preference information in group decision making method. System Engineering and Electronics 27:63–65 (In Chinese)
4. Xu Z (2002) An integrated approach of the four types of preference information in multiple attribute decision making. Systems Engineering-Theory practice 11:117–120 (In Chinese)
5. Liu Y, Yang S et al (2002) The method for constructing judgement matrix based on Rough Set theory method. System Engineering Journal 17:182–187 (In Chinese)
6. Liu R (2007) The research of multiple attribute complex huge group-decision methods based on clustering algorithm. PhD thesis, Central South University (In Chinese)
7. Enrique H, Herrera F, Chiclana F et al (2002) A consensus model for multiperson decision making with different preference structures. IEEE Transaction on Systems, Man and Cybernetics-Part A: Systems and Humans 32:394-402
8. Chen J, Xu J (2008) The method an the application of the interactive TOPSIS group decision making. Journal of Systems Engineering 276–281 (In Chinese)
9. Yue C (2003) Decision theory and method. Science Press, Beijing (In Chinese)
10. Sun X, Tian P (2008) The expert opinions aggregation method based on consistency strength in group decision making. System Engineering and Electronics 1895–1898 (In Chinese)
11. Yoon K (1989) Thepropagation of errors in multiple-attribute decision analysis: A practical approach. Journal of Opeational Research Society 40:681–686
12. Shen F, Chen J (2011) An multi attribute group decision making method based improved ELECTRE-III. In: Proceedings of the Fifth International Conference on Management Science and Engineering Management

Chapter 24
Based on the Teaching Module in Intelligent Tutoring System

Xinhua You, Gang Liu, Wenjia Long and Zhibin Pan

Abstract In this paper, the intelligent tutoring system and the function of each module, the design ideas of the method of teaching modules on the core module, the function of teaching strategies, the choice of teaching strategies and teaching decision-making algorithm is described, that the best teaching decision-making algorithm is intelligent tutoring system core, building methods and the important position of the modular design of teaching strategies, and adopt a forward reasoning and backward reasoning, teaching decision-making, come to the important position of conclusion of the teaching module in intelligent tutoring system.

Keywords Intelligent teaching systems · Teaching modules · Teaching strategies

24.1 Introduction

In many areas of computer science, artificial intelligence (based Artificial Intelligence, AI) is undoubtedly the most challenging and creative [3]. Accompanied by the birth and development of artificial intelligence, artificial intelligence in the field of education has been widely used, and education, the teaching process to produce a profound impact [5]. With the maturing of the artificial intelligence technology [6], intelligent tutoring system in the teaching field will gradually realize the teaching module in intelligent tutoring system is proposed a new way of thinking and ideas [1]. In the second part gives the module structure and its description of the intelligent tutoring system; third part describes the tertiary structure of the teaching

---

X. You (✉) · G. Liu · W. Long
Zhixing College, Hubei University, Wuhan 430011, P. R. China
e-mail: yxh687273@163.com

Z. Pan
Department of Electronics and Information Engineering, Huazhong University of Science and Technology, Wuhan 430074, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_24,

modules [7], teaching strategies and teaching decision-making algorithm and summarizes the advantages of the algorithm; Part IV summarizes the teaching modules mature and perfect, the importance of intelligent tutoring system applications, and discuss the prospects of the application of intelligent tutoring system [2].

24.2 Intelligent Tutoring System

Intelligent tutoring system is the product of artificial intelligence technology and teaching, the learning environment to guide students in a particular subject area, according to students 'learning behavior in the students' learning process dynamic formation of the interaction of teaching. Intelligent teaching system did not reach a completely practical level, but it is an important role in the teaching of intelligent tutoring system has formed a basic consensus, we are conducting individual guidance in any form, requires the instructor has the discipline domain knowledge, able to understand students and to make instructional decisions based on students' learning behavior, the way to send students to easily accept the teaching content, intelligent tutoring system, the expert module, student module [8], teaching module and interface module completed, its structure is shown in Fig. 24.1.

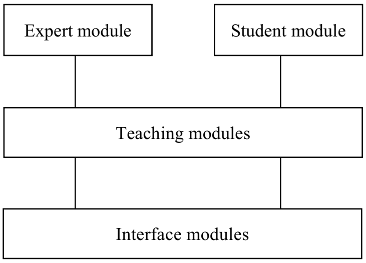


Fig. 24.1 Intelligent tutoring system

This system, the expert module is an expert system to teach the subject, its knowledge base is stored in the disciplines of knowledge (expert knowledge), the expert module is run within the scope of the subject areas to take advantage of the knowledge in knowledge topics required for the content generated by the rules, expert knowledge can be dynamically provided to the teaching modules, specifically, the expert module has two functions, one to generate questions, answers and explanations, then the role of the expert module is to serve as resources to teach the courses; the second is involved in the evaluation of students' learning behavior, then the role of the expert module is to act as evaluation criteria in order to accurately evaluate the students' learning behaviors, the expert module must be able to generate for each subject the correct answer to the path and detailed evaluation criteria, then the role of the expert module to act as evaluation criteria in order to accurately evaluate the students' learning behavior, the expert module must be able to generate for each subject the correct answer to the path and detailed evaluation criteria.

The student module is an expert system, stored in its knowledge base the students' various learning behavior. The role of the student module is to identify student learning characteristics, diagnostic methods, namely the establishment of a student model. Specifically, student module to complete two tasks, one is the wrong identification of students, identify students what kind of misunderstanding or lack of what kind of skills thus resulting in the error answer; the other is the interpretation of student behavior, namely, that the students error generation process.

The interface module's role is to deal with students with information exchange between systems. The teaching module is also an expert system, it is at the core of intelligent tutoring system.

24.3 Teaching Modules

In intelligent teaching systems, teaching modules to guide the capacity of the system. The interaction of CAI courseware, teaching strategies and course content together, to reflect the branch of teaching, doing so is the lack of a teaching content can only be a one (or several) fixed teaching strategies to teach. In intelligent teaching systems, teaching strategies and course content are separate, so that in the teaching process, the system may at any time according to the needs of teaching, different teaching strategies, teaching decision-making generated showing which part and how to send, teaching module is designed to accomplish this task.

The role of the teaching modules is a model of student teaching content and student module generated by the expert module generated for comparison to identify the students lack of knowledge, and then use the knowledge base of teaching strategies to generate instructional decisions. Stored in its knowledge base teaching strategies, teaching strategies are three levels [3]: first, second and third stages, shown in Fig. 24.2.

Teaching strategies

The first level: Planning	Second level: individual activities	Thethird level: the interaction
Select the sub-goals Select topics Select teaching module series Select guidance level (general, medium, advanced, etc.)	Participation in the learning process To end an activity	Choice of teaching media Explanation Remedy Manage unexpected situations Activities carried out in the guidance Select examples

Fig. 24.2 Intelligent tutoring system

Teaching modules to make instructional decisions, first determine what level of teaching strategies and instructional decisions based on the level of teaching strategies as well as expert module and student module generated for teachers to make instructional decisions is a very delicate matter, because there are many factors which are difficult to express. Of course, there are certain laws.

24.3.1 Functions of Teaching Strategies

Teaching modules deal with different students take different teaching strategies to guide student learning, teaching strategies consisting of general rules of operation by a variety of teaching, its main function is reflected in the following points:

- According to the student model to reflect the selection and generation problems, so students can answer;
- Provide individual guidance and explain;
- Adjust teaching procedures;
- The organizational arrangements for the teaching content;
- Diagnose students 'errors, and pointed out that the students' error types based on the results presented review materials and remedial measures, when the system enters the teaching status, it can provide a good learning environment: presentations, the practice test.

24.3.2 Selection of Teaching Strategies

Different teaching modules focused on different and difficult, teaching strategies should be individualized, and when to choose which level of teaching strategies, which require experience. To this end we use different teaching programs to guide the teaching of students of different levels. We have chosen the basic steps of teaching strategies can be described the method level [4]:

```
Production rules to select the teaching strategies in the form:
    IF (teaching content)
       AND (student model)
    THEN (generate teaching strategies)
Specific such as:
    IF (teaching content) = (low)
        AND (requiring a lower level of the student model)
    THEN (teaching strategy selection for the general)
    IF (teaching content)> = ()
        AND (student model requirements)> = ()
    THEN (teaching strategy selection medium)
    IF (teaching content) = (H)
        AND (the requirements of the student model) = (H)
    THEN (teaching strategy selection is higher)
```

24.3.3 Teaching Decision-making Algorithm is Described

Based on the characteristics of teaching, you can use forward reasoning I and backward reasoning II level [2] for teaching decision-making, achieve positive reasoning I, first extracts the student module, knowledge base and knowledge base of expert modules characteristic parameters, and then compare the knowledge base and teaching strategies to identify the best teaching strategies (three extraction), the final instructional decisions. Currently: student module Knowledge in SDB1 knowledge base of expert modules for EDB2 Knowledge of teaching strategies for TDB3, the algorithm can be described as follows:

```
Procedure Date_Drive (TDB3, SDB1, EDB2)
BEGIN
    $S$ ←ScanFirst (TDB3, SDB1, EDB2);
    ScanFirst function does is to search teaching strategy library;
    If found eligible teaching decision-making, and make Solving_flag flag is set;
    While (NOT ($S = \Phi$)) AND Solving_flag = 0 Do;
            If it finds more than one teaching decision-making, into the circulation
                $R$: = Conflict_Resolution ($S$);
                Conflict resolution, elect a priority of the highest teaching decision-making
                Excute the ($R$);
                Elect the operating part of the teaching decision-making
                $S$ ← ScanFirst (TDB3, SDB1, EDB2);
                Call ScanFirst function to find the next instructional decisions
    EndWhile
END
```

Use the teaching strategies of this algorithm can be divided into different priority, and then the priority order from highest to lowest organize teaching decision-making to ensure that each elected by teaching decision-making with the highest priority, this algorithm can be for a knowledge The point of the implementation of a variety of instructional decision-making, in order to better help the students' understanding of the knowledge points.

To achieve backward reasoning II, took the initiative to the intelligent tutoring system applies to students to want to learn a knowledge of the teaching process, in this teaching process, teaching decision-making to the students a knowledge point to assume that the target (*M*) Knowledge of teaching strategies (TDB3) to identify the set of all pre-order knowledge (*A*), in the Student Module Knowledge Base (in SDB1) to find out the knowledge of all pre-order learning situation, if the pre-order learning of knowledge The situation does not meet the requirements, while the points come to teaching decision-making as the goal reverse reasoning, the algorithm can be described as follows:

```
Procedure Goal_Drive ($M$, TDB3)
Scan (TDB3, $M$);
Search for pre-order knowledge of the point set $A = \{A_1, A_2,$ of $A_n\}$
The if ($A = \Phi$) OR (all ($A$) $\geq$ pass) then
    If the pre-order set of points is empty
        Date_Drive (SDB1, TDB3, $M$);
        You learn the target knowledge points $M$
    Else
        A collection of pre-order knowledge is not empty
        While i;
                Inspect each pre-order knowledge
                Goal_Drive ($A$, TDB3);
                The recursive call Goal_Driv process, learning the knowledge
                Endif
        Endwhile
    Endif
END
```

24.4 Conclusions

Teaching module in intelligent tutoring system, we can easily find that it is the soul of intelligent tutoring system, the development of teaching modules and a direct impact on the development of intelligent tutoring system, with the development of the Internet, teaching modules will also be further improved on the future and development of intelligent tutoring system to play a greater role in promoting the teaching of intelligence will also be further improved.

References

1. Lu YJ (2009) Artificial intelligence (volume). Science Press, Beijing (In Chinese)
2. Sun P (2010) Computer aided instruction. Inner Mongolia University Press, Hohhot (In Chinese)
3. Wang YC (2010) Artificial Intelligence — the principle method. Xi’an Jiaotong University Press, Xi’an (In Chinese)
4. WU QY (2010) Artificial intelligence and expert systems. National Science and Technology University Press, Beijing (In Chinese)
5. Wang WS (2009) Artificial intelligence theory and its application. Publishing House of Electronics Industry, Beijing (In Chinese)
6. Bruce Eckel (2007) The thinking In Java. Machinery Industry Press, Beijing
7. Chen Y (2006) Yao Xiaokun compiled Java programming experiment guidance. Tsinghua University Press, Beijing (In Chinese)
8. Schidt H (2006) Java reference Yanai Lan Deer River spring translation. Tsinghua University Press, Beijing

Chapter 25
Value-added Performance Contract — A Business Mode of Sharing from Consumer's Added Value

Yongjun Tang and Xiaoguo Xiong

Abstract The global competition and demanding customers require organizations to look more outward toward customers, as indicated by the many calls for organizations to compete on superior customer value delivery. Value-added performance contract (VaPC) is a business mode which is popular in telecom services sector in many developed countries, like Japan and USA. Under the VaPC, telecom service providers created added value for the telecom operators, and then shared a certain percent from the added value of the telecom operators in certain percentage that is agreed and stipulated in the contract. By adopting such mode, the value-added service provider companies provide a whole package of integrated value-added services for the clients, and then share the added profits with the clients according to the contract. For clients, there investment and risks are largely reduced while the value-added service provider companies could easily develop a niche market and enjoy high profit margins. This article presents frameworks for thinking about customer value, customer value learning, and the related skills that managers will need to create and implement superior customer value strategies.

Keywords Value-added Performance Contracting · Value-focus thinking · Energy service companies (ESCo) · Added value

25.1 Introduction

Driven by global competition, slow-growth economies and industries and more demanding customers, many companies are forced to search for new ways to achieve

---

Y. Tang
Baise University, Baise 533000, P. R. China

X. Xiong (✉)
Business School, Guangxi University, Nanning 530004, P. R. China
e-mail: evia@vip.sina.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_25, © Springer-Verlag London 2013

and retain a competitive advantage. In the past, people attempt to look internally within the companies for better competences. The global competition and demanding customers require organizations to look more outward toward customers, as indicated by the many calls for organizations to compete on superior customer value delivery Journal of the Academy of Marketing Science Value-added Performance Contracting (VaPC) refers to a kind of business mode in which the value-added service providers sign contracts with the clients on value-added services, provide a whole package of integrated value-added services for the clients, and share the added profits with the clients during the term of the contract in order to recoup its expenses and gain profits. The process of the value-added services include: potential analysis, engineering and designing, financing, purchasing, plan implementation, monitoring and maintaining, evaluating and calculating of the profits and staff training. Of all the items, "financing"can be in the charge of the value-added service companies by offering the funds, or in the charge of the clients, while the value-added service companies give assistance to them. And the evaluating and calculating of the added profits is under the charge of both the value-added service companies and the clients (or authorized intermediate agents).

This article firstly establishes some basic definitions that are often used in Value-added performance contract and the general model of such services. The current adoption of VaPC in telecom sector as well as other sectors is then be discussed. After that, the advantages as well as some implied problems of such business mode are concluded in this article. The implementation of VaPC is then analyzed and generalized. The main contribution of this article is to promote a new business mode which has been widely used in telecom industry in developed countries to China, especially in energy saving industry and other services industries.

25.2 Some Basic Definitions in VaPC

In the practice of the telecom value-added services, EPC and the VaPC of other industries, both the exceeded information fees and the saved energy and sewage disposal costs bring benefits to the enterprises, and the added profits are shared by both sides. Thus, by an extension of that logic, a brand new business mode, the mode of VaPC, is pushed forward.

Added value refers to the added value or saved costs in the value chain of the client companies through the value-added services provided by value-added service companies. Usually, there are two ways of adding value:

One is to increase the price directly. It includes: (1) to increase the price of the products. By advanced techniques, new functions are added to the products or the original functions are improved, or the quality is enhanced, or the appearance is beautified, so that the value of the products is increased which result in the increase of the price. Or, the price of the products is increased by any other possible way; (2) to expand the scope of services. Base on the clients? platform, the value-added service companies satisfied the customers with new attracting services. Taking the telecom value-added service mode as an example, while seen from the perspectives of the clients' consumers, it is the clients who provide them with the services.

The other is to cut down the costs, for example, the EPC mode and the mode of shared sewage disposal cost, which is actually has the value of the product increased indirectly.

Value-added Service Provider is a professional company that provides a whole series of integrated value-added services for the clients, and recoups its expenses and gains its profits by sharing the added profits with the clients. Added profits include the economic benefits of the development of the clients value chain and saved costs.

According to definition of VaPC, its general model is: the value-added service companies provide a whole package of integrated value-added services for the clients, and then share the added profits with the clients according to the contract, just like what is showed in Fig. 25.1.

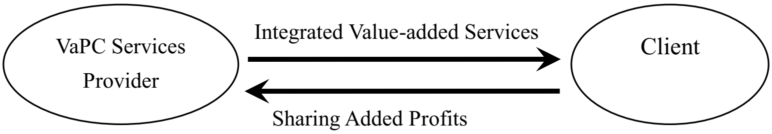


Fig. 25.1 The general model of VaPC

25.3 The Practical Origin of VaPC

Cooperated with many service providers (SP for short, referring to those developers that deal with mobile internet applications), NTT DoCoMo, the biggest mobile communication corporation in Japan, brought out various wireless internet value-added services with a brand cell phone — "i-mode" Those services cover net-surfing, comics, online music, online games, karaoke, picture-downloading, individual animal signs and corresponding constellations, and movie trailers, and so on. Such services created a new business mode: service providers offer telecommunication value-added services to the clients through telecommunication networks and other apparatus of NTT DoCoMo Inc. The fees would be charged by NTT DoCoMo and be divided into proportion to 9:91, namely 9% of the fees go to NTT DoCoMo as service charge and the remaining will go to the service providers. The business mode has achieved the great success and almost everyone in Japan has a mobile phone of "i-mode" Consequently, the business mode soon spread to other countries, including China.

The case mentioned above is a typical one on value-added performance contract (VaPC): the service providers created added value for the telecom operators (clients), and then shared a certain percent (91%) from the added value of the telecom operators in a way of VaPC.

25.3.1 The Value-added Service Mode in Telecom Industry

The telecom value-added service mode is one type of business mode [1] in which the telecom operators, as the client of VaPC, offer platforms of telecom services as value basis, the VaPC service companies, as services providers of VaPC, offer services that create added value, and both parties gain their share of benefit from the added value according to the VaPC contract.

Vodafone Co., a famous British telecom operator, has also adopted the VaPC mode to provide their services to mobile phone users. Cooperated with the top service providers of different fields, Vodafone Co. put forward various value-added services to the mobile communication users. The relevant income was jointly shared by Vodafone Co. and the cooperative companies. In 2003, it cooperated with Microsoft in the field of mobile network service; in 2006, cooperated with Google, the search giant, to provide mobile search service to the "Vodafone live" users, and formed strategic alliances with Yahoo to promote mobile advertisement; and in 2007, cooperated with YouTube to launch cell phone video services, as well as cooperated with eBay to step into the field of E-business.

In China, the application of VaPC has also gain some popularity. "Monternet" originated from the "Monternet Business Plan" brought out by Guangdong Mobile Communication Corporation (GMCC) after it had followed the "i-mode"business mode of NTT DoCoMo. The word "Monternet" is the blend of "Mobile" and "Internet" Meaning "a mobile and open internet", "Monternet" is now the representation of the merging of mobile communication and internet in China. In October, 2000, GMCC took the lead to come out with the idea of "Monternet Business Plan" and signed contracts with its first three service providers in 2001. By November, 2001, GMCC's monthly balanced information fees had surpassed 100 million RMB. Based on the successful experience of GMCC, China Mobile brought the united brand of mobile data services-"Monternet" to the whole country. "Monternet"covers various diversified telecom value-added services, such as SMS, MMS, CRBT, WAP, Mobile Newspaper, JAVA Services (cell phone games), Fetion, and Central Music Platform, and so on. Learning from the business mode of "I-mode" "Monternet" took advantage of China Mobile's network resources, application supporting platforms, marketing networks, advertising networks, and user resources, and then launched various telecom value-added services offered by many service providers. Taking advantage of its own billing and accounting system, China Mobile charged the service fees in place of the service providers, and gained service charge from the service providers. China Mobile and the service providers shared the SMS fees of value-added services to the proportion of 15:85. In 2003, China Unicom and China Telecom also adopted the business mode of telecom value-added services, respectively pushed forward their own united brand on data services, namely the "U-max" and the "Vnet".

25.3.2 The Value-added Service Mode in Energy Saving Industry: EPC

Energy Performance Contracting (EPC), is one type of market-oriented energy saving mechanism and business operating mode [2]. In this mode, the energy service companies (ESCo) sign contracts on energy saving service with the clients (proprietors) and provide series of services for the clients (proprietors).

Energy service companies (ESCo) are market-oriented and profit-driven enterprises with EPC mechanism as its major business model. In order to implement the project with the EPC contract and to provide the clients with one-stop energy saving services, the energy service companies will closely work together with other market players, involving banks, guarantee companies, design institutes, equipment providers, engineering companies, and insurance companies, etc. In practice, the types of EPC mode are listed as followed:

1. Shared Savings. Offering the financing and services of the whole project, ESCo implement the project with the cooperation of the clients, and share the savings with the clients according to the proportion agreed in the contract. After the contract expires, the energy savings and ownership of the project belong to the clients. During the whole project, the cash inflow of the clients is positive [6].
2. Guaranteed Savings. Both the clients and the ESCo are allowed to invest the project. As the major investor, clients will obtain a certain amount of energy savings guaranteed by the ESCo. The ESCo will make up for the gap between the real amount of energy savings and the guaranteed amount. On the other hand, both sides will share the exceeding parts of guaranteed energy savings until the ESCo can recoup all investments and gain due profits. After the contract expires, the apparatus are in the charge of the clients and the afterwards energy saving profits belong only to the clients.
3. Chauffage. The ESCo are entrusted by the clients with the modification and operation of the energy system as well as pay for the costs. The ESco will reduce the energy costs (with the additional management fees deducted) by increasing energy efficiency, and enjoy all or part of the energy costs saved according to the contract.

25.3.3 VaPC Practice in Other Industries

As a matter of fact, in reality, there are many other industries that apply the VaPC mode in practice in addition to the industries of telecom and energy service. These industries focus on creating added value, which is the extra value beyond the basic value, for the clients and then share from the added value profit according to the contract [3]. For example, there is a sales agent mode in the real estate industry. In the mode, the agent will sign contracts with the real estate agencies and have the allocation proportion of the added value settled if he thinks that he is able to sell the houses in a price higher than that of the agency. After the houses are sold, the added profit will be divided according to the proportion agreed in the contract. In the ornamental plants industry, some specialized horticultures work on the value-added services on potted landscape. Being cultivated and conserved for a period of time, the price of the potted landscapes increased markedly, so the specialized horticultures can share from the added sales revenue in accordance with the settled proportion. In the sewage treatment industry, the sewage treatment enterprises sign contracts with the proprietors on helping them to modify the production or sewage disposal equipments and purify the sewage into reclaimed water, which save the proprietors the penalties, so that the enterprises can share from the expenses saved from the penalties. Besides, the sewage treatment enterprises may explore some beneficial materials during their dispose of the sewage water, such as organic fertilizer and precious metal. While in the internet industry, Sina.com brought the "profit-sharing" system to the blogs. In the system, the bloggers accept the user agreements voluntarily, and advertisements provided by Sina.com will turn up on the screen of their blogs. The profits from the advertisements will be calculated according to the times that the advertisements shown, and will be shared by the bloggers and Sina.com in the proportion of 50:50 stipulated in the agreement after the operating costs is deducted. Besides, forming alliances with the video sites such as Sohu.com, Tudou.com, PPS and UITV, Baofeng.com provides videos, such as movies, TV series and DIY videos, etc., for the video sites, and it will share the profits from the advertisements with the video sites. A fourth example is in the tourist industry, where the self-employed rent the amusement facilities, such as ATV, to the tourists in the hotels, have the hotels to charge the fees in place of themselves, and share the income with the hotels [4].

25.4 The Advantages of VaPC Mode

"Value-focus thinking" is the fundamental characteristic of the VaPC mode. In general, enterprises gain value-added profits through independent investment, whereas the VaPC mode enables them to sign contract with a value-added service company. The services provided by the value-added service company can create value-added profits and cover project development, design, implementation and even investment.

Based on the fundamental characteristic, the VaPC mode has three specific characteristics as follows:

1. The invested fund is covered by the value-added service company. In addition to the mode of promised value-added profits (mentioned as follows) the entire investment of value-added project is assumed by the value-added service company. In the contract period, the property rights of project belongs to the value-added service company, while at the end of the contract, it will be transferred to a client for free, so that the client can solely access to ongoing value-added profits.

2. Integrated services. In the VaPC mode, the client can gain revenue with less cost for a whole package of integrated value-added services provided by value-added service company.
3. Value-added profits sharing. In the VaPC mode, the client would share the value-added profits of the VaPC project with the value-added service company, instead of paying the fees of project and services [5].

The VaPC mode holds remarkable advantages for both the client and value-added service company.

25.4.1 Advantages for the Client

(1) Zero investment

The client usually suffers capital bottleneck for purchasing value-added technologies (management) and products to initiate value-added projects. While in the VaPC mode, in addition to the mode of promised value-added profits (mentioned as follows), the entire investment capital of value-added project is covered by the value-added service company. By this way, the client can resolve the problem of capital shortage through nearly zero investment.

(2) Largely reducing investment risks

If the client initiates a value-added project by himself, he needs to assume the major risks of project as following.

Table 25.1 The major risks of value-added projects

Type	Description
Risk of Technology	If the value-added technologies are feasible, dependable and advanced enough.
Risk of value-added function products	If the selection of specification of value-added function products is right and if the value-added function products have reliable quality, little fault in operation and long service life.
Risk of Engineering	If the value-added engineering are qualified.
Risk of operation and management	If the decision-makings of project operation and management are right, and if enforcement is in place.
Risk of Finance	If the input capitals can be returned.
Risk of Market	If the value-added products and innovative services can reach the expected marketing performance.

In the VaPC mode of "Value-added marketization", the value service company plans and implements the value-added project for the client. The client pay the company by the mode of value-added profits sharing. If the project reduce the profits instead of creating profits, the client could refuse the payment and the company should reinstate the production system for free. If the targeted value-added profits fail to be reached, the value-added service company should compensate the balance to the client. Thus, all project risks have almost been taken by the value-added company, leaving nearly zero risk to the client [6].

(3) Obtain return with less investment

If the client independently initiates the value-added project, it will requires a large amount of manpower, time and energies. In the VaPC mode, the value-added service company will provide a whole package of services from the value-added potential analysis to personnel training. The client can easily earn the value-added profits only by offering necessary coordination.

25.4.2 Advantages of the Value-added Service Company

(1) Low-risked business on the basis of the client.

The VaPC mode is practiced based on the client's existing business. The value-added service company could analyze of the client's existing value chain to dig out the untapped derivative business. Cooperated with the client, the company could develop the derivative business in light of the existing value chain through technological or managerial expertise. The company shares the value-added profits with the client. Hence, it is particularly applicable to the low-input and low-risked business initiated on the client basis by entrepreneurial enterprises with technological and managerial specialties [7].

(2) Easily overcome the barriers of entry of the market.

Due to the potential capital shortage and the client's avoidance of risks of value-added technologies and of value-added function products as well as project risks including the market risks of value-added products and innovative service, it may be hard to open up the market when resorting to the common ways to sell technological products and offer after-sale services. But in the VaPC mode, the client can gain return with nearly zero investment, zero risk and less work. Thus such mode is popular among clients, which helps value-added service companies to tap the market.

(3) Obtain high profit margin.

It is uneasy to find inroad into the market when adopting the common ways of selling technological products and offering after-sale services. That would lead to the low prices of value-added technologies and value-added function products, trigging the low profit margin. But in the VaPC mode, on the one hand, the value-added service company can fully make use of the value of value-added technologies through the client's platform, and gain return by means of sharing value-added profits. Also, the value-added service company can specify a higher sharing proportion through the contract, and the client, who gains return with zero risk and even zero investment, would be ready to give the higher sharing proportion to value-added service company. On the other hand, the value-added service company would generate scale economies effect through development, mass reproduction and enforcement of the like projects, which lowers the project cost. Both the two methods above enable the value-added service company to create high margin.

To sum up, in the VaPC mode, the client can gain value-added profits with nearly zero investment, zero risk and less work. Meanwhile, the value-added service company is able to successfully enter the market and achieve high porfit margin. The win-win cooperation is the main advantage of the VaPC mode.

25.5 The Implementation of VaPC

In the practice of VaPC, there can be three specific implementation modes as below.

25.5.1 The Mode of Sharing Value-added Profits

The value-added service company assumes all project invested capitals, provides a whole package of value-added services for the client and shares value-added profits with the client in proportion stipulated in the contract during the contract term. For bearing all project investments, the value-added service company is allowed to gain a fair share in the distribution of value-added profits and high profits.

25.5.2 The Mode of Promised Value-added Profits

The client provides all or part of the project capitals, and the value-added service company provides integrated value-added service. Meanwhile, the value-added service company will promise certain value-added profits to the client so as to guarantee that the client can recoup the project outlay or repay the loan principal and interest in contract period. In case of not achieving the promised value-added profits, the value-added service company shall pay for balance, while the excess part of the promised profits shall be shared between both parties in proportion provided in the contract.

For providing the project capital, the client can obtain the large part of the value-added profits. When compared to the mode of sharing value-added profits, the value-added service company gains low profit in this mode as well.

Coming to the VaPC project of raising product prices, the value-added service usually promise the added value or the lowest priece of value-added product prices. If the promised prices can not be achieved, the value-added service company shall directly compensate for the loss caused by the sold products. For the unsold products, the compensation shall be carried out by means of "Buying products with the promised prices".

With regard to the VaPC project of increasing service items and saving cost, the value-added service company, in general, pays for balance when not achieving the promised value-added profits.

25.5.3 *The Mode of Mandating Income and Cost*

In general, the value-added service company takes on all project invested funds and provides integrated value-added service for the client. The client firstly provides certain sharing proportion of the value-added profits in the contract, and then entrusts the value-added service company to practically make the increasing profit or decreasing cost in the market. In the light of different types, such mode can be divided into two types as beneath.

(1) The Type of Mandating Income

For the VaPC project of rising product prices, the value-added service company serves as a sales agent of value-added products in accordance with the prices or prices floor provided in the contract. The client and value-added service company share the value-added profits.

For the VaPC project of increasing service items, the value-added service company pays resource use fees to the client. For example, the telecom value-added service providers pay network flow fees to the telecom operator. So the client provides a platform for the value-added service company to create profits, and he collects the value-added service fees. Thereby the sharing of value-added profits can be achieved.

(2) The Type of Mandating Cost

For the VaPC project of saving cost, the client pays the purchasing expenses of productive materials to the value-added service company according to the contract. The expenses stipulated in the contract is lower than the costs of products before added value. Or, the expenses is lower than costs of purchasing materials of the original manufacturing condition. When the value-added service company buys the productive materials for the client, the practical fees is lower than costs of the contract. It makes the value-added profits and both the client and value-added service company share the profits.

25.6 The Problems in the Application of the VaPC Mode

Although the VaPC mode has numerous advantages, the flaws still inevitably exist.

(1) The Obstacles of Confirming the Calculation of Value-added Profits

The public sectors ,such as government agencies, public institutions, schools and so on, is unable to determine the current cost of the originally technological and managerial conditions based on production yield, but only able to calculate the value-added profits based on the cost before rise in value. But the result of calculating the value-added profits may be incorrect due to the potentially large changes of related costs and other influential factors (like the large influence of temperature on power consumption of building air conditioning). In the VaPC project of value-added products, the present market prices are hard to determine when the products without added value pull out of the market, which can but calculates the value-added profits based on the original prices. However, due to the potentially large change of the prices of value-added products, the result of calculating the value-added profits may be incorrect as well. In sum, the incorrect result of calculating the value-added profits may lead to the dispute over trifles when the client is affirming the value-added profits with the value-added service company. Therefore, the VaPC mode is more applicable to the value-added projects with the relatively correct methods to calculate the value-added profits.

(2) The Capital Shortage of Value-Added Service Company

In the VaPC mode, in addition to the mode of promised value-added profits, the value-added service company needs to take on all project invested capitals, and recoup outlay by sharing value-added profits in the future. The slow capital recovery may lead to the capital shortage of the value-added service company and inefficient operation of more VaPC projects.

(3) Inapplicable in China's Public Sectors

This is because the saved cost can not be transformed into the value-added profits for the financial system of "separation of revenues and expenditures" and "reimbursement for the actual expenses" in China's public sector. Instead, the mode would reduce the public sectors' fiscal budgets of the project in next year, causing their opposing attitudes.

25.7 Conclusion

The telecom value-added service mode has a promising future in the telecom industries, and the energy performance contracting mode can be widely promoted and many other industries have practiced the VaPC mode. It shows that the VaPC mode is able to apply and implement in the value-added projects in more industries. It is unsuitable for the value-added projects which are hard to precisely calculate the value-added profits. These projects may have the potential capital shortage in practice. But the VaPC mode has numerous advantages and different specific methods applicable to various practical conditions. Thus, in the modern society with upgrading technological innovations and management specialization, the VaPC mode is a commercial mode worth a trying for both enterprises and entrepreneurs.

References

1. Woodruff RB (1997) Customer value: The next source for competitive advantage. Journal of the Academy of Marketing Science 25:139–153
2. Tang Y, Xiong X (2011) An innovative mode of China's energy performance contracting. In: Proceedings of the Fifth International Conference on Management Science and Engineering Management
3. Prahalad CK, Ramaswamy V (2004) Co-creating unique value with customers. Strategy & Leadership 32:4–9
4. Paul M, Koen B (2008) Moving from basic offerings to value-added solutions: Strategies, barriers and alighment. Industrial Marketing Management 37:316–328
5. Tang Y, Xiong X (2010) A new method of strategic positioning: STP3 Pyramid. In: Proceedings of the Fourth International Conference on Management Science and Engineering Management
6. Kuo Y, Wu C, Deng W (2009) The relationships among service quality, perceived value, customer satisfaction, and post-purchase intention in mobile value-added services. Computers in Human Behavior 25:887–896
7. Tang Y, Xiong X (2009) A study on operational strategy and innovation of implementation model for environment protection in business. In: Proceedings of the Third International Conference on Management Science and Engineering Management

Chapter 26
A Conflict Eliminating Coordination Method for Emergency Decision of Unexpected Incidents

Xuanhua Xu, Zhili Huang and Xiaohong Chen

Abstract Aiming at the problem for the characteristics of emergency decision making conflict and the difficult forming the decision scheme with high consistency, firstly the causes of conflict generating of emergency group decision making are analyzed by combing emergency decision problem with decision environment. The coordination framework for conflict eliminating of emergency decision making is constructed. The group conflict measure method for emergency decision making is proposed. On the basis of that, the conflict eliminating model and method for emergency decision making are proposed to form the conflict eliminating coordination mechanism for emergency decision making of unconventional outburst incidents, so that the conflicts of emergency group decision making gradually constringe to obtain the emergency decision scheme with enough low conflict degree. Finally, a calculating example validates the realizing process & validity of conflict coordination method & mechanism for emergency decision making.

Keywords Unexpected incidents · Emergency decision making · Conflict Eliminating · Coordination mechanism

26.1 Introduction

In near years, various types of unexpected incidents occurred one after another and there was an upward trend in China. Only 2010 serious natural disasters caused the calamity of 43 million people with direct economic losses as high as 53399 million Yuan. This type of incidents has these characteristics of outburst, urgency and high destruction etc [1]. Therefore, emergency management problem of incidents has aroused great attention from all walks of life [2].

X. Xu (✉) · Z. Huang · X. Chen
School of Business, Central South University, Changsha 410083, P. R. China,
e-mail: xuxh@csu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_26,

Group decision making is an important decision-making mode in modern emergency management [3]. The group participating in emergency decision involves many fields and lots of decision-making experts with different levels, which decides the complexity of personnel making up of decision-making group and there will be cognitive conflict or interest conflict among decision-making members. The group members must rapidly make decision under the high time pressure, high information indetermination and insufficient conditions [3]. The conflicts will be more obvious than that under conventional decision making. Thus prior to obtaining the final decision scheme, the conflicts among decision makers must be eliminated and coordinated. If these problems can't get to solve very well, the conflicts might escalate, the decision time may delay, the group decision may reduce its efficiency, the decision result will is difficult to be generated or produce incoherent result and the best time of emergency rescuing will be delayed, which will cause more casualties and economic loss. Therefore, in the special environment of emergency rescue, it is one of urgent problems to need to be solved that obtains a group satisfactory emergency decision scheme with low conflict degree and high opinion coherence.

At present, the conflicts of general group decision have been studied by some scholars. In group decision-making, two steps were needed to get the final decision scheme, conflict coordination process and selection process [4, 5]. In which, the process for conflict coordination is that how the decision makers coordinate to reduce the conflicts in group so as to obtain the maximal-degree coherence or consensus, while the selection process is that how the optimal scheme is selected from decision experts views. The behavior and process of conflict group decision making were studied, which put forward a cognitive-based framework for the conflict coordinating of group decision making and described the ACTOR implementation under the environment for conflict group decision making coordination [6]. A research model for group decision-making conflicts including leadership factors was proposed that integrated these researches of group dynamics, conflict management, leadership behavior and group decision making, put forward [7]. The conflict management model and the index design of decision variables for group decision making were proposed based on the three-dimensional model for caring oneself, caring others and caring decision task [8]. The Conflict-Coordinated Learning (CCL) as a conflict coordination mechanism was explored by [9], which can improve the ability, conversely strengthen coordination and build together. The positive attitude for conflicts is related to CCL.

However, the studies on the conflict coordination emergency of group decision don't still see more. The coordination is divided into two-level coordination of decision-making structure and individual [10]. Therefore, it is necessary to do further research on the conflict emergency decision coordination.

26.2 Conflict Eliminating Coordination Framework for Emergency Decision

Prior to understanding the principle of conflict & coordination, it is necessary to fully understand the causes of conflict produced by [11], which can really coordinate the conflicts. There are over 40 reasons of producing conflicts were summarized that were related to personal characteristics and interpersonal factors etc. The conflicts for them to study generally refer to all the conflicts, which especially pay attention to the conflict among individuals or organizations. For emergency decision conflict, the conflict reasons of emergency group decision are analyzed by combining the emergency decision problem with the particularity & uniqueness of decision environment is to the reason analysis. The group-external environment (e.g. pressure and threat etc.) can induce the aggravating of conflict degree within group [12]. So the external environment of emergency decision group will make the conflict of this group decision to be more obvious than the conflict of general group decision.

Combining the features and the external environment of emergency decision-making of unconventional outburst incidents, the main reasons for conflict produced within emergency decision group include.

1. Heterogeneous group members. The emergency decision-making group is composed of numerous decision experts of interdisciplinary, cross regional and cross sections. There exist differences in them such as their characters, experiences, attitudes, cultural, professional background and knowledge level etc. These differences conflict will directly influence the cognitive conflict among group members.
2. The complexity of decision relation. Emergency decision group tend to be temporarily organized. The decision makers come from different level organizations, which decided the majority decision members have dual or multiple roles. In emergency rescue, the operating mode among organizations is not the same as others, and the concerned interests are also not the same. The opinions of members participating in decision-making are surely affected by their organizations who surely consider the benefits of their departments when making decision, which emerge in decision preferences. Thus it results in the great difference among views of decision makers.
3. External environmental pressure. High time pressure, the decision must be achieved in very short time. Incomplete information, uncertainty and non-correctness, the decision members must make decision under limited information and incomplete cognition. These huge pressures aren't conducive to the decision-making and the much deviation conflict will be produced by the cognition among decision makers, which is also the important reason for conflict intensification that the emergency group decision is compared with conventional group decision.

Conflict coordination process is a conflict eliminating process with dynamic & interactive discussion & negotiation among decision makers, the conflict eliminating coordination mechanism is used to make their opinions tend to coherence. In actual decision-making process, since certain conflict can inhibit group thinking and all decision members may not agree each other completely, it is neither possible nor necessary that all their opinions reach the complete coherence. Combining with the actual situation, a reasonable conflict level is set that is denoted with a threshold of Conflict Level (CL). Throughout conflict eliminating coordination process, the decision members to fully express their opinions and aggregates these preferences of all decision members are urged to form temporary group preference. The distance between each member' preference and group preference is measured to express actual conflict level. If the conflict level can't be accepted, more than the preset reasonable conflict level threshold CL, it means there exists great difference-conflict within the group. Then the decision members are organized to entry into the consultation & feedback and prompts decision makers to further negotiate and discuss their opinions with less conflict & more coherent preference as far as possible. On the contrary, if the conflict level is within acceptable range, the selection process will be applied to obtain the final result with low conflict degree and high coherence. The advantage of this method is the use of decision maker preferences to obtain the conflict degree, which can master more information in real conflict situations. In the process of emergency consultation and feedback, the attention must be paid to obtain effective consultation results in provision consultation times. At the same time, the conflict degree after coordination every time of consultation & feedback is ensured to be less than that of the last round to reach the conflict convergence goal. Thus the conflict coordination time can be saved. Thereby the decision result with low conflict degree can be obtained in a relatively short time. The coordinating frame for emergency decision conflict eliminating is shown in Fig. 26.1.

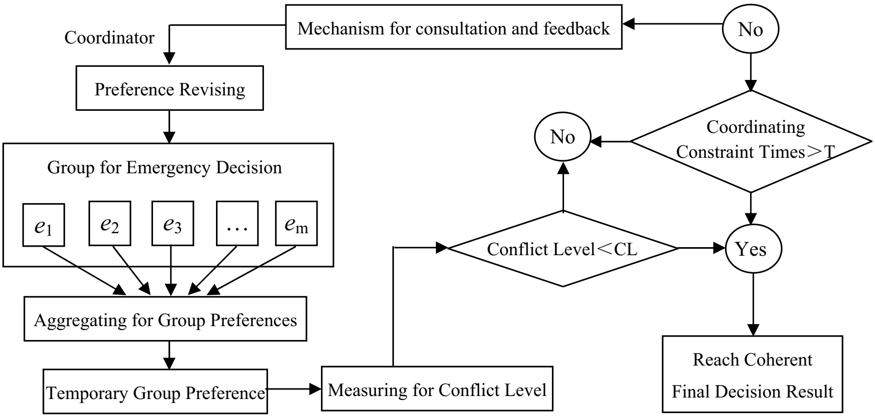


Fig. 26.1 Group conflict coordination framework for emergency decision

26.3 Group Conflict Measure for Emergency Decision Making

26.3.1 Aggregating for Group Preferences

Group decision making is an important feature in modern emergency programming and management [3]. The decision makers participating in emergency decision-making provide their decision preferences for multiple decision attributes according to their own holding information. Then the individual preferences were aggregated to form group preference, thereby the group satisfying final decision result can be obtained. Thus the development of group decision making provides a basis for application of emergency management and decision-making.

There are m decision makers to form the emergency decision group $E = \{e_1, e_2, \cdots, e_m\}$, in which the e_i is ith member. There are n attributes in decision making problem that compose attribute set $X = \{x_1, x_2, \cdots, x_n\}$, in which is the x_j is jth attribute. The preference given by the ith member in emergency decision group on jth attribute is r_{ij}, in which $r_{ij} \geq 0$, $i = 1, 2, \cdots, m$, $j = 1, 2, \cdots, n$. The preference matrix V is structured by these preferences given by the m members on the n decision attributes, in which the decision preference vector given by decision member e_i is marked as $V_i = (v_{i1}, v_{i2}, \cdots, v_{in})$. Then:

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} = \{V^1, V^2, \cdots, V^n\}. \tag{26.1}$$

Since the emergency decision group is a complex large group, the group preference structure needs to firstly be analyzed in order to more accurately aggregate these preferences of all decision-making members. The $\Omega = \{V^i\}$ of group preference vectors needs to be clustered to form the clusters structure of group preferences, which is based to conduct the aggregating for group preferences. The clustering method [13] is used to cluster the $\Omega = \{V^i\}$ into K clusters to form the cluster structure, in which the kth cluster is marked as C^k. Set n_k is the number of preference vectors of kth cluster, then $\sum_{k=1}^{K} n_k = m$, where the K is a positive integer and $1 \leq K \leq m$.

According to the clustering standard that is the clustered degree between two preference vectors, these preferences given by the decision members in the same cluster are comparatively close. Therefore the weights of decision members belonging to same cluster may be considered to be same. According to majority principle, these members in the cluster with large capacity are endowed greater weight. Conversely these members in the cluster with less capacity are endowed less weight. Then the weight of member e_i is [14]:

$$w_i = w_{n_k} = \frac{n_k}{\sum\limits_{k=1}^{K} n_k^2}, \ i = 1, 2, \cdots, m. \tag{26.2}$$

The whole group preference vector U is aggregated as follows:

$$U = \{u_j\} = W \cdot V = (w_1, w_2, \cdots, w_m) \cdot V = (u_1, u_2, \cdots, u_n). \tag{26.3}$$

26.3.2 Group Conflict Measure

Utilizing the group preference vector and the decision-making member preference vectors, the index for group conflict degree can be constructed and calculated by use of distance deviation.

Definition 26.1. According to following Equation (26.4), the θ can be obtained by calculating that is defined as the group conflict degree index.

$$\theta_i = \sum_{j=1}^{n} \frac{|v_{ij} - u_j|}{v_{ij}}, \tag{26.4}$$

$$\theta = \frac{1}{m} \sum_{i=1}^{m} \theta_i. \tag{26.5}$$

Since the difference between individual preferences and group preference in θ_i is calculated, it delegates the conflict degree between the preferences of all decision makers and the group preference. The θ delegates the conflict level of whole decision-making group. The larger the θ is, the higher the conflict level within group is. The smaller the θ is, the lower the conflict level within group is. When $\theta \leq CL$, the group conflict has reached an appropriate level. Without the need for conflict coordination, the final decision result with enough low conflict level which can be obtained. When $\theta \geq CL$, the group conflict level is very high level without reaching the satisfactory state. Then by Equation (26.4), these members for their conflict larger compared with group opinion will be searched, then coordinator organizes them to enter into the phase for negotiation and feedback.

26.4 Conflict Eliminating Method for Emergency Decision

In the phase for negotiation and feedback, the coordinator encourage the decision members actively participating in the negotiation and feedback to ensure the sharing of emergency decision making information, so that the decision-making members can find the cause of inducing conflict. Through the mechanism for coordination and discussion, the cognitive deviation of decision makers is gradually decreased. Especially those decision-making members with the great conflict between them and group opinion need to understand more about the information of emergency decision situation to adjust their decision preferences. Thereafter through entering next round program of conflict eliminating coordination, the decision result can be implemented with low conflict level and high coherence within allowable coordination time. Throughout the conflict eliminating coordination process, there exist many rounds of group conflict eliminating coordination. After each round of coordination, a conflict degree index $\theta^t(t = 0, 1, \cdots, T)$ can be obtained, in which the $\{\theta^t\}$ response the change of conflict degree within decision group. In emergency decision conflict coordination process, the convergent trend should be ensured that the $\{\theta^t\}$ gradually decreases, so the validity of every-time conflict coordination can be ensured, which forms the group decision-making result with the conflict degree less than the conflict threshold CL.

However, the current certain strategy proposed in preference revision of decision makers to reach coherence has the random uncertainty [12]. And it can't guarantee the trend that the adjusted conflict level gradually converge, then this interaction times for conflict coordination may be increased, the stability of conflict coordination can't be reached. In this paper, a method is proposed to revise the preferences to make the conflict-coordination effect more prominent and obtain the decision result as soon as possible with enough low conflict level, which can reduce the time for conflict coordination of emergency decision and thus can obtain the effective emergency decision result to evolve emergency rescue.

Definition 26.2. The revising method for decision-making preferences. According to the tth round preferences of decision makers and temporary group decision-making preference, the $(t+1)$th round preferences are adjusted as follows.

$$V_i^{t+1} = p_i^t \cdot V_i^t + (1 - p_i^t) \cdot U^t. \tag{26.6}$$

In which, the $p_i^t(p_i^t \in [0, 1])$ is the amendment coefficient for decision member e_i on tth round that is set up by preference by the emergency decision makers based on the actual situation. If the degree for themselves opinions to be adhered is relatively large, the p_i^t is set larger $(p_i^t > 0.5)$. If the respect degree for group opinion or the degree for themselves opinions to be given way is relatively large, the p_i^t is set relatively small. If $p_i^t = 0.5$, the decision maker hasn't any preference for the opinion between him and group. In this way, after the method is used to adjust the decision-making preference, the randomness of preference revising can be effectively avoided. The next step is to verify after the decision-making preferences are revised, the conflict degree within group gradually decreases that converges in the range of predetermined conflict degree threshold, which ensures the validity of mechanism for group consultation & feedback and can gradually obtain the result with low conflict degree that is reach the result with group satisfaction.

Theorem 26.1. *After the group decision making preferences are adjusted based on the Equation (26.6), the conflict degree obtained by Equation (26.5) is gradually reduced. It is that the conflict degree change sequence* $\{\theta^t\}$ *converges.*

Proof. In the $(t+1)$th round conflict coordination process, suppose only emergency decision member e_i adjusts the tth round preference v_i^t to v_i^{t+1}, while the other decision preferences don't change. Then based on the formula $V_i^{t+1} = p_i^t \cdot V_i^t + (1-p_i^t)u_j^t$, following formula can be obtained: $v_{ij}^{t+1} = p_i^t v_{ij}^t + (1-p_i^t)u_j^t$. In which $u_j^t = \sum_{i=1}^m w_i v_{ij}^t$, $p_i^t \in [0,1]$. Then $v_{ij}^{t+1} \in [\min(v_{ij}^t, u_j^t), \max(v_{ij}^t, u_j^t)]$. According to Equation (26.5),

$$\theta^t = \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \frac{|v_{ij}^t - u_j^t|}{v_{ij}^t},\ \theta^{t+1} = \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \frac{|v_{ij}^{t+1} - u_j^{t+1}|}{v_{ij}^{t+1}},$$

$$\theta^{t+1} - \theta^t = \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \left(\frac{|v_{ij}^{t+1} - u_j^{t+1}|}{v_{ij}^{t+1}} - \frac{|v_{ij}^t - u_j^t|}{v_{ij}^t} \right).$$

Then:
(1) when $v_{ij}^t > u_j^t$, $v_{ij}^t > v_{ij}^{t+1} > u_j^t$ based on formula $v_{ij}^{t+1} = p_i^t v_{ij}^t + (1-p_i^t)u_j^t$. Then $u_j^{t+1} = \sum\limits_{i=1}^m w_i v_{ij}^{t+1} < \sum\limits_{i=1}^m w_i v_{ij}^t = u_j^t$. So, $v_{ij}^t > v_{ij}^{t+1} > u_j^t > u_j^{t+1}$.

$$\begin{aligned}
\theta^{t+1} - \theta^t &= \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \left(\frac{(v_{ij}^{t+1} - u_j^{t+1})}{v_{ij}^{t+1}} - \frac{(v_{ij}^t - u_j^t)}{v_{ij}^t} \right) \\
&= \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \left(\frac{u_j^t}{v_{ij}^t} - \frac{u_j^{t+1}}{v_{ij}^{t+1}} \right) \\
&= \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \left(\frac{\sum\limits_{k=1}^m w_k v_{kj}^t}{v_{ij}^t} - \frac{\sum\limits_{k=1}^m w_k v_{kj}^{t+1}}{v_{ij}^{t+1}} \right) \\
&= \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \left(\frac{w_i v_{ij}^t \sum\limits_{k=1,k\neq i}^m w_k v_{kj}^t}{v_{ij}^t} - \frac{w_i v_{ij}^{t+1} \sum\limits_{k=1,k\neq i}^m w_k v_{kj}^{t+1}}{v_{ij}^{t+1}} \right).
\end{aligned}$$

Based on hypothesis condition, $\sum_{k=1,k\neq i}^m w_k v_{kj}^t = \sum_{k=1,k\neq i}^m w_k v_{kj}^{t+1}$, mark:

$$Q = \sum_{k=1,k\neq i}^m w_k v_{kj}^t = \sum_{k=1,k\neq i}^m w_k v_{kj}^{t+1} > 0.$$

So,

$$\theta^{t+1} - \theta^t = \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \left(\frac{w_i v_{ij}^t + Q}{v_{ij}^t} - \frac{w_i v_{ij}^{t+1} + Q}{v_{ij}^{t+1}} \right) = \frac{1}{m}\sum_{i=1}^m \sum_{j=1}^n \left(\frac{Q}{v_{ij}^t} - \frac{Q}{v_{ij}^{t+1}} \right).$$

Since $v_{ij}^t > v_{ij}^{t+1}$, and v_{ij}^t, $v_{ij}^{t+1} \in (0,1]$, $Q > 0$, so that $\theta^{t+1} - \theta^t < 0$, it is $\theta^{t+1} < \theta^t$.
(2) When $v_{ij}^t < u_j^t$, similarly the inequality $\theta^{t+1} < \theta^t$ can be proofed.

Integrating above proof, the result $\theta^{t+1} < \theta^t$ can be obtained.

Above proof is given to only adjust a decision-maker's preference every time. Actually in the process for each round's decision conflict coordination, when $M(> 1)$ decision makers revise their preferences, this round adjustment can be regarded as preference alterations for M times with the revise of only a decision member preference each time. After above-mentioned proof process is recurred, the inequality $\theta^{t+1} < \theta^t$ can also be hold. Thus, through above preference revise, the conflict degree of emergency decision group gradually reduces and converges to the pre-set threshold range. So the final decision-making result can be obtained with low conflict level.

26.5 Example Analysis

In order to verify the implementation process and effectiveness of emergency decision conflict coordination mechanism mentioned in this paper, the optimal select for a metro fire-accident disposal schemes is set up for conducting the calculate example analysis. After subway fire-accident occurs, the passengers should be peremptorily evacuated. Generally the front station for train to drive into is chosen to evacuate passengers. Or, the train parks in interval of tunnel, then the ventilation system is adopted to exhaust to reduce fire smoke. However when the passengers are bidirectionally evacuated, the fluctuating tuyere for ventilation system to ventilate has influence on passengers. To sum up, five kinds of passenger evacuation schemes are drafted with the consideration of all the circumstances: (1) After the train drives into front station, it is adopted that the passengers are bidirectionally and synchronously evacuated; (2) The train parks in tunnel, the ventilation system is opened and the passengers doesn't be evacuated for a while; (3) The train drives into front station, the ventilation system exhaust toward the direction for the train to run and the passengers doesn't be provisionally evacuated; (4) The train parks in tunnel, the ventilation system is opened and the passengers are unidirectionally and orderly evacuated; (5) The train parks in tunnel, the ventilation system doesn't be opened and the passengers are bidirectionally and synchronously evacuated.

Aiming at the field involved in accident with the convenience of calculating, five experts are selected to make up of emergency decision-making group $E = e_1, e_2, \cdots, e_5$. Each expert independently gives his decision-making preference $V_i = v_{i1}, v_{i2}, \cdots, v_{i5}$ on five decision schemes $X = x_1, x_2, \cdots, x_5$. The data are transacted by standardizing to obtain the preference matrix $V = \{v_{ij}\}$ shown in following Table 26.1.

Apparently $m = 5$ and $n = 5$. Using clustering method (Clustering threshold $\gamma = 0.85$) [13], the decision preference vector set V can be clustered to obtain the clustering number $K = 3$ and group preference vector $U = (0.301, 0.285, 0.45, 0.585, 0.526)$. The cluster structure is shown in Table 26.2.

Table 26.1 Initial decision preference matrix V for decision experts

Decision Members	Decision Schemes				
	x_1	x_2	x_3	x_4	x_5
e_1	0.4	0.5	0.6	0.8	0.7
e_2	0.3	0.4	0.7	0.9	0.6
e_3	0.5	0.3	0.6	0.8	0.7
e_4	0.4	0.4	0.5	0.6	0.8
e_5	0.4	0.3	0.6	0.8	0.7

Table 26.2 Clustering result of vector set for decision experts

Cluster C^k	Group member Number n_k	Group member preference vector V^i
Cluster C^1	3	V^1, V^3, V^4
Cluster C^2	1	V^2
Cluster C^3	1	V^5

Based on Equation (26.2), the weights of all decision-making members can be obtained as $w_1 = 0.273$, $w_2 = 0.273$, $w_3 = 0.273$, $w_4 = 0.091$ and $w_5 = 0.091$. Then according to Equation (26.3), the group synthesis preference on decision schemes can be calculated to obtain the temporary synthesis preference vector $U = (w_1, w_2, w_3, w_4, w_5)$, $V = (0.4004, 0.3913, 0.6188, 0.8099, 0.6825)$ of group on five decision schemes.

The coordinator sets the index threshold $CL = 0.38$ of group conflict degree according to actual condition. In order to avoid to delay the coordinating time, the conflict coordination constraint number is set as $T = 3$. Firstly, according to Equation (26.4), the initial conflict degrees between each member and group are calculated as $\theta_1^0 = 0.265$, $\theta_2^0 = 0.826$, $\theta_3^0 = 0.492$, $\theta_4^0 = 0.675$ and $\theta_5^0 = 0.292$. Then based on Equation (26.5), the conflict degree index of whole emergency decision group can be calculated as $\theta^0 > 0.38$, which shows there exists higher conflict within group. The coordinator organizes decision-making group into a phase for consultation & feedback and encourage each decision makers to conduct negotiating & discussing according to the information for they to seize and group preference. The preferences of decision makers are adaptively adjusted to achieve the conflict eliminating. Through consultation and feedback, the conflict degrees between each decision maker and group calculated by Equation (26.4) are $\theta_2^0 > \theta_4^0 > \theta_3^0 > \theta_5^0 > \theta_1^0$, which explains that the conflict between decision makers (e_2, e_4) and group is larger. So, their preferences need to be revised. In order to conveniently calculate, in this paper, only the decision member is considered to revise his preference that the conflict degree between he and group is the greatest.

The preference of decision-making member e_2 with the greatest conflict degree in first round conflict coordination is optionally revised to be shown in following Table 26.3. Then the decision group conflict degree is calculated after first round adjustment as $\theta^1 = 0.582 > \theta^0 = 0.510 > CL = 0.38$, which needs second round of preference adjustment. The preference of decision maker e_4 is optionally revised to form preference matrix to be shown in following Table 26.4. Then the group conflict degree is calculated as $\theta^2 = 0.628 > \theta^1 = 0.582 > CL = 0.38$, which needs to repeatedly conduct conflict coordinating, is unable to make the conflict coordination effective and wastes valuable time for conflict coordinating.

Table 26.3 Group decision preference matrix after first round adjustment

Decision Members	Decision Schemes				
	x_1	x_2	x_3	x_4	x_5
e_1	0.4	0.5	0.6	0.8	0.7
e_2	0.45	0.60	0.75	0.79	0.62
e_3	0.5	0.3	0.6	0.8	0.7
e_4	0.4	0.4	0.5	0.6	0.8
e_5	0.4	0.3	0.6	0.8	0.7

Table 26.4 Group decision preference matrix after second round adjustment

Decision Members	Decision Schemes				
	x_1	x_2	x_3	x_4	x_5
e_1	0.4	0.5	0.6	0.8	0.7
e_2	0.45	0.6	0.75	0.79	0.62
e_3	0.5	0.3	0.6	0.8	0.7
e_4	0.52	0.45	0.55	0.6	0.89
e_5	0.4	0.3	0.6	0.8	0.7

The preferences of decision makers are standardly adjusted after negotiation & feedback on group conflict to achieve conflict coordinating. The decision member e_2 chooses respecting entire group preference based on emergency practical situation. The first round preference revising coefficient is set as $p_2^1 = 0.2$, then the preference matrix of decision makers after first round adjustment is shown in Table 26.5.

After first round adjusting, the group conflict degree index is recalculated to obtain the conflict degree between each decision maker and group as $\theta_1^1 = 0.385$, $\theta_2^1 = 0.278$, $\theta_3^1 = 0.523$, $\theta_4^1 = 0.639$, $\theta_5^1 = 0.395$ and $\theta^1 = 0.444 > 0.38$, which explains that the conflict degree reduce but still don't reach the pre-set threshold, so need to enter into the second-round conflict coordinating (But no more than the constraint time of conflict coordination). Through calculating shows that the conflict degree between member e_4 and group is maximal, its decision preference is standardly adjusted. The e_4 is supposed to relatively adhere to own point of view, then its preference revising coefficient is set as $p_4^2 = 0.7$. The preference matrix

Table 26.5 Group decision preference matrix after first round adjustmen

Decision Members	Decision Schemes				
	x_1	x_2	x_3	x_4	x_5
e_1	0.4	0.5	0.6	0.8	0.7
e_2	0.38	0.384	0.62	0.804	0.68
e_3	0.5	0.3	0.6	0.8	0.7
e_4	0.4	0.4	0.5	0.6	0.8
e_5	0.4	0.3	0.6	0.8	0.7

Table 26.6 Group decision preference matrix after second round adjustment

Decision Members	Decision Schemes				
	x_1	x_2	x_3	x_4	x_5
e_1	0.4	0.5 0.6	0.8	0.7	
e_2	0.38	0.384	0.62	0.804	0.68
e_3	0.5	0.3	0.6	0.8	0.7
e_4	0.406	0.391	0.534	0.664	0.766
e_5	0.4	0.3	0.6	0.8	0.7

of decision makers after second round adjustment is shown in above Table 26.6. The integrated decision-making preference of decision group on five emergency decision schemes is the vector $U = (0.417, 0.375, 0.591, 0.774, 0.709)$. The group conflict degree after second conflict coordinating is calculated as $\theta^2 < 0.38$, which shows that the conflict degree among group members is very small and the decision result can be accepted to obtain the satisfactory result with lower conflict degree. Thus the final integrated decision preference of decision group on five emergency decision-making schemes is the obtained result after second round adjusting, which is $x_4 > x_5 > x_3 > x_1 > x_2$. So, the scheme x_4 is the optimal decision scheme. In whole process for conflict coordinating, after each round conflict coordinating, the group conflict degree $\{\theta^t\} = \{0.510, 0.444, 0.370\}$ shows the trend of gradually converging until it is relatively small. So, the stability and effectiveness of conflict coordinating can be ensured.

26.6 Conclusion

The response decision for unconventional outburst incidents is a typical conflict emergency decision-making due to the heterogeneity of decision group. Jointing the unconventional emergency decision problem and decision-making setting, this paper analyzes the cause of the conflict generated by emergency decision group and proposes the coordination mechanism for emergency decision conflict eliminating. Through the measuring on the conflict degree within emergency decision-making group, the group conflict level can be obtained. Then, the coordinator organizes the group makers to conduct the consulting & feedback, and the preference of decision making members are revised or perfected, which make the group decision conflict after coordinating gradually decreases and converge to realize the conflict eliminating coordination of emergency decision-making. Consequently, the satisfying emergency decision scheme can be rapidly obtained with sufficiently low conflict degree, and the loss of emergency rescue can also be furthest reduced. In whole process of emergency decision conflict coordinating, the realistic objective difference conflict between decision members is fully considered to be more in line with the characteristics of emergency decision. Finally a calculating example demonstrates the implementing process and validity of above-mentioned method and mechanism.

Acknowledgements The work was supported by the Natural Science Foundation of China (No. 71171202, 70871121) and the Science Foundation for National Innovation Research Group of China (No. 70921001).

References

1. Ji L (2006) Emergency management of unexpected events. Higher Education Press, Beijing (In Chinese)
2. Fan W (2007) Advisement and suggestion to scientific problems of emergence management for public incidents. Science Foundation in China 2:71–76
3. Cosgrave J (1996) Decision making in emergencies. Disaster Prevention and Management 4:28–35
4. Herrera F, Herrera-Viedma E, Verdegay JL (1996) A model of consensus in group decision making under linguistic assessments. Fuzzy Sets System 1:73–87
5. Herrera-Viedma E, Herrera F, Chiclana F (2002) A consensus model for multiperson decision making with different preference structures. IEEE Transactions on Systems Man and Cybernetics 3:394–402
6. Hai Z (2000) Conflict decision training through multi-space co-operation. Decision Support Systems 29:111–123
7. Lang C, Xi Y, Bi P (2005) Study on conflict in group decision making process. Forecast Ing 5:1–8
8. Chen X, Liu Z (2008) Research on three-dimensional model for group decision-making conflict management. Statistics and decision 3:13–15
9. Chang KH, Gotcher DF (2010) Conflict-coordination learning in marketing channel relationships: The distributor view. Industrial Marketing Management 2:287–297
10. Zeng W, Zhou J, Wang H (2009) Research on the theory and methods of emergency decision-making. China Safety Science Journal 3:172–176
11. Wall JA Jr, Callister RR (1995) Conflict and its management. Journal of Management 3:515–558
12. Shen J, Wang L, Huang H (2005) Consensus measuring and adjusting for multi-attributes group decision under fuzzy logic. Industrial Engineering and Management 5:79–87
13. Xu X, Chen X (2008) Research of a king of method of multi-attributes and multi-schemes large group decision making. Journal of Systems Engineering 2:137–141
14. Xu X, Chen X, Wang H (2009) A kind of large group decision making method oriented utility valued preference information. Control and Decision 3:440–445, 450 (In Chinese)

Chapter 27
The Research on the Customers' Demand Value Realized Degree in Modern Enterprise Production Mode

Longan Deng

Abstract Through the analysis, the customers' demand value has the different realized degree in different enterprise production modes. So, this paper thinks that in the enterprise organization management mode must to do "customer-centered management mode" shorten the communication time between the top decision maker and the first line worker to fit customers' rapid demand. At the same time, it also requires the organization decision scattered, to make the different levels of management all have certain decision-making authority.

Keywords Customer demand · Production mode · Mass Customization

27.1 Customers' Demand Value and Factor Analysis

The customers' demand value is an overall evaluation of product utility after knowing the tradeoff by the view of customers between the benefit that can be perceived by customers for product requirement and the pay cost when get the product. From the results of extensive theoretical discussion of customer value, we can see factors impacting the value of customer demand including the following.

27.1.1 Product Prices

Products have become the product is because it has a use value, the price is the economic pay when customers want to obtain the use value of certain products. When customers think the product or service value is higher than the price it needs

---

L. Deng (✉)
Business School, Sichuan University, Chengdu 610064, P. R. China
e-mail: deng05912@sohu.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_27,

to pay,the satisfaction is higher. The price includes the selling price of the product and the use cost. The American marketing experts Lauteborn is one of the earlier scholars to understand the customer value. His elaboration for the customer value is mainly embodied in the 4Cs theory put forward in 1990. Lauteborn thinks customer acceptable price is the determining factor for enterprise making production cost, while he also believes customers' shopping expenditure is not only referring to the monetary expenditures of shopping, but also including shopping time consuming, energy and stamina costing as well as risk exposure (Losses brought by the difference between customers' purchase and requirement caused by asymmetric information). Contained Se Moer puts forward in his perceived value theory, value is the low price, he believes that some customers' equal value to low price, because the currency to be paid for the value feeling is the most important. Visibly, whether it is Lauteborn or Contained Se Moer, in their view, price is one of the main factors that affect the customers' demand value.

27.1.2 Product Quality

Product quality is a complex reflecting the capacity characteristics of products meeting the requirement and the potential need. Product quality includes product use performance, reliability, security, energy efficiency and appearance quality. Contained Se Moer believes, customer value is the quality that customers paid for. In his survey found that many customers conceptualize the value as a tradeoff between "the money paid" and the get "quality". And such tradeoff is one of the core of the contained Se Moer perceived value theory, that is a tradeoff between perceived benefit and perceived sacrifice. It shows product quality is also an important factor affecting the customers' demand value.

27.1.3 Availability

Availability refers to the customer to get the desired product or service according to the required time. Lauteborn thinks Customer shopping expenditure, not only refers to the shopping monetary spending, but also includes shopping time consuming. Contained Se Moer finds in his perceived value theory, the evaluation of the value when customers buy products contains the expenditure of their time. So he thinks, time buying is an important reference background for customer product valuation. Kotler believes in delivered value theory, the customer total cost includes monetary cost, time cost, spiritual cost and physical cost. Therefore, the availability will be an important factor affecting the customers' demand value.

27.1.4 Credibility

Credibility is to meet the individual customer requirement as far as possible, establish a trust relationship between the customer and the enterprise by providing various kinds of service and guarantee in the purchase, use, and discard the product process. Lauteborn pointed out in the 4Cs theory that enterprise should not only sell their products but also sell the service, so customers can not only buy the products but also purchase the convenience. He believes that enterprises should pay attention to the customer two-way communication to meet the customers' emotion in a positive way, and establish a new enterprise-customer relationship based on common benefits. Find in the Contained Se Moer's perceived value theory that the value gain of customers includes product or business reputation, corporate image and a higher level of abstract interest. Kotler believes in the delivered value theory, customer total value is a series of benefits that customers obtained from a particular product or service, which includes the product value, service value, personnel value, image value and so on. Therefore, the credibility in the product transactions is an important factor affecting the customers' demand value.

27.1.5 Product Differentiation

Product differentiation refers to the unique properties that had by the products features or external characteristics. Contained Se Moer thinks, in value the income composition including significant internal features, external features is as the main part of the value gains, but overall measure of the value gains are still including such as packaging, color and other external features and products or companies reputation, convenience, image and a higher level of abstract interest. Moreover, the internal properties of the product itself may not directly related to the customer perception value, to the contrary, they often have to be reflected through the external characteristics of the product even the abstract interest of customers' personal perception. It shows that product differentiation is an important factor affecting the customers demand value. And for enterprises, the more product varieties it can provide, the more able to meet the customers' various demand will be.

27.2 Enterprise Production Mode and Its Customer Demand Value Realization Condition

Products or services are all provided by the production, production is the foundation of the enterprise competition. If the enterprises want to meet the demand of the price in the customer value, quality, availability,reputation,product differentiation and so on, it is bound to establish the corresponding production mode. Since the emergence of the industrial society, the most representative production mode can be summarized as follows: mass production, fine production,flexible manufacturing, agile manufacturing and mass customization several production modes.

27.2.1 The Customers' Demand Value Realization Condition in the Large Group of Production Mode

The mass production based on the scale economy theory is mainly in the form of assembly line production organization. After the enterprise pipeline operations, the amount of unit product labor reduced, the wage costs and cost-sharing of the unit product has also been reduced, therefore, reduce the cost of the product. However, pipeline operation can not be adapt to the change of the market demand for product specifications and varieties timely, and reflect slowly in meeting the customers' requirement for production differentiation.

27.2.2 The Realizing Condition of Customers' Demand Value in Lean Production

Lean production refers to less occupation and higher utilization for all resources. Resources include land, plant, equipment, materials, personnel, time and money. Enterprises should keep lean not only in product design, process planning, supply, manufacturing and inventory, but also in the relationship of users, the development about new products and the suppliers. For example, they always keep in contact with the users closely, and submit the productions what the users desired, this form of delivery is not only reduce the inventory cost, but also meet the obtain psychology of customers well. Obviously, for production of "lean" timely and the development of new products should meet the different customers' demand. However, lean production is just for "lean", it tends to ignore the customers' demand value about other aspects, especially for the demand value of reputation.

27.2.3 The Realizing Condition of Customers' Demand Value in Agile Manufacturing

When the seller's market turns into the buyer's, in order to reduce the response time of customers' products or service as soon as possible, enterprises must study the whole production process (product planning, development, manufacturing, sales). In the historical development of production management, the concept of manufacturing is implemented by agile manufacturing comprehensively. In the 18 characteristics about agile manufacturing enterprises which are proposed by Yakeka, have detail description for product planning and development, manufacturing system configuration, product delivery and some other agile characteristics. Above all, achieving the most effective response to customers' demand, then making "agile" response is the main purpose of the production for agile enterprises in the entire product running. Although agile manufacturing give out a significant effect to the available demand value of customers, it is definite difficult to ensure product quality and price requirements of the customer value system not affected for such "agile".

27.2.4 The Realizing Condition of Customers' Demand Value in Flexible Production

When the difference of productions influence customers' demand value seriously, the enterprises in market should have ability to product more varieties, functions, features and be in accordance with customers's demand. Obviously, the production system of enterprises should be flexible before it product different productions. Flexibility is organizing the ability of adapt new forms or new changes for environment quickly and without consumption, such as the equipment, technology and operation flexibility. Flexible manufacturing enterprises products based on this requirement. This form of productions not only improve the operational flexibility of enterprises, but also enhance the ability of its productive response. However, when the production of flexible manufacturing product in small quantities, multi-species, more features, be in accordance with customers' demand and function, the factors except of productions or services are ignored easily, such as demand value of customers' reputation. At the same time, with the small quantities of production, it is inadequate to meet the production price in customers' value.

27.2.5 The Realizing Condition of Customers' Demand Value in Mass Customized Production

When the credibility become impacting customers' demand value, it requires enterprises to provide customers with personalized products or service. In order to meet customers' personalized demand, enterprises often adopt product-differentiation strategy, which means more products, more types and more colorful products to meet the different demand of customers. But the personalization of products and the differentiation of products are different. Differentiation is based on the market prediction, providing products or service with different function, type, specification and color to meet the different demand of customers. Because it's based on the market prediction, the situation that things don't match customers' actual need is hard to avoid. While personalized product is designed and produced on the basis of customers' actual need. So, enterprises have to let the customers participate in the design and productive process of products. Establishing a whole new mode of production which directly facing the customers is an important way to realize the personalization of products or service. Letting customers participate in the design and productive process of products and producing them in a large number is mass customized production. The concept of mass customized production is raised by David. Stanley in the book "the Future perfection". He thinks that the goal of mass production is developing products or service with a low price that everyone can afford. While the goal of mass customized production is everyone can afford the goods they want. However, in the actual process of manufacturing products, letting customers participate in the development of product will inevitably influence the speed of products' development. Therefore, using the Internet media which let the customers participate in the products development become a important part of mass customized production. Customers design their needed products through the interface of the Internet not only can meet the need of customer personalized products, but also have a promoting function in deepen the relationship between customers and enterprises. Although mass customized production meet the need of price, differentiation, credibility in customers' value in many aspects. Mass customized production is still not good at the need of product quality and availability in customer value.

27.3 The Implemented Condition of Customers' Demand Value in Enterprises' Mode of Production

Analyzing the mode of production from the perspective of customer value, the degrees of customers' value realized in the mode of production are different (such as Table 27.1). This results can get the same explanation from the constantly change of customers' consumption level.

Table 27.1 The implemented condition of customers' value in enterprises' mode of production

Production mode	Customer value				
	Price	Quality	Differentiation	Availability	Credibility
Mass production	***	**			
Lean production	*	***	*	*	*
Flexible manufacturing	*	*	***	*	*
Agile manufacturing	*	*	**	***	**
Mass Customized Production	**	*	**	*	***

*** means highly correlated; **means correlated; * relatively correlated.

First of all, in mass production period, because of the low level of customers' consumption, the problem of "Is there any" is prominent. Products are popular as long as they are usable and cheap, and the main factor to influence the demand of customers' value is price. When the quality and price reach a certain level, and customers pursue the diversity of products and service, products will be eliminated even though they are durable. So the enterprise must change the original mode of production, and adopt flexible production, to meet customers' demand value of differentiation with manufacturing diversified products. But increasing varieties lead the manufacturing process and management complicated, and ignored the high cost and quality of products. As the pace of people's lives speeding up, the availability of customers' demand value that products are delivered on time and appear on the market as soon as possible has become the goal the enterprises pursue. So, the mode of manufacturing represented by agile manufacturing become the main productive mode to meet customers' value of availability. When the difference between products and service provided by a enterprise and other enterprise in the same industry is little, the credibility of customers becomes the goal that enterprises pursue and any one who solves customers' problem, meet customers' need of personalization amd provides the best service and guarantee to customers, can meet the credibility need of customers' value.

27.4 Conclusion and Suggestion

Analyzing the mode of production from the perspective of customers' value shows that the degrees of customers' value realized in the mode of production are different and this results can get the same explanation from the constantly change of customers' consumption level. So, how can organizations construct a best mode of production that customers are satisfied with? From the whole text, first of all, the organization's management must be "customer-centred management model". It has to be fully reflected in the plan, organization, command and control of management. Secondly, the structure of organization has to be flat, to shorten the communication time between the top decision maker and the first-line staff. Meanwhile, the decisions of organization have to be scattered, making sure that managers of different level have certain decision-making power. Moreover, the organization should focus on the need of customers when restructure the organization. The organization must reorganize the business process, eliminate activities that increase customers' value, form mutli-function teams. Finally, the organization must carry out the technology innovation. Technology innovation is the most powerful guarantee that products meet customers' demand. The organization's technology innovation must be combined with the market need, to avoid the capital waste from the technology innovation.

References

1. Tyler F (1999) The principle of scientific management. Solidarity Publishing, Beijing

2. Ryan D (1986) The evolution of management thought. China Social Science Press, Beijing
3. Stevenson W (2000) The management of production operation. China Machine Press, Beijing
4. Jay H, Barry R (1999) Production and operations management. Prentice Hall, Beijing
5. Chen R, Zhou S (2000) The theory and practice of production operation management. China Renmin University Press, Beijing

Chapter 28
Analysis and Countermeasure Study on Human Resource Plight of Small and Medium-sized Enterprises

Feng Lin and Qian Zhao

Abstract Small and medium-sized enterprises in China have always played an important role in the national economy. However, in the context of global economic integration, small and medium-sized enterprises in China are now enduring numerous unfavorable effects caused by decline in economic growth, domestic inflation, the continuous appreciation of RMB, blocked export, the tension of capital lack, shortage of talented people, etc, which lead to more and more serious predicament. Affected by talents issues most, the enterprises are facing Human Resource Plight—Difficulty in recruiting, employing and maintaining talented people. This research will reveal the existing difficulties and problems by analyzing the status quo of the plight. Finally, the research will work out various feasible countermeasure programs from aspects of recruitment, training and development and salary system design, based on theory of Human Resource Management. Meanwhile, healthy development of SMEs can't be separated from the joint efforts of government and society.

Keywords Small and medium-sized enterprises · Human resource · Plight · Countermeasures

28.1 Introduction: Overview of Development of SMEs in China

Since the reform and opening up, especially the beginning of the new century, SMEs in China have continued to grow and develop. As an important force in the development of our national economy, SMEs have an important impact on national economy and social development. With the advent of knowledge economy era, Human Capital elements are increasingly becoming the crucial elements in the realization of the strategic objectives for the enterprises. Regardless of the type and size, those

---

F. Lin (✉) · Q. Zhao
Business School, University of Shanghai for Science and Technology, Shanghai 20093, P. R. China
e-mail: linfeng@usst.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_28,

enterprises have increasingly high demand for human resource. Human resource, together with material resource and land resource, have become the key elements in deciding the fate of the enterprise: rise or fall, success or failure. Especially in the period of “12th Five Year”, the impact on SMEs by human resource is more prominent in the process of economic restructuring and upgrading of the structure.

Currently, compared to the large-scale state-owned enterprises, the vast majority of SMEs in China have obvious disadvantage in corporate management, internal staff training and development, performance assessment, benefits program, salary distribution, because of the limited scale, weak technology development capability, low level of innovation and weak financing capability. So that it is difficult for SMEs to attract and retain the outstanding talented people. And the competition for talented people is becoming increasingly fierce. Thus, strengthening study on SME human resource, discovering and analyzing the causes and developing appropriate countermeasures have great and positive significance in the promotion of the healthy development of SMEs as well as China’s national economic and social development.

SMEs in China have always played an important role in the national economy. According to what our Chief Engineer of Ministry of Industry and Information Technology said in “2010 China’s non-public-owned economic development forum” which was held in Sep. 26th, 2010: Accounting for 99% of the total number of the enterprises, SMEs provide 80% of the urban jobs and the final product and service value SMEs create is equivalent to about 60% of GDP. The tax from SMEs is approximately 50% of the total state tax revenue. At present in China, 65% of the invention patents, more than 75% of the technology innovation and more than 80% of the new product development are completed by SMEs. It is estimated that the number of SMEs in China in 2011 will reach 46.6 million, of which the number of firms with corporate web site will reach 3.63 million. At the same time, SMEs are the main undertaker to ease the social employment pressure. Compared with large enterprises, SMEs are mostly engaged in labor-intensive industries, and tend to use more and more labor resource because of the low capital formation. According to the study by American Scholar David Parky, among every 10 new jobs, eight are created by those small enterprises which employ fewer than 100 people [1]. Represented by SMEs, the status and role of non-public-owned economy in China’s economic and social development is continuously enhanced.

However, in the context of global economic integration, small and medium-sized enterprises in China are now enduring numerous unfavorable effects caused by decline in economic growth, domestic inflation, the continuous appreciation of RMB, blocked export, the tension of capital lack, shortage of talented people, etc, which lead to more and more serious predicament. It is found in the research that among current SMEs, about 10% are upgrading, around 20% are in transition, and still a large number of SMEs (60% $\sim$ 70%) are now facing serious survival difficulties. The profit margin of SMEs is less than 3% [2]. According to the report, the relevant departments of the state spend more than half a year doing systematic research on Guangdong, Zhejiang, Jiangsu and other 16 provinces. It is shown from the data that from January to July in 2011, among 310,000 small and medium-sized private enterprises, the number of loss-making enterprises was 40,000, the loss was 12.7%, and the overall change of the loss of every month wasn't big. But it is noteworthy that the degree of business loss was increasing monthly: The rate of increase of the loss rose from 22.2% (from January to February) to 41.6% (from January to June), and further to 46.9% (from January to July). Among those surveyed enterprises, more than 50 percent of them believe that "The financial Crisis" will reappear, enterprises generally expressed concern about the overall situation. Referring to the comparison between current operational state and last year, 36.4% of business decision makers included believe that the business situation of their own enterprises has become worse in the last year; in the context of the monetary tightening, up to 75.5% of the surveyed SMEs believe that the current bank loan supply is tight; 42.6% of the enterprises think that there is already a "Collapse Tide" among SMEs [3]. Due to the superposition of multiple factors: borrowing rate, RMB exchange rate, tax rate, wages to workers, land-transferring fees, SMEs are facing high cost and operational difficulties. Apart from those factors above, the talent problem which affects operation of SMEs, is also a very important factor, furthermore, the labor shortage phenomenon, which is very common in the eastern coastal regions, has begun to spread to other regions. SMEs are now facing a series of Human Resource plights: difficulties in recruiting, employing, retaining people and so on.

28.2 Problem Statement: Analysis of Human Resource Plight for SMEs

28.2.1 Difficult for SMEs to Recruit People

28.2.1.1 Huge Employment Gap, Difficult to Recruit

Since the financial crisis, there have been difficulties in recruiting people to varying degrees among many places and enterprises. Although many SMEs revived from the 4 trillion yuan economic support policies, the "difficult to recruit, shortage of labor" situation has risen again since last year and is becoming more and more worse. According to a survey report recently completed by the Toy Industry Association of Guangdong Province, currently, toy industry in Guangdong, especially those trading and processing-based enterprises have "recruitment difficulties" to varying degrees, the general gap is 10% $\sim$ 30%, some is even high to over 50% [4]. In 2011, according to the report, it is shown from the information from the Labor Department of Shenzhen that the lack of labor will be about 200,000 after the Spring Festival [5]. According to the report from People's Daily, the employment in Suzhou is generally stable. However, the employment gap of SMEs, newly-opened enterprises, as well as textile printing and dyeing enterprises is still large, which causes great difficulties to their operation. The rate of labor lack of SMEs is 20% $\sim$ 30% and the labor lack in foreign enterprises is 110,000 [6]. Among the 92 interviewed enterprises in Ji'nan, the survey result shows that 56% of SMEs have labor shortage. Among those enterprises which have recruitment difficulties, up to 52% of them have seriously low recruitment: the real recruitment number only accounts for less than 40% of the planned number [7]. The enterprise employment cost has greatly increased: the average cost has increased by 20% $\sim$ 30%.

28.2.1.2 Structural Imbalance between Supply and Demand Exists among Majority of SMEs

In the recruitment of human resource market in Shenzhen, the middle and high-end positions accounts for around 35% of the total positions, however, technicians on the job market can't satisfy the need of the development of the enterprise. A research on Demand for talents among SMEs of Pearl River Delta was held. They focused on the selected 33 enterprises. Through the combination of field and online survey, they distributed 147 questionnaires and got 135 valid returned questionnaires. The survey result shows that what the employer needs most is the professional and technical talents, followed by followed by marketing, R & D and human resource management talents. The demand for the general production worker is even less than 5%. Currently, about 45% of the enterprises need the undergraduate talents, which work best in the operation of the enterprises. However, the demand for those with Doctor degree and those with junior school or even lower education background is pretty low. According to the persons in charge of human resource department from some SMEs, it is very difficult for the SMEs to recruit blue-collar workers who master the production technology very well because the high salary requirement is far beyond the range which the enterprises can bear. Additionally, the demand for different types of talented people are not on the same level: the proportion of demand for professional talents, universal talents, innovative talents and skilled talents are as follows: 30%, 37%, 22% and 11% [8].

28.2.2 Difficult for SMEs to Employ People

The quality of business and employees are generally low in SMEs because of the foundation of development and historical background. Statistics show that 76% of the SME owners are university graduates or above, but in China only less than 1% of the SME owners are university graduates. Among every 100 people in large enterprises in China, the number of scientific and technical personnel is 6.7, while the number in SMEs is only 5.5. Referring to those who have college education or above among every 100 staff, the number is 10.46 in large enterprises, while the number is only 2.8 in small township enterprises [9]. The SMEs spend very little on education and training of the staff, some even don't have long-term education spending. Only 37.9% of the SME owners participate in various short-term trainings, far less than the proportion in large state-owned enterprises (58.6%) and foreign-funded enterprises (68.1%). It also reflects that the phenomenon of heavy management and light development universally exist among the SMEs [10].

According to the results of a survey on the training status of the SMEs in Jiangsu province, only 21.3% of the SMEs established a training department, 65.4% of the SMEs appointed responsible persons instead of establishing a training department. While those with no training department and responsible persons account for 13.3% of the SMEs. It is obvious that the attention paid to the training by the enterprises is not enough: 39.9% of the sample enterprises attach great importance to the staff training and make it a priority. While 53.3% of the enterprises place emphasis on the staff training but take no effective measures. 6.8% of the enterprises even pay little attention to the staff training [11].

Most SMEs often don't have an continuous and comprehensive training system. Corporate management level regard training, wages and benefits just as a cost rather than an investment. Many enterprises even don't offer the same opportunities for women on the job promotion. In other countries, generally, the human resource development and training expenses account for about 7% of the total profits of the SMEs, while in our country, the expenditure only accounts for less than 1%. Many SMEs only employ instead of training people. What they need is instantly available practical talents which can make immediate contributions to the enterprises after being hired. There are more or less some short-term behaviors on personnel training among most SMEs because of the reluctance to assume the risk of the talents loss after training. Only employing without training has become a common phenomenon [12].

28.2.3 Difficult for SMEs to Maintain People

28.2.3.1 High Staff Turnover Rate in SMEs

According to the survey results from the research on 3967 enterprises (sample enterprises consist of foreign-funded, privately owned and state-owned enterprises with the proportion of "3 : 6 : 1") by Zhaopin salary data center, in 2011, the staff turnover rate was 13.9%, among which the initiative loss rate is 6.6% and passive loss rate is 7.3%. Comparatively speaking, the turnover rate of talents in SMEs is far above the average level. Relevant data show that in 2008, the turnover rate of talents in SMEs is more than 50%, far higher than 15% which was the reasonable turnover rate [13]. According to a survey conducted by department of Sociology at one university, based on the research on 62 privately owned enterprises, the results show that the working age of the medium and high level talents and scientific and technical personnel are generally very short, always 2 $\sim$ 3 years, the shortest is 50 days while the longest is no more than 5 years [14]. At present in China, the turnover rate of medium and high level talents in some SMEs is as high as 50% $\sim$ 60%. Excessive turnover rate is bound to bring a considerable negative impact to the enterprise, may eventually affect the potential and competitiveness of the sustainable development of the enterprise, and can even lead to the ultimate decay of the enterprise.

28.2.3.2 Low Pay Satisfaction among the Staff

A survey on salary level and satisfaction conducted by ChinaHR found that, the staff salary of SMEs is on the general level (as shown in Table 28.1) [15]. Among those interviewed staff, there are two different viewpoints towards remuneration package: the "yes, I am very satisfied" only accounted for 0.063% and the "just so so, not very satisfied" accounted for 59.73% (as shown in Table 28.2). All above reflects that the SMEs lacks attractiveness in the remuneration package and also a serious problem in the compensation design.

Table 28.1 Salary levels of units of different natures

Nature of Units	Average of Annual Pay (Yuan)	Median of Annual Pay (Yuan)
State-owned enterprises	47585	36000
Business units	41330	32000
SMEs	33351	24000
Foreign-funded enterprises	31899	24000
Government agencies	27596	29000
Sino-foreign joint ventures	24787	18000

Table 28.2 Viewpoints toward the current pay in units of different natures

	Viewpoints toward current pay				
Nature of Units	Very satisfied (%)	Satisfied (%)	Comparatively satisfied (%)	Not very satisfied (%)	Too little satisfied (%)
State-owned enterprises	0.73	10.45	4.57	55.97	27.28
Business units	1.20	12.07	4.21	55.10	27.42
SMEs	0.63	13.31	4.76	59.73	21.58
Foreign-funded enterprises	1.33	18.98	6.66	56.68	16.36
Government agencies	1.83	11.38	4.22	55.41	27.16
Sino-foreign joint ventures	1.32	17.3	18.55	5.9	56.92

28.3 Modeling and Solution: Countermeasures for Pulling the SMEs Out From the Human Resource Plight

Human resource has been widely recognized as one of the most important enterprise resources since the beginning of the 21st century. Human resource management has become one of the crucial factors in the corporate strategy. It is found in the study that effective human resource management have a positive impact on the organizational performance which includes higher productivity and better financial performance. Therefore, in order to get out from the current human resource plight, the main way is to take full advantage of the principles and methods of the human resource management, aim at attracting effective labor, training and retaining the outstanding workforce and solve the problem the SMEs are facing.

28.3.1 Enhance the Attractiveness of the SMEs, Optimize the Staff Recruitment and Selection Mechanism

Previous studies have found that because of the limited financial and material resources, the recruitment of the SMEs is often sporadic, unplanned and always provides a lot of work which needs to take a variety of functions and doesn't have clear responsibilities itself. Thus, the SMEs are not seen as a suitable alternative employer. Because of lack of resources, the SMEs tend to use some non-formal way in the staff recruitment methods to make the SMEs unattractive. Meanwhile, SMEs have a pressing demand for labor, therefore, the "staff choose the enterprise" and "enterprise choose the employee" are the both issues the SMEs must take into consideration during the recruitment and selection process. As to the issues above, we can effectively use the matching model between enterprises and employees, as shown in Fig. 28.1. The matching model can help enterprises and employees fully understand their characteristics and needs, and find the talents and positions that can satisfy their needs, interests and values. In order to let the employees choose the SMEs, the enterprise must solve the survival and development issues fundamentally from their own point of view. This requires that SMEs continuously improve their business, enhance the technology and management level, and implement the industrial upgrading and restructuring. Meanwhile, the level of management and technology of the enterprise is positively correlated with the demand for human capital. With the further deepening of industrial upgrading and restructuring, the technical and management level of the SMEs will continue to increase and so will the demand for the human capital. The production and business activities of the en-

	Matching model	
Incentive by enterprise		**Contribution by staff**
Wages and benefits	Match with each other	Ability
Meaningful work		Education level and working experience
Space for development		Creativity
Training		Loyalty
Challenging		Professional skills and knowledge

Fig. 28.1 Matching model between enterprises and staff

terprises follow to the logic of profit maximization and the profit depends on the marginal productivity of labor. So when the marginal productivity of labor is positive, the enterprise will increase the demand for the human capital, and reduce the demand on the contrary [17]. Only the enhancement of the profitability of the enterprise can effectively improve the attraction level of the talents.

The recruitment and selection of the enterprise has become complex because of the complexity of the current business environment and conditions. A serious shortage of front-line staff, fierce competition for high-level talents, and rising human resource cost require the SMEs to optimize the staff recruitment and selection mechanism so that the enterprise can reduce the costs by making full use of the advantages of the information technology. A research on the transformation of the electronic human resource from the traditional human resource found that Internet and the information technology have made a significant impact on the strategy of recruitment, training and retaining. Take human resource information system as an example. It is a computer integrated system and can provide the information and data needed in the human resource planning and decision-making. It can also deal with the wages, benefits, retirement plans and other administrative matters automatically. Thus, it can save significant cost. In order to obtain the needed talents, the enterprise can expand the recruitment channels by making full use of the advantage of the internet, that is fast-spreading information, wide-covering range, and low-leveling cost.

28.3.2 Carry out Continuous Human Resource Training and Improve the Staff Evaluation Mechanism

Staff training can improve the working ability of the employee, and also can increase the satisfaction of the employee. Therefore, to carry out continuous training on staff is an important method to retain the required talents. As a main part of the market competition, the enterprise should be rational. That is why it is necessary for the enterprise to make a detailed analysis of the training needs before the training and then determine the training program according to the actual demand. Meanwhile, in order to make the personal development goals of the employee consistent with the enterprise objectives, the enterprise should help the employee determine the individual career and direction of development, basing on its own characteristics combined with the human resource training plan. And also it should make an effective combination of the staff training and the establishment of learning organization. The SMEs should establish the concept of "lifelong learning" among the staff and integrate the learning into work and form a strong learning atmosphere. The SME can also carry out "learning, innovation, development" activities. Educational management should be established to adapt to the development of the enterprise while learning promote system should be established to motivate the staff to learn. The enterprise should actively mobilize and guide the workers to study hard.

SMEs should also establish a sound scientific appraisal system. So that the staff can get a comprehensive and effective evaluation. The system also avoid the simple randomness, so that the staff can feel fair and equitable. In order to let those excellent staff get development opportunities and have a sense of belonging to the enterprise, the enterprise should establish appropriate internal promotion mechanism and avoid favoritism and glass ceiling.

28.3.3 Scientific Design of the Pay System and Enhancement of the Employee Motivation

The SMEs have to improve their existing pay system, by taking the scientific pay design as the alternative. And it should reflect the principle of combing material incentives with spirit incentives and combing static design with dynamic adjustment.

From the perspective of the employees, the pay is the process during which the employees become relatively satisfied, and also the basic conditions for them to maintain their basic living and improve the quality of life. From the perspective of the enterprise, not only the supportability salary is needed to retain the talents, but also the competitive salary is more needed to attract the talents, which will then result in the forward flow of the staff and strong staff loyalty. Although the material incentive compensation will play a role in motivating the staff and mobilizing the enthusiasm of the staff in the short or medium term. However, the incentive of material reward is temporary. On the contrary, the incentive brought by spirit incentive compensation is more effective and can last longer. Thus, we must pay attention to the use of all kinds of internal salary which has the spirit incentive. In broad terms, the salary can be divided into two parts: internal and external salary. The specific forms of the internal salary are as follows:

1. the right to participate in the decision making.
2. opportunity to fulfill one's potential.
3. the autonomy and freedom to arrange one's own working hours.
4. more authority.
5. interesting work.
6. opportunities for personal development.
7. a wide range of activities, etc.

External salary is directly related with the expenditure of the money and material objects of the organization. Internal salary reflects the satisfaction that the employees get from the work itself and generally it hardly consume any of the economic resources of the enterprise. When the internal salary is very low, the employees will call for relatively high external salary to compensate. And this is a reminder that when the SME is in poor economy and has poor competitiveness in external salary, it can make some compensation through internal salary design.

Meanwhile, dynamic remuneration system should be constructed. On one hand, in order to understand the expectation of the employees on the salary and determine

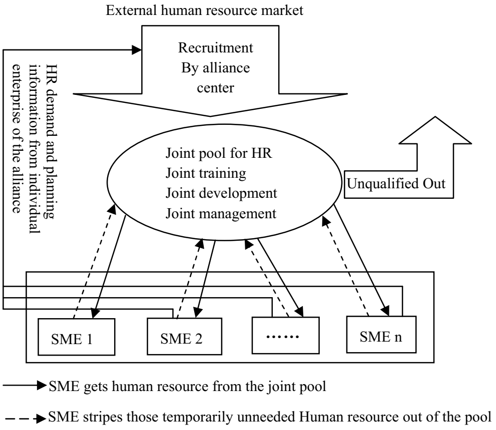


Fig. 28.2 A joint reserve model of the human resource sharing alliance

an appropriate salary level, salary survey should be conducted on salary level in the same industry and related industries and internal salary status. On the other hand, it should be taken into consideration that under the circumstances of market economy and information technology, it is difficult for a simple static salary system to retain highly skilled talents, let alone to satisfy the goal of the corporate salary incentive. Therefore, a dynamic salary incentive model must be built. To build a dynamic salary system, firstly, it is necessary to consider the average salary of the scarce talents in the labor market. Secondly, the strength of the enterprise should be taken into consideration. Thirdly, the performance of the staff should also be taken into consideration. In addition, you can adjust the salary level and structural proportion according to the results of the survey on the salary satisfaction of the staff.

28.3.4 Building Human Resource Sharing Alliance to Reduce the Cost of Human Resource for SMEs

Human resource sharing alliance refers to a loose organization, which occurs between two or among more enterprises. For the consideration of the overall strategic objectives and business risks of the enterprise and aiming at sharing human resource, those enterprises united to complement each other's advantages, share the risk and benefit of the human resource through a variety of agreements and equity integration. Human resource is a special resource and human resource reserves from various enterprises can be seen as "human resource" inventory which also need inventory cost. However, the cost will be very high to the social economy if individual enterprises maintain this inventory separately. And it also means a pretty high cost and risk to the enterprise, especially to those SMEs which have limited resources. Based on the idea of sharing resources, the SMEs can jointly build the pool of human resources, in which they can share both the benefits and risks. The model is shown in Fig. 28.2.

From the schematic we can see that such human resource sharing alliance needs to set up a shared human resource service center and a joint human resource pool. The shared human resource service center is in charge of the joint human resource pool, including recruitment, training, performance management and remuneration [18].

28.3.5 Strong Support from Government

From the perspective of the government, it should create a favorable environment for the survival and development of the SMEs through the formulation of the policies and measures to encourage and support the development of the SMEs. Firstly, the government should strengthen the planning and construction of the labor market and create a favorable employment environment to ease the situation of "labor shortage". Secondly, the survival and development of the SMEs must be achieved through industrial upgrading and restructuring while the restructuring and upgrading of the enterprise should be innovation-driven instead of relying on the development of the cheap labor in the past. Thirdly, in order to improve the human capital stock of the whole community and effectively increase the supply of human capital for all types of enterprises, including the SMEs, the government should continue to increase the level of investment in the education.

28.4 Conclusion

The SME is an indispensable force in the development of economy of China. Human resource, as an important strategic resource, is a key factor in the development of the SME. Currently, in face of a series of plights–difficulty in recruiting, employing and maintaining talented people, the enterprise should enhance its own ability and strength and constantly improve its management level through the optimization of the recruitment, continuous training and development and scientific salary design. Under the strong support from the government which strengthens the investment in the human capital and implement favorable policies for improving the business environment for the SMES, the SMEs will definitely have a greater space for development and make greater contribution to the development of China's economy through the joint efforts of government, communities, enterprises and individuals.

Acknowledgements This work is supported by National Nature Science Foundation under Grant No. 71171135.

References

1. Chen HT (2006) Discussion on the status and role of SMEs in the national economy. Popular Science 5:119–120 (In Chinese)
2. Qin F, Ai J (2011) The profit margin of SMEs in China is less than 3%, the supportive policy is imminent. Shanghai Securities News (In Chinese)
3. Han F (2011) Where is the way out for Wenzhou in the Crisis. www.emkt.com.cn, 2011.10.18 (In Chinese)
4. Jiang Y, Wang Y (2010) Investigation on status of 'labor shortage' in Pearl River Delta. China Economic Times (In Chinese)
5. Zhang X, Liu R (2007) The lack of labor is estimated to be 200,000 after festival: The number of craftsmen cannot meed the demand. Network News (In Chinese)
6. Lin L, Cheng S (2011) Employment gap among SMEs in Suzhou is 30%, the lack of labor in foreign companies is 110,000. Suzhou Channel, People's Daily Online
7. Sun T (2011) Simple analysis of domestic 'labor shortage' in SMEs-based on the research on Jinan. Learning Theory 5:158–160 (In Chinese)
8. Chen Y, Yao Y, Rao Z et al (2010) Survey on the demand for talents of SME in the PRD and reflections about the employment problem. Comprehensive Digest (Management Version) 23–24 (In Chinese)
9. Hu HP (2005) Fight a guardian war for 'talents security'. International Exchange of Talents 2:34–37 (In Chinese)
10. Wu C (2010) Current situation and countermeasures of China's private enterprises in staff training. China Business 15:10–12 (In Chinese)
11. Zhou L, Zhao S, Zhu W (2010) The training status of small and medium enterprises (SMEs) in Jiangsu Province and countermeasures. East China Economic Management 24:10–14 (In Chinese)
12. Yu J, Qu B (2010) Human resource strategies for the SMEs in China under the standard of social responsibilities system. Science & Technology Progress and Policy 27:142–145 (In Chinese)
13. Shui S (2010) Loss management of knowledge worker for small and medium-sized private enterprises. Market Modernization 157–158 (In Chinese)
14. Zhou Z (2009) Causes and analysis of characters of staff turnover in SMEs. Management and Technology of SME 6:3 (In Chinese)
15. Fan E (2010) Research on salary status and design for small and medium-sized enterprises. Journal of Industrial Technology Economics 27–31 (In Chinese)
16. Draft R (2003) Management. China Machine Press, Beijing
17. Ge Y (2010) Principles of human capital. Economic Management Press, Beijing (In Chinese)
18. Lin F, Zhao F (2010) Research on enterprise human resource-sharing alliance. In: Proceedings of The Fourth International Conference on Management Science and Engineering Management

Chapter 29
The Empirical Research between the Financial Industry Clusters and Regional Economic Development

Lixia Yu, Wenchao Yu and Wen Wen

Abstract This paper builds a set of evaluation index system to measure competition of the financial industry cluster in different regions by using the principal component analysis method. By using the 2003-2008 index data of 31 provinces, autonomous regions and municipalities as research sample, the index for evaluating the competitiveness of the various financial industry clusters in different regions in China has been calculated. Then based on the calculated index which will later be used as production factors, we have managed to construct a model which connects the index with the tertiary industry and industrial structure. This paper's empirical results explain that cultivate financial industrial cluster in a financial region is very important, which provides a theoretical support for local government to take a series of measures to promote the formation of financial agglomeration and establish a regional financial center.

Keywords Financial industry clusters · Financial industry cluster competitiveness · Industrial structure · Tertiary industry

29.1 Introduction

Since the first time when Tobin introduced the currency factor to the research of economic growth in 1955, economists had been starting to pay attention to the role of financial in economic growth from various points of view, in which the most famous is Goldsmith's "financial development theory" and McKinnon, Shaw's "financial repression and financial deepening theory". Theory research and empirical

---

L. Yu (✉) · W. Wen
Business School, Sichuan Normal University, Chengdu 610101, P. R. China
e-mail: ylx6209@163.com

W. Yu
Research Institute of Economics and Management, Southwestern University of Finance and Economics, Chengdu 610041, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_29,

test by domestic and foreign scholars have shown that the financial development and economic growth are interrelated and interacted with each other. Especially in the take-off stage, financial is even the biggest driving force. When the research between the financial development and economic growth comes into the regional levels, studies like the internal function mechanism between the thing as a process of financial development and a new organization form of financial industry clusters and regional economic growth, the important role of financial agglomeration level in regional economic growth become quite important. In our country, more than 20 years ago, "pearl river delta" area (represented by Shenzhen) opening up to the outside world; More than 10 years ago, the "long triangle" economic prosperity marked by Pudong development; until now economic in the area of "the Beijing-Tianjin-Hebei" taking off, and regional economic developments are always growing as twins with regional financial industry cluster.

29.2 The Construction of Competitiveness of Financial Industry Cluster Evaluation System

Formation and development of financial industry clusters need a good external environment and system background, which have a very high demand to the interfiled social economic development level, industrial foundation and advanced professional talent. Based on the financial industry cluster formation condition, this paper has constructed the evaluation index system which measure different areas of financial industry cluster competitiveness. At the same time, when looking up the domestic related literature, the author found that, the principal component analysis is one of the methods constructing the relevant evaluation index system. That is, selecting all-round objective measure from different dimensions of a region or a city to measure the financial industry of a district. The existing literature has some common features in selecting indicators. For example: Hu and Yang [4] Zhang [14] and Liang [9]'s international financial center measure system, regard a national political risk as an important measure; Yin et al [12] drew support from the distribution of financial resources to measure the city's financial competitiveness. They picked 15 cities as research samples, divided the 15 cities into three classes, and classify Shanghai as the first kind city; Huang [6] and Wang [10] have constructed the comprehensive evaluation index of regional financial center. They all think that a regionally financial center competitiveness is decided by the economy, finance, the development of the city and legal system environment. In [16], the author has correspondingly screened the indicators used in above documents, which are based on the principle of metrics' multiple perspectives, relativity, and metrizability (shown in Table 29.1).

1. The development of financial industry. The financial industry clusters' formation and development need a lot of financial institutions, financial markets with perfect system and sound financial regulations. Therefore, this paper has selected

Table 29.1 The financial industry cluster competitiveness index

Aggregate indicators	Specific measures	Variable names
Financial industry development	RMB deposit balance of Urban and rural residents ($one hundred million)	X_1
	Foreign currency savings deposit balance (Billions of Dollars)	X_2
	Premium income ($one hundred million)	X_3
	The quantity of domestic listed company (home)	X_4
	The financial industry production value/in GDP (%)	X_5
	The financial industry practitioners/town practitioners (%)	X_6
Economic base	In GDP per capita (RMB/person)	X_7
	The total amount of investment in fixed assets ($ one hundred million)	X_8
Financial market	Financial marketization index	X_9
The Infrastructure	Railway and highway miles (kilometers) business	X_{10}
	The number of Internet access (ten thousand)	X_{11}
Human capital	The number of high school graduates (people)	X_{12}

urban and rural residents' RMB savings deposit balance at the end of the year, premium income and the domestic listed company's quantity to measure the development scale of banking, insurance and securities. This paper uses ratio of financial industry production value in GRDP and the proportion of the financial industry practitioners in the urban employment personnel to Measure the overall scale of the financial industry; and selects proportion index in order to guarantee the rationality of the comprehensive evaluation and comparability.

2. Economic basis. Economic development is the condition of financial industry clusters' formation. Also, the fast growth of the economy produces huge demand for financial products, and then promotes the development of the financial market. The author uses GDP per capita to measure a region's economic scale, while the fixed assets investment plays an important role in promoting economic growth. This paper regards it as an important index of measuring the pace of economic growth.
3. The financial market. Lacking of direct quantitative indicators which measure the financial market system perfect degree and financial regulations sound degree, the author uses the mercerization index which is provided in FanGang and WangXiaoLu's book "the China market index, provinces and regions marketization relative progress report" (2007)to describe the development degree of regions financial market system. The series index provided in this book has been widely applied in the academic research, which has a high credibility. The book does not provide the data in 2008, so the author uses data in 2007 instead.
4. Infrastructure. Having developed and sound basis supporting auxiliary facilities or not are key factors in decision-making of many multinational companies, do-

mestic and foreign financial institutions, and financial talents. This paper uses railway and highway mileage to measure the traffic convenience degree in an area. And it uses the number of Internet access to measure the communication convenience degree in an area.

5. Human capital. The human capital is the core production elements of the financial industry development. It decides the sustainable development degree of the financial industry cluster in an area. The formation and development of financial industry cluster in an area need a large number of senior professionals. We use the number of college graduates in this region to replace the region's human capital situation.

29.3 The Sample Selection and Data Sources

29.3.1 The Sample Selection and Data Sources

This paper selects 31 provinces, autonomous regions and municipalities as research samples in constructing the regional financial industry cluster competitiveness. This study will use stata. 10's statistical software to do the principal component analysis and regression estimation model.

29.3.2 The Variable Descriptive Statistics (Shown in Table 29.2)

From the view of residents RMB savings deposit balance, foreign currency savings deposit balance and premium income, there are obvious differences between the regions. However, financial industry total scales of using employees and output measures are basically the same, with a proportion of about 3% in the whole national economy.

29.3.3 The Financial Industry Cluster Competitiveness Index Structure

Standardized treatment: changing the original variables into mean value 0, the standard deviation into new variables 1, in order to eliminate the effects of differences that the disagreed unit and the standards bring.

Appropriate analysis: using KMO method and SMC method to find out the principal component analysis for proper inspection. All the KMO of variables are around 0.8, and the KMO is 0.85. Most of the variables' SMC value is about 0.7. It shows

Table 29.2 The variables of the descriptive statistics (2003-2008)

Variables	Observation number	Mean	Standard deviation	Minimum value	Maximum Value
Residents RMB savings deposit balance (one hundred million yuan)	186	4909	4360	91.90	27501
Foreign currency savings deposit balance (Billions of Dollars)	186	21.15	34.24	0.0600	184.7
Premium income ($ one hundred million)	186	190.4	178.3	1.030	1125
The listed company number (home)	186	44.57	36.43	8	202
The financial industry value accounts for the proportion in GDP (%)	186	3.65	0.0245	0.00607	0.147
The financial industry practitioners in the proportion of urban employees (%)	186	3.22	0.00581	0.0222	0.0549
In GDP per capita (RMB/person)	186	18088	12960	3603	73124
Investment in fixed assets (one hundred million yuan)	186	3349	2932	134.0	15436
Financial marketization index	186	7.163	2.127	0.730	12.01
Highway and railway total mileage (km)	186	90535	57680	6741	244687
The number of Internet access (ten thousand)	186	499.8	550.0	7	4554
Average number of college graduates (person)	186	11133783552		1745	411143

that the linear relationship and general character between variables are strong. It fits for the principal component analysis (shown in Table 29.3).

Table 29.3 Variable correlation coefficient matrix

Variable names	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}
x_1	1											
x_2	0.652	1										
x_3	0.955	0.611	1									
x_4	0.811	0.715	0.856	1								
x_5	0.250	0.595	0.386	0.538	1							
x_6	0.282	0.327	0.326	0.422	0.322	1						
x_7	0.535	0.606	0.651	0.707	0.687	0.429	1					
x_8	0.835	0.304	0.854	0.635	0.0629	0.224	0.443	1				
x_9	0.651	0.402	0.655	0.615	0.264	0.421	0.531	0.682	1			
x_{10}	0.394	−0.154	0.359	0.102	−0.347	−0.185	−0.159	0.557	0.248	1		
x_{11}	0.909	0.442	0.902	0.729	0.177	0.154	0.456	0.815	0.589	0.471	1	
x_{12}	0.733	0.177	0.754	0.538	−0.00870	0.116	0.323	0.871	0.559	0.639	0.717	1

Calculating correlation coefficient matrix and extracting principal component: from the correlation coefficient matrix we can conclude, the correlation coefficient between variables is mostly more than 0.5. Further, through the rubble figure (Fig.

29.1) and the accumulation contribution rate of principal component (Table 29.4), we find the variance accumulation contribution rate of the first three principal components is up to 83.52%. It will be relatively appropriate to extract three principal components, which means these three main components already have contained most of the information of the original variables.

Table 29.4 The characteristic value and variance accumulation contribution

Principal component	Characteristic value	Variance contribution rate (%)	Accumulation contribution rate (%)
1	6.683	0.5569	0.5569
2	2.478	0.2065	0.7634
3	0.861	0.0718	0.8352

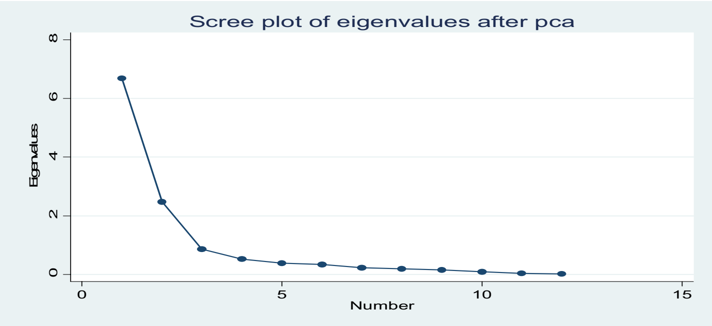


Fig. 29.1 The 2003-2008 financial industry cluster competitiveness index public factor gravel figure

29.4 Calculation of Financial Industry Cluster Competitiveness Index

After acquiring the result of three principal components, we use the contribution rate of each principal component to these three main components cumulated variance as weight, to structure the model of calculating the financial industry cluster competitiveness index: $C = 0.667 \times C_1 + 0.247 \times C_2 + 0.086 \times C_3$. We can figure out the average competitiveness index in each region during 2003-2008 periods. See Table 29.2. What needs to explain is that the comprehensive score, as a relative measure, will cause a positive or negative score due to the standardization of data. We find that the highest score in several provinces is Guangdong, Shanghai, Beijing, Jiangsu and Zhejiang respectively. These provinces and cities have obvious advantages no matter in economic development or in the scale of the financial industry. At the same time, we find that some other provinces have lower total score. They are at a disadvantage in each the index, such as Tibet, Xinjiang, Qinghai and Guizhou provinces in the Midwest.

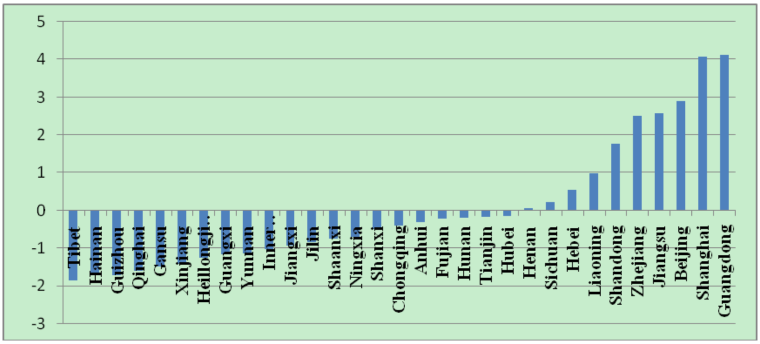


Fig. 29.2 The 2003-2008 year local financial industry cluster competitiveness index scoring average

29.5 The Tertiary Industry Development, the Upgrading of the Industrial Structure and Financial Industry Cluster Competitiveness

The tertiary industry is the essential part in the whole social reproduction process. Its healthy development is the only way to realize the upgrading of the industrial structure and optimization and to improve the economic social benefits. Along with the development of society and economy, the economic development of all countries in the world history proves that the national economy would present a softening trend and manufacturing would present the service trend. The proportion of the tertiary industry would continuously increase, and it would become an important industry department which has an important strategic position in modern society. At the same time, the existing literature points out that financial sector, as the tertiary industry and the important part in the entire national economy, would influence industry department in the following two ways:

- Financial development can effectively transform savings into investment, so as to improve the efficiency of investment, and promote the expansion of industrial department incremental.
- The financial capital has configuration function on industry department. Financial capital can recognize the industry department that has good investment re-

turn and low risk factors, thus to guide the industry department to develop in the direction of adaption [7, 8].

Among the domestic study of financial development and economic growth on the relationship, Zhou and Wang use financial related ratio (TFIR) and financial market ratio (FMR) as a local financial development measure level, and discuss the relationships between financial development and economic development [15]. Chen and Zhang use VAR causality test and variance decomposition to explore the causal relationships between the financial development and economic growth in China [1]. Wu used Cobb-Douglas production function as the research paradigm to discuss the interactive relationship between financial development and economic growth [11]. However, in the literature about financial development and the changed relationship of industrial structure, Fan and Zhang use the ratio, the second and third industry proportion in GDP, to measure the industrial structure height of an area. They also discuss the relationship between financial development and the upgrading of the industrial structure [2]. Zeng and Wang use the data of 1952-2005 periods to consider the influence that the financial development has on the three big industrial employment structure. They find out that financial development of industry has a remarkable effect on employment proportion [13].

Based on the literature, we think that the improvement of a regional financial industry cluster's competitiveness would have a positive role in promoting a region's economic development and upgrading industrial structure.

29.5.1 The Financial Industry Cluster Competitiveness and the Empirical Analysis of the Tertiary Industry Development

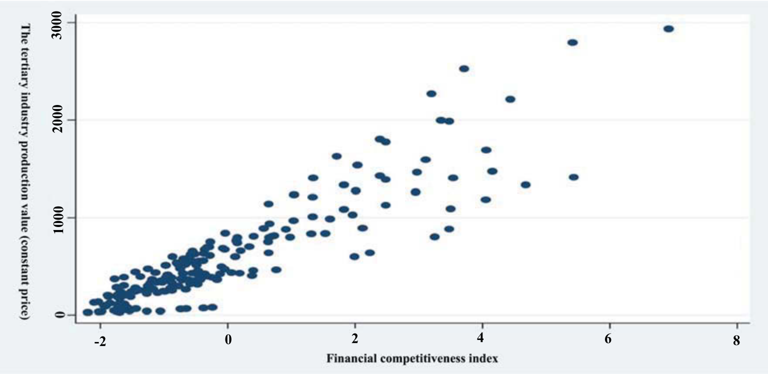


Fig. 29.3 Financial industry cluster competitiveness index and the tertiary industry production value scatter plot chart

First we draw the scatter plot chart of the relationship between the financial competitiveness index and the tertiary industry production value (Fig. 29.3). We can find that they have obviously the positive relationship with each other. It is, in such area, the higher the financial industry cluster competitiveness index is, the higher the third industry production value will be.

Furthermore, we still use Cobb-Douglas production function, and regard the financial industry cluster competitiveness as a production factor to explore the relationship between financial industry cluster competitiveness and the third industry production value:

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln K_{it} + \alpha_2 \ln L_{it} + \alpha_3 \mathrm{Comp}_{it} + \mu_{it}. \tag{29.1}$$

Among them, Y represents the third industry values; Krepresents the third industry capital investment. We use the fixed assets investment of third industry in statistical yearbook instead. L is for the labor input of the third industry, represented by the third industry employment researchers. Comp represents local financial industry cluster competitiveness index; Virtual variable is on behalf of the annual year. μ represents residual items. At the same time, in order to eliminate price factors, we use GDP deflator to convert Y into the actual value which is based on the price of the year 1978. We use fixed asset price index to converse the fixed assets investment of each year into the actual value as a reference which is based on the price in 1991. Local financial industry cluster competitiveness index data (Comp) is the index of a qualified asset under acquisition and construction that we go through the principal component analysis. In this part, the other data are all derived from China statistical yearbook of each year. The time spans of the data in empirical study in this part are for 2003-2008.

Through using the random effects model of panel data and the fixed effects model that are given in Table 29.5 to estimate the result of Equation (29.1), we found: although the coefficient of $\ln L$ is negative in fixed effects model, it's not significant. However,whether using random effects model or fixed effects model, variable coefficient of Comp is 1% in significance level. It shows that rising of the competition ability of financial industry cluster will significantly increase the output value of the tertiary industry. The stronger the area's financial industry cluster competitiveness is, the higher the output value of the tertiary industry will be. It proves that the development of financial industry cluster has promoting function on the third industry development.

29.5.2 The Financial Industry Cluster Competitiveness and the Empirical Analysis of Upgrading the Industrial Structure

Through the first part of the empirical analysis, it can be figured out that the financial formation and development of industrial clusters will greatly promote the development of the third industry. In this part, we continue to empirical test the influence

Table 29.5 Financial industry cluster competitiveness and growth of the tertiary industry

Variable names	Random effects		Fixed effects	
	Estimated value	Standard deviation	Estimated value	Standard deviation
$\ln K$	0.5512***	0.0434	0.4533***	0.0422
$\ln L$	0.2869***	0.0435	−0.0106	0.0613
Comp	0.0669***	0.0199	0.0979***	0.0221
constant term	0.6940**	0.3028	3.1665***	0.4843
Observation number	186		186	
R-squ	0.9407		0.9192	

***, **, * are respectively showed that the estimated value is 1% and 5% in significance level.

which the developments of the financial industry cluster have on the upgrading of the industrial structure[1].

We use Huang and Chen's control variable [6] to structure the following model:

$$\text{Thirdpro}_{it} = \beta_0 + \beta_1 \text{Forei}_{it} + \beta_2 EI_{it} + \beta_3 \text{stud}_{it} + \beta_4 \text{Comp}_{it} + \beta_5 \text{year} + \varepsilon_{it}. \quad (29.2)$$

Among them, Thirdpro represents the proportion the third industry value accounts for in GRDP. The increasing proportion of the third industry values shows the upgrading of industrial structure in a region. Forei represents the proportion the industrial enterprise value accounts for foreign investment to the total industrial output, which is used to indicate a region the proportion of foreign economy. EI is on behalf of the proportion of total import-export volume in GRDP, which represents a local economic openness. On behalf of the student number (every ten thousand people) in the school, the stud measures the human resources of an area. Comp is on behalf of the financial industry cluster competitiveness index. We construct the competitive index through the principal component analysis. Year is the year DUM; ε is a model's residual items. The other data in this part are all derived from the China statistical yearbook in the year of 2004-2009. The main variables descriptive statistics are showed in Table 29.6. We find that the variables in different areas are largely differ from each other.

Table 29.7 presents the estimated result in model (29.2), through Hausman inspection, rejecting the null hypothesis; we choose the fixed effects model of panel data. We find that when the other factors are in control, the improvement of financial industry cluster's competitiveness has significant positive effects on the upgrading of industrial structure, and is 1% in significance level. This shows that the improvement of financial industry cluster's competitiveness could optimize and improve the industrial structure in an area.

---

[1] What is not agree with we expected is that the variable coefficient of Stud is negative and significant, Generally speaking, the accumulation of the human capital in an area will promote a region's upgrading of industrial structure. Using the number of students in the school (every ten thousand people) to measure a region's human capital may make some mistake.

Table 29.6 The descriptive statistics of main variables

Variables	Observation Number	Mean	Standard Deviation	Minimum value	Maximum Value
The third industrial output value of GDP (%)	186	0.3928	0.0728	0.2863	0.7325
Foreign industrial enterprise value proportion (%)	186	0.1991	0.1759	0.0019	0.6581
Every ten thousand people in the school student number (person)	186	131.5154	69.2776	38.5519	357.8615
The total amount of import and export of GDP (%)	186	0.3674	0.4370	0.0429	1.8750

At the same time, we find that the coefficient of variable Forei is positive and significant. It shows that the introduction of foreign capital enterprise will promote a ascension of regional industrial structure .

Table 29.7 Financial industry cluster competitiveness and the upgrading of the industrial structure

Variable names	Random effects		Fixed effects	
	Estimated value	Standard deviation	Estimated value	Standard deviation
Comp	0.0147∗∗∗	0.0046	0.0153∗∗∗	0.0040
Forei	0.1070∗∗	0.0425	0.1022∗∗	0.0419
Stud	−0.0008∗∗∗	0.0002	−0.0003∗	0.0001
EI	−0.0264	0.0286	−0.0245	0.0230
year	control		control	
constant term	0.4664∗∗∗	0.0172	0.4151∗∗∗	0.0183
observed value	186		186	
R-squ	0.0962		0.0235	

∗∗∗, ∗∗, ∗ respectively shows that the estimated coefficient is 1%, 5% and 10% in significance level.

29.6 Policy Conclusions

According to the financial industry cluster competitiveness index system we built before, we can draw two basic conclusions:

First, the improvement of the financial industry cluster competitiveness will significantly increase the output value of the tertiary industry. This shows that a regional financial development of industrial clusters has a strongly promoting role to the third industry development in this area.

Second, the promotion of financial industry cluster of competitiveness can optimize and improve the industrial structure in an area. At the same time, we find that the introduction of foreign capital enterprise will promote a regional industrial structure of ascension.

The empirical results show that, the formation of regional financial industry clusters and the promotion of competitiveness are particularly important for a region's economic sustainable development. The practice of our country also presents this view. In China, the three big national areas of economic development, the Pearl River delta, Yangtze River delta and the Bohai sea, all have a corresponding financial industry clusters to function in it. They are the three financial industry clusters with Shanghai, Shenzhen and Beijing as the center respectively. Therefore, the development of regional economy cannot live without the support of the financial industry. Good financial industry clusters have the biggest radiation and leading role to the development of regional economic.

Acknowledgements This research was supported by the Research Funds of Sichuan Provincial Education Department (Grant No. 09SA042) and Chengdu Philosophy and Social Science Planning Project (2012).

References

1. Chen WG, Zhang HW (2008) Financial development and economic growth — Based on the second examination of Chinese data from 1952 to 2007. Modern Economic Science 3:49–56 (In Chinese)
2. Fan FZ, Zhang LJ (2003) The research of China regional financial structure and industrial structure upgrade. Financial Research 11:36–48 (In Chinese)
3. Fan G, Wang XL (2010) Market index in China — The report of every province's commercialize relative progress. Economic Science Press (In Chinese)
4. Hu J, Yang SL (2003) Construction of the evaluation index system in international financial center. Journal of Peking University 5:40–47 (In Chinese)
5. Huang JY, Yang ZB (1994) Financial structure and economic development. Shanghai Sanlian Bookstore (In Chinese)
6. Huang RF, Chen XH (2007) FDI and industrial structure upgrading based on central region's theory and empirical study. Management World 3:154–155 (In Chinese)
7. Goldsmith RW (1969) Financial structure and development. Yale University Press, New Haven
8. Greenwood J, Jovanovic B (1990) Financial development, growth, and the distribution of income. National Bureau of Economic Research
9. Liang Y (2006) The macro season of financial industrial agglomeration. Nanjing Social Sciences 11:56–62 (In Chinese)
10. Wang RX, Shi D (2005) The construction and fuzzy comprehensive evaluation of regional financial center index system. Statistics and Decision 9:14–16 (In Chinese)
11. Wu Z (2010) Financial development and economic growth: Analysis from Chinese experience. Financial Research 5:58–67 (In Chinese)
12. Yin XS, He YF, Xu HS (2003) The analysis of financial agglomeration and competitiveness enhance in Yangtze Delta. Shanghai Financial 8:42–44 (In Chinese)
13. Zeng GP, Wang YF (2007) Chinese financial development and industrial structure evolution. Economy of Finance and Trade 8:12–19 (In Chinese)
14. Zhang ZH (2005) Evaluation method of index and evaluation index system in international financial center. Social Science Research 1:45–48 (In Chinese)

15. Zhou L, Wang ZM (2002) An empirical analysis of financial development and economic growth in Chinese regions 1978-2000 10:1–13 (In Chinese)
16. Zong XW (2008) The research of financial agglomeration factor of Chinese regional economic growth. Doctoral Dissertation of Nanjing Normal University (In Chinese)

Chapter 30

A Research on Modern Service Industry Innovation and Its Development Strategy

Guoqin Song and Junjie Zhang

Abstract Driven by economic globalization and informatization, the world has entered into the service economy era. In such context, modern service industry is not only becoming a leading and pillar industry for economic development, but also an important indicator of measuring the degree of production socialization and market economic development. Therefore promoting industrial innovation becomes the key to upgrading modern service industrial structure and the foundation to completing the historical mission of modern service industry. This paper integrates the concept of industrial innovation against the background of fast-developing modern service industry. Based on correlational research at home and abroad, this paper applies chain integration theory and service industry development theory comprehensively to show the status of industrial innovation in the development of modern service industry. By revealing the connotation, characteristics, dynamics, modes and influencing factors of industrial innovation of modern service industry, this paper puts forward a set of strategic plans with pertinence and operability

Keywords Modern service industry · Industry innovation · Development strategy

30.1 Introduction

Since the 1970s, global industrial structure has witnessed the transformation from ‘industrial-based economy’ to ‘service economy’. The overall volume of the global services industry has reached $28 trillion, accounting for 68% of global GDP. In places like New York and London, the figure is even as high as 90%. It can be

---

G. Song
Zhijiang College, Zhejiang University of Technology, Zhejiang 310024, P. R. China

J. Zhang (✉)
School of Business Administration, Zhejiang University of Technology, Zhejiang 310024, P. R. China
e-mail: neigo123@126.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_30, © Springer-Verlag London 2013

safely said that the world has entered into an era of service economy. The research on global development patterns indicates that service industry is changing from a labor-intensive one to a knowledge-intensive one. Modern service industry characterized by knowledge and high technology gradually occupies the dominant position of service, becoming the leading and pillar industry in economic development. It has become not only an important indicator of measuring the degree of production socialization and the market economic development, but also an important driving force of today's world economic growth.

With the growing influence of modern service industry, a large number of scholars have put forward its definitions, including the following typical examples: Chang [1] defined it as one consisting of two components: the new service industry emerging from the modernization process and the reformulated traditional service industry after using new technology, new process, new operation type and new service form. Tan [2] proposed that modern service industry is the fast-growing service industry following the stage of massive consumption of industrial production. It mainly contains information and knowledge intensive service industries, relying on information technology and modern managerial methods. Modern service industry also includes those industries which do not produce goods such as information, logistics, finance, accounting, consulting, legal service and other industries.

With the rapid development of modern service industry, how to apply the theory of industrial innovation to modern service industry becomes an efficient way to break through the bottlenecks of modern service industry development. It is an issue that both government and academia must solve together. Based on this and after fully drawing on domestic and international research related to industrial innovation, this paper incorporates the characteristics of modern service industry, and presents four dynamics (internal driving force of enterprise, government promotion, market demand and competition) and four modes(research and development mode, specialization mode, organization mode, and alliance mode). After analyzing the influencing factors, this paper proposes pertinent development strategies, such as implementing system innovation, expanding financing channels, strengthening human resources training, perfecting knowledge utilization and innovating enterprise management.

30.2 Connotation and Characteristics of Service Industry Innovation

30.2.1 Connotation of Service Industry Innovation

The essence of innovation is to introduce new contents and production changes and then to produce economic values. Zhu [3] proposed that industrial innovation is a complex system. It is a network environment driven by market demand, oriented by policy regulations, and supported by a good domestic and international environment. It takes innovative technology as its core in order to achieve a specific innovative target. In a narrow sense, industrial innovation refers to the fact that innovative subjects make inventions or introduce new technologies by regarding technological innovation as core. In broader terms, industry innovation means that innovative subjects foster new industries or upgrade existing industries through institutional innovations, technological innovations, organizational innovations and environmental innovations, thus contributing to a qualitative leap of industrial development.

Innovating activities in service industries, especially in knowledge-intensive service industries are very active, including service concept innovation, service management innovation, technological innovation and customer-oriented innovation and many other aspects [4]. Milesi [5] put forward that modern service industry, from the very beginning, is closely linked to innovation and is becoming more and more innovative. In addition, industrial innovation can be reflected in technological innovation, operation type innovation, business model innovation and so on. It is an innovation comprehensive in nature.

30.2.2 Characteristics of Service Industry Innovation

Different from innovation of individual enterprises, industrial innovation of modern service industry has both common characteristics of service industry innovation and its own distinct innovative features. It mainly includes the following.

(1) Integrated Innovation

Innovation contains many aspects such as products, process, organization and market, so technological innovation, institutional innovation, managerial innovation and organization innovation among enterprises of an industry are all pars of the industry innovation. As modern service industry has a high degree of relevance and knowledge spillover and has to provide specialized services for production and market development, it requires more innovative behavior at a variety of levels.

(2) Technological Innovation as Its Basis

Technological innovation with products and manufacturing technological innovation at its core, is undoubtedly the industry's most fundamental element of innovation. It is the source of dynamism for companies and industries alike. It is also closely connected with organization innovation as well as market innovation.

(3) Holistic Innovation

For technical or organizational reasons, closely-related similar products can appear together around a certain period of time and therefore make innovation activities continuous. Contacts among enterprises can promote the development of the whole industry chain. Only when innovation technology gets popularized in the industry in terms of products, technology, organization, management, can industrial innovation be realized [6].

(4) Highly Customer-oriented

The modern service industry shows a high level of customer orientation and customer participation. It is heavily influenced by customers so that customer demand has become an important source of innovation. Because the modern service industry innovation shows a trend of diversify and knowledge fusion, enterprises often need to provide customer with highly customized service.

30.3 Driving Force, Mode and Influencing Factors of Modern Service Industry Innovation

30.3.1 Driving force of modern service industry innovation

(1) Internal Driving Force of Enterprise Development

In the quest for market competitive edge and maximization of profits, enterprises launch technology innovations and organizational innovations spontaneously. Thus emerging in the industry are new products, new techniques, new organization forms and management methods. The internal driving force of this innovation can either take the form of some individual enterprises blazing the trails and others follow, or enterprises making similar innovations around the same time. Its fundamental purpose is the formation and development of enterprise core competitiveness.

(2) Government Promotion in Industrial Innovation

Because of different technological and organizational polices, different degree of participation by the local governments in the industry, the driving force of industrial innovation turns to be different [7]. The governments may give support in terms of capital and tax. They may also be the organizers of some significant technology research activities. In addition, the governments may also promote the integration among enterprises in the industry to take full advantage of the scale economy and to enhance their technical innovation ability.

(3) Pressure from Market Demand and Competition

When the new demand or competition of the market burgeons, the enterprises of a certain industry are impelled to produce new products, expand production scales, optimize structure and management, and adjust their relationships with their competitors. In this process, the enterprises will reduce production cost and sharpen their competitiveness through technical innovation, organization and management innovation. Therefore, market demand is a new starting point for industrial technology. In addition, the pressure of market competition will also prompt innovative activities within industry enterprises [8].

30.3.2 Mode of Modern Service Industry Innovation

(1) Research and Development Mode

Research and development mode can often be found in large-sized knowledge-intensive service enterprises with standardized production, such as large informa-

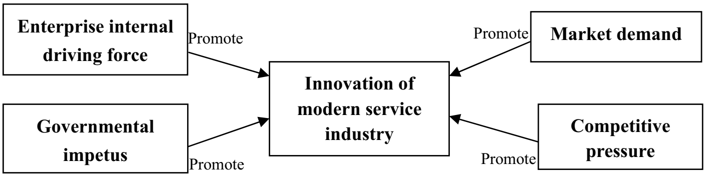


Fig. 30.1 Driving force of modern service industry innovation

tion data-processing companies, and network maintenance companies, etc. Based on technological innovation and professional services, and thanks to two-way, internal interaction between research institutes and management organizations, customers are changed from passive participants into active ones in service activities.

(2) Specialization Mode

Specialization mode means providing specialized professional services to customers. It is a kind of innovation aimed at meeting the special needs of the customers. Knowledge-intensive service industry supplies professional service with expertise. Since this mode is the result of the accumulation of various professionals' different innovative skills, it is often characterized by flexibility and efficiency.

(3) Organization Mode

Organization model is the most common form in the service innovation. It is an innovation in enterprise's policies and strategies. Every employee is a participant. Generally, organizational innovation involves changes in function system, management structure, management system and several aspects of management behavior. The innovation is realized by the co-operation between enterprises and employees. The effects of innovations can reach suppliers, customers and the public sector and other areas.

(4) Alliance Mode

To respond to the scarcity of innovation resources, it is imperative to form an alliance among related enterprises to make the overall technological advancement. Alliance model is intended to provide sufficient flow of innovative resources. The purpose is to break the geographical restrictions, to strengthen collaboration among agencies, and to maximize individual creativity and collective wisdom. The interactions among the members in the alliance can provide channels and platforms for the integration of resources, ease the contradiction between the huge demands and scarce supplies, and improve the overall effectiveness of social resources.

30.3.3 Influencing Factors of Modern Service Industry Innovation

(1) Culture of Innovation

Practice shows that the development of new services could improve a business's performance, and thus become its key competitive advantage. The new service development calls on enterprises and industries to constantly maintain their internal corporate culture, in order to enhance their core competitiveness. Corporate culture of innovation is a set of consistent values and beliefs to encourage staff's creativity, exploration and a sense of risk-taking.

(2) The Research and Development Capacity

The research and development capacity is the source and internal driving force for an enterprise's development. It is the basic guarantee for enterprises to obtain a long-term competitive advantage. It also showcases enterprises' innovative power. On the one hand, when technology innovation is implemented, resources will be reallocated accordingly. On the other hand, improved efficiency brought by technological breakthrough will spur more demands and create more space for further innovation.

(3) Human Resources

In the context of global economic integration, human resources are the core resources and the foundation of innovation. Talents with a strong sense of innovation are the key to promoting industrial innovation. For the modern knowledge-intensive service industries, it is particularly important to attract a large number of talents with both professional skills and innovative capacity.

(4) Market Demand

Whether the industry innovation is successful or not is ultimately determined by the market feedback. By stimulating market needs and developing products that meet consumers' need, enterprises can successfully realize innovative commercialization and industrialization. In today's competitive market society, it is essential to get timely feedback from market.

(5) Innovation Environment

Industry's survival, development, and growth are inseparable from their environment. A good environment is the premise for an industry to access information and to implement innovation [9]. Therefore, in order to better promote innovation of modern service industry, it is imperative to have preferential government polices, a sound financial system and a good atmosphere of innovation inside the industry. In addition, because of the fierce global competition in the service market, a better environment is needed for innovation to encourage the modern service industry to create new services, cultivate their core competitiveness, so as to bring the innovation to a higher level in the service industry.

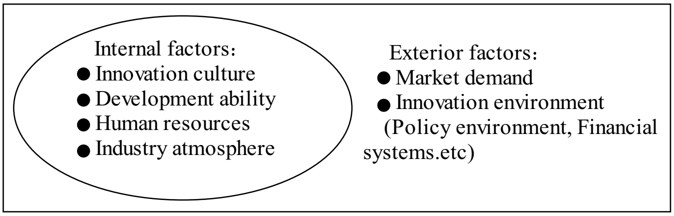


Fig. 30.2 Influencing factors of modern service industry innovation

30.4 Strategy to Promote Modern Service Industry Innovation

30.4.1 Constructing Good External Environment and Optimizing External Innovation Mechanism

30.4.1.1 Implementing System Innovation and Safeguarding the Industrial Innovation

(1) Introducing Competition Mechanism

To carry out system innovation of modern service industry, it is acknowledged that monopoly needs to be broken down, competition mechanism introduced and corporate competitiveness enhanced through competition [10]. The government needs to ease up on market access restrictions of modern service industry, lower the entry threshold for enterprises and standardize market order. For a fair and competitive market, various economic and legal means are available. The government should also be responsible for releasing market information. With sufficient information, enterprises can bring their full potential into play.

(2) Issuing Relevant Policies

For enterprises, the attraction of newly emerging industries comes mainly from low cost, low risk and a highly innovative environment. Therefore, the government should make policy innovation with all sorts of economic and policy leverages by mainly focusing on financial support and preferential tax and so on. And through the establishment of innovation risk insurance mechanisms, it is hoped that risks can be decentralized. Knowledge is the core of innovation, so the government needs to step up market supervision, intensify protection of intellectual property, standardize service trading market and market of information resources, and resolutely crack down on all acts of intellectual property infringements, and encourage enterprises' development and utilization of core proprietary technologies. The government should carry forward the establishment of social credit system emphatically and methodically, fully exerting its function in promotion and guidance.

30.4.1.2 Expanding Financing Channels to Increase Industrial Innovation Support

Innovation investment faces lots of risks, so the government needs to vigorously channel venture capital funded by social capital to the technological innovation of new industries. It also needs to set up special funds for indigenous innovation of new industries and make loans from commercial banks more accessible to modern service industry enterprises equipped with technology, strength and prospect, and improve banks' risk compensating mechanism. It should focus on supporting high-growth-oriented small and medium-sized service enterprises, bettering SMEs' survival and development environment [11].

Meanwhile, the government should actively expand financing channels and be active in guiding and encouraging financial institutions to provide credit support to service enterprises. It should also encourage financing guarantee agencies to provide credit guarantee to modern service industry. It must encourage modern service industries to actively carry out industrial innovation in various ways, including assets reorganization, merger and so on. Financial institutions should perfect their financial investment mechanism to support the development of service industry, establish a cooperation platform with service enterprises, and encourage all kinds of venture investment institutions, credit guarantee institutions and credit insurance institutions to do business with service enterprises. They should support eligible service enterprises to enter the financing capital market and to positively broaden financing channels such as listing their shares on the stock market, issuing corporate bonds, implementing project financing and property right replacement.

30.4.2 Building a Better Internal Environment and Strengthening Internal Innovation Mechanism

30.4.2.1 Strengthening Human Resources Training and Consolidating Industrial Innovation Foundation

(1) Perfecting mechanism of talent training

Improvement of human resources skills can be accomplished through training. In this respect, support from the government to basic research and education training system plays a key role [12]. The government should actively encourage colleges and universities at home and abroad to take a variety of forms of cooperation in running schools and cultivating high-quality, multi-skilled and international personnel. It is essential for colleges and universities to foster specialized personnel who can meet the demands of the knowledge service industry by making necessary changes to the teaching contents and training methods. It is also needed to strengthen vocational training and establish professional qualification standard system to improve the skills of the employees.

(2) Making more efforts to pool talent

To seize the favorable opportunity of accelerated flow of global talents, the government should stipulate more favorable policies and measures with the industry layout as the guidance and enterprises' need as the key point. The government should focus on the introduction of outstanding talents, top-notch personnel and excellent innovation teams, through means such as team introduction, core talent introduction and so on. The government should also introduce senior managerial personnel through various channels.

(3) Establishing a talent incentive system

The government should attract and retain talents through a sound rewarding mechanism. The government should establish a reasonable evaluation system, stipulate sound income distribution incentive policies, and form a mechanism which gives full play to the innovation passion and creativity of the outstanding talents. In addition, team's incentive can not only build a sense of cooperation between members, but also actively create a harmonious corporate culture.

30.4.2.2 Perfecting Knowledge Utilization and Strengthening the Core of Industrial Innovation

(1) Strengthening knowledge interaction

Development of modern service industry results from the interaction between the upper and the lower sectors in the industry chain. So a constant interactive process is essential to effectively promoting development of modern service industry [11]. Each branch industry in the industry chain should contribute actively to a favorable interactive environment. They should take necessary steps to shorten knowledge gap and to maximize knowledge transfer. In the industry chain, they should do utmost to create a standardized knowledge transfer system to avoid impassability of knowledge via interaction.

(2) Conducting knowledge integration

Integrating internal and external knowledge of modern service industry is becoming increasingly important to knowledge innovation and knowledge service. This integration can be realized through various means. The First method is the establishment of an effective human resources management system. Second is the establishment of proper organizational structure, such as building a cooperation system among enterprises. Third is the formation of an effective network, such as close cooperation with suppliers and customers. Forth is the application of market mechanism.

(3) Making technological breakthrough

Technical breakthrough is the key to innovation. Enterprises should be encouraged to make key technological breakthroughs in ecommerce, e-government, financial insurance, modern logistics, intelligent traffic management systems and information value-added services, speeding up popularization and application of information network technology in service industry. The government should encourage enterprises to vigorously develop their own technology and core technology, to improve product quality, and to boost market prestige and service. It should also encourage enterprises to actively introduce and develop individual service styles, tap development potential, extend services and increase value-added services.

30.4.2.3 Innovating Enterprise Management and Operation and Developing Industrial Innovation Ways

Introduction of new management styles and modern management concepts can make full use of innovation effects of new technology and management, maximizing the role of modern service industry. First, enterprises can establish a modern system of property rights, perfect equity division, change their management mechanism, clarify principal-agent relationship and promote establishment of modern corporate institution. Second, they can introduce advanced modern management concepts, absorb well-known enterprises' management mode and strengthen the concept of innovation in modern service industry in keeping with its own characteristics. Moreover, they can transform traditional service industries such as circulation and catering industry with modern service mode of operation, encourage operating format innovation and establish modern service management mode.

30.5 Conclusion

With development of economic globalization, modern service industry's features of creating a beneficial economic cycle and its strong ability to promote consumption make it the dominant industry for economic development. And promoting industrial innovation is a way to modify modern service industrial structure, and also the foundation to complete historical mission of modern service industry. This paper combines the background of high speed development of modern service industry with idea of industrial innovation. Based on correlative research at home and abroad, industrial innovation theory and service industry development theory are comprehensively applied to show status of industrial innovation in the development of modern service industry. By revealing connotation, characteristic, dynamic, mode and influencing factors of industrial innovation, this article puts forward a set of strategic plans with pertinence and operability. The innovation of this paper lies in clarifying connotation and characteristics of industrial innovation of modern service industry, putting forward dynamic and mode of industrial innovation of modern service industry, analyzing influencing factors of industrial innovation of modern service industry, and gradually building up a theoretical framework of industrial innovation of modern service industry. It is hoped that the result of this paper can be of enlightenment to the upgrading and structural optimization of the modern service industry in China.

Acknowledgements The research is funded by "the research on development space and innovation path of modern service industry of Zhejiang Province under the background of industry transformation and upgrading, 2011 Scientific and Technological Project of Zhejiang Province (No. 2011C35002)."

References

1. Chang X (2005) China system innovation in the development of modern service industry. Theory and Modernization 4:8–9
2. Tan Z, Xiang L (2007) Research on modern service industry. The Press of China Economy, Beijing 38–79

3. Zhu Y (2007) Research on operation mechanism of improving the advantage industry innovation ability in Jilin. Jilin University 16–19
4. Den P, Bilderbeek R (1999) Conceptualising service innovation and service innovation patterns. Netherlands: Directorate for General Technology Policy, The Ministry of Economic Affairs 6–10
5. Milesi F (2005) Services and R&D: measurement and more. In: The Measurement and Analysis of Innovation and Productivity Growth, ECIS Conference 5–6
6. Gou Z (2006) Innovation capacity measurements and analysis of chinese electronic information industry. Acta Electronica Sinica 12:2502–2509
7. Meng L, Xin Y (2004) Industrial technology innovation and government policy support. Journal of Inner Mongolia Finance and Economies College 2:97–100
8. Lu G (2003) Power sources of industrial innovation and risk analysis. The Journal of Guangxi Economic Management Cadre College 2:38–42
9. Sun C (2010) Optimizing innovation environment, improving emerging industry innovation ability. Jiangnan Forum 12:42–43
10. Gerasimova A, Khasuntsev I (2011) Institutional characteristic features of innovation systems development of BRICS countries. In: International Conference on Management Science and Engineering
11. Zhang Z (2009) On industry chain angle of view knowledge service industry development. Friend of Science Amateurs 6:82–83
12. Song S (2011) Research on human resource plan model of medium and small private enterprise based on spanning development strategic—with medium and small private enterprise as an example. In: International Conference on Management Science and Engineering

Chapter 31
Energy Efficient Cloud Data Center Management based on Fuzzy Multi Criteria Decision Making

Shahzad Ali, Siyuan Jing and Kun She

Abstract In computing cloud the ultimate goal is to get optimal performance by utilizing minimum computing resources, this can be achieved by avoiding wasting of resources as a result of under-utilization and to cut lengthy response time, due to over-utilization. Power consumption among cloud data centers is growing at a rapid pace and efficient energy management is one of the most challenging research issues. Furthermore, Virtualization and live migration of VMs among PMs Plays a vital role in data center load management. In this paper we propose and evaluate an approach for power and performance management through intelligent decisions over hotspot detection and migration time of VMs across heterogeneous PMs for mitigation of hotspot of a cloud computing data center. We used two dynamic threshold levels (peak and off-peak) load strategy to implement our decisions. The focus of this paper is to present a new method to find overloaded nodes at upper level threshold (peak load), and also perform PMs consolidation at lower-level threshold and putting idle server to sleep state, by using Best Fit Decreasing based on TOPSIS-one of the most efficient Multi Criteria Decision Making techniques. Finally, we perform simulation to evaluate the work and results show that proposed method brings substantial energy saving, while ensuring reliable QoS.

Keywords Cloud data center · MCDM · Load management · Server consolidation · Live migration

---

S. Ali (✉) · S. Jing · K. She
Department of Computer Science and Engineering, University of Electronic Science & Technology, Chengdu 610054, P. R. China
e-mail: rsdcsiub@hotmail.com

S. Ali
Department of Computer Science and IT, The Islamia University of Bahawalpur, Bahawalpur, Pakistan

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_31,

31.1 Introduction

Recently, cloud computing has attracted considerable attention [1]. Cloud computing is a cost effective model for provisioning services and it makes IT management easier and more responsive to the changing needs of the business [2]. Cloud data centers have become popular in a variety of domains such as web hosting, enterprise systems, and e-commerce sites [3]. PMs in a data center is multiplexed across multiple applications. Furthermore, each application sees dynamic workload fluctuations caused by incremental growth, time-of-day effects, and flash crowds [4]. Workload management and migration, a hot topic in IT research during the 1980s [5, 6], has seen very little use for real-world applications. Virtualization of data center, resources provides numerous benefits. It enables application isolation since malicious or greedy applications can not impact other applications worked on the same PM. Virtualization also provides a means for server consolidation through on-demand allocation and live migration, it helps to increase server utilization allow to reduce the long term use of computer resources and their associated power demands. Specifically, the ability to dynamically distribute PM workloads in a data center allows for reduction of energy consumption. Perhaps the biggest advantage of employing virtualization is the ability to flexibly remap PM to VMs in order to handle workload dynamics. Migration is transparent to the applications and all modern VM support this capability. More recently, Xen and VMWare have implemented "live" migration of VMs that involve extremely short downtimes ranging from tens of milliseconds to a second [7, 8]. VM migration has been used for dynamic resource allocation in Grid environments [9–11]. VMware's DRS [12] uses migration to perform automated load balancing in response to CPU and memory. Dedicated hosting is a category of dynamic provisioning in which each PM runs at most one application and workload increases are handled by spawning a new replica of the application on idle servers [13]. Shared hosing is the other technique of dynamic provisioning which allows single PM to be shared across multiple services. Mechanisms to partition and share resources across service, as well as various economic and resource models to allocate shared resources have been presented in [14, 15, 19]. The EPA affirmed that data centers consumed about 61 billion kilowatt-hours (kWh) in 2006, roughly 1.5 percent of total U.S. electricity consumption, for a total electricity cost of about $4.5 billion [22]. Some of the authors assumed that much energy is wasted by hardware when it is idle. At idle, PMs are still drawing about 60% of peak power. A typical data center, average utilization is only 20-30% [16–18].

With the comparison to the above discussed studies, our work assumes a shared hosting platform and uses VMs to partition CPU, memory, and network resources, but additionally leverages VM migration to meet SLA objectives. In this paper we are discussing four problems: (1) hotspot detection and its mitigation by selection of suitable timing of migrated VMs and its host; (2) improve the probability of detection and management of malfunctioning of any PMs (Predicting the failure mechanism and its management); (3) consolidation of PMs; (4) improve the energy efficiency of data center due to power aware reallocation of migrated VMs and putting the idle PMs to sleep mode. We gave the proposed solutions of above discussed problems in: (1) a design for hotspot detection (overloaded PMs) at peak load and its mitigation; (2) a design for PMs Consolidation at off peak load with power aware reallocation of migrated VMs and putting the idle servers to sleep state.

The rest of this paper is organized as follows. Sect. 31.2 introduces the background and related work. We present dynamic load management framework in Sect. 31.3 and we evaluate the work with a simulation in Sect. 31.4. The paper is finally concluded in Sect. 31.5.

31.2 Background and Related Work

The focus of this paper on decisions and management work differentiates from literature on hotspot detection, and its migration mechanisms. We evidence three main phases of the workload and migration management process: to decide when a dynamic redistribution of load is necessary; how to choose which VM is convenient to migrate; to place VM to other PM. Although migration is further complicated by the need to consider multiple resources-CPU, network, and memory- for each VM and PM. Sandpiper implements a hotspot detection algorithm that determines when to migrate virtual machines, and a hotspot mitigation algorithm that determines which and where to migrate [20]. The basic idea is to move load from the most overloaded servers to the least-overloaded servers, while attempting to minimize data copying incurred during migration have presented in [21]. Bobroff et al [23] have proposed an algorithm for virtual machine migration that aims to guarantee probabilistic SLAs. The scheme have proposed by Khanna et al[24] moves the virtual machines with minimum utilization to the physical host with minimum available resources that are sufficient to host those virtual machines without violating the SLA. Stage et al [25] have considered bandwidth consumed during migration, they proposed a system that classifies the various loads and consolidate more virtual machines on each host based on typical periodic trends, if they exist. The authors in [23] have adopted prediction techniques and a bin packing heuristic to allocate and place virtual machines while minimizing the number of activated physical machines.

Our work differ from all these global optimization models that are applicable at runtime when there is a small set of machines to consider, but they cannot work in a cloud context characterized by thousands of PMs. Since a VM or a PM can be overloaded along one or more of three dimensions- CPU, network and memory-it defined a new metric that captures the combined CPU, network, and memory load of a PM. If multiple resources are heavily utilized by these parameters then the PM is overloaded. Unfortunately, in such numerical ranking methods, the influence of each parameter is verified separately and the mutual effects of parameters are ignored. Also in these, all the criteria are assumed to have equal weights in decision making, but considering the status of each parameter makes such an assumption unrealistic. For example, when the virtual machines are CPU-intensive, the probability of CPU saturation is more than RAM saturation. In the other word, the weight of CPU and RAM influence are not equal.

TOPSIS is a major decision making technique as compared with others techniques available in literature such as AHP [26, 27]. The basic disadvantages of the AHP technique are that it focuses mainly on the decision maker, many pair-wise comparisons to reach a decision, while possibly using subjective preferences. Furthermore, other disadvantage of this method is the artificial limitation of the use of the nine-point scale. So AHP is not practical applicable if the number of alternatives and criteria are large since the repetitive assessments may cause fatigue in the decision maker [28, 29].

31.3 Dynamic Load Management Framework

The proposed framework is shown in Fig. 31.1 and it is composed of two important steps; (1) hotspots detection and its mitigation; (2) consolidation of PMs with power aware reallocation of migrated VMs and putting the idle PM to sleep state.

31.3.1 A New Method for Dynamic Load Management

In this section we are discussing the two problems of our work. Dynamic Load balancing is a most recent technique aim to reduce hardware cost and power consumption in data center. It can be used to distribute the total workload of the data center among different servers evenly in order to balance the server workload. The existing decision making models for server selection have restricted applications, like as decision maker ambiguities, uncertainties and vagueness, which cannot be handled by crisp values. Traditionally, the hotspot only depends on resource utilization, actually it is not true. In fact, some other factors are also caused of hotspot, just like surrounding temperature, hardware malfunctioning and Qos. TOPSIS provides a uniform model to put all theses together and give a result.

Our work is referring to a dynamic load management which receives flexibility by using VMs. With the help of live migration technique the VMs and therefore also the load connected with them can be migrated at runtime. A server can be overloaded along one or more dimensions like resource utilization (such as CPU, Memory, Net Bandwidth), SLA (such as Response time), temperature of PMs, Frequency (CPU speed), and number of hosted VMs. If multiple resources of a PM are heavy workload or high temperature or unsatisfactory QoS, then corresponding PM position is near to the top in the sorting table and results in a correspondingly high score. The high score captures the degree along multiple dimensions in a weighted fashion and can be used by the algorithms to handle all hotspots. As the workload on the PMs increases or some times sudden changing in temperature with high amplitude is a sign of malfunctioning of hardware. If the cooling component is down

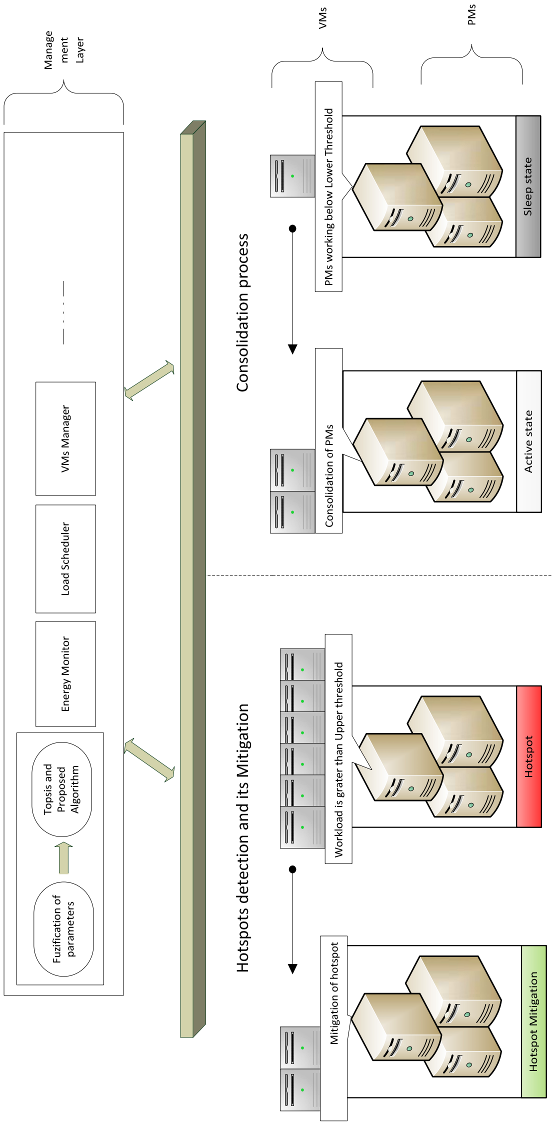


Fig. 31.1 Proposed framework

or works poorly the temperature of PM rising suddenly and as a consequence PM may be failed. Due to these kind of problems all VMs can be migrated to available servers to ensure that service level agreements and response times are met. So, this parameter can be used as a predicting failure mechanism.

In this paper we are adopting the Fuzzy TOPSIS with two specified levels of threshold. High value of threshold is used to detecting and mitigates the hotspot and low threshold value is used for consolidation. For hotspot detection, TOPSIS is operated as: All physical nodes are being compared to each other against decision criteria. After this, nodes are sorted from the more overloaded to the idle ones (if available). Some parameters are used for this decision are shown in Table 31.3.

Algorithm:1 Dynamic Load Management at Peak Threshold with Minimum Migration

```
Input: 1) A selecting hostlist, denoted by PM'; 2) Threshold: Tmax, Tmin
Output: VMMigration List
Begin
    Foreach Pm in PM' do // for each host in hostlist
        VM' ← Pm.getVmList ();
        VM'.sortDecreasingUtilization ();
        PmUlit ← Pm.getUlit ();
        BestFitUlit ← max; // max is assign value of BestFitUlit upper and lower level.
        While PmUlit > Tmax do    //    Tmax means upper limit of Threshold
                    Foreach vm in VM' do
                        IF vm.getUlit ()  >  PmUlit - Tmax Then
                            t ← vm.getUlit - PmUlit + Tmax
                                IF t < BestFitUlit Then
                                    BestFitUlit ← t
                                    BestFitVm ← vm
                                EndIF
                        ElseIF BestFitUlit = = max
                            BestFitVm ← vm
                            Break
                        EndIF
                    EndFor
                    PmUlit ←PmUlit - BestFitVm.getUlit ();
                    VMMigrationList.add(BestFitVm);
                    VM'.remove(BestFitVm);
            IF PmUlit < Tmin Then // Tmin means lower limit of Threshold
                VMMigrationList.add(Pm.getVmList())
                VM'.remove(Pm.getVmList());
            EndIF
        End While
    EndFor
    Return VMMigrationList
    Return Reallocation
End Begin
```

After finding the hotspot, we used again TOPSIS with Best Fit Decreasing (BFD) strategy for selection of suitable VM candidate for migration from overloaded server against some parameters which are shown in Table 31.4. If the threshold level exceeds the limit on any PM then we try to mitigate its load by migration the most appropriate VM to the least loaded PM. Migration processes continue until required smooth load of data center. Algorithm 1 explains the procedure of hotspot detection and its mitigation. The pseudo-code of this algorithm sorts the lists of VMs in decreasing order of CPU utilization. Then it repeatedly search the VMs and finds the VMs that is suitable to migrate from the PM. The suitable VM is the one that satisfies two conditions. First the VM should have the utilization higher than the difference between the PMs' utilization and upper level utilization threshold. Second, if the VM is migrated from PM, the difference between the upper level utilization threshold and the new utilization is the minimum across the values provided by all VMs. If there is no such a VM, the algorithm selects the VM with highest utilization, removes from the list of VMs and proceeds to new iteration. The algorithm stops when the new utilization is of PMs is below the upper level utilization threshold. The complexity of the algorithm is proportional to the product of number of hotspots and the number of VMs allocated to these hotspots. The basic idea is to move load from the overloaded PMs to the least-overloaded PMs for load management, while attempting to minimize data copying incurred during migration. In our work, to minimize the migrating data, another property of TOPSIS has been applied. For more illustration, with referring to Table 31.3 and 31.4, we can see that there is a column in the tables that labeled with Type. This column gets two words, Benefit or Cost. In the other words, when we label a parameter as Cost, it means that we want to select the Alternative which has this parameter as less as possible. For the Benefit, it is vise versa.

31.3.2 Consolidation of PMs

In this section we are discussing other two problems of our work. In [30, 31], authors described several foundational techniques for power management that result in significant power savings in large data centers with run-time load allocation capability. For determining underloaded PMs we use a low score of utilization of PMs by TOPSIS. Although low score shows that the working or load of PMs is under control but may be the resources are under-utilized propose a simple approach.

```
Algorithm: 2 Consolidation Process
Input: 1) A selecting VM, denoted by $VM'$; 2) A set of under load PMs, each PM is composed of a set of VM.
Output: Selecting PM
Begin
    Best_Fit_PM = null;
    Gain = 0;
    For i = 1 to n      //n is the number of PMs
        If $Uti(PM_i \cup VM') < threshold$ &&
        $Uti(PM_i \cup VM') - Uti(PM_i) < Gain$
            Gain = $Uti(PM_i \cup VM') - Uti(PM_i)$;
            Best_Fit_PM = $PM_i$;
        End if
    End For
    Return Best_Fit_PM;
End Begin
```

First, all the overloaded PMs are found using the selected overloading detection TOPSIS algorithm, and the VMs selected for migration are allocated to the destination hosts. Then, the system finds the host with the minimum utilization compared to the other hosts, and tries to place the VMs from this PM on other PMs keeping them not overloaded. If this can be accomplished, the VMs are set for migration to the determined target PMs, and the source PM is switched to the sleep mode once all the migrations have been completed. If all the VMs from the source PM cannot be placed on other PMs, the source PM is kept active. This process is iteratively repeated for all PMs that have not been considered as being overloaded. During the migration process, it should consider the factors in to account: migration cost, distance between PMs, etc. If several migrations are required at the same time on the same PM, then they are queued and processed one by one by the hypervisor (this can also be influenced by the network bandwidth). All aspects of consolidation are difficult to explain here, because of restriction of pages of paper. We try our best to give a useful guideline for novice researchers. Consolidation process is explained in Algorithm 2 and Best Fit Decreasing BFD is only related to resources utilization, because it can increase the efficiency of consolidation. In other words, under BFD strategy, a PM may host more VMs. $Uti(PM_i)$ is a function to compute the resource utilization. A Best solution is that (1) the combination can not exceed the resource utilization threshold; (2) the gain is the smallest.

31.3.3 Re-allocation of Migrated VMs

In our work, we sort all the VMs and PMs in the decreasing order of current CPU utilizations. We reallocate each migrated VM to a PM that provides the least increase of the power consumption caused by this reallocation, because at maximum execution of PM, the performance of this PM is energy efficient. This allows the leveraging the nodes heterogeneity by choosing the most power-efficient ones first. The pseudo-code for this strategy is presented in Algorithm 3. The complexity of the algorithm is $n.m$, where n is the number of PMs and m is the number of VMs that have to be allocated.

31.3.4 Topsis and Fuzzy Topsis

TOPSIS is a technique for order preference by similarity to ideal solution and proposed by Hwang and Yoon [33]. Then Chen and his partners extended it to deal with fuzzy MCDM problem [34]. The principle behind TOPSIS is simple: The chosen alternative should be as close to the ideal solution as possible and as far from the negative-ideal solution as possible. The ideal solution is formed as a composite of the best performance values exhibited (in the decision matrix) by any alternative value for each attribute. The negative ideal solution is the composite of the worst

```
Algorithm:3    Re-Allocation of Migrated VMs
Input: 1) A selecting hostlist, denoted by $PM'$ ; 2) A selecting VMlist, denoted by $VM'$  Output: Reallocation of migrated Vm
Begin
    $VM'$.sortDecreasingUtilization () // Sort the vm list in decreasing order of its VM utilization
    Foreach vm in $VM'$ do    //  For each vm in VM list
            MinPower  ←  max //  Assign MinPower as max
                AllocatedPm  ←  null // and allocated host as null.
                Foreach Pm in $PM'$ do //  For each host in host list
                    IF Pm allotted sufficient Vm Then // if host has enough resource for vm
                        Power  ← CalculatePower (Pm, vm) // Estimate power of vm & host.
                        IF Power < MinPower Then // If Power is less than MinPower
                            AllocatedPm  ←  Pm // then allocated host is current host
                            MinPower  ←  Power //
                        EndIF
                    EndIF
                EndFor
        IF AllocatedPm  ≠  null Then //  If AllocatedPm is not null
                    Assign vm to AllocatedPm // then allocate vm to the Allocated host;
        EndIF
    EndFor
    Return Reallocation
End Begin
```

performance values. Proximity to each of these performance poles is measured in the Euclidean sense (e.g., square root of the sum of the squared distances along each axis in the “attribute space”), with optional weight of each attribute. The fuzzy theory is a modern theory, which was proposed by Zadeh [32].

31.3.5 Parameters Type

TOPSIS can receive three types of information, including deterministic, linguistic, and fuzzy information. These three parameters affecting the decision making process for selecting the overloaded servers. In our model, some parameters are suitable to express as a linguistic, such as QoS and Temperature of host PM. To apply mathematical formula over linguistic statement, we need to map them with numbers shown in Table 31.1. Although there is a relationship between load of a server and these parameters, sometimes variation in QoS with low workload is also signal of poor performance in the system. So, this parameter can be used as a predicting migration condition. But the QoS, sometimes maybe replace by response time, is not suitable to describe as a specific value. In this circumstance, it is a good to describe these parameters as a Fuzzy statement is shown in Table 31.1.

Table 31.1 Mapping and transformation for fuzzy membership function

Rank	Number	Abbreviated	QoS (ms)	Temperature (°C)
Very Low	1	VL	(150,150,0)	(30,0,10)
Low	3	L	(300,150,150)	(40,10,10)
Mol Low	4	ML	(450,150,150)	(50,10,10)
Medium	5	M	(600,150,150)	(60,10,10)
Mol High	6	MH	(750,150,150)	(70,10,10)
High	7	H	(900,150,150)	(80,10,10)
Very High	9	VH	(1050,0,150)	(90,10,0)

31.4 Simulation

For simulation, we used a cluster server with 5 PMs as shown in Table 31.3, P0 is used for controlling and other 4 PMs are used for computing resources. Each node also has some VMs and VMs occupied different size RAM. The VMs run a mix of applications with software is Xen 3.3.0 and the host operation system and guest operation system is Fedora7 (2.6.18). Data collection module is developed and embedded in Xen. The service used for testing was gotten from SPECweb2005 [35]. The task generations follow Poisson process. All of tasks have same priority.

To verify the performance of our method, we simulate the service visitation at peak-time and off-peak time by controlling the task generation. At peak load we observed hot spots and mitigate it by VM migration to maintain the load of the system. On the other hand, at off-peak load, we performed consolidation of PMs and putting idle PMs to sleep state. After the starting simulation, the workload of each PM varies over time. So PM1, PM2, PM3 are overloaded and near to upper threshold level, while PM4 is idle. Control unit runs every 3 minutes because some of the workloads change quickly. Depends on the VMs nature this interval can be set. Information from all nodes come to the control unit and verifies every 2 minutes to observe hotspot. Decision technique tries to sort servers from high to low score. In order to remove a dimension, the decision matrix is normalized and calculated using weighted normalized ratings automatically. The next action is to find the positive as well as the negative ideal solutions.

Table 31.2 Environment of experiment

PMs	Type	CPU	Ram	Net bandwidth	VM Number (Xen 3.3.0)
PM0	Manage	Intel Pentium4 , 2.0G	2.0G	100M	0
PM1	Computing	Intel Core 2 Duo E7400, 2.8G	2.0G	100M	VM1, VM2, VM3
PM2	Computing	Intel Core 2 Duo E7400, 2.8G	2.0G	100M	VM4, VM5, VM6
PM3	Computing	Intel Core 2 Duo E7400, 2.8G	2.0G	100M	VM7, VM8, VM9
PM4	Computing	Intel Core 2 Duo E7400, 2.8G	2.0G	100M	VM10

Table 31.3 Parameters of physical machine (PM)

No.	Name	Data Type	Type	Weight	Description
1	CPU%	Deterministic	Benefit	VH	CPU Usage
2	RAM %	Deterministic	Benefit	ML	RAM Usage
3	NET%	Deterministic	Benefit	ML	NET Usage
4	CPU Cycle	Deterministic	Cost	VH	CPU Clock Speed (HZ)
5	Bandwidth	Deterministic	Cost	ML	Bandwidth of each PM
6	RAM Capacity	Deterministic	Cost	ML	RAM of each PM (GB)
7	Temperature	Linguistic	Benefit	M	Host Temperature

Table 31.4 Parameters of virtual machine (VM)

No.	Name	Data Type	Type	Weight	Description
1	CPU%	Deterministic	Benefit	H	CPU Usage
2	MEM%	Deterministic	Benefit	ML	Memory Usage
3	NET%	Deterministic	Benefit	ML	NET Usage
4	RAM Capacity	Deterministic	Cost	H	RAM Assign to VM
5	QoS	Linguistic	Benefit	VH	Qos for VM

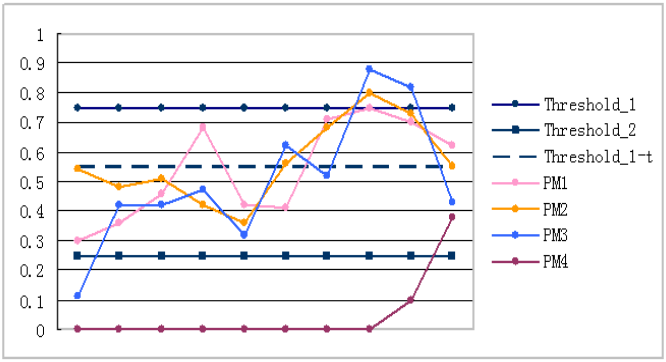


Fig. 31.2 Removing hotspot of PM3

As Fig. 31.2 shows the PM4 has reached the threshold, it means that this node is in danger and migration is inevitable. Moreover, workload of every node had been shown in Fig. 31.2. During test bed, the threshold is set to 0.75. After this we find VM causing hotspot in PM4. If we do not use algorithm to balance the load, some PM will be down and stop working. Fig. 31.2 explains this condition. By using load balancing control unit we can detect hotspot on PM3 and via migrate candidate VM8(This contain the lowest capacity of RAM as compared to others) from PM3 to

PM4 (the least loaded server) the load will be distributed evenly (see Fig. 31.2). In this figure, load of PM3 by relocating VM decreased to about 50% and the hot spot was eliminated. On the other hand, Workload on PM4 increased because it hosted migrated VM8. If sufficient resources are not available, then the algorithm evaluates the next least loaded server and so on, until a match is found for the candidate VM. If no PM can host the selected VM, then the algorithm moves on to the next VM and attempts to move it in a similar fashion. The process repeats until the score of utilizations of resources on the physical server fall below the thresholds.

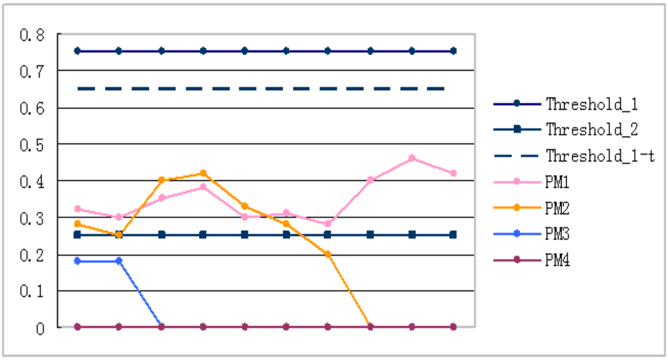


Fig. 31.3 Putting PM2 and PM3 to sleep state

Fig. 31.3 illustrates the process of consolidation. It shows that PM2 and PM3 have a workload less than specified lower threshold level (Threshold_2). At this stage consolidation is performed and putting the PM2 and PM3 to sleep mode for saving the energy. Threshold_1-t indicates threshold tolerance and adjusts dynamically at different stages to keep the performance of the system.

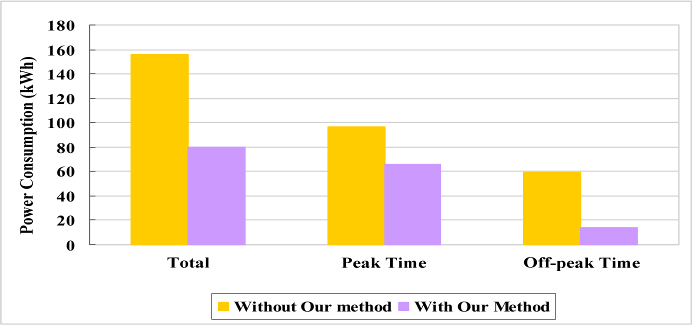


Fig. 31.4 Power consumption comparison

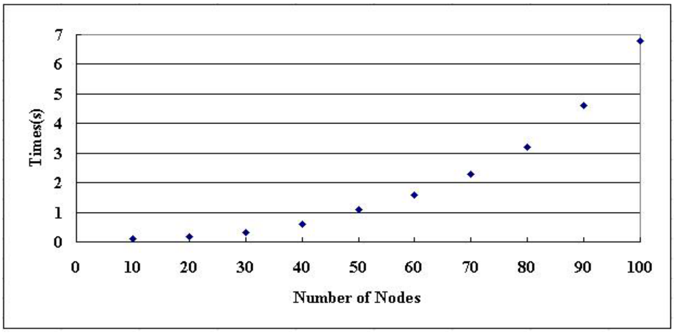


Fig. 31.5 Time used to run TOPSIS

At the end, Fig. 31.4 illustrates the comparison between our method and the original (only include DVS method). Without our method, the 5 devices consume 155 kWh per week, which composes of 96 kWh in peak load and 59 kWh in off-peak load and with our method, the 5 device consumes 79 kWh per week, which composes of 66 kWh in peak load and 13 kWh in off-peak load. That means our model can save 32.3% power in peak load and 78% in off-peak load, total is 49%. The method we used clearly achieved greater energy savings.

31.4.1 Power Estimation Model

Recent studies mentioned that the power consumption by servers can be accurately described by a linear relationship between the power consumption and CPU utilization, even when Dynamic Voltage and Frequency Scaling (DVFS) is applied. The reason lies in the limited number of states that can be set to the frequency and voltage of CPU and the fact that voltage and performance scaling are not applied to other system components, such as memory and network interface. Moreover, these studies show that on average an idle server consumes approximately 70% of the power consumed when it is fully utilized. Therefore, for our experimental studies we define the power consumption as a function of energy consumed by CPU as shown below:

$$E = \left(\sum_{i=1}^{3} (\alpha_i \times r_i) \right) \times \left(E_{\text{peak}} - E_{\text{idle}} \right) + E_{\text{peak}}, \tag{31.1}$$

$$P = \int_T E dt. \tag{31.2}$$

According to this model, the energy consumption by a server is determined by the CPU utilization. Therefore, to reduce the energy consumption, our approach is to improve the CPU utilization of physical nodes in a data center.

31.4.2 TOPSIS Algorithm Performance

Although the disadvantages of numerical ranking methods have been removed partly in the decision making models offered, this methods have its own limits. In decision making models, which are based on multicriteria decision making techniques, there is no limitation on the number of criteria and alternatives, but these models face the problem of time-consuming calculations as shown in Fig. 31.5. This figure illustrates that complexity of TOPSIS algorithm increases when the number of PMs runs is increases. Reducing the migration overhead (i.e., the amount of data transferred) is important, since Xen's live migration mechanism works by iteratively copying the memory image of the VM to the destination while keeping track of which pages are being dirtied and need to be resent. This requires Xen to intercept all memory accesses for the migrating domain, which significantly impacts the performance of the application inside the VM. By reducing the amount of data copied over the network, we can minimize the total migration time, and thus, the performance impact on applications. So, the time complexity of algorithm is $O(n) + O(n^2)$.

31.5 Conclusion and Future Work

The main contribution of this paper included: (1) a design for hotspot detection (overloaded PM) by using the Fuzzy TOPSIS with Best-Fit solution to make more accurate decision and mitigate it to migrate the suitable VMs from overloaded to less loaded server; (2) a design for server consolidations at off- peak time and putting the idle server to sleep state with the help of TOPSIS.

Moreover, TOPSIS considers the uncertainty associated with the input parameters (linguistic variables) used in the selection process. We plan on extending our current study to real-time and ad hoc environments.

Acknowledgements This work was supported by the National High-tech Research and Development Program of China (Grant No. 2008AA04A107).

References

1. Weiss A (2007) Computing in the clouds. Computing 11:16–25
2. Buyya R, Yeo CS, Venugopa S (2008) Market-oriented cloud computing: Vision, hype, and reality for delivering it services as computing utilities. In: Proceedings of the 10th IEEE International Conference on High Performance Computing and Communications
3. Parkan C, Wu ML (2003) On the equivalence of operational performance measurement and multiple attribute decision making. International Journal of Production Research 35:2963–2988

4. Appleby K, Fakhouri S, Fong L et al (2001) Oceano-Sla-based management of a computing utility. In: Proceedings IFIP/IEEE Symposium on Integrated Management
5. Jul E, Levy H, Hutchinson N et al (1988) Fine-grained mobility in the emerald system. ACM Transactions on Computer Systems 6:109–133
6. Barak A, La'adan O (1998) The MOSIX multicomputer operating system for high performance cluster computing. Journal of Future Generation Computer Systems 13:361–372
7. Clark C, Fraser K, Hand S et al (2005) Live migration of virtual machines. In: Proceedings NSDI '05
8. Nelson M, Lim B, Hutchins G (2005) Fast transparent migration for virtual machines. In: Proceedings USENIX 2005
9. Ruth P, Rhee J, Xu D et al (2006) Autonomic live adaptation of virtual computational environments in a multi-domain infrastructure. In: Proceedings IEEE ICAC '06
10. Sundararaj A, Gupta A, Dinda P (2005) Increasing application performance in virtual environments through run-time inference and adaptation. In: Proceedings HPDC '05
11. Grit L, Irwin D, Yumerefendi A et al (2006) Virtual machine hosting for networked clusters: Building the foundations for autonomic orchestration. In: Proceedings VTDC '06
12. VMware Dynamic Resource Scheduler
13. Urgaonkar B, Shenoy P, Chandra A et al (2005) Dynamic provisioning for multi-tier internet applications. In: Proceedings ICAC '05
14. Aron A, Druschel P, Zwaenepoel W et al (2000) Cluster reserves: A mechanism for resource management in cluster-based network servers. In: Proceedings ACM SIGMETRICS '00
15. Chase J, Anderson D, Thakar P et al (2001) Managing energy and server resources in hosting centers. In: Proceedings SOSP '01
16. Barroso L, Hölzle U (2001) The case for energy-proportional computing. IEEE Computer
17. Lefurgy C, Wang X, Ware M (2007) Server-level power control. In Proceedings of the IEEE International Conference on Autonomic Computing
18. Femal M, Freeh V (2004) Safe over-provisioning: Using power limits to increase aggregate throughput. In: Power-Aware Computing Systems (PACS), December 2004
19. Menasce D, Bennani M (2006) Autonomic virtualized environments. In: Proceedings IEEE ICAC '06
20. Wood T, Shenoy P, Venkataramani A et al (2007) Black-box and gray-box strategies for virtual machine migration. In: Proceedings of the 4th USENIX Symposium on Networked Systems Design and Implementation (NSDI'07) 229–242
21. Tarighi M, Motamedi SA, Sharifian S (2006) A new model for virtual machine migration in virtualized cluster server based on Fuzzy Decision Making. International Journal of Telecommunications 1:40–51
22. EPA US (2007) Report to congress on server and data center energy efficiency. U.S. Environmental Protection Agency, Technology Report
23. Bobroff N, Kochut A, Beaty K (2007) Dynamic placement of virtual machines for managing SLA violations. In: Proceedings of the 10th IFIP/IEEE International Symposium on Integrated Network Management
24. Khanna G, Beaty K, Kar G et al (2006) Application performance management in virtualized server environments. In: Proceedings of Network Operations and Management Symposium
25. Stage A, Setzer T (2009) Network-aware migration control and scheduling of differentiated virtual machine workloads. In: Proceedings of 31st International Conference on Software Engineering
26. Sundararaj A, Gupta A, Dinda P (2005) Increasing Application Performance in virtual environments through run-time inference and adaptation. In: Proceedings of HPDC
27. Theimer MM, Cheriton DR (1985) Preemptable remote execution facilities for the V-system. In: Proceedings of SOSP
28. Shyur HJ (2006) Cost evaluation using modified TOPSIS and ANP. Applied Mathematics and Computation 177:251–259
29. Shyur HJ, Shih HS (2006) A hybrid MCDM model for strategic vendor selection. Mathematical and Computer Modeling 44:749–761

30. Milenkovic N, Castro-Leon E et al (2001) Power-aware management in cloud data centers. Cloud Computing 5913:668–673
31. Femal M, Freeh V (2009) Safe over-provisioning: Using power limits to increase aggregate throughput. In: Power-Aware Computing Systems (PACS)
32. Zadeh LA (1965) Fuzzy sets. Information Control 8:338–353
33. Hwang CL, Yoon K (1981) Multiple attribute decision making: Methods and applications. Springer, Berlin
34. Cheng S., Chan CW, Huang GH (2003) An integrated multicriteria decision analysis and inexact mixed integer linear programming approach for solid waste management. Engineering Applications of Artificial Intelligence 16:543–554
35. http://www.spec.org/web

Chapter 32
An Optimal Routing Model of High-level Picker-to-part System

Rui Wang, Luning Zang and Xiu Tan

Abstract Planning a reasonable order-picking route has been one of the keys to improve the efficiency of distribution center. Currently research on the optimal path in low-level picker-to-part system has been mature, but don't fit for the high-level system, due to ignore the stacker's vertical running time. The paper builds a new three-dimensional TSP programming model to overcome the problem, and design the corresponding genetic algorithm to solve the model. In addition, the paper compares the new model and algorithm with the two traditional methods named transversal strategy and s-shape strategy, by a same numeric example. The comparison result shows that the new method is efficient either in the picking time saved or in the picking path shortened.

Keywords Multi-attribute evaluation · Individual research output · Evaluation index system · Bibliometric indices

32.1 Introduction

Order picking is a basic warehousing process,which may involve as much as 60% of all labor activities and may account for as much as 65% of all operating expenses in a distribution center [1]. This makes order picking one of the most controlled logistic processes, so that the efficiency of an order-picking system seriously influence the productivity of the distribution center and the whole supply chain.

The efficiency of an order picking system is typically determined by seven factors: batching, picking sequence, storage policy, zoning, layout design, picking equipment and design of picking information. Some research has been mainly concerned with studying the effect of the several factors, on the efficiency of order

---

R. Wang (✉) · L. Zang · X. Tan
Business School, Sichuan University, Chengdu 610064, P. R. China
e-mail: wangggrui@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_32,

picking systems. The research has grown rapidly recently and considerable literature exists on various methods of picking an order as efficiently as possible [2].

The time index is often used to measure the system efficiency. The time to pick an order can be divided on three components: time for traveling between items, time for picking the items and time for remaining activities. Most methods of improving operational efficiency of order-picking focuses on reducing travel times, and can be categorized into one of three groups of operating policies: routing, storage and batching [3]. Routing methods determine the sequences and routes of travelling, trying to minimize total travel distances. Storage methods, or assigning items to storage locations based on some rules, could also reduce travel distances compared to random assignment. Order batching methods, or grouping two or more customer orders in one picking order, are also very efficient in reducing total travel distances. The fact that about 50% of total order-picking time is spent on travelling gives a potential to improve order-picking efficiency by reducing travelling distances [4].

However, the distance-reducing policies to ensure a good route through the warehouse is closely related with the type of the order-picking system. Many different types can be found in warehouses. Often multiple orderpicking systems are employed within one warehouse. The majority of warehouses employ humans for order picking. Among these, the picker-to-parts systems, where the order picker walks or drives along the aisles to pick items, are most common [5]. There are two types of picker-to-parts systems can be distinguished: low-level picking and high-level picking.

In low-level picker-to-parts systems, the order picker picks requested items from storage racks or bins (binshelving storage), while travelling along the storage aisles. Other order-picking systems employ high storage racks and order pickers travel to the pick locations on board of a lifting order-pick truck or crane. The crane automatically stops in front of the appropriate pick location and waits for the order picker to perform the pick. This type of system is called a high-level or a man-aboard picker-to-parts system.

The problem of routing order pickers in the low-level system is actually a special case of the Travelling Salesman Problem (TSP), see also [6]. TSP owes its name to the problem described by the following situation. A salesman, starting in his home city, has to visit a number of cities exactly once and return home. He knows the distance between each pair of cities and wants to determine the order in which he has to visit the cities such that the total travelled distance is as small as possible. Clearly, the situation of the travelling salesman has many similarities with that of an order picker in a warehouse. The order picker starts at the depot (home city), where he receives a pick list, has to visit all pick locations (cities) and finally has to return to the depot.

Based on the theories and algorithms for solving TSP, the current research on optimal path in low-level picker-to-part system has been quite mature. There are three ways to solve the order-picking path. The first is the optimization method, which finds the best order-picking path by means of mathematical programming and its solving technology. The second is simulation, which often provides a satisfied solution by some professional simulation softwares. The third is various heuristic methods, such as Return, Transversal, Midpoint, Largest Gap, Composite, S-shape, etc. Though these heuristic methods cannot find the shortest order-picking path, but the methods are enough easy to be implemented. The order picker can easily determine order-picking path without complex calculation, and reduce the probability of error.

However, the above ways to solve the low-level system don't consider the time that the truck and stacker crane lift from low to high location in high-level system. For the reason, the path strategy which was used in the low-level picker-to-part system will not be appropriate in the high-level system. In fact, the essential difference between the two systems is derived from the spatial dimension, which classifies the low-level and high-level system into a two-dimensional routing problem and a three-dimensional routing problem, respectively.

In the paper, we build an optimal order-picking path model with the vertical lifting time of stacker for the three-dimensional high-level picker-to-part system. At the same time, the special genetic algorithm is designed to solve the model. The result is proved efficient to shorten the length of the order-picking path and save the order-picking time.

32.2 Basic Model Form

By virtue of the complexity of the three-dimensional order-picking system, we will firstly study its basic model form and the characteristics of the model's prototype system.

32.2.1 Hypotheses of the System

The characteristics of the studied high-level picker-to-part system can be described with the following hypotheses:

Hypothesis 1. The depot is in the middle of the warehouse. Stacker starts from the depot and back to the depot, the activity like that is defined as one order-picking process. And the height of the depot is zero.

Hypothesis 2. Order-picking activity is completed together by order picker and stacker. The stacker can pick the stored goods in different height.

Hypothesis 3. The order-picking system uses the high multilayer three-dimensional shelves, that means the height of the cargo location, the stacker's vertical running distance and time must be considered.

Hypothesis 4. There has a horizontal cross aisle in the order-picking system of the warehouse.

Hypothesis 5. The width of the aisle is enough for the stacker, and the stacker can pick up the cargo stored on the both sides shelves.

Hypothesis 6. The stacker's total picking time only consists of its horizontal and vertical running time. The other time such as searching for goods, picking, adjustment,

stacker acceleration and deceleration etc. are not considered.
Hypothesis 7. The stacker's horizontal and vertical speed is constant, that means the movement of the stacker is uniform motion.
Hypothesis 8. The width and height of each rack space in the shelf are same. This means the height difference between two racks may be calculated by the difference of the two racks' layer numbers.
Hypothesis 9. Stacker should move in only one direction at the same time, either vertical or horizontal.
Hypothesis 10. The stacker has a unlimited capacity.

32.2.2 Variables of the System

Based on the above system, the operation activities of the system and the decision-making behavior in the system can be described by the following variables.

d_{ij} : the horizontal distance when a stacker move from rack i to rack j;

h_{ij} : the vertical distance when a stacker move from rack i to rack j;

x_{ij} : the decision variable represents the decision-making behavior whether the stacker will move from rack i to rack j by the path connecting rack i and rack j. When the movement happened, $x_{ij} = 1$, otherwise, $x_{ij} = 0$;

v_x : the moving speed in the horizontal direction. It implies the stacker's horizontal running time from rack i to rack j or from rack j to rack i is $\frac{d_{ij}}{v_x}$;

v_y : the moving speed in the vertical direction. It implies the stacker's vertical running time from rack i to rack j or from rack j to rack i is $\frac{h_{ij}}{v_y}$;

V : the set of all picking locations (that is the racks which have the ordered goods) in the order-picking system, the number of the locations is n;

S : the subset of set V, $S \subseteq V$.

32.2.3 Model of the System

For the purpose of finding a optimal order-picking path in the three-dimension order-picking system, we will build the following model. The objective of the model is to minimize the total order-picking time.

$$\begin{cases} \min z = \sum\limits_{i=1}^{n} \sum\limits_{j=1, j \neq I} \left(\frac{d_{ij}}{v_x} + \frac{h_{ij}}{v_y} \right) x_{ij} \\ \text{s.t.} \begin{cases} \sum\limits_{i=1, i \neq j} x_{ij} = 1, \ j = 1, 2, \cdots, n \\ \sum\limits_{j=1, j \neq i} x_{ij} = 1, \ i = 1, 2, \cdots, n \\ \sum\limits_{i,j \in S, i \neq j} x_{ij} \leq |S| - 1, \ \text{for } \forall S \in V \\ x_{ij} = 0, 1, \ i \neq j, i, j = 1, 2, \cdots, n. \end{cases} \end{cases} \tag{32.1}$$

32.3 Application of the Model

Based on model (32.1), the distribution center of company A is selected as a studied case. Its detailed information can be seen in the literature [7]. According to the center's warehouse layout and related data, we construct a numerical example, which may reflect the basic characteristic of the researched high-level picker-to-part system.

32.3.1 Numerical Example

Suppose the depot is located in the middle of the company's warehouse, the warehouse has a cross aisle and the storage of goods adopt the within-aisle ABC classification. The width of the cross aisle and 9 aisles are all 2 meters. Every shelf has 10 layers, each layer has 2 columns and each column has 8 racks. For simplifying the distance's calculation, the dimension of each rack is set $1 \times 1 \times 1$ meter. The heights of the depot, the initial location of the stacker and the first layer of the shelves are in the same horizontal plane, that means when the stacker staying at initial location moves to the first layer of the shelf, the movement distance on the vertical direction is 0. The researched system of company A is shown in Fig. 32.1. We suppose there are 20 picking locations marked by digital 1-20 (seen in Fig. 32.1), their layers and

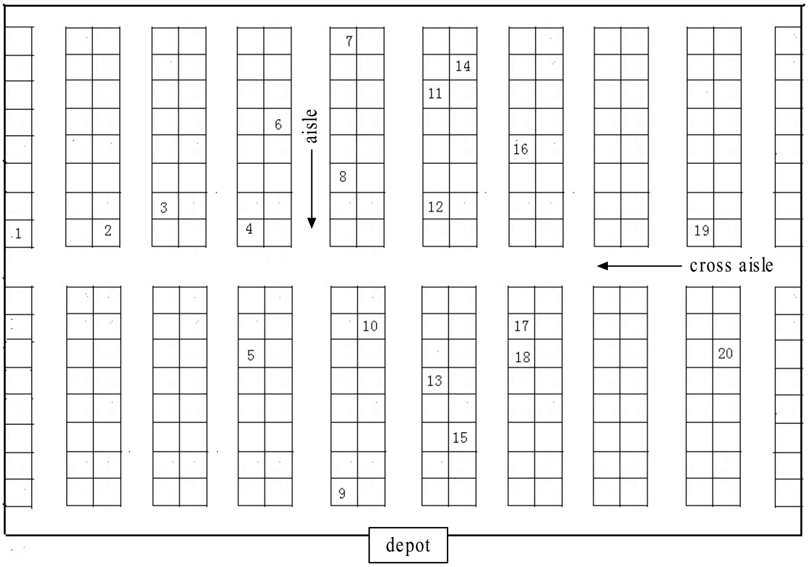


Fig. 32.1 The warehouse layout of company A and the order-picking locations

heights in the shelves are given in Table 45.1. Besides, we let the horizontal speed of the stacker, $v_x = 2$ m/s, the vertical speed $v_y = 1$ m/s.

Table 32.1 The storage layers of the 20 picking locations on the shelves

location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Layer	3	5	4	1	8	10	2	7	6	4	10	6	2	8	5	7	1	4	6	10

32.3.2 Parameter Calculation

Let the depot be location 0. In order to build the order-picking path model of company A , we need to know the horizontal distance d_{ij} and time $\frac{d_{ij}}{v_x}$, as well as the vertical distance h_{ij} and time $\frac{h_{ij}}{v_y}$, when a stacker move between rack i and j. According to the above data, we can calculate these distance and time parameters. The results are given in Table 32.2 to Table 32.5.

The total running time t_{ij} that the stacker moves from rack i to rack j is the sum of its horizontal and vertical running times, i.e. $t_{ij} = \frac{d_{ij}}{v_x} + \frac{h_{ij}}{v_y}$, $i, j = 1, 2, \cdots, 20$. Their values can be calculated by Tables 32.4 and 32.5. The results are shown in Table 32.6.

Now, these specific data can be brought into model (32.1) and determine the coefficients of the programming model which describes the three-dimension order-picking system.

32.3.3 The Specific Form of the Programming Model

The model is described as follows:

$$\begin{cases} \min z = \sum\limits_{i=1}^{20} \sum\limits_{j=1, j\neq i} t_{ij} x_{ij} \\ \text{s.t.} \begin{cases} \sum\limits_{i=1, i\neq j}^{20} x_{ij} = 1, \ j = 1, 2, \cdots, 20 \\ \sum\limits_{j=1, j\neq i}^{20} x_{ij} = 1, \ i = 1, 2, \cdots, 20 \\ \sum\limits_{i,j\in S, i\neq j} x_{ij} \leq |S| - 1, \ \text{for} \ \forall S \in V \\ x_{ij} = 0, 1, \ i \neq j, i, j = 1, 2, \cdots, 20, \end{cases} \end{cases} \tag{32.2}$$

where, the data of t_{ij}, $i \neq j$, $i, j = 1, 2, \cdots, 20$, come from Table 32.6.

Table 32.2 The stacker's horizontal running distance between any two picking locations (units: m)

d_{ij}	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	27	23	24	19	14	19	22	17	5	7	16	12	5	23	7	20	11	10	23	22
1	27	0	6	7	10	14	18	21	16	23	21	23	19	23	28	29	25	25	26	30	38
2	23	6	0	1	6	10	14	17	12	19	17	19	15	19	24	25	21	21	22	26	34
3	24	7	1	0	7	11	15	18	13	20	18	20	16	20	25	26	22	22	23	27	35
4	19	10	6	7	0	6	10	13	8	15	13	15	11	15	20	21	17	17	18	22	30
5	14	14	10	11	6	0	14	17	12	11	13	19	15	15	24	21	21	17	18	26	30
6	19	18	14	15	10	14	0	3	2	15	13	15	11	15	20	21	17	17	18	22	30
7	22	21	17	18	13	17	3	0	5	18	16	18	14	18	23	24	20	20	21	25	33
8	17	16	12	13	8	12	2	5	0	13	11	13	9	13	18	19	15	15	16	20	28
9	5	23	19	20	15	11	15	18	13	0	12	20	16	10	25	12	22	16	15	27	27
10	7	21	17	18	13	13	13	16	11	12	0	10	6	2	15	12	12	8	9	17	21
11	16	23	19	20	15	19	15	18	13	20	10	0	4	12	9	16	12	14	15	19	27
12	12	19	15	16	11	15	11	14	9	16	6	4	0	8	13	14	10	11	10	15	23
13	5	23	19	20	15	15	15	18	13	10	2	12	8	0	17	12	14	10	11	19	23
14	23	28	24	25	20	24	20	23	18	25	15	9	13	17	0	15	3	11	12	16	24
15	7	29	25	26	21	21	21	24	19	12	12	16	14	12	15	0	12	4	3	17	21
16	20	25	21	22	17	21	17	20	15	22	12	12	10	14	3	12	0	8	9	13	21
17	11	25	21	22	17	17	17	20	15	16	8	14	11	10	11	4	8	0	1	13	17
18	10	26	22	23	18	18	18	21	16	15	9	15	10	11	12	3	9	1	0	14	18
19	23	30	26	27	22	26	22	25	20	27	17	19	15	19	16	17	13	13	14	0	10
20	22	38	34	35	30	30	30	33	28	27	21	27	23	23	24	21	21	17	18	10	0

Table 32.3 The stacker's vertical running distance between any two picking locations (units: m)

h_{ij}	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	2	4	3	0	7	9	1	6	5	3	9	5	1	7	4	6	0	3	5	9
1	2	0	2	1	2	5	7	1	4	3	1	7	3	1	5	2	4	2	1	3	7
2	4	2	0	1	4	3	5	3	2	1	1	5	1	3	3	0	2	4	1	1	5
3	3	1	1	0	3	4	6	2	3	2	0	6	2	2	4	1	3	3	0	2	6
4	0	2	4	3	0	7	9	1	6	5	3	9	5	1	7	4	6	0	3	5	9
5	7	5	3	4	7	0	2	6	1	2	4	2	2	6	0	3	1	7	4	2	2
6	9	7	5	6	9	2	0	8	3	4	6	0	4	8	2	5	3	9	6	4	0
7	1	1	3	2	1	6	8	0	5	4	2	8	4	0	6	3	5	1	2	4	8
8	6	4	2	3	6	1	3	5	0	1	3	3	1	5	1	2	0	6	3	1	3
9	5	3	1	2	5	2	4	4	1	0	2	4	0	4	2	1	1	5	2	0	4
10	3	1	1	0	3	4	6	2	3	2	0	6	2	2	4	1	3	3	0	2	6
11	9	7	5	6	9	2	0	8	3	4	6	0	4	8	2	5	3	9	6	4	0
12	5	3	1	2	5	2	4	4	1	0	2	4	0	4	2	1	1	5	2	0	4
13	1	1	3	2	1	6	8	0	5	4	2	8	4	0	6	3	5	1	2	4	8
14	7	5	3	4	7	0	2	6	1	2	4	2	2	6	0	3	1	7	4	2	2
15	4	2	0	1	4	3	5	3	2	1	1	5	1	3	3	0	2	4	1	1	5
16	6	4	2	3	6	1	3	5	0	1	3	3	1	5	1	2	0	6	3	1	3
17	0	2	4	3	0	7	9	1	6	5	3	9	5	1	7	4	6	0	3	5	9
18	3	1	1	0	3	4	6	2	3	2	0	6	2	2	4	1	3	3	0	2	6
19	5	3	1	2	5	2	4	4	1	0	2	4	0	4	2	1	1	5	2	0	4
20	9	7	5	6	9	2	0	8	3	4	6	0	4	8	2	5	3	9	6	4	0

Table 32.4 The stacker's horizontal running time between any two picking locations (units: s)

$\frac{d_{ij}}{v_x}$	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	13.5	11.5	12	9.5	7	9.5	11	8.5	2.5	3.5	8	6	2.5	11.5	3.5	10	5.5	5	11.5	11
1	13.5	0	3	3.5	5	7	9	10.5	8	11.5	10.5	11.5	9.5	11.5	14	14.5	12.5	12.5	13	15	19
2	11.5	3	0	0.5	3	5	7	8.5	6	9.5	8.5	9.5	7.5	9.5	12	12.5	10.5	10.5	11	13	17
3	12	3.5	0.5	0	3.5	5.5	7.5	9	6.5	10	9	10	8	10	12.5	13	11	11	11.5	13.5	17.5
4	9.5	5	3	3.5	0	3	5	6.5	4	7.5	6.5	7.5	5.5	7.5	10	10.5	8.5	8.5	9	11	15
5	7	7	5	5.5	3	0	7	8.5	6	5.5	6.5	9.5	7.5	7.5	12	10.5	10.5	8.5	9	13	15
6	9.5	9	7	7.5	5	7	0	1.5	1	7.5	6.5	7.5	5.5	7.5	10	10.5	8.5	8.5	9	11	15
7	11	10.5	8.5	9	6.5	8.5	1.5	0	2.5	9	8	9	7	9	11.5	12	10	10	10.5	12.5	16.5
8	8.5	8	6	6.5	4	6	1	2.5	0	6.5	5.5	6.5	4.5	6.5	9	9.5	7.5	7.5	8	10	14
9	2.5	11.5	9.5	10	7.5	5.5	7.5	9	6.5	0	6	10	8	5	12.5	6	11	8	7.5	13.5	13.5
10	3.5	10.5	8.5	9	6.5	6.5	6.5	8	5.5	6	0	5	3	1	7.5	6	6	4	4.5	8.5	10.5
11	8	11.5	9.5	10	7.5	9.5	7.5	9	6.5	10	5	0	2	6	4.5	8	6	7	7.5	9.5	13.5
12	6	9.5	7.5	8	5.5	7.5	5.5	7	4.5	8	3	2	0	4	6.5	7	5	5.5	5	7.5	11.5
13	2.5	11.5	9.5	10	7.5	7.5	7.5	9	6.5	5	1	6	4	0	8.5	6	7	5	5.5	9.5	11.5
14	11.5	14	12	12.5	10	12	10	11.5	9	12.5	7.5	4.5	6.5	8.5	0	7.5	1.5	5.5	6	8	12
15	3.5	14.5	12.5	13	10.5	10.5	10.5	12	9.5	6	6	8	7	6	7.5	0	6	2	1.5	8.5	10.5
16	10	12.5	10.5	11	8.5	10.5	8.5	10	7.5	11	6	6	5	7	1.5	6	0	4	4.5	6.5	10.5
17	5.5	12.5	10.5	11	8.5	8.5	8.5	10	7.5	8	4	7	5.5	5	5.5	2	4	0	0.5	6.5	8.5
18	5	13	11	11.5	9	9	9	10.5	8	7.5	4.5	7.5	5	5.5	6	1.5	4.5	0.5	0	7	9
19	11.5	15	13	13.5	11	13	11	12.5	10	13.5	8.5	9.5	7.5	9.5	8	8.5	6.5	6.5	7	0	5
20	11	19	17	17.5	15	15	15	16.5	14	13.5	10.5	13.5	11.5	11.5	12	10.5	10.5	8.5	9	5	0

Table 32.5 The stacker's vertical running time between any two picking locations (units: s)

$\frac{d_{ij}}{v_y}$	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	2	4	3	0	7	9	1	6	5	3	9	5	1	7	4	6	0	3	5	9
1	2	0	2	1	2	5	7	1	4	3	1	7	3	1	5	2	4	2	1	3	7
2	4	2	0	1	4	3	5	3	2	1	1	5	1	3	3	0	2	4	1	1	5
3	3	1	1	0	3	4	6	2	3	2	0	6	2	2	4	1	3	3	0	2	6
4	0	2	4	3	0	7	9	1	6	5	3	9	5	1	7	4	6	0	3	5	9
5	7	5	3	4	7	0	2	6	1	2	4	2	2	6	0	3	1	7	4	2	2
6	9	7	5	6	9	2	0	8	3	4	6	0	4	8	2	5	3	9	6	4	0
7	1	1	3	2	1	6	8	0	5	4	2	8	4	0	6	3	5	1	2	4	8
8	6	4	2	3	6	1	3	5	0	1	3	3	1	5	1	2	0	6	3	1	3
9	5	3	1	2	5	2	4	4	1	0	2	4	0	4	2	1	1	5	2	0	4
10	3	1	1	0	3	4	6	2	3	2	0	6	2	2	4	1	3	3	0	2	6
11	9	7	5	6	9	2	0	8	3	4	6	0	4	8	2	5	3	9	6	4	0
12	5	3	1	2	5	2	4	4	1	0	2	4	0	4	2	1	1	5	2	0	4
13	1	1	3	2	1	6	8	0	5	4	2	8	4	0	6	3	5	1	2	4	8
14	7	5	3	4	7	0	2	6	1	2	4	2	2	6	0	3	1	7	4	2	2
15	4	2	0	1	4	3	5	3	2	1	1	5	1	3	3	0	2	4	1	1	5
16	6	4	2	3	6	1	3	5	0	1	3	3	1	5	1	2	0	6	3	1	3
17	0	2	4	3	0	7	9	1	6	5	3	9	5	1	7	4	6	0	3	5	9
18	3	1	1	0	3	4	6	2	3	2	0	6	2	2	4	1	3	3	0	2	6
19	5	3	1	2	5	2	4	4	1	0	2	4	0	4	2	1	1	5	2	0	4
20	9	7	5	6	9	2	0	8	3	4	6	0	4	8	2	5	3	9	6	4	0

32.4 Genetic Algorithm for Solving the Problem of Optimal Order-picking Path

Model (32.2) can be seen as a special TSP model, that means a Hamilton cycle corresponds to a order-picking path. The fact that TSP is a NP-hard problem implies the number of the model's solution may reach $\frac{20!}{2}$, so that the traditional solution methods would encounter some difficulties.

As all know, the genetic algorithm (GA) is quite efficient to solve TSP, therefore we design an algorithm to seek the optimal path, according to the principle of GA and the actual situation of the researched order-picking system. The process of the algorithm is shown as follows

Step 1. The initial population is randomly generated. An individual in the population can be expressed by a string with numbers 1 to 20. The arrangement of these numbers is random and a string can be seen a chromosome corresponding to an order-picking path. The two adjacent figures in a chromosome will be seen as the row's number and column's number in the total time matrix of Table 32.6, so that the computer program can find the stacker's total running time between two neighbor locations. Therefor, the chromosomes can not have figure 0. The number 1 in a chromosome corresponds to location 0, i.e. the depot in the order-picking system, the number 2 corresponds to location 1 of the system, and so on. In order to facilitate the program, the number 20 isn't contained in the chromosome, we default location 20 of the system is arranged in the middle of the two locations, which correspond the last gene and the first gene of a chromosome. For example, the first number of a chromosome is 3, the last number is 12, then it represents the order-picking route should be 11-20-2. Here, we let the population equal to 3000.

Step 2. Set the parameters of genetic algorithm. Here, crossover probability is 0.9. The percentage of the crossover section is 0.3. The mutation probability is 0.009. The remained maximum number of the best individual is 1. The protected probability of the best individual are 1, 0.999 and 0.99, during the selection, crossover and mutation processes, respectively. The maximum epoch is 1000.

Step 3. Select the best chromosome in the initial population, according to the fitness function defined by the order-picking time.

Step 4. Start the iteration. Each cycle contains a crossover, mutation and selection operation.

Step 5. Terminal condition. Condition 1, if the number of iterations reaches 1000, then the program terminates, and the optimal individual found in the past will be taken as the approximate global optimal solution. Condition 2, if the epoches that the optimal solution remains unchanged exceed 300, then this solution will be taken as the approximate global optimal solution.

32.5 The Optimal Solution and Its Effectiveness

Based on the above algorithm, an optimal order-picking path is obtained as follows:

(1) Optimal Order-picking Path

The shortest path: 0-13-10-12-20-19-16-14-11-6-8-7-4-1-3-2-5-9-15-18-17-0.

The shortest order-picking time is 126 seconds. This shortest order-picking route is shown in Fig. 32.2.

(2) The Interpretation of the Solution

Someone may say there are some seemingly unreasonable in this order-picking route map. For example, the obtained optimal picking route includes 6-8-7, rather than the 7-6-8. Similar examples may also seen in the aisle with location 2 and 3, when the stacker moves to the entrance of the aisle, it did not enter the aisle at first, it directly arrives at location 1 in the next aisle. After picking goods in location 1, the stacker then picks the goods at location 2 and 3. In fact, the "unreasonable" just disclose the difference between the 2D order-picking system and 3D orderpicking system. When we consider the hight of these locations, the unreasonable can be explained reasonably. Let's see the optimal path 11-6-8-7-4, if we only consider the horizontal running time, it will be slower than the time running on the path 11-7-6-8-4. Nevertheless, the vertical moving distance on the path 11-7-6-8-4 is 17 m, the optimal path 11-6-8-7-4 only 9 m. Therefore, seen from the total time including the horizontal and vertical movement, the optima path's time is 2 seconds less than the path 11-7-6-8-4.

(3) Methods Comparison

In order to prove the effectiveness of the above method, we will compare it with the traditional transversal strategy and s-shape strategy. The compared results is shown in Table 32.7.

32.6 Conclusions

In the paper, we research the path optimization problem in the high-level picker-to-part system and consider the stacker's vertical moving time, which is often neglected by the past research. Our research expand the traditional two-dimensional TSP to the three-dimensional TSP, and build a programming model to find an optimal order-picking route in the high-level picker-to-part system, which has been popularly adopt by many modern companies. In addition, we also design a special GA to solve the programming model. The result derived from the numerical example express: compared with the currently used methods, our method may be more efficient in the picking time saved and the picking path shortened.

But our research base on the enough simple high-level order-picking system, the real situation is more complex than the assumed. The real system may be determined by the seven factors: batching, picking sequence, storage policy, zoning, layout design, picking equipment and design of picking information. So, the next research will consider the different factors condition. Besides, the improvement of the design of algorithm may be an important work.

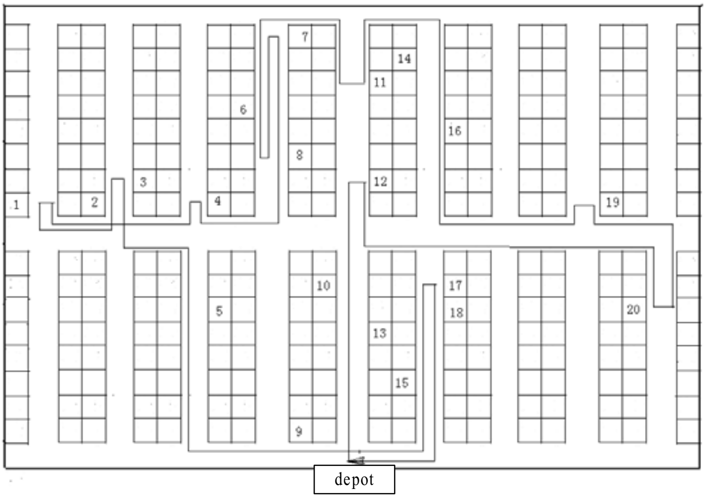


Fig. 32.2 The optimal order-picking route of the researched high-level picker-to-part system

Table 32.6 The stacker's total running time between any two picking locations (units: s)

t_{ij}	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	15.5	15.5	15	9.5	14	18.5	12	14.5	7.5	6.5	17	11	3.5	18.5	7.5	16	5.5	8	16.5	20
1	15.5	0	5	4.5	7	12	16	11.5	12	14.5	11.5	18.5	12.5	12.5	19	16.5	16.5	14.5	14	18	26
2	15.5	5	0	1.5	7	8	12	11.5	8	10.5	9.5	14.5	8.5	12.5	15	12.5	12.5	14.5	12	14	22
3	15	4.5	1.5	0	6.5	9.5	13.5	11	9.5	12	9	16	10	12	16.5	14	14	14	11.5	15.5	23.5
4	9.5	7	7	6.5	0	10	14	7.5	10	12.5	9.5	16.5	10.5	8.5	17	14.5	14.5	8.5	12	16	24
5	14	12	8	9.5	10	0	9	14.5	7	7.5	10.5	11.5	9.5	13.5	12	13.5	11.5	15.5	13	15	17
6	18.5	16	12	13.5	14	9	0	9.5	4	11.5	12.5	7.5	9.5	15.5	12	15.5	11.5	17.5	15	15	15
7	12	11.5	11.5	11	7.5	14.5	9.5	0	7.5	13	10	17	11	9	17.5	15	15	11	12.5	16.5	24.5
8	14.5	12	8	9.5	10	7	4	7.5	0	7.5	8.5	9.5	5.5	11.5	10	11.5	7.5	13.5	11	11	17
9	7.5	14.5	10.5	12	12.5	7.5	11.5	13	7.5	0	8	14	8	9	14.5	7	12	13	9.5	13.5	17.5
10	6.5	11.5	9.5	9	9.5	10.5	12.5	10	8.5	8	0	11	5	3	11.5	7	9	7	4.5	10.5	16.5
11	17	18.5	14.5	16	16.5	11.5	7.5	17	9.5	14	11	0	6	14	6.5	13	9	16	13.5	13.5	13.5
12	11	12.5	8.5	10	10.5	9.5	9.5	11	5.5	8	5	6	0	8	8.5	8	6	10.5	7	7.5	15.5
13	3.5	12.5	12.5	12	8.5	13.5	15.5	9	11.5	9	3	14	8	0	14.5	9	12	6	7.5	13.5	19.5
14	18.5	19	15	16.5	17	12	12	17.5	10	14.5	11.5	6.5	8.5	14.5	0	10.5	2.5	12.5	10	10	14
15	7.5	16.5	12.5	14	14.5	13.5	15.5	15	11.5	7	7	13	8	9	10.5	0	8	6	2.5	9.5	15.5
16	16	16.5	12.5	14	14.5	11.5	11.5	15	7.5	12	9	9	6	12	2.5	8	0	10	7.5	7.5	13.5
17	5.5	14.5	14.5	14	8.5	15.5	17.5	11	13.5	13	7	16	10.5	6	12.5	6	10	0	3.5	11.5	17.5
18	8	14	12	11.5	12	13	15	12.5	11	9.5	4.5	13.5	7	7.5	10	2.5	7.5	3.5	0	9	15
19	16.5	18	14	15.5	16	15	15	16.5	11	13.5	10.5	13.5	7.5	13.5	10	9.5	7.5	11.5	9	0	9
20	20	26	22	23.5	24	17	15	24.5	17	17.5	16.5	13.5	15.5	19.5	14	15.5	13.5	17.5	15	9	0

Table 32.7 The compared results of the three methods

	Horizontal distance	Horizontal running time	Vertical distance	Vertical running time	Total time
Transversal strategy	208 m	104 s	66 m	66 s	170 s
S-shape	174 m	87 s	73 m	73 s	160 s
Our method	164 m	82 s	44 m	44 s	126 s

References

1. Gademann N, Van De Velde, S (2005) Order batching to minimize total travel time in a parallel-aisle warehouse. IIE Transactions 37:63–75
2. De Koster R, Le-Duc T, Roodbergen KJ (2007) Design and control of warehouse order picking: A literature review. Operational Research 182:481–501
3. Roodbergen KJ, Vis IFA (2006) A model for warehouse layout. IIE Transactions 38:799–811
4. Tompkins JA, White JA, Bozer YA et al (2010) Facilities planning. John Wiley & Sons, New York
5. De Koster R (2004) How to assess a warehouse operation in a single tour. Technology Report. RSM Erasmus Unversity, the Netherlands
6. Lawler EL, Lenstra JK, Rinnooy Kan AHG et al (1985) Travelling salesman problem. John Wiley & Sons, Chichester
7. DeKker R, De Koster R, Kalleven H et al (2004) Improving Order-picking response time at Ankor's warehouse. Interfaces, 34:303–313

Chapter 33
The Comparison of Dividend-paying Policy of to be Listed between China and the United States

Hongchang Mei and Wei Yang

Abstract Since the formulation of dividend-paying policy has related to the development of the company and the interests of shareholder in different shareholder structures, the different results to the shareholders by the same dividend-paying policy could arise. In China some listed corporations often send out less cash bonus, even no dividend in several years, this situation hurts the small and medium investor's confidence to the domestic stock market, but in the United States the shareholders of listed corporation have received a dividend payment higher than 50% of the net profit. The listed corporations which accept stock dividend methods account for only 15% of the total. This article analyzes the dividend policy of the both countries as a contrast, Firstly it compares the present situation of the dividend policy. Then, explores the factors from multiple perspectives that affect the dividend-paying policy and obtains some enlightenment for policy improving, and finally considers relevant measures for optimizing the regulations to Chinese listed corporation.

Keywords Dividend-paying · Policy · Comparison · Enlightenment

33.1 Introduction

The dividend policy is a kind of policy-making question that listed corporation distributes its profit or preserves it for reinvestment. Dividend policy's reasonable formation has profound influence on the company's development and shareholder's benefit. The moderate dividend policies can attract massive investors effectively, speed up the company's finance efficiency, and supply a long-term, stable and health development environment. In China, there exist many problems on dividend allocation, such as no dividend or low dividend rate, the dividend yield ratio is relatively

---

H. Mei (✉) · W. Yang
Management School, Chongqing Technology and Business University, Chongqing 400000,
P. R. China
e-mail: mhchang68@hotmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_33,

low, especially a multiple variety of distribution modes, lack of stability, this situation affect the investor's uncertainty prediction on the slowdown stock market. In addition, there were many profit-oriented speculators in China's market, the company's dividend policy in the past years making failed to reflect the company's market value correctly. For keeping Chinese capital market progress stable and healthy, we should use foreign mature market's good experience and current dividend-paying policy for a reference. We believe the win-win situation can be very hopeful that domestic investors enjoy capital investment benefits while the capital market increases reasonably.

To this point, this paper analyzes listed corporation's present dividend-paying situation and factors which effect the formation of the dividend policy in China and The United States, we use a contrasting analysis, and try to draw enlightenment from dividend-paying policy practice in the two countries.

33.2 Different Situation of Dividend Payment between China and the United States

33.2.1 Comparison on Dividend Payment Modes

The main ways for American listed corporation to pay dividend are through cash, stock dividend and stock repurchase. Generally, most of corporation adopts cash dividend to payoff the shareholders, they rarely use the way of stock dividend. And the dividend can be given quarterly. So the investors can often understand each company's level of net profit, and thus make long-term investment decision. Since mid-80s of the 20th century, stock buyback has become one of the main forms for the company that distributes profit to the shareholders. The proportion of cash paid to shareholders through buybacks has almost reached the same level with cash dividend. This is because that stock buyback can be used as a replace of dividend without thinning the value of per share. The listed corporation uses stock buyback as the managers share subscription and issues some stock option plan to inspire strata of management for further effort. Meanwhile there are other advantages to use stock buyback, such as distributing profit to shareholders, optimizing capital structure by raising debt-to-equity ratio, and reducing the enterpriser's tax bearing.

The dividend-paying modes of Chinese listed corporation public are diversified. At the present, there are more than three modes as follows: firstly, cash bonus is the most common way of dividend-paying; secondly, sending stock dividend to the shareholders; thirdly, turning add capital stock; finally the integrate of three modes and allotment of stock. Under the diversified modes of dividend-paying, Chinese listed corporation prefer the stock dividend. Compared with American listed corporation, there are different reasons.

33.2.2 Comparison on Dividend Payment Ratio

Usually in USA most of listed corporation use a large part of their annual profit to pay dividends. But in recent years, about 20% United States listed corporation pay cash dividends, and the average dividend yield ratio usually ranges from 1% to 2.5%. Meantime, considerable number of listed corporation use cash to buy back stock to replace the cash dividend. When considering this factor, The listed corporation average dividend payout ratio is much higher, which accounted about 30%-40% for the company's net income in 70s of last century; By the 1980s, increased to 40%-50%. Now, 50%-70% of the after-tax profits are used to pay dividends.

Before 2003, the dividend payout ratio of listed corporation in China had been less than 40%, SFC 's introduction of new policies in 2004 made the situation a significant changes, the average payout ratio in recent seven years has reached to 40%; Now 1645 corporation show their the 2011 annual distribution of profits (including the donation of equity) program, expected cash dividend amounting to 606.7 billion yuan renminbi, an increase of 21.21% than the previous year, account for 31.35% of the total net profit. However, compared with mature foreign capital markets, the dividend payout ratio of listed corporation in China is relatively low. From 1990 to 2010, holders of circulation stock in China obtain the average dividend yield ratio is 0.55 percent, from 1970 to 2010, on the mature stock markets, four countries' average dividend yield ratio is 1.97% (USA), 1.74% (JAP), 2.19% (UK), 1.11% (GER) respectively, the trend of escalation was slightly obvious. Chinese listed corporations whose dividend yield ratio surpasses 2% are greatly less than the level of external market. And In 2011, there is only 4.6% of Chinese listed corporations whose dividend yield ratio surpasses 2%. At the blue chip stock market in Shanghai and Shenzhen 300, only 14%, which is significant lower than the US and other developed country market [2].

33.2.3 Comparison on the Concentration of Dividend Payment

The United States payment dividends exists concentrating tendency. At the present, dividend distribution presents dual structure, i.e. there are dividend payments and profit highly centralized trend, a few of quality company produces the major parts of earnings and dividends. It is demonstrated that in 1989-1996, almost 20% of listed corporation pay the dividend of 90.4%; In 1999-2006, 10% of listed corporation pay 79.5% of the dividend. At the same time, about 80%-90% of listed corporation paid dividend no more than 20%. In fact, in the United States the enterprise number which paid dividend to its shareholders accounted for a low the proportion.

In 2004 China had 232 listed corporation that had not paid any dividend, accounted for 20%. In 2005 those of so called "iron cock" company increased to 444, accounted for 36.27%; In 2007 the stock market obtains the unusual abundant harvest, the high proportion cash distribution is the new anticipation, but still had 624 listed corporation to announce has no dividend-paying-plan, the proportion reaches to 46.57% of the listed company's total [4]; From 2008 to 2011, the quantity and the proportion of no dividend-paying company are respectively 609 (42.32%), 677 (39.41%), 746 (35.27%), 1645 (68.46%).

33.2.4 Comparison on the Long-term Net Assets Return Ratio

In the United States, bank deposits bring low interests, but stockholders can obtain bonus higher than the bank interest. Therefore many residents do not like depositing, but choose investing stock market. Thanks to a quite stable bonus's circumstance, the majority of the listed company have the ability to balance the dividend distribution between high profits year and deficit year. The listed company does not arrange a very high dividend return in a good harvest year and a no dividend return in a difficult one, it can always executing a dividend-paying rate decided in advance. This enables the majority investors do not pay great attention on cash bonus, but prefer the capital's long-term repayment. So the long-term capital rate of return has more attraction compared to the short-term, this is also profitable to listed company to use cash flow on seizing a investment chance, while having more market shares. In turn, after the listed company's performance enhanced, more idle cashes can be used to pay the bonus, then, the listed company marches into a good economic cycle.

In compared with USA, the China's long-term net assets rate of return is relatively lower.

It can be seen from the Fig. 33.1, In China, that long-term net assets rate of return is lower than that in USA, and Most of small investors are willing to hold small-cap stocks, low-priced stocks, stocks of low performance so they pay more attention on short-term cash dividends, or have speculation, their frequent trading and short-term behavior further reduce the popularity of the listed corporation which can arrange a higher dividends. This resulted in most of the investors involved in the stock transaction but did not really enjoy the dividends, so the markets and investors generally felt the dividend too little to hold themselves. Based on the reason above, Chinese investors at the present could not pursues the long-term investment return come from listed corporations (as Fig. 33.1).

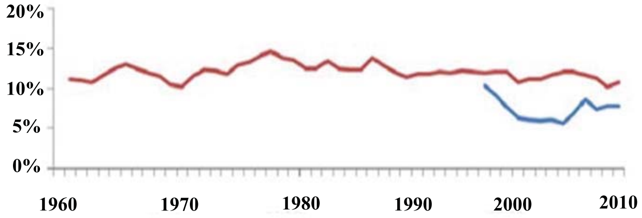


Fig. 33.1 United States (red) and China (blue) net assets return

33.2.5 Dividend Stability Contrast

The US listed corporation's managements trust the signal transmission theory, the continual and stable dividend policy can transmit the company's steady growth information, investor's confidence are strengthened by this [3]. In most of Chinese listed corporations dividend policy lack of both stability and continuity, the dividend policy's making and the implementation lack the foresight, the goals of the policy are not clear and appear capricious, policy maker blindly caters to the market requirement. Sometimes market prefers stock dividends, sometimes market favors cash bonus, as following crowd behavior appears obviously fluctuated. The distribution pattern is uncertain, sometimes only sends cash, sometimes only deliver the stock, sometimes both sends cash and deliver the stock, sometimes no dividend, no rule can be followed, which causes the investors have many difficulties in mastering the company's future dividend policy. In the recent several years, only several dozens corporations distributes the cash dividends annually, maintains their assignment policy relatively stable. This also explained why Chinese listed corporations holding shareholders do not relate the cash dividends policy to company's long-term development, and why the short-term behavior do not have the careful decision-making.

33.3 The Reason Analysis on China-US Dividend Policy Differences

The dividend policy-making is influenced by the factor of both the external and the internal. The internal factors include company values, stockholder's rights structure and so on, The external factor mainly comes from the maturity of the capital market, the country's related legal regime, the company's finance environment and so on [1]. They are changing unceasingly and playing different influence to the dividend policy.

33.3.1 External Reason Comparison

(1) The capital market's maturity difference

Because the US whole economy scale tends to the maximum in all the world, the economical environment is relatively stable, the capital market basically has achieved saturation, the opportunity for the investor gain income through the capital principal and interest is quite few, this causes the cash dividends and the stock buy-back becomes the direct benefit way. According to the signal hypothesis theory [7], draws bonus number was often considered as to judge whether the company has the value of investment, which not only represents listed corporation's present's profitability, but also represent its future prospects for the further development, Big bonus can let the investors have more confidence in listed corporation's cash flow and future management level. Certainly, the enterprise may transmit company's information through the announcement to the investor, but the cash bonus has more persuasive power than the language. Therefore, to a certain extent, the cash bonus may be regarded as in the future operation indicator of the enterprise, and played certain restriction role to operator's low dividend payment.

Now China capital market's existing condition is that the overall scale is small, waiting for expanding, the direct finance scale is limited, the stock market and bond market are unbalanced, and the partial economic environment is turbulent. For a long time, the investors lack of the value investment consciousness, they buy or sell the stock is mainly to seek the capital principal and interest, but not the dividend, so the investment behavior tending to short-term, and blindness is very obviously strong. In order to cater to the investor demand the listed company in China carries on some unreasonable dividend policy. Through the red chips, loans, and the great proportion of granting the stock, part of listed corporations cause the stock price to a new high after a new high, in this case, the enterprise market true value is very easy to be twisted. As a result of speculator's existence, this causes the genuine investor has difficult in obtaining benefits from the cash dividends, investor's vested interest cannot get the effective safeguards, simultaneously the confidence lost in next investment decision making.

(2) Legal regime difference

Various countries' laws and regulations involved company's profit distribution order, preserved profit, capital sufficient, the debt to reimburse, and so on. The cash accumulation, the dividend policy must conform to the legal norm. Therefore, before dividend policy formulation, the decision maker wants to formulate a boundary for the dividend policy, then consider other influencing factor. The different company's dividend policy definition which limits in the different country is not similar. The relevant laws have three principles to the dividend assignment: (1) The dividend must be offered by the company's profit from now or in the past; (2) dividend could not be paid by the company's capital; (3) when company's debt surpasses its property, but reimburses time is incapable for the debt, the company could not distribute the dividend. At the same time, Due to "Domestic Income Law" stipulated the U.S. listed corporation, the accumulative net profits surpass 250,000 US dollars will be levied high taxes, this greatly increased company's cost not to distribute a reasonable dividend.

(3)financing environment difference

The financing environment refers to certain company system, the company finance affected by an active kind of factor set. It provides both of opportunity and negative effect on company's financing. Under the loose financing environment, the company may come through providing debt to finance dividend, the rights and interests. In general, the bigger the company size is, the stronger its dividend payment ability and financial flexibility is on the capital market, Otherwise for the small or newly established company, it is difficult to carry on financing. Because USA market opening degree is high, the capital market is relatively mature, the credit guarantee system is relatively consolidated, when the companies at beginning period meet questions of tightness of money, it can be offered loans through the unsecured channels. But in China, company's financing environment appears relatively weak, the financing channel is relatively unitary, the majority of the corporation can only loan from the bank, nearly no other ways to loan without a high cost or high risk. The financing system's imperfect also causes the company financing difficulty.

33.3.2 The Structure Difference of Stockholder's Rights

(1) the structure difference of stockholder's rights

In the United States enterprises there are many individual shares, account for 53.5%, the corporate shares account for 34%, the government and the association shares account for 12.5%, because a lot of individual shares, the listed corporations probably take the highest investment yield, a higher stock price as the most important financial control goal. Individual shareholder quantity is very large, and also causes the company to pay great attention to set up the public image, to take the dividend policy as the indication lamp of enterprise development condition in the future. For instance, once the dividend assignment policy is unsteady, the dividend payment ratio drops, or the reason has not been explained, why the cash dividends form replaced by stock dividend form, this will cause the public to worry the company's future development, then sell the stock in the market as soon as possible, and lead to the stock price fall. Therefore, that is the real reason that enterprises in the United States can be expected for maintaining a steady posture in the dividend assignment, and carrying on the taxed profit distribution at a high payout ratio [6].

In China, most of stock price systems are occupied by the state-owned shares, the circulate stock only accounts for about 30%. For enterprise's long-term development. generally, the government pays great attention to state-owned enterprise's accumulation, instead of the cash dividends type of distribution which lead enterprise's cash outflow; Pays great attention to enterprise's management performance, namely profit index, but cares relatively few about the stock price. On the other hand, under the situation that in state-owned shares holding universal existence, the state-owned subject of investment is vacant. Enterprise's operators always stand in their own angle not the non-owner's angle to make decision, even the superintendent is also in favor of increasing the investment by retained earnings in order to reduce financial risk. In addition, most of Chinese enterprises are entering into a growth period, the fund demand is big, the low dividend payout ratio is advantageous to enterprise's growth.

(2) Company's Core Values Difference

The core values (core values) that usually referred to the ultimate faith which Chinese company essentially possess, it is the most important component of the leading function of the business philosophy, it is a series of criteria for the company in the development to solve inside and outside the contradictory. The United States is the typical individualism country, whose culture even emphasizes more about the personal interest, but non-collective interests' pursue. Most of American company's core values are under the guidance of humanist, profit maximization, and customer demand. But China belongs to the collectivism country, stresses the collective interests more than the personal interest, therefore the most of Chinese company's core values are under the guidance of team cooperation and community responsibility. Dividing the company's core values into six aspects, the good faith, the innovation, humanist, the customer guidance, the team spirit and community responsibility. on the comparison of the Sino-US 25 well-known Enterprise's core values, we obtain the next results. The United States enterprise value keep the principle of "humanist", the proportion has surpassed 50%, therefore when formulating the dividend policy, company pays great attention to each shareholder's benefit, But what Chinese Corporation pays great attention to is the entire company's benefit, therefore when formulating the dividend policy, collective interests is placed at the first place, for company's long-time development, the company's major incomes will be used for the company's longer-term investment, basically will not provide the cash dividends, but the stock dividends to the shareholder.

(3) Fund Raising Ability and Profitability Difference

In front of the company financing environment, we have mentioned. Compared with China Corporation, the U.S. Corporation's financing environment is looser, thus its fund raising ability was stronger. Therefore America Corporation may consider providing high dividend, and will satisfy the enterprise future need in monetary fund, but Chinese Corporation must consider retaining more funds to use to internal capital turnover or to repay that is going to expire. To the small scale and limited finance, these corporation usually needs to manage a period of time to obtain the fund from exterior, thus they often need to limit the cash dividend payment [5]. Cash ability's strong and weak directly related to company normal management operation, the company can only provide the cash dividends. when its operation fund is unimpeded. If company cash ability is strong, the cash flow is sufficient, then it has ability to pay the high cash dividends. Otherwise, the enterprise meets the good opportunities for investment while the cash flow is not sufficient, it must reduce the cash dividends payment rate.

33.4 Inspiration and Countermeasures

33.4.1 To Optimize the Equity Structure

The state-owned shares stockholder's rights proportion is too big. the stockholder's rights proportion of the non state-owned need to be increased more and more. The individual shareholders have more power to participate company's governance, to improve listed corporation's scientific management, to promote capital flow and optimizing disposition resources.

33.4.2 To Improve the Relevant Regulations of Listed Corporate Dividend Distribution

The restriction to listed corporate cash dividend may be achieved by set an upper and lower limits: To set a minimum limit for listed corporate dividend distribution, could strengthen the shareholder confidence to long-term stock, and change Chinese stock market's blindness, speculative trend; The upper limitation is to limit some corporation to obtain the qualification of share matching, and encourage the corporation send the dividend reasonably. In addition, the security exchanges continue limit the refinance of the listed corporation which have no dividend distribution. When the net profit arrives at a certain level, the company must carry on the policy of cash dividend distribution, otherwise policy surveillance and penalty mechanism would regulate the listed company's daily behavior.

33.4.3 To Increase Fund Raising Channel

Diligently to expands the fund raising channel, to unceasingly promote the market economy system to be matured, to coordinated reforms corresponding political system, build a good fund raising environment for some listed corporation whose financing ability is bad.

33.4.4 To Form a Stable, Continual Dividend Policy

The companies can not merely depend upon the preferential policy to strengthen its financing ability. They should expand its financing channel to formulate stable dividend assignment policy through their own endeavor. this is very helpful to enhance the investor's confidence in holding stocks, and to transmit the stock market a signal that company will health develop in the future.

References

1. Tang GQ, Zou H (2005) To be listed cash dividends policy influencing factor empirical study. Finance and economics Science 2:147–153
2. Xin XS (2011) China and US to be listed encouragement policy contrastive analysis. Cooperative economy and science and technology 12:50–51
3. Xin Y (2009) Western Country's to be listed dividend policy enlightenment. Cooperative economy and science and technology 3:98–99
4. Liu Y, Li A (2007) Our country's to be listed dividend policy brief analysis. Finance and accounting research 5:53–56

5. Huang P, Wang WH (2011) China and US privately operated to be listed’s cash bonus influencing factor contrast research. The Chinese Petroleum university
6. He JB (2012)Domestic and overseas listed corporation draws bonus difference and reason empirical study. The shenzhen stock exchange comprehensive research institute
7. Fama EF, Babiak H (1968) Dividend policy: An empirical analysis. Journal of the American Statistical Association 1132–1161

Part IV
Industrial Engineering

Chapter 34
A Bi-level Multiobective Optimization Model for Risk Management to Utilize Wastes in Stone Industry under Fuzzy Environment

Abid Hussain Nadeem, Muhammad Hashim and Muhammad Nazim

Abstract Control and management of waste materials created during stone production is one of the most important problems of stone industry and modern societies today. Waste materials which are different depending on properties of structure and construction technique generally consist of materials such as concrete, brick, stone, briquette, wood, metal, glass, gypsum, plastic, ceramic [1]. This paper is about how to optimize the stone industry. The plant considered as the leader level will make a strategy to utilize the wastes amount for waste department. The waste department considered as the follower level will make a decision to produce different stone products under the utilizing constraint. Due to the lack of historical data, some emission coefficients are considered as fuzzy numbers.Therefore, a bi-level multiobjective optimization model with possibilistic constraints are developed to get the maximum profit and control the pollution. At the end, a case study is proposed to show the efficiency of the proposed model.

Keywords Bi-level multi-objective programming · Possibilistic constraint · Waste utilization in stone industry · Fuzzy simulation

34.1 Introduction

Waste generation is a major issue in every country, and waste quantities are generally growing. Stone is an essential material for the construction industry but stone industry is always regarded as a high-emission industry for the stone dust and waste water. Waste management is the systematic assessment of potential hazards, disposal and proper utilization of waste in mining and allied industries. Due to waste there is a great environmental concern and resource constraint. These wastes can

---

A. Nadeem (✉) · M. Hashim · M. Nazim
Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, P. R. China
e-mail: abidnadeem.iub@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_34, © Springer-Verlag London 2013

affect the environment through it intrinsic property. Proper planning is essential to manage the waste. Management indicates managing wastes in such a way that it would be beneficial in any way. Recycling of marble material is used as liquid additive, cement additive, lime production and in construction industry as refractor material as wastes in the form of powder and particle [9]. As is shown in Fig. 34.3, these four products are major products which could be produce by utilization of wastes. If we utilize the waste in efficient and effective way we can produce many high quality products. Which can increase the profit of the plant and as well as can make contribution the economic development. One of the major waste generating industries is the marble quarry and production industry by which around 70% of this precious mineral resource is wasted in the mining, processing, and polishing procedures. Around 40% of marble waste is generated world widely during quarrying operations in the form of rock fragments and being dumped either in nearby empty pits, roads, river beds, pasture lands, agricultural fields, or landfills leading to wide spreading environmental pollution [2]. Nasserdine et al [4] used the a review of existing practices and jar test experiments to optimize the water recycling and treatment facilities in the stone cutting industry. In view of associated environmental hazards and their impacts on public health and safety, efforts must be made to minimize waste generation, systematic disposal practices must be followed and sound waste management methodologies need to be adopted. This paper describes the use of both natural stone waste and production waste as coarse aggregates in concrete landscaping products. Many of these concrete products routinely include industrial by products and recycled/secondary aggregates. The manufacturing of concrete products inevitably generate production wastes (for example, damaged or imperfect concrete units) [8]. Some other scholars considered the use of the marble powder to reduce the waste, but few literatures discussed the quantitive relationship between the emission and the exploring and processing amount [5–7]. During the stone cutting process, water is used for the purpose of cooling and for collecting stone dust. The annual amounts of wastes generated by this process include 600,000 tons of slurry waste in addition to 1.2 million tons of solid waste. Dealing with this waste in open areas has created several environmental problems, and negatively impacts agriculture and human being. However, although the sustainable development is required for every industry in Pakistan, there is little literature considering a systematic method to reduce the emission in the stone industry.

This paper proposed a bi-level model considering the plant as the leader level and the waste department as the follower level to realize the reduction of the emissions and the growth of the economy. Bi-level optimization has also been previously used for related applications in process systems engineering, but at the same time uncertainties in their objectives and constraints exist. However, a satisfactory (near-optimal or satisficing) solution can be reached by providing tolerances in the objective functions and constraints, and by defining corresponding degrees of satisfaction through membership functions to indicate the preference of the decision-makers as is typical of decision-making. For the application considered in this paper the decision hierarchy is illustrated with the plant as the upper-level decision maker having the objective of maximizing profit and minimizing the emissions, and the wastes management the lower-level decision makers having objectives of maximizing the profit and minimizing emissions. In Bi-level the upper-level decision-maker takes decisions according to his objective and variables, and then allow the lower-level decision-makers to optimize their objective functions, in this way, that these tolerances are met. The followers then communicate their results to the leader, who modifies his goals and control variables. The process continues until the goals of both leader and follower are achieved.

Since the emissions of stone dust and waste water were not constantly monitored in the exploring process of the stone mine and producing the stone products inside the plant, so here is lack of the historical data about the emissions of the stone dust and waste water. We have to consider them as fuzzy numbers according to the experts. Bi-level programming is a complicated problem and it is especially difficult under the fuzzy environment to find its numerical solutions. The methods like genetic algorithm [12], simulated annealing [14], hybrid tabu-ascent algorithm [13], and so on. They must be designed according to single objective problem with crisp coefficients and it is difficult to find a normal pattern for the bi-level model with fuzzy coefficients.

The other part of this paper are organized as follows. In Sect. 34.2, we explained the basic problem and why we use the bi-level multi-objective model to optimize the stone industry. A suitable example is proposed to help the readers to understand the problem background. A possibilistic bi-level multi-objective programming model is developed in Sect. 34.3. In Sect. 34.4, a practical case is given to show the importance of the proposed models. Finally, some conclusions are made in Sect. 34.5. The objective of this paper is to describe this type of problem clearly, provide a novel mathematical formulation and an effective solution technique for the construction site fortification problems.

34.2 Problem Statement

In stone industry, utilizing wastes is very important and it is a main way to connect the upper level and lower level. Utilizing wastes in a proper way has a direct effect on the plant efficiency. And at the same time production cost has direct influence on the profit of the plant. Because the quantity and quality of products can increase or decrease the profit. So they both have to follow the decisions and it will create relationships between plant and the waste management department. As we know, the production in stone industry creates wastes and waste is the cause of pollution of the environment. Wastes pollute the air, environment and land which can be the cause of minimize the fertilizing of land, due to limitations they have to consider the emissions seriously, because it is the cause of pollution and also at the same time minimize the quantity of products which can be the cause of low profit. In the stone industry all the parties are dependent on each others, they have to consider minimum emissions as one of main problem and try their best to overcome it and at the same time they have to maximize the profit. It can be possible by just one way, as they follow each other, and here is direct exchange of information such that objectives and constraints are known. In the stone industry a plant has different departments so this is the objective of plant higher authority to maximize the profit and minimize the emissions. This paper considers the design of the processing of waste amount for different products to increase the profit of plant and to optimize the development of the stone industry.

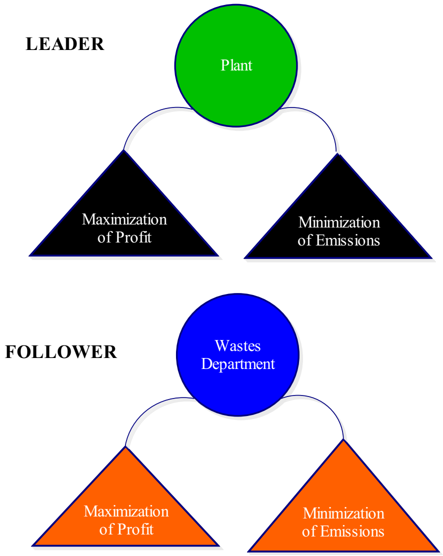


Fig. 34.1 Decision-making hierarchy of the stone plant

As we know, plant has to control the emissions, because the stone dust and waste water will pollute the air and rivers when processing the stone, the plant usually makes a sustainable plan to avoid the over-emissions and the pollution of environment. The plant usually takes maximization of profit and minimization of the emissions as important goals. Therefore, a reasonable plan for utilizing of wastes is very important for the plant to assure the sustainable development. Energy saving and emission reduction becomes a mandatory policy for many highly polluting heavy industries, especially for the stone industry. In the following level, stone plant usually consider the profit as it's first goal. Due to the requirement of environmental protection, plant has to consider the minimum emissions and energy consumption. At the same time, plant should try it's best to tackle the problem of satisfactory production according to their capacity under the policy of the plant. In addition, plant should also care about the modern technology and machinery to improve the capacity of energy saving and emission reduction in order to achieve the goals. Including all above limitations and requirements, it is also important for the plant and as well as for the waste management department to consider the production level by utilizing the wastes, it should be satisfactory and should be according to the market demands. In the above problem statement here (as is shown in Fig. 34.1) is a bi-level optimization problem where plant is the leader and waste management department is a follower and both have direct relationship. For the stone industry which contains several plants, these are the objectives of the plant (upper-level decision-maker) to maximize the profit and minimize the environmental pollution. This can be achieved by optimizing the design of wastes amount between the participating plants, which is assumed as a lower-level decision-maker. Here is direct exchange of information between Leader (plant) and follower (waste department). leader (plant) will take decision about the wastes utilization and the follower (waste department) will follow these instructions. Every plant have its goal, which is to maximize the profit by first level production and utilization of wastes, and to minimize the emissions of stone dust and waste water. During the whole production process, so much stone dust and waste water are produced. The owners of the plants should try their best to decrease the emissions and energy consumption to satisfy the requirement of the environmental protection (as is shown in Fig. 34.2). But we can process that waste again and can produce many others products. By this plant can minimize the emissions and also can maximize the profit. Bi-level optimization has also been used for related applications in process systems engineering, like supply chain planning [15], design of reliable process networks [16] and collaborative design decision making for forearm crutch [17]. However, there is not enough historical data to describe the capacity of emission reduction due to the raw development in the last decade. For example, some considered the handling (cost of wastes utilization) cost as the uncertain coefficients because of the changing markets rates and condition. In this paper, the coefficient of emission cannot be estimated so they considered as fuzzy numbers. Here is a bi-level optimization problem and direct exchange of in-formations between plant manager and waste dealing management.

34.3 The Optimal Model

The problem of optimization in waste department is formulated as a bi level multi-objective optimization problem with fuzzy coefficients in which plant is taken as upper level decision maker (leader) and waste department lower level decision maker (follower).

34.3.1 Assumptions and Notations

Some assumptions should be introduced before developing the optimization model.

1. Profit is in proportion to the amount of wastes which is used to process into production.
2. Emission of stone dust and water is in proportion to the amount of wastes used to process into production.

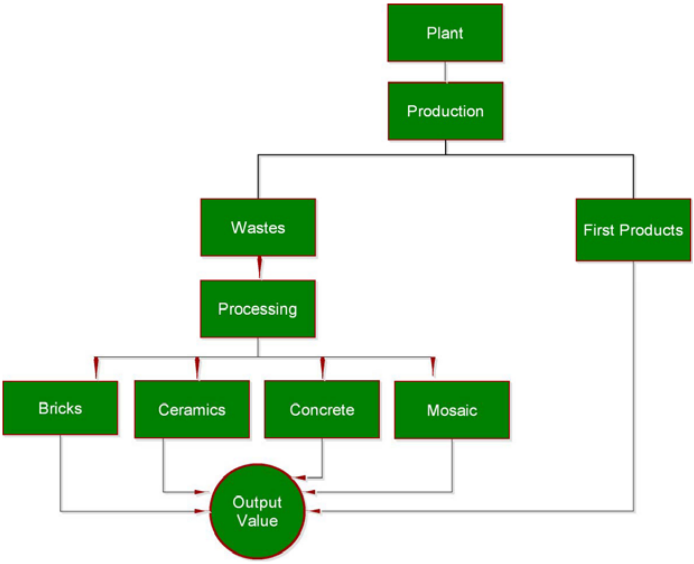


Fig. 34.2 Flow diagram for wastes processing operations

3. The constant cost for production of q will be considered only when the waste management actually produces the production.

The following notations are used to describe the subsidy model under investigation.

Indices

$\varPhi$: set of waste departments $p \in \varPhi = \{1,2,3,\cdots,m\}$;
$\varOmega$: set of products $q \in \varOmega = \{1,2,3,\cdots,n\}$.

Parameters

$\widetilde{Ed}_p$: stone dust when waste department p explores;
$\widetilde{ed}_{pq}$: stone dust that waste department p produces products q;
$\widetilde{ew}_{pq}$: waste water that waste department p produces products q;
C_q : unit price of product q;
t_{pq} : unit variable cost that waste department p produces product q;
h_p : unit cost that waste department p holds the remnant material;
$\varTheta_{pq}$: transform rate that waste department p produces product q;
c_{pq} : constant cost if waste department p produces product q;
R^U : upper limitations of total wastes in the plant;
D_q^L : lower limitation of demand of products q;
ED^U : upper limitations of total emission of stone dust;
EW^U : upper limitations of total waste water;
PC_p^U : upper limitations of production cost of waste department p;
P_{pq}^L : lower limitations of products q that waste department p should produce.

Decision variables

Y_P : amount of wastes that the plant allows to waste department p to explore;
X_{pq} : amount of products q. that waste department p has to produce.

34.3.2 Model Formulation

The bi-level multi-objective programming model under fuzzy environment for optimizing the waste management can be mathematically formulated as follows.

34.3.2.1 Plant Model (Leader)

To be a leader, plant manager has the objectives to maximize the profit and at the same time minimize the emissions.

- To get the maximum profit, the following function is obtained.

$$\max H_1 = \sum_{p=1}^{m} \sum_{q=1}^{n} C_q \Theta_{pa} X_{pq}. \tag{34.1}$$

- To get the minimum emission including stone dust and waste water, the waste departments utilize the waste and produce the products, and $\widetilde{Ed}_p$, $\widetilde{ed}_{pq}$, $\widetilde{ew}_{pq}$ are all fuzzy numbers which are obtained by experts, due to insufficient data, it is difficult to get the exact emission and decision maker can only obtain minimum objective under some possibility level.

So we can obtain the following possibility constraint problem,

$$\begin{cases} \min \widetilde{H}_2 \\ \text{s.t. } Pos\left\{ \sum\limits_{p=1}^{m} \sum\limits_{q=1}^{n} (\widetilde{ed}_{pq} X_{pq} \tilde{+} \widetilde{ew}_{pq} X_{pq}) \le \widetilde{H}_2 \right\} \ge \delta_1^v, \end{cases} \tag{34.2}$$

where Pos is the possibility measure proposed by Dubois and Prade [10], and δ_1^v is the possibility level which represents the possibility that decision maker get the minimum objective. All the fuzzy arithmetic and the following equations come from the operation proposed by Kaufmann et al [11].

Generally, some necessary conditions must be fulfilled when the plant manager makes the decision. They are listed as follows.

- The utilizing amount cannot exceed the upper limitation which is the total wastes, in this region.

$$\sum_{p=1}^{m} Y_p \le R^U. \tag{34.3}$$

- Production of some products should fulfill the demand of market. For example, if the Ceramics demands increases in the market, then wastes department should produced the enough output to fulfill the demand.

$$\sum_{p=1}^{m} Q_{pq} X_{pq} \geq D_q^L. \tag{34.4}$$

34.3.2.2 Waste Department Model (Follower)

As the follower level, waste departments usually try to maximize the profit and then try their best to reduce the emission. Hence, the following two objectives should be introduced.

- Waste department wants to get the maximum profit, then we obtain the following objective function,

$$\max F_1 = \sum_{q=1}^{n} C_q \Theta_{pq} X_{pq} - \sum_{q=1}^{n} f(X_{pq}) - h_p \left(Y_p - \sum_{q=1}^{n} X_{pq} \right). \tag{34.5}$$

$f(X_{pq})$ is utilization cost,

$$f(X_{pq}) = \begin{cases} t_{pq} X_{pq} + C_{pq}, & \text{if } X_{pq} > 0 \\ 0, & \text{if } X_{pq} = 0. \end{cases} \tag{34.6}$$

- As a follower the waste department will also try its best to get the minimum emission. However, since the emissions $\widetilde{ed}_{pq}$ and $\widetilde{ew}_{pq}$ are fuzzy numbers, it is usually difficult to obtain the exact minimum emission and decision makers only require the minimum objective under some possibilities level. Hence, we get the possibilistic constraint problems as follows,

$$\begin{cases} \min \widetilde{F}_2 \\ \text{s.t. } Pos\left\{ \sum\limits_{p=1}^{m} \sum\limits_{q=1}^{n} (\widetilde{ed}_{pq} X_{pq} \widetilde{+} \widetilde{ew}_{pq} + pq) \leq \widetilde{F}_2 \right\} \geq a_2^L, \end{cases} \tag{34.7}$$

where a_2^L is the possibilistic level under which decision makers require the minimum objective.

Since the production of wastes department will be influenced by the decision of plant and the demand from the market, some limited conditions as follows should be fulfilled.

- The production cost should not exceed the predetermined level,

$$\sum_{q=1}^{n} X_{pq} + \sum_{q=1}^{n} c_{pq} + h_p \left(Y_p - \sum_{q=1}^{n} X_{pq} \right) \leq PC_p^U. \tag{34.8}$$

- Some products should be not less than the lower level for production in plant Φ.

$$\Phi_{pq} X_{pq} \geq P_{pq}^L. \tag{34.9}$$

- The amount used for the production should not exceed the total limitation Y_p,

$$\sum_{q=1}^{n} X_{pq} \leq Y_p. \tag{34.10}$$

34.3.3 Bi-level Model

Here both the upper level and the lower level should simultaneously consider the objectives and constraints with each other and then make the decision. Therefore, from Equations (34.7) $\sim$ (34.10), the whole bi-level optimization model under fuzzy environment should be given as follows,

$$\begin{cases} \max H_1 \\ \min \widetilde{H}_2 \\ s.t. \begin{cases} Pos\left\{ \sum\limits_{p=1}^{m} \sum\limits_{q=1}^{n} (\widetilde{ed}_{pq}X_{pq} \tilde{+} \widetilde{w}_{pq}X_{pq}) \leq \widetilde{H}_2 \right\} \geq \delta_1^v \\ \sum\limits_{p=1}^{m} Y_p \leq R^U \\ \sum\limits_{p=1}^{m} Q_{pq}X_{pq} \geq D_q^L \\ \begin{cases} \max F_1 = \sum\limits_{q=1}^{n} c_q \Theta_{pq} X_{pq} - \sum\limits_{q=1}^{n} f(X_{pq}) - h_p \left(Y_p - \sum\limits_{q=1}^{n} X_{pq} \right) \\ \min \widetilde{F}_2 \\ s.t. \begin{cases} Pos\left\{ \sum\limits_{p=1}^{m} \sum\limits_{q=1}^{n} (\widetilde{ed}_{pq}X_{pq} \tilde{+} \widetilde{ew}_{pq}X_{pq}) \leq \widetilde{F}_2 \right\} \geq a_2^L \\ \sum\limits_{q=1}^{n} X_{pq} + \sum\limits_{q=1}^{n} c_{pq} + h_p \left(Y_p - \sum\limits_{q=1}^{n} X_{pq} \right) \leq PC_p^U \\ \Theta_{pq} X_{pq} \geq P_{pq}^L \\ \sum\limits_{q=1}^{n} X_{pq} \leq Y_p. \end{cases} \end{cases} \end{cases} \end{cases} \tag{34.11}$$

34.4 Case Study

In the following part, a practical example in Pakistan will be proposed to show the whole process of the modeling and the algorithm.

34.4.1 Background Review

NORTH WEST FRONTIER PROVINCE is famous in Pakistan due to it's rich mineral products.According to a survey 97 per cent of countrys marble deposits are located here. Nauser, Nowshera, Swabi, Shangla par in Swat region, Khyber Agency, Chitral these areas are rich in mineral products and most of them can be explored and used for building materials in this county. Here the marble available in Chitral is of white, grey, pink, and black colour. White marble is medium-grained crystalline, grey marble is compact in comparison to white marble and pink marble is fine-grained. The black marble is much harder as compared to the other three varieties. This marble compact and thin to medium bedded and highly fractured. It is used as crushed material and as building stone. There are two types of byproducts of stone processing. During stone processing 30% of the stone (incase of unprocessed stone) goes to scrap because of being in smaller size and/or irregular shape. This is then sold to chip manufacturers. Incase of semi processed slab the scarp level reduces to 2-5%. The other waste material is slurry. It is basically the water containing marble powder. The water is reused till it gets thick enough (70% water 30% marble powder) to be insoluble for marble powder. Waste management is the systematic assessment of potential hazards, disposal and proper utilization of waste in mining and allied industries. Due to waste there is a great environmental concern and resource constraint. These wastes can affect the environment through it intrinsic property. Proper planning is essential to manage the waste. Management indicates managing wastes in such a way that it would be beneficial in any way. In view of associated environmental hazards and their impacts on public health and safety, efforts must be made to minimize waste generation, systematic disposal practices must be followed and sound waste management methodologies need to be adopted. Air pollution in this mine is caused from different sources of dust formation at mines as well as due to movements of trucks for transportation exploitation of coal cause air pollution by dust particles and gases. Particles results from the disintegration and their suspension in the atmosphere causes pollution, which ultimately leads to ecological disturbances. Blasting causes noxious fumes which are harmful to health. Nitrogen oxides are formed during blasting of high explosives. They are also found in exhaust fumes of fuel combustion engines used in transportation. So its too much important for plant to minimize the waste rate as well as it can, Although the stone resources are very abundant, but the stone industry is not well developed in this region. There are some main reasons listed as follows:

- NORTH WEST FRONTIER PROVINCE Government did not make effective plan to explore the stone mine. The stone mine is being explored in an ineffective way and it results in the vegetation deterioration, air pollution and water pollution.
- Stone plants don't make an efficient strategy to utilize the wastes. Some of them don't have the advanced technologies and it results in the lower production rate and environment pollution. This also leads that a lot of stone resources are destroyed and wasted.

- Stone plants can't utilize the wastes in efficient way so many high valuable products come from wastes such as ceramics, none calcium carbonates. Concrete are not being produced in enough quantity in this region. It means that the stone industry doesn't provide this region with high economic growth and enough employment.

Above all, it is necessary for both the NORTH WEST FRONTIER PROVINCE Government and those stone plants in this region to optimize the stone industry.

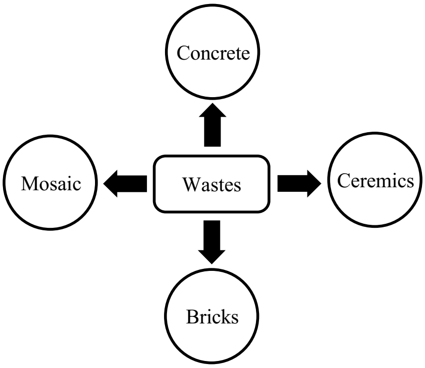


Fig. 34.3 Products from the wastes

34.4.2 Data and Computation

Up to now, there are about 1.5 billion m^3 stone available being explored in NORTH WEST FRONTIER PROVINCE according to the investigation, and this high volume production is always associated by considerable amount of waste materials that may adversely impact the surrounding environment. From the experts advices, all the emission coefficients of the stone dust when the stone plant explores the stone mine are triangular fuzzy numbers. According to the environmental sector in this province, the emission of stone dust should not exceed 3500 ton and the emission of waste water should not exceed 3500 ton. Although it is difficult to satisfy the constrained index in a short time due to some uncertain factors, they hope that the possibility holding the two constraints should not be under 1.4. This means that the possibilistic levels for the government should be 1.4. For the total emission, the environmental sector requires the minimum objective under the possibilistic level δ_1^v 1.2. As the demand and the price of the four wastes products sharply increase, the plant requires that their output from the waste management department should at least satisfy the basic market demand D_q^L $(q = 1,2,3,4)$. The possibilistic level a_2^L that plant p want to obtain the minimum emissions should be achieved. Since every plant has different capacities in controlling the emissions, the fixed and unit variable cost, emission coefficients and constant costs are different from each other.

The transform rate Θ_{pq} and the lower limitation of the product q in plant p should be considered. Since all the fuzzy coefficients are triangular, it is easy to convert the fuzzy model into a crisp one. Then we apply some algorithm to obtain the Pareto optimal solution and objectives. Of course, for the general fuzzy model, it is also easy to simulate the model by the fuzzy simulation-based . Therefore, both of them in this case study are used to solve the problem and we will compare the results. Take all the numerical values and set the initial temperature $T_0 = 500$, the last temperature is 0 and the cooling method is 1 decrement once. After the simulation with many cycles, we get the Pareto optimal solution and objective value.

34.4.3 Sensitivity Analysis

Actually , we can adjust the parameter to obtain different level solutions. From the theoretical deduction, we know that the possibilistic level is a key factor that impacts the results. If the accuracy δ_1^L and a_2^L decrease, the feasible set is expanded and then the better Pareto optimal solution and better Pareto optimal point can be got. We know that the emission increases and the profit decrease as the possibilistic level δ_1^L $(i = 1,2,3)$ decrease. This means that the plant requirement is less strict and it results in that the wastes department will mainly pursue the profit but neglect the emission. Finally, the total emission will increase and the profit for the plant will decrease. On the other hand, if the possibilistic level δ_1^L $(i = 1,2,3)$ increases, it means that the plant requirement is more strict and hence we will take the result that the total emission will decrease and the tax income for the government will increase. Similarly, for the following level, if the possibilistic levels a_2^L $(i = 1,2,\cdots,10)$ decreases, it means that the wastes department pays less important to the emission of the stone dust and waste water and then it will result in that the profit of the plant and consequently generate more emission.

34.5 Conclusion

In this paper, we have developed a bi-level multi-objective optimization model with possibilistic constraints under the fuzzy environment. In the model, the plant was considered as the leader level for maximizing the profit and minimizing the stone dust and the waste water and then stone plants were considered as the follower level for maximizing the profit and minimizing the emissions. For some special fuzzy numbers, the developed mode has been converted into the crisp equivalent one. Then we proposed an algorithm to solve the model. Finally, a practical case proved that the proposed model was efficient. Although the model proposed in this paper should be helpful for solving some realworld problems, it is only dealt with by the possibilistic 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.

References

1. Altuncua D, Kasapsekina M (2011) Management and recycling of constructional solid waste in Turkey. In: International Conference on Green Buildings and Sustainable Cities
2. Aukour F, Al-Qinna M (2008) Marble production and environmental constrains: Case study from Zarqa Governorate, Jordan. Jordan Journal of Earth and Environmental Sciences 1:11–21
3. Yao LM, Xu JP (2012) A stone resource assignment model under the fuzzy environment. Mathematical Problems in Engineering (accepted)
4. Nasserdine K, Mimi Z, Bevan B et al (2009) Environmental management of the stone cutting industry. Journal of Environmental Management 90:466–470
5. Corinaldesi V, Moriconi G, Naik TR (2010) Naik characterization of marble powder for its use in mortar and concrete. Construction and Building Materials 24:113–117
6. Saboya F, Xavier GC, Alexandre J (2007) The use of the powder marble by-product to enhance the properties of brick ceramic. Construction and Building Materials 21:1950–1960
7. Bilgin N, Yeprem HA, Arslan S et al (2012) Use of waste marble powder in brick industry. Construction and Building Materials 29:449–457
8. Dunster AM (2007) Crushed waste stone and production waste in concrete landscaping products. Characterisation of Mineral Wastes, Resources and Processing technologies — Integrated waste management for the production of construction material
9. Senturk A, Gunduz L, Tosun Y et al (1996) Marble technology. Tugra Pres, Isparta
10. Dubois D, Prade H (1978) Operations on fuzzy numbers. International Journal of System Sciences 9:613–626
11. Kaufmann A (1985) Introduction to fuzzy arithmetic: Theory and applications. Van Nostrand Reinhold, New York
12. Hejazi SR, Memariani A, Jahanshahloo G et al (2002) Linear bilevel programming solution by genetic algorithm. Computers and Operations Research 29:1913–1925
13. Gendreau M, Marcotte P, Savard G (1996) A hybrid tabu-ascent algorithm for the linear bilevel programming problem. Journal of Global Optimization 29:217–233
14. Muhammad A (2011) Temporary workforce planning with firm contracts: A model and a simulated annealing heuristic. Mathematical Problems in Engineering Volume. http://www.hindawi.com/journals/mpe/2011/209693/
15. Ryu JH, Dua V, Pistikopoulos EN (2004) Bi-level programming framework for enterprise-wide process networks under uncertainty. Computers and Chemical Engineering 28:1121–1129
16. Takama N, Umeda T (1980) Multi-level, multi-objective optimization in processing engineering. Chemical Engineering Science 36:129–136
17. Teresa W, Som S, Mengqi H (2011) The application of memetic algorithms for forearm crutch design: A case study. Mathematical Problems in Engineering http://www.hindawi.com/journals/mpe/2011/162580/

Chapter 35

Prediction of Energy Consumption in Steel Enterprises based on BP_Adaboost Algorithm

Rui Hu and Qun Zhang

Abstract Low-carbon production is the aim of every heavy industry enterprises. Iron and steel companies are no exceptions. This thesis complished the prediction goal by applying the framework of BP neural network and Adaboost algorithm based on Matlab platform. Data used as training set were the energy consumption from 2005-2009 and the data of 2010-2015 were set as target. The result indicated that the main trend of the energy consumption in this industry was declining and the gaps between companies were decreasing eventually.

Keywords BP neural network · Energy consumption · Prediction · Iron and steel enterprise

35.1 Introduction

With the widespread of "Energy-saving and emission reduction" perception, companies have started to take the control of energy consumption under consideration. As an important part of traditional heavy industry, iron and steel industry is duty-bond in pioneering in this trend.

It's very obvious that solving problems after they took place is way harder than preventing them from happening before things went wrong. This is why prediction is needed. The forecasting results are good evidences for decision makers to give the wise choice [1].

The forecast is meaningful for both the whole industry and individual enterprises. It includes these two aspects:

First of all, for the entire industry, forecast supports the stability and fast-development. Iron and Steel industry is the fundamental property, and its health

---

R. Hu · Q. Zhang
School of Dongling Economics and Management, University of Science and Technology, Beijing 100083, P. R. China
e-mail: hurui870929@hotmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_35,

is critical for the society. Any problem might cause great chain-reaction. Energy consumption control is a major part of Steel producing process. Focusing on this has its own social significance.

Secondly, forecast on energy consumption helps the organization to keep an advantageous position in the competition. From one side, the ahead-of-time forecast enables the companies to prepare enough for the coming problem and stop it in its early period; from another side, the energy consumption plan can be made in advance. Thusly, companies with forecasting system have surpassed their counterparts without doubt.

As we discussed above, prediction on energy consumption for iron and steel industry is pretty necessary. This article introduced an algorithm of forecasting based on BP neutral network and applied it to factual data which were collected from 15 large-scale companies during 2005-2009.

35.2 The Main Idea of BP_Adaboost Algorithm

35.2.1 BP Neutral Network

Most methods in predicting area are complicated, because the estimates for the future are always subject to various external related factors. In ordinary statistical calculation method, relevant factors are listed, and the weights of their impact are given by methods such as principal component analysis [2]. However, steel industry is so complex in both the input side and the output side that common ways cannot satisfy its demand. Therefore, the self-studied neural network can appropriately fit this system. It’s able to take all varieties under consideration and efficiently avoid the uncertainties caused by input factors [3].

BP neural net work is considered to be the most classic ANN(artificial neural network) algorithm. The three-layer feed-forward BP network is composed by an input layer, an output layer and a hidden layer which is designed for processing the data [4]. This particular structure is believed to be the most suitable way to simulate the input-output system in real world.

The basic mode of BP network is showed in Fig. 39.1 below:

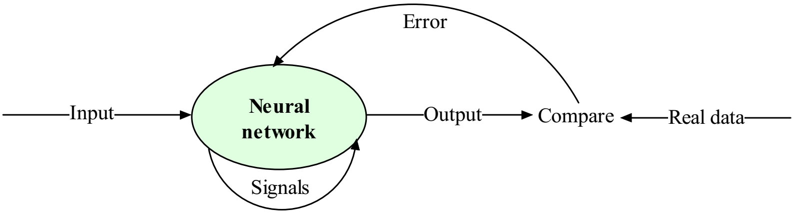


Fig. 35.1 Model of BP neural network

That ellipse in Fig. 39.1 represents the hidden layer, which is the key layer of this network. This black-box part executes two functions: the transferring and the training. Transfer function is used to standardize the results and link the three-layer structure; training function is used to complete the relative operations about results obtained from the training sets.

There are three commonly used functions in the transferring process: log-sigmoid, tan-sigmoid and purelin function. The latter one is a linear function while the first two non-linear ones:

$$f(x) = \frac{1}{1+\varepsilon^{-x}}, \quad \text{(Form. 1) log-sigmoid,}$$

$$f(x) = \frac{1-\varepsilon^{-x}}{1+\varepsilon^{-x}}, \quad \text{(Form. 2) tan-sigmoid.}$$

The range of nonlinear function is limited: logsig in $(0,1)$, and it is the unipolar function; tansig in $(-1,1)$, and it is the bipolar function. The range of linear function is not limited. Because of these differences, tansig and logsig are generally used as transfer function for hidden layer; and purelin is used as the output layer transfer function, which can satisfy the requirements of variety for different output results [5].

Training function is vital in determining the performance. Its core idea is that the gradient descent method. The so-called gradient descent method is a function of the gradient along the direction of the search, to find the optimal value of the process. Methods commonly used in the training function are traingd, traingdm, traingdx, trainrp, traincgf, traincgp, traincgb, trainscg, trainbfg, trainoss, trainlm, trainbr, etc [3].

Although the BP neural network algorithm is the most widely used one in this area, it also has its own deficiencies. The main cause of these deficiencies is the principle of BP algorithm, which means that a gradient algorithm for nonlinear optimization problems can easily lead to convergence problems.

Here are some disadvantages of this algorithm:

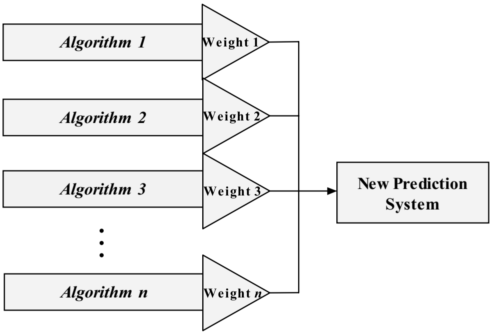
1. Local minimum problem. The search principle applied in BP algorithm is not so efficient in the uneven surface. It might be trapped in a local minimum point of a pit and cannot jump out.
2. Decreased rate problems. On the surface, where some flat area might exist, the derivative of the function approaches zero, which limits the decreasing rate in a rather small area. Then even with large error, the gradient of the adjustment process would still be at a standstill [6].
3. Relatively low stability. This has nothing to do with the gradient algorithm; it's determined by the neural network structure itself. Because of the parallel structure, neurons activated each time are not exactly the same ones. So the results are different every time, sometimes a larger gap. This is the main reason of the non-repeatability of the results, which also makes the test result data seem less credible [7].

These shortcomings result in many discussions about improved algorithm. Each algorithm has its own advantages, to solve the shortcomings of the algorithm from different angles. This article discusses a Adaboost-frame based algorithms to improve the BP network. That is, the frame would improve its stability and reliability through multiple parallel neural networks, making the results more credible and realistic.

35.2.2 BP_Adaboost Algorithm

The main purpose of applying Boosting framework is to improve the accuracy of the ordinary prediction algorithm. This framework constructs a more powerful prediction system by building a sequence composed by original forecasting algorithm. The basic principle of Boosting is showed below Fig. 39.2:

Fig. 35.2 Boosting framework



Algorithm 1 to n could be different algorithms. In our case, they are the same, all BP network. And several BP network would form a more accurate system. The number "n" is decided by the data structure.

Traditional Boosting algorithm has a serious defect, that is, to solve practical problems, it requires knowing the correct rate of algorithm 1 to n in advance. This specific requirement cannot be easily satisfied. For this case, Freund and Schapire proposed AdaBoost algorithm [8] based on Boosting algorithm, which has better performances in practice. At the same time, there isn't any significant decline in efficiency compared with traditional Boosting method. The core idea of Adaboost algorithm is: training the different predictors using only one set of training samples, and then combining those predictors into a better one by giving each of them an unique weight. The stronger predictor is what we want as a final result.

In our case, BP neural network is used as weak predictor, aiming at building a new predictor based on Adaboost algorithm. The main steps are as follows [9]:
Step 1. Data selection and initialization: select m groups of training data from the sample space, and initialize the weights distributed on the sample: $D_t(i) = l/m$.

Then build the structure for BP network based on the sample's input and output dimension; initialize the neural network and identify the thresholds;
Step 2. Prediction by weak predictor: activate a weak predictor by training the specific BP neural network and use it to predict. After comparison between the real data and the output, calculate the error sequence:

$$e_t = \sum_i D_i(i), \quad i = 1, 2, \cdots, m, \quad (g(t) \neq y),$$

where $g(t)$ stands for the prediction; y is the expected results;
Step 3. Calculation of the weights on the predicted sequence: According to the prediction error sequence e_t, calculate the weight sequence a_t, whose formula is:

$$a_t = \frac{1}{2} \ln \left(\frac{1 - \varepsilon_t}{\varepsilon_t} \right).$$

Step 4. Adjustment for the weight of the test data: modify the weight sequence for the training sample for the next round according to a_t. The formula is:

$$D_{t+1}(i) = \frac{D_t(i)}{B_t} * \exp[-a_t y_i g_t(x_i)], \quad i = 1, 2, \cdots, m,$$

where B_t is the normalization factor, which is applied to ensure the summary of all weight is 1;
Step 5. Prediction by strong predictor: there we get T groups of training function $f(g_t, a_t)$ after several rounds of training which can be composed into a stronger predictor $h(x)$:

$$h(x) = \text{sign} \left[\sum_{t=1}^{T} a_t \cdot f(g_t, a_t) \right].$$

This process can be showed as follows Fig. 39.3.

35.3 Implementation of BP_Adaboost Algorithm

35.3.1 BP Network as Weak-predictor

Since this paper is about to study the energy state of iron and steel enterprises, certain amount of data are required. But the energy consumption data are limited, only 2005 to 2009 are available, which asks a special arrangement for those numbers. The selection of company scale comes first. To facilitate the study, the so-called "large" companies which satisfied these two screening criteria: first, the annual output of crude steel is more than 500 million tons; second, production amount occupies at least 60% of cumulative production should be picked out. Then the five

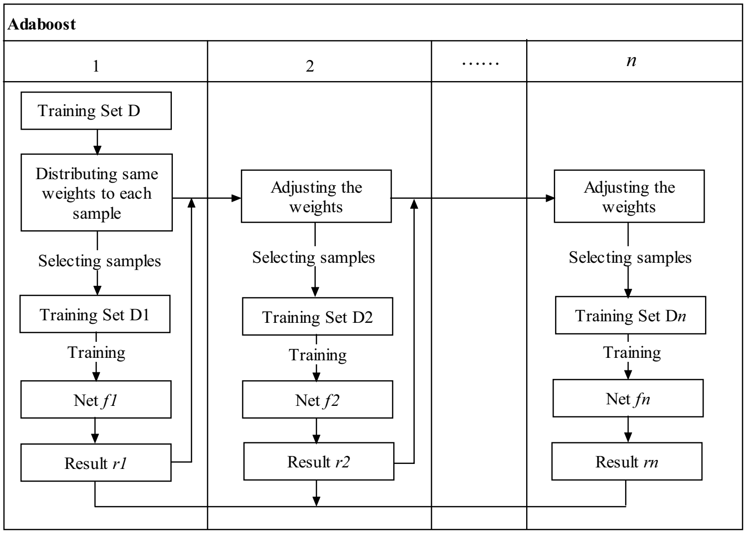


Fig. 35.3 Ada_boost framework

years data are reorganized into two parts: two training sets $S1 = (X_{2005}, X_{2006}, X_{2007})$, $S2 = (X_{2006}, X_{2007}, X_{2008})$ and one testing set $S3 = (X_{2007}, X_{2008}, X_{2009})$. For confidential purpose, the name of these companies are replaced by letters.

Thusly, we get a sample of $15 * 5$ array after normalization.

Then the training function needs to be chosen. After testing training, the performances of different functions are showed as follows.

The graphs displayed above indicates that, in the case, traingdx behaved itself in the initial iteration, but due to its own shortcomings, that it cannot control the results of the last iteration, fluctuation appeared at around 90. And finally, it lead to complete divergence because of the lack of artificial control.

Traincgf, traincgp and traincgb can meet the training requirements of accuracy, but the convergence process is not smooth enough considering the fluctuation in process. Instability of the algorithm on the entire operation will not cause any reliability.

Traingd and traindgm's performances are much more smooth and stable. Traindgm is an improved algorithm over the traingd function, whose parameters can easily be artificially set to control the effectiveness. It is pretty suitable for this case.

There is a key parameter to set in traingdm function: that is the momentum factor α. α locates between $[0, 1]$, representing level of correlation of the weight between this training process and the previous one. The closer α to 0, the less dependency there is. The result showed that when $\alpha = 0.5$, we got the most smooth convergence curve, which also meant the best results. According to the selected training function and parameter settings, we quote the following statement to predict:

```
net=newff（minmax(p)，[5，1]，{ ‘logsig ’，’ purelin ’ }，’ traingdm ’），
net.trainParam.mc=0.3(0.5，0.8，0.9);
net.trainParam.epoch=2000;
net.trainParam.goal=le-3，
[net，tr]=train(net，p，t);
```

The number of hidden nodes are determined by empirical formula $m = \log 2n$. Theory has been proved, that with unrestricted number of hidden layer nodes, only one hidden layer can achieve any nonlinear mapping [10, 11]. In this case, there would be five neurons in one hidden layer.

The simulation result based on this structure is showed in Fig. 35.4 and the curve also proved that the real value and predict result are very close. So this model is acceptable in forecasting. Here comes the prediction result in Fig. 35.5

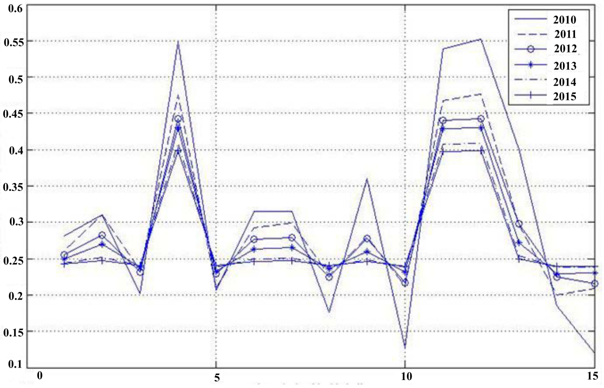


Fig. 35.4 Simulation result by weak predictor

35.3.2 BP_Adaboost Framework as Strong Predictor

According to the framework introduced in Sect. 35.2.2, a stronger predictor can be formed by paralleling several weak predictors. Here, the value of D and at would be adjusted after each iteration step. Thusly, they represent comparative weights rather than absolute weights. That is to say, both D and at are modified based on the last result or the nearest weak predictor’s accuracy.

This new predictor takes the influence of weights into consideration, and also increases the iteration time apparently. Therefore, the accuracy of the algorithm has greatly enhanced.

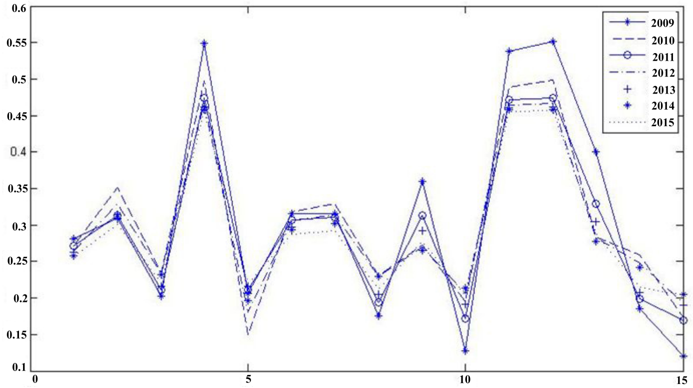


Fig. 35.5 Forcasting results by weak predictor

The simulation results got from weak predictor were generally larger than real value, while the strong ones fluctuated around the real value. There might be some exception caused by the activation of different neurons and was not objective enough to get the conclusion, but it also revealed that the stronger one was more stable and reliable in certain aspect.

After the test, the BP_Adaboost algorithm has proven to be good enough to forecast the energy consumption in the next few years. So, here comes the result.

There are several conclusions that can be drawn from the trend:

- The tendency of all 15 big companies about energy consumption level are declining;
- The gap between high energy consumption enterprises and lower ones has contracted. The difference existed in early years is disappearing as the development of technology, equipment, scale and other reasons;
- The rate of decline in energy level was lowered. During the first period, there's larger space for improvement. As time goes by, the space decreases, so does the decline-rate.

35.4 Summary

This article talks about the trend of energy consumption in iron and steel industry by applying the BP_Adaboost framework. The conclusions can be drawn from two aspects:

1. The improved algorithm had a better performance in prediction in this case. The errors varied in a relatively small range than the original BP neural network. And by selecting appropriate parameters, the precision of weak predictors had also been raised. Constructing the strong predictor by distributing improved weak

predictors with Adaboost framework had built a more accurate forecasting system.

2. The forecasting outcomes indicated that the main trend of energy consumption level in iron and steel industry was declining. Although the difference between good and average performance still existed, the gap was shrinking as time went by. Moreover, the later the time, the lower the declining rate would be.

In a word, there're still spaces for companies to improve their technologies and energy strategies to control the energy consumption in the near future, for the sake of both themselves and the society.

References

1. Zhang JY, Zhang DJ, Zhang L (2009) Summary of the metheds of energy consumption forecast in iron and steel enterprises. Energy for Metallurgical industry 28:11–14
2. Zeng ZL, Zheng Y (2009) The grey model and its application to forecast of inbound visitors from Mainland China to Macau. In: Proceedings of Third International Conference on Management Science and Engineering Management 48–54
3. Huan HY, Huan HJ (2008) Application of improved BP neural network in economic forecasts. Statistics and Information Forum 23:58–62
4. Ma ZQ, Meng QB (2009) The research on customer satisfaction evaluation of energy-saving buildings based on RBF neural network. In: Proceedings of Third International Conference on Management Science and Engineering Management 190–194
5. Zhu K, Wang ZL (2010) Mastering the neural network in MATLAB toolbox. Publishing House of Electronics Industry, Beijing (In Chinese)
6. Wang W, Zhang YT (2007) Analysis and improving way of BP ANN in predicting time series data. Computer Engineering and Design 28:5292–5294
7. Hong T, Ma ZQ, Fan Q et al (2009) The research of ability evaluation on green manufacturing of Chinese manufacturing enterprises based on fuzzy neural network. In: Proceedings of Third International Conference on Management Science and Engineering Management 117–123
8. Schapire ER, Freund Y, Bartlet TP et al (1998) Boosting the margin: A new explanation for the effectiveness of voting methods. The Annals of Statistics 26:1651–1686
9. Shi F, Wang XC, Yu L et al (2010) 30 case-studies about neural network in Matlab. Publishing house of Beihang University, Beihang (In Chinese)
10. Huang L (2009) With improved BP algorithm to realize the evaluation of forecast system. Sun Yat-sen University, Nanjing (In Chinese)
11. Li CH, Li TQ (2005) Application of an improved feature selection method in text classifying system. Journal of Xiamen University 44:94–98

Chapter 36

Evaluation on the Sustainable Development Abilities of Different Branches in Zhanjiang Industry

Weiji Lv, Yi Meng and Yao Sun

Abstract An evaluation model, constructed by grey correlation method used to evaluate the sustainable development ability of Zhanjiang's industrial department. This model analysis the sustainable development abilities of twenty nine branches in the industry from aspects of economic development and resource environment protection. It can provide a foundation for sustainable development adjustment of Zhanjiang's industrial department.

Keywords Economic development reference · Resource environmental protection standard · Grey correlation method · Zhanjiang industry

36.1 Introduction

How to establish Zhanjiang industry sustainable development capability evaluation model is guidance for Zhanjiang to adjust and optimization of industrial structure is the core issue. From the data collected, many studies analysis index using principal component analysis, hierarchical analysis, and comprehensive comparative advantage. And select the sustainable development ability of the leading industry, regional industrial structure adjustment. In view of these evaluation methods demanding of indicators, there are many difficulties, for example: the strict price factors, constant prices of year target of a lot of trouble; different index dimension, indicators with different dimensions, such indicators calculated results deviate from the actual; the data requirements are very strict too, objective, detailed and a large number of. Because of the available Zhanjiang industrial department of relevant data is limited,

---

W. Lv (✉) · Y. Meng
Business School, Zhanjiang Normal University, Zhanjiang 524048, P. R. China
e-mail: Luwjgxglcy@126.com

Y. Sun
China Life Insurance Company Limited Dalian Branch, Dalian 116001, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_36,

and to evade the shortcomings above, this paper uses the method of grey correlative degree analysis to evaluate Zhanjiang industrial sustainable development capacity.

36.2 The Basic Principles of Gray Correlation Analysis

The research object of the grey system theory is “partial information is known, the partial information unknown”, and uncertainty system “poor information”, It based on the known information generation, development and implementation of the real world to the exact description and understanding. The correlation degree analysis method of the grey system theory is based on the factors between the development trend of the similarity or dissimilarity degree to measure factors correlation degree method. The correlation analysis, we must first identify the data sequence, that is what data to reflect the system’s behavior. When the system behavior data columns, according to the correlation calculation formula can be calculated correlation degree. Correlation response close to order of each evaluation object to the standard objects, that is the pros of the evaluation object, the best is the biggest evaluation of grey relational degree [1]. The calculation steps are as follows.

(1) Determine the Optimal Index Set (F^*)

Set $F^* = [j_1^*, j_2^*, \cdots, j_n^*], (k = 1,2,\cdots,n)$ is the optimal value of k. This optimal value is the optimal value of the various programs, it also recognized as the optimal value of the assessor. However, in setting the optimal value, we need to take into advanced and the feasibility. If the optimal selection of indicators is too high, not reality, can not be achieved, the results of the evaluation also can not correctly.

After the optimal set of selected indicators, we can construct matrix D:

$$D = \begin{bmatrix} j_1^* & j_2^* & \cdots & j_n^* \\ j_1^1 & j_2^1 & \cdots & j_n 1 \\ \vdots & \vdots & & \vdots \\ j_1^m & j_2^m & \cdots & j_n^m \end{bmatrix}, \tag{36.1}$$

where j_k^i is the original numerical of k for i scheme.

(2) Normalized Value of the Indicators

As a result of evaluation indexes is usually have different dimensions and orders of magnitude, so it cannot be directly compared. In order to ensure the reliability of the results, we need for normalized the original index values.

Set change interval of index k is $[j_{k1}, j_{k2}]$, j_{k1} is the minimum of index k in all scenarios, and the j_{k2} is the maximum, so we use Equation (36.2) make the original values converted into dimensionless values of Equation (36.1).

$$C_k^i = \frac{j_k^i - j_{k1}}{j_{k2} - j_{k1}}, i = 1,2,\cdots,m; k = 1,2,\cdots,n. \tag{36.2}$$

So $D \rightarrow C$.

$$C = \begin{bmatrix} C_1^* & C_2^* & \cdots & C_n^* \\ C_1^1 & C_2^1 & \cdots & C_n 1 \\ \vdots & \vdots & & \vdots \\ C_1^m & C_2^m & \cdots & C_n^m \end{bmatrix}. \tag{36.3}$$

(3) Calculated Correlation Coefficient

According to the theory of grey system, $\{C^*\} = [C_1^*, C_2^*, \cdots, C_N^*]$ is the reference sequence.

$$\xi_i(k) = \frac{\min_i \min_k |C_k^* - C_k^i| + \rho \max_i \max_k |C_k^* - C_k^i|}{|C_k^* - C_k^i| + \rho \max_i \max_k |C_k^* - C_k^i|}, \tag{36.4}$$

$\rho \in [0,1]$, general $\rho = 0.5$.

(4) Seek Correlation Degree

Correlation analysis is essentially the geometric relationship between the comparative sequence data, if the two sequences at each point are superposed together, that is correlation coefficient is 1, so the correlation degree is 1 too. Others, comparison of two sequences can not be vertical at any moment, so correlation coefficient greater than 0, so the correlation degree is also greater than 0. So, two sequences of correlation degree is calculation by the mean value correlation coefficient with two comparison sequences, that is:

$$\gamma_i = \frac{1}{n} \sum_{k=1}^{n} \xi_i(k). \tag{36.5}$$

Then γ_i is the correlation degree between $\{C^i\}$ and $\{C^*\}$. If the correlation maximum is γ_i, then $\{C^i\}$ and optimal index $\{C^*\}$ closest.

36.3 Zhanjiang Industry Sustainable Development Capability Evaluation Index Selection Criteria

Choice of industry sustainable development capability evaluation index, establish scientific and reasonable evaluation index system of the sustainable development is the correct choice of sustainable ability of dominant industry premise. On the establishment of evaluation index system, general should abide by the following [2]:

1. Overall, the evaluation index should be able to cover for the basic content on the purpose of evaluation. As in the industry sustainable development capacity evaluation, selected indicators must reflect sustainable economic development, social development and resource environmental protection thoughts.
2. Objectivity, in screening evaluation process is not affected by subjective factors, analyzing the meaning of selected indicators objectivity.

3. Feasibility, as far as possible the data support for the index, must adopt the qualitative indexes, consideration should be given to its measurement method.
4. Brief, the evaluating index of hierarchy, each index meaning clear, avoid repetitive.
5. Comparability, evaluation the same caliber, as far as possible using relative indicators, for different object comparison. But in order to reflect the difference between the object, it should choose some absolute index too.
6. Adaptability, from the economic and social development situation, for the regional industry sustainable development capability evaluation index, should not copy other countries and regions evaluation index system.

In view of the largest affect for the resource and environment is industry, the industry is a pillar of Zhanjiang economic development, therefore evaluation on the sectors of industry sustainable development capacity for guide the industry development of Zhanjiang. According to the Zhanjiang industry sustainable development capability evaluation index selection reference, combine industry characteristic and data support ability, we can establishing two sustainable development capacity evaluation benchmark, At the same time in each reference to choose corresponding index, form industry sustainable development capability evaluation index system.

36.3.1 Economic Development Reference

Economic development is an important consideration standard for the sustainable development level. Not only focus on the speed of economic development, but also pay attention to the quality of economic development. Here introduces the proportion of output value, growth rate and output value concentration index to reflect the industrial economic development.

The output value reflects the industry on the economic development of the whole area of contribution degree, that is: $a_{1i} = q_i/q$. There, a_{1i} is the output value for industry i; q_i is the total value for industry i; q is the social product for the area. Higher values of a_{1i} indicate more contribution on the whole regional economic.

Growth rate reflects the impetus of development of estate of strength. That is: $a_{2i} = (q_{i(t)} - q_{i(t-1)})/q_{i(t-1)}$. There, a_{2i} is the growth rate for industry i; $q_{i(t)}$ is the total value for industry i at t; $q_{i(t-1)}$ is the total value at $t-1.a_{2i} \geq 0$ show that the industry is growing, a_{2i} greater showed stronger development momentum, $a_{2i} < 0$ show that the industry is in decline.

Value index of concentration is location quotient, through the determination of various industrial sectors in the region of the relative degree of specialization to reflect the regional economic linkage structure and direction indirectly [3], that is: $a_{3i} = (q_i/q)/(Q_i/Q)$. There, a_{3i} is the professional degree for industry i at the area; Q_i is the total value for industry i at the area where the largest area; Q is the total value at the large area. $a_{3i} > 1$ indicates that the I industry in the area of specialization degree over a large area level, in advantages on industrial scale, the product is self-sufficient, belongs to the region of specialized departments. The larger a_{3i} the higher level specialization. $a_{3i} < 1$ show specialization levels below the district level at the region of industry i, at a disadvantage in the industrial scale, need the outer input product at the area; $a_{3i} = 1$ show specialization level at industry i and large area quite, basically provide for oneself.

36.3.2 Resource Environmental Protection Standard

The resource of our country is very low compared with the average level of the world and resource use efficiency is not high, growth of economy of our country is mostly based on the excessive consumption of resources to achieve. Meanwhile, as industrialized process, pollutant emissions are also increasing year by year, the increasingly serious environmental pollution. Rational use of resources, improve the efficiency of resources utilization, reducing emissions of pollutants, strengthening environmental protection is the guarantee of realizing a sustainable development important condition. We introduce the energy consumption, waste water consumption of two indicators.

Energy consumption indicates with various sectors of the energy consumption per unit of output, that is: $b_{1i} = n_i/q_i$. There, b_{1i} is the energy consumption for industry i; n_i is the total consumption for industry i. b_{1i} smaller shows that energy consumption per unit output value of small.

Water consumption reflected the wastewater discharged situation of departments, Use wastewater emissions to express, that is: $b_{2i} = m_i/q_i$. There, b_{2i} is the water consumption for industry i; m_i is wastewater emissions for industry i. b_{2i} smaller shows that unit value less emission, to reduce environmental pollution is conducive to the sustainable development of ecological environment.

Gas consumption reflects departments exhaust emission condition, we use unit value to express emissions, that is: $b_{3i} = N_i/q_i$. There, b_{3i} is the gas consumption for industry i; N_i is the exhaust emissions for industry i. b_{3i} smaller shows that unit value less emission, to reduce environment pollution is conducive to the sustainable development of ecological environment.

Solid waste consumption reflects solid waste condition of departments, we use unit value to express, that is: $b_{4i} = M_i/q_i$. There, b_{4i} is the solid waste consumption for industry i; M_i is the solid waster emission for industry i. b_{4i} smaller shows that unit value less emission, to reduce environment pollution is conducive to the sustainable development of ecological environment.

Based on the statistical yearbook of Zhanjiang and Guangdong Province statistical yearbook data relating to finishing, calculated industries corresponding index value according to the national economy classification will Zhanjiang industry into twenty-nine sectors, see Table 36.1.

(1) Selection of optimal index set h_0, according to the requirement of sustainable development, energy consumption, water consumption, gas consumption and solid waste consumption of the minimum value, the rest of the maximum. So the optimal index set is: $h_0 = (16.88, 188.57, 15.48, 0.006, 0.36, 0.60, 0.10)$.

Table 36.1 The assessment index of the sustainable development capabilities of different industrial departments in Zhanjiang

Industry		Proportion (%)	Accelerate (%)	Location quotient	Energy consumption (Million tons of standard coal/billion)	Water consumption (tons /billion)	Gas consumption (tons /billion)	Solid waste consumption (tons /billion)
		a_1	a_2	a_3	b_1	b_2	b_3	b_4
Petroleum and natural gas	h_1	10.09	14.40	15.48	0.12	1.20	44.16	393.13
Non ferrous metal ore mining	h_2	0.07	−34.78	0.80	0.18	18.95	5.26	0.10
Non metal ore mining	h_3	0.27	39.8	3.06	0.36	6.34	97.00	504.38
Agricultural food products	h_4	16.88	30.03	13.26	0.17	8.49	129.06	95.69
Food production	h_5	0.40	26.73	0.60	0.21	7.05	17.36	2.87
Beverage production	h_6	0.84	45.69	1.71	0.25	12.43	28.57	3.73
Tobacco processing	h_7	0.80	20.41	3.06	0.03	0.76	40.58	10.86
Textile	h_8	0.81	−2.27	0.48	0.49	12.02	5.53	0.76
Down leather	h_9	0.58	−9.59	0.52	0.18	4.57	21.60	1.87
Timber processing bamboo grass products	h_{10}	1.40	98.25	3.97	0.28	1.37	5.58	0.95
Furniture	h_{11}	0.80	−2.85	1.05	0.16	0.76	23.70	2.34
Papermaking and paper products	h_{12}	1.03	15.06	0.91	0.52	67.13	11.98	0.10
Oil processing and coking	h_{13}	12.25	3.84	6.66	0.66	4.1	116.25	15.23
Printing, record medium reproduction	h_{14}	0.36	19.78	0.62	0.2	0.93	601.09	252.04
Chemical products	h_{15}	1.67	39.14	0.57	0.35	12.09	1.69	0.31
Pharmaceutical	h_{16}	0.55	52.15	1.13	0.22	6.74	64.63	12.81
Rubber products	h_{17}	0.38	45.14	1.21	0.37	1.86	20.06	3.93
Plastic products	h_{18}	0.95	33.88	0.41	0.29	0.51	18.12	0.84
Non metallic mineral products	h_{19}	1.10	37.15	0.54	1.48	2.59	5.50	0.32
Nonferrous metal smelting	h_{20}	0.31	−71.18	0.18	0.21	1.76	473.64	39.34
Metal products	h_{21}	0.47	25.74	0.16	0.2	2.91	52.37	18.11
General equipment	h_{22}	0.53	9.74	0.42	0.15	0.66	7.97	0.76
Special equipment	h_{23}	1.1	25.39	1.05	0.16	0.89	4.91	2.41
Transportation equipment	h_{24}	0.83	57.25	0.25	0.06	0.81	3.81	1.22
Electrical machinery and equipment	h_{25}	3.52	20.188	0.5	0.10	0.36	3.99	0.43
Communication, computer and electronic equipment	h_{26}	0.07	188.57	0.0043	0.09	0.76	0.86	0.16
Electricity production and supply	h_{27}	4.04	2.26	1.06	0.52	6.61	0.60	0.10
Gas production and supply	h_{28}	0.23	51.74	0.84	0.006	2.87	546.31	27.08
Water production and supply	h_{29}	0.10	6.85	0.45	0.60	19.99	45.07	5.30

(2) The reference sequence and comparative sequence be dimensionless processing, see Table 36.2.

Table 36.2 Standard index of the Table 36.1

Index	a_1	a_2	a_3	b_1	b_2	b_3	b_4
h_0	1	1	1	0	0	0	0
h_1	0.5961	0.3295	1	0.0773	0.0126	0.0725	0.7794
h_2	0	0.1401	0.0418	0.1180	0.2784	0.0078	0
h_3	0.0119	0.4273	0.1893	0.2402	0.0896	0.1605	1
h_4	1	0.3896	0.8551	0.1113	0.1218	0.2139	0.1896
h_5	0.0197	0.3769	0.0287	0.1384	0.1002	0.0279	0.0055
h_6	0.0459	0.4499	0.1012	0.1655	0.1808	0.0466	0.0072
h_7	0.0435	0.3526	0.1893	0.0163	0.0060	0.0666	0.0213
h_8	0.0440	0.2653	0.0209	0.3284	0.1746	0.0082	0.0013
h_9	0.0303	0.2371	0.0235	0.1181	0.0631	0.0350	0.0035
h_{10}	0.0791	0.6523	0.2487	0.1859	0.0151	0.0083	0.0017
h_{11}	0.0434	0.2631	0.0581	0.1045	0.0060	0.0385	0.0044
h_{12}	0.0571	0.3320	0.0490	0.3487	1	0.0190	0
h_{13}	0.7246	0.2888	0.4243	0.4437	0.0560	0.1926	0.0300
h_{14}	0.0173	0.3502	0.0300	0.1316	0.0085	1	0.4996
h_{15}	0.0952	0.4247	0.0268	0.2334	0.1757	0.0018	0.0004
h_{16}	0.0286	0.4748	0.0633	0.1452	0.0956	0.1066	0.0252
h_{17}	0.0184	0.4478	0.0685	0.2469	0.0225	0.0324	0.0076
h_{18}	0.0523	0.4045	0.0163	0.1927	0.0022	0.0292	0.0015
h_{19}	0.0613	0.4171	0.0248	1	0.0334	0.0082	0.0004
h_{20}	0.0143	0	0.0013	0.1384	0.0210	0.7878	0.0778
h_{21}	0.0238	0.3731	0	0.1316	0.0382	0.0862	0.0357
h_{22}	0.0274	0.3115	0.0170	0.0977	0.0045	0.0123	0.0013
h_{23}	0.0613	0.3718	0.0581	0.1045	0.0079	0.0072	0.0046
h_{24}	0.0452	0.4944	0.0059	0.0366	0.0067	0.0053	0.002
h_{25}	0.2052	0.3518	0.0222	0.0638	0	0.0056	0.0007
h_{26}	0	1	0.0102	0.0570	0.0060	0.0004	0.0001
h_{27}	0.2362	0.2827	0.0587	0.3487	0.0936	0	0
h_{28}	0.0095	0.4732	0.0444	0	0.0376	0.9088	0.0535
h_{29}	0.0018	0.3004	0.0189	0.4030	0.2940	0.0741	0.0103

(3) Calculate column difference is $\Delta_i(k) = |C_k^* - C_k^i|$, see Table 36.3.

(4) Solve $\max\max\Delta_i(k)$ and $\min\min\Delta_i(k)$

Table 36.3 was $\max\max\Delta_i(k) = 1, \min\min\Delta_i(k) = 0$.

(5) For grey correlation coefficient $\xi_j{}'$, take the resolution coefficient $\rho = 0.5$.

$$\begin{aligned}
\xi_1{}' =&\ (0.5532, 0.4272, 1, 0.8661, 0.9754, 0.8734, 0.3908),\\
\xi_2{}' =&\ (0.3333, 0.3677, 0.3429, 0.8091, 0.6423, 0.9846, 1),\\
\xi_3{}' =&\ (0.3360, 0.4661, 0.3815, 0.6755, 0.8480, 0.7570, 0.3333),\\
\xi_4{}' =&\ (1, 0.4503, 0.7753, 0.8179, 0.8041, 0.7004, 0.7251),\\
\xi_5{}' =&\ (0.3378, 0.4452, 0.3400, 0.7832, 0.8331, 0.9471, 0.9891),
\end{aligned}$$

Table 36.3 Index of the row difference

Index	Δa_1	Δa_2	Δa_3	Δb_1	Δb_2	Δb_3	Δb_4	$\min \Delta_i(k)$	$\max \Delta_i(k)$
h_1	0.4039	0.6705	0	0.0773	0.0126	0.0725	0.7794	0	0.7794
h_2	1	0.8599	0.9582	0.118	0.2784	0.0078	0	0	1
h_3	0.9881	0.5727	0.8107	0.2402	0.0896	0.1605	1	0.0896	1
h_4	0	0.6104	0.1449	0.1113	0.1218	0.2139	0.1896	0	0.6104
h_5	0.9803	0.6231	0.9713	0.1384	0.1002	0.0279	0.0055	0.0055	0.9803
h_6	0.9541	0.5501	0.8988	0.1655	0.1808	0.0466	0.0072	0.0072	0.9541
h_7	0.9565	0.6474	0.8107	0.0163	0.0060	0.0666	0.0213	0.0060	0.9565
h_8	0.9560	0.7347	0.9791	0.3284	0.1746	0.0082	0.0013	0.0013	0.9791
h_9	0.9697	0.7629	0.9765	0.1181	0.0631	0.0350	0.0035	0.0035	0.9765
h_{10}	0.9209	0.3477	0.7513	0.1859	0.0151	0.0083	0.0017	0.0017	0.9209
h_{11}	0.9566	0.7369	0.9419	0.1045	0.0060	0.0385	0.0044	0.0060	0.9566
h_{12}	0.9429	0.668	0.951	0.3487	1	0.0190	0	0	1
h_{13}	0.2754	0.7112	0.5757	0.4437	0.0560	0.1926	0.0300	0.0300	0.7112
h_{14}	0.9827	0.6498	0.97	0.1316	0.0085	1	0.4996	0.0085	1
h_{15}	0.9048	0.5753	0.9732	0.2334	0.1757	0.0018	0.0004	0.0004	0.9732
h_{16}	0.9714	0.5252	0.9367	0.1452	0.0956	0.1066	0.0252	0.0252	0.9714
h_{17}	0.9816	0.5522	0.9315	0.2469	0.0225	0.0324	0.0076	0.0076	0.9816
h_{18}	0.9477	0.5955	0.9837	0.1927	0.0022	0.0292	0.0015	0.0015	0.9837
h_{19}	0.9387	0.5829	0.9752	1	0.0334	0.0082	0.0004	0.0004	1
h_{20}	0.9857	1	0.9987	0.1384	0.0210	0.7878	0.0778	0.0210	1
h_{21}	0.9762	0.6269	1	0.1316	0.0382	0.0862	0.0357	0.0357	1
h_{22}	0.9726	0.6885	0.9830	0.0977	0.0045	0.0123	0.0013	0.0013	0.0977
h_{23}	0.9387	0.6282	0.9419	0.1045	0.0079	0.0072	0.0046	0.0046	0.9419
h_{24}	0.9548	0.5056	0.9941	0.0366	0.0067	0.0053	0.002	0.002	0.9941
h_{25}	0.7948	0.6482	0.9778	0.0638	0	0.0056	0.0007	0	0.9778
h_{26}	1	0	0.9898	0.057	0.0060	0.0004	0.0001	0	1
h_{27}	0.7638	0.7173	0.9413	0.3487	0.0936	0	0	0	0.9413
h_{28}	0.9905	0.5268	0.9556	0	0.0376	0.9088	0.0535	0	0.9905
h_{29}	0.9982	0.6996	0.9811	0.4030	0.2940	0.0741	0.0103	0.0103	0.9982

$$
\begin{aligned}
\xi_6{}' &= (0.3439, 0.4761, 0.3574, 0.7513, 0.7344, 0.9147, 0.9858),\\
\xi_7{}' &= (0.3433, 0.4358, 0.3815, 0.9684, 0.9881, 0.8825, 0.9591),\\
\xi_8{}' &= (0.3434, 0.4050, 0.3380, 0.6036, 0.7412, 0.9839, 0.9974),\\
\xi_9{}' &= (0.3402, 0.3959, 0.3386, 0.8089, 0.8879, 0.9346, 0.9930),\\
\xi_{10}{}' &= (0.3519, 0.5898, 0.3996, 0.7290, 0.9707, 0.9837, 0.9966),\\
\xi_{11}{}' &= (0.3433, 0.4042, 0.3468, 0.8271, 0.9881, 0.9285, 0.9913),\\
\xi_{12}{}' &= (0.3465, 0.4281, 0.3446, 0.5891, 0.3333, 0.9634, 1),\\
\xi_{13}{}' &= (0.6448, 0.4128, 0.4648, 0.5298, 0.8993, 0.7219, 0.9434),\\
\xi_{14}{}' &= (0.3372, 0.4349, 0.3401, 0.7916, 0.9833, 0.3333, 0.5002),\\
\xi_{15}{}' &= (0.3559, 0.4650, 0.3394, 0.6818, 0.7399, 0.9964, 0.9992),\\
\xi_{16}{}' &= (0.3398, 0.4877, 0.3480, 0.7750, 0.8395, 0.8243, 0.9520),\\
\xi_{17}{}' &= (0.3375, 0.4752, 0.3493, 0.6694, 0.9569, 0.9391, 0.9850),
\end{aligned}
$$

$$
\begin{aligned}
\xi_{18}{}' &= (0.3454, 0.4564, 0.3370, 0.7218, 0.9956, 0.9448, 0.9970),\\
\xi_{19}{}' &= (0.3475, 0.4617, 0.3389, 0.3333, 0.9374, 0.9839, 0.9992),\\
\xi_{20}{}' &= (0.3365, 0.3333, 0.3336, 0.7832, 0.9597, 0.3883, 0.8654),\\
\xi_{21}{}' &= (0.3387, 0.4437, 0.3333, 0.7916, 0.9290, 0.8530, 0.9334),\\
\xi_{22}{}' &= (0.3395, 0.4207, 0.3372, 0.8365, 0.9911, 0.9760, 0.9974),\\
\xi_{23}{}' &= (0.3475, 0.4432, 0.3468, 0.8271, 0.9844, 0.9858, 0.9909),\\
\xi_{24}{}' &= (0.3437, 0.4972, 0.3346, 0.9318, 0.9867, 0.9895, 0.9960),\\
\xi_{25}{}' &= (0.3862, 0.4355, 0.3383, 0.8868, 1, 0.9889, 0.9986),\\
\xi_{26}{}' &= (0.3333, 1, 0.3356, 0.8977, 0.9881, 0.9992, 0.9998),\\
\xi_{27}{}' &= (0.3956, 0.4107, 0.3469, 0.5891, 0.8423, 1, 1),\\
\xi_{28}{}' &= (0.3355, 0.4869, 0.3435, 1, 0.9301, 0.3549, 0.9033),\\
\xi_{29}{}' &= (0.3337, 0.4168, 0.3376, 0.5537, 0.6297, 0.8709, 0.9798).
\end{aligned}
$$

(6) According to the correlation formula $\gamma_i = \frac{1}{n}\sum_{k=1}^{n}\xi_i(k)$:

$$
\begin{aligned}
\gamma_1{}' &= 0.7266,\ \gamma_2{}' = 0.6400,\ \gamma_3{}' = 0.5425,\ \gamma_4{}' = 0.7533,\ \gamma_5{}' = 0.6679,\\
\gamma_6{}' &= 0.6519,\ \gamma_7{}' = 0.7084,\ \gamma_8{}' = 0.6304,\ \gamma_9{}' = 0.6713,\ \gamma_{10}{}' = 0.7173,\\
\gamma_{11}{}' &= 0.6899,\ \gamma_{12}{}' = 0.5721,\ \gamma_{13}{}' = 0.6595,\ \gamma_{14}{}' = 0.5315,\ \gamma_{15}{}' = 0.6539,\\
\gamma_{16}{}' &= 0.6523,\ \gamma_{17}{}' = 0.6732,\ \gamma_{18}{}' = 0.6854,\ \gamma_{19}{}' = 0.6288,\ \gamma_{20}{}' = 0.5714,\\
\gamma_{21}{}' &= 0.6604,\ \gamma_{22}{}' = 0.6998,\ \gamma_{23}{}' = 0.7037,\ \gamma_{24}{}' = 0.7256,\ \gamma_{25}{}' = 0.7192,\\
\gamma_{26}{}' &= 0.7934,\ \gamma_{27}{}' = 0.6549,\ \gamma_{28}{}' = 0.6220,\ \gamma_{29}{}' = 0.5889.
\end{aligned}
$$

(7) Grey correlation rank is:

From industrial interior twenty-nine industry sustainable development capacity evaluation results, sustainable development ability is communication, computer and electronic equipment, agricultural food products, petroleum and natural gas, transportation equipment, electrical machinery and equipment, bamboo grass products, tobacco processing, special equipment, general equipment, furniture should give aid to. And the weaker is pharmaceutical, beverage production, non ferrous metal ore mining, textile, non metallic mineral products, gas production and supply, water production and supply, papermaking and paper products, nonferrous metal smelting, non metal ore mining, printing, record medium reproduction, elimination to these industries backward production technology, pollution is serious, economic benefits is not good business. Enhance the capacity for sustainable development for industry technical reformation, improve the comprehensive utilization rate of energy and reduce industrial "three wastes" emissions.

Acknowledgements This research is supported by the Zhanjiang Normal University Professor fund (Z0415).

Table 36.4 Incidence sort of the index

Serial	Industry	Correlation degree	Serial	Industry	Correlation degree
1	communication, computer and electronic equipment	0.7934	16	oil processing and coking	0.6595
2	agricultural food products	0.7533	17	electricity production and supply	0.6549
3	petroleum and natural gas	0.7266	18	chemical products	0.6539
4	rransportation equipment	0.7256	19	pharmaceutical	0.6523
5	electrical machinery and equipment	0.7192	20	beverage production	0.6519
6	bamboo grass products	0.7173	21	non ferrous metal ore mining	0.6399
7	tobacco processing	0.7084	22	textile	0.6304
8	special equipment	0.7037	23	non metallic mineral products	0.6288
9	general equipment	0.6998	24	gas production and supply	0.6220
10	furniture	0.6899	25	water production and supply	0.5889
11	plastic products	0.6854	26	papermaking and paper products	0.5721
12	rubber products	0.6732	27	nonferrous metal smelting	0.5714
13	down leather	0.6713	28	non metal ore mining	0.5425
14	food production	0.6679	29	printing, record medium reproduction	0.5315
15	metal products	0.6604			

References

1. Du D, Pang Q (2005) Modern comprehensive evaluation method and case selects. Qinghua University Press, Beijing (In Chinese)
2. Qin S (2003) Principle and application of overall merit. Beijing Publishing House of Electronics Industry, Beijing (In Chinese)
3. Li S, Di Y (2006) Grey correlation degree for sustainable development coordination degree evaluation. Journal of Liaoning Institute of Technology 76–80 (In Chinese)
4. Yuan Y, Dong K (2008) Changes and optimization of industrial structure: Theoretical explanation and quantitative analysis. Dalian University of Technology Press, Dalian (In Chinese)
5. Jiang S (2004) The adjustment of regional industrial structure and the choice of leading industry research. Shanghai People's Publishing House, Shanghai (In Chinese)
6. Zhanjiang Municipal Bureau of Statistics (2003-2011) Zhanjiang Statistical Yearbook (In Chinese)
7. BOX G, Jenkins G (2005) Time series analysis: Forecasting and control. The People's Posts and Telecommunications Press, Beijing

Chapter 37
An Empirical Analysis of Inpatients' Loyalty: A Case in West China Hospital

Sheng Zhong and Yanding Guo

Abstract The purpose of this study was to assess inpatients' loyalty impact factors in medical service in hospital in Chengdu. The survey was conducting through field interviews based on a questionnaire that was designed by the researchers and conducted in West China Hospital of Sichuan University in autumn of 2011 on a sample of 315 inpatients that were selected at random. And structural equation model was used to explore those factors' impact degree. An empirical test of the relationships among these factors, some valuable clues for establishing core competitive power of the hospitals in China and improving the management of health care marketing were drawn based on the study findings.

Keywords Medical service · Patient loyalty · Factor analysis · Structural equation model

37.1 Introduction

Since the 20th century late 70 s, customer satisfaction is always a hot issue among business management theorists and is deeply concerned by business management practitioners. Interest in patients' opinions developed alongside the sociological interest in interpersonal relationships, giving rise to studies of patient-practitioner relationships which demonstrated the importance of understanding the patient's point of view [1, 2]. Then the practitioners began to imitate the strategies of a competitive health care market, in which hospitals have to ensure the higher level of patient satisfaction not only to maintain their patient base but to expand it [3]. And some health care evaluations were also established. For example, the evaluation in the nursing context has been defined by Risser [4] and Van Maanen [5]. Then many

---

S. Zhong (✉) · Y. Guo
Business School, Sichuan University, Chengdu 610064, P. R. China
e-mail: szhong666@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_37, © Springer-Verlag London 2013

factors impact patient satisfaction have been found by many models of health care evaluation and criteria have been proposed.

The enterprises should make every effort to meet or exceed and improve customer satisfaction, finally improve economic benefits. Frederick F.Reichheld who was from the U.S. management consulting firm—Bain who was professor and W. Earl Sasser. Jr from Harvard Business School firstly pointed out that it was necessary to enhance competitiveness and improve economic benefits, and companies must also cultivate a sense of customer loyalty.

Influencing factors on customer loyalty have had a large number of results. McDougall [6] showed in a typical study of service industry that customer loyalty influence factors are core quality, relationship quality, perceived value, switching intentions and customer satisfaction; Ryan [7] built a loyalty model structure for energy services indicating that the factors include customer value, company reputation and customer satisfaction. And more study showed loyalty influence factors can be: customer satisfaction, trust relationship, switching cost and alternative attractiveness, customer perceived value, switching costs, customers trust and competitors attraction, environmental factors and switching costs, customer value and switching costs, and customer value also contains two factors which are service quality and corporate image.

ECSI model has showed that customer perceived value and customer satisfaction were the results of expected quality, perceived quality and corporate image. Therefore, this paper argued that the impact factors listed in the literature above-mentioned, quality of service, brand image, trust relationship and switching costs are more origin and main factors for loyalty. Moreover, those four aspects were presupposed as the patient loyalty influence factors in this study.

In order to get the pictures of hospital building clearly and improve the management of hospital construction and medical industries' service, this article plans to build an index system, analysis the impact elements of inpatient loyalty. An empirical research on the West China Hospital of Sichuan University which located in Chengdu was performed. This study wants to offer some valuable clues for each type of hospitals to build and upgrade their core competencies.

37.2 Methodology

37.2.1 Sample Selection

Research data of this paper was collected in the form of questionnaire and chose West China Hospital of Sichuan University which is located in Chengdu as a research object.

West China Hospital of Sichuan University is a classic medical institution with the technology and brand ensuring. The hospital has 95,000 patients discharged from the hospital visits per year. It has a high reputation in China. This shows that patients with a high degree of loyalty to the hospital. It has a stronger representation to select West China Hospital of Sichuan University as the research object. Inpatients' emphasis on hospital choice taken into consideration, and they had experienced the various processes more fully, so research data chose inpatients as the collection object.

In order to avoid patients' concerns and ensure that the data can reflect the wishes of patients truly, the survey was anonymous and the implementation was standing in the third-party's neutral point of view.

The questionnaire was designed on the base of service flow. We received responses from a total of 315 patients, 287 of which returned the paper questionnaire, forming a 91.11% response rate. 43 surveys were disqualified for lacking of completeness forming an 85.01% effective rate.

The basic characteristics of the sample are as follows: men accounted for 51.5% while female 42.2% and missing 6.4%; under 30 years of age accounted for 47.4%, 31-50 years of age were 42.7%, over the age of 50 accounted for 9.9%; respondents from Chengdu accounted for 39.2%, Other cities in Sichuan Province were 49.5%, patients from other provinces accounted for 4.4% and missing is 6.9%; 1,500 Yuan in monthly family income per capita was less than 36.2%, 1500-3000 Yuan was 25.8%, there were 29.7% patients whose monthly income were more than 3,000, 8.3% is missing. The data can be a better response to structure and characteristics of the patients in West China Hospital.

37.2.2 Reliability and Validity of Measurement Scales

The questions in questionnaire were arranged by logical order of medical treatment and were mainly answerable by 5-point Likert scales. A 5-point Likert-type scale (1 = "strongly disagree", 9 = "strongly agree") was used to measure each item.

In order to ensure that the model fit evaluation and the effectiveness of hypothesis testing, it is necessary to test the reliability and validity of the data. The reliability statistics - the value of the Cronbach's Alpha- is 0.923 shows that the data has a good reliability.

The data has to be appropriate for factor analysis. Two measures are commonly used to decide this. The first one is the Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy that assesses the extent to which variables of the construct belong together. The other is the Bartlett's test of sphericity that is a statistical test to assess whether or not the correlation matrix is appropriate for factoring. The Bartlett test examines the extent to which the correlation matrix departs from orthogonality. Due to the special binary structure of the data, besides the expositional nature of the study, as long as the data structure has some positive support by one of the two measures, the use of factor analysis is deemed acceptable.

Regarding the appropriateness test on the data, the value of the KMO measure is 0.945 and the Bartlett test statistic is highly significant ($p(0.000)$). This implies that the data is appropriate for factor analysis. This implies that the data is appropriate for confirmatory factoring.

From Table 37.1 some results can be found: (1) There are three service quality factors: nursing service quality, doctor service quality, auxiliary service quality. (2) All indices for nurses were reserved and this may show that the all aspects of nursing service quality in the whole medical treatment process which are contacted with patients closely have an impact on the patients; (3) The pre-set hospital image was consisted with three aspects: brand image, facilities and equipments, medical care environment. (4) Auxiliary service quality indicated that patients in the course of medical treatment not only concerned about the doctors and nurses' service quality, but also pay attention to the inquiries and complaints service, and other auxiliary services such as service attitude.

37.2.3 Research Model and Hypotheses

Based on the above analysis, and combined with the basic characteristics of health care services to determine and the relationship that may exist between pairs of factors, this article made hypotheses as the following:

37.2.3.1 Service Quality

Product and it's price can be easily copied in today's heat competitionbut high quality of service is not such thing to go, so service quality is differentiation tool for the corporations. And other studies show that service quality has significant relationship with repetitive buying and recommendation intention. Service quality is also continued tested that a good service quality is the precondotion of loyalty behavior.

Product and service quality have a fundamental and direct impact on customer loyalty. Zeithaml shows that product or service quality continuously maintains a positive relationship with loyalty in the condition of paying higher prices or in the case of price increasing [8–11]. There are some differences in relevance with product and service quality from different industries. And service quality and willingness to repeat purchase had a positive correlation. Ruyter and other researchers discover that perceived service quality has a positive correlation with customer loyalty in health-care industry, theaters, fast food, supermarkets and amusement parks, etc [12].

Service quality is also an important case in health care field. Service quality in hospital including many attached service when the patients go through the whole progress from register to recover, like: treatment, enquiry, nurse tender and information communication, etc. If the health care organization provide a good quality of service to the patients, they can get a great satisfaction from hospital and further

Table 37.1 The IT patient loyalty influence factors extraction table

Factor	Indices	Component						
The quality of nursing service	V13 The nursing level of nurses	0.69						
	V14 The nursing efficacy of nurses	0.601						
	V19 The degree of nurses arrival speed	0.607						
	V20 The detail level of nursing care	0.686						
	V21 The detail level of nursing health guidance	0.627						
	V25 The attitude of nursing care		0.586					
The quality of doctor service	V12 The curative effect level of attending doctors		0.686					
	V16 The detail level of attending doctors explain and guidance			0.788				
The quality of auxiliary service	V22 The thoughtful Level of medical inquiry service			0.788				
	V23 The efficiency of handling medical care issues and complaints			0.782				
	V26 The service attitude of other medical technicians			0.836				
	V29 The degree of saving rehabilitation time			0.782				
Switching costs	V30 Patients have to pay a high cost for collecting other hospitals' information before changing hospital				0.776			
	V31 Patients have to pay a high cost to give up already spent cost after changing hospital				0.738			
	V32 Patients have to pay a high cost to build new trust relationships with doctors after changing hospital				0.735			
	V33 Patients have to pay a high cost to build new trust relationships with hospital after changing hospital				0.702			
Hospital facilities and equipments	V6 Degree of advanced of hospital medical equipment					0.706		
	V7 Degree of goodness of hospital infrastructure					0.729		
Time cost	V8 The convenience of taking medicine from the hospital dispensary						0.735	
	V28 The degree of saving traffic time when go to hospital						0.667	
Hospital brand image	V1 Hospital reputation							0.651
	V4 The accessibility of collecting hospital information							0.634

to trigger their loyalty to accept service from it again and again. Service quality could improve the perceived customer value.

Therefore, the following research hypothesis will be tested:

- Quality of technical service:

Hypothesis 1a. Nursing service quality has a positive impact on inpatient loyalty.
Hypothesis 1b. Doctor service quality has a positive impact on inpatient loyalty.
Hypothesis 2a. Nursing service quality has a positive impact on hospital band image.
Hypothesis 2b. Doctor service quality has a positive impact on hospital band image.
Hypothesis 3a. Nursing service quality has a positive impact on switching costs.
Hypothesis 3b. Doctor service quality has a positive impact on switching costs.

- Quality of functional service

Hypothesis 4a. Auxiliary service quality has a positive impact on inpatient loyalty.
Hypothesis 4b. Auxiliary service quality has a positive impact on hospital band image.
Hypothesis 4c. Auxiliary service quality has a positive impact on switching costs.

37.2.3.2 Switching Costs

The customers' behavior loyalty is from not only customer satisfaction or the trust relationship, but also customers' switching costs or a potential alternative in the market. Porter defined switching costs as "one-time cost that buyers face, when they change one supplier to another". When measure swithing costs, there are two important level: economic level and mentally level.

The customers' behavior loyalty is from not only customer satisfaction or the trust relationship, but also customers' switching costs or a potential alternative in the market. As the customers perceive high switching costs or lacking of available market alternatives to provide products or services, customers are locked in the current relationship, and thus the behavior loyalty generated. Customers' attitudinal loyalty includes emotional loyalty, cognitive loyalty and intention loyalty. It is viewed the relationship customers and enterprises maintaining from a psychological perspective, including customer satisfaction to the quality of service, brand commitment, interpersonal trust and psychological identity and so on. In this paper, the customers' attitudinal loyalty includes the customers' preference attitude to the product or service, promising to repeat purchase and recommending business products or services to others.

The level of switching costs has a direct impact on maintaining customer loyalty, features of non-substitutability of products or services can greatly enhance customer loyalty. Andreasen through an empirical study of medical services found that a high switching costs caused by the patient's psychological attachment to private doctors and conflict with the replacement of a doctor, which shows a high perceived switching costs, thereby forming the high customer loyalty in medical services market.

The switching costs for the hospital are that the economic and psychological costs the patient will face when they make the turning hospital choices, including not only economic costs, but also the mental and psychological costs resulting from the trust relationship with the doctor.

Therefore, we assume the following assumptions:

- Switching costs

Hypothesis 5. Switching costs has a positive impact on inpatient loyalty.

- Time cost

Hypothesis 6a. Time cost has a positive impact on hospital band image.

Hypothesis 6b. Time cost has a positive impact on inpatient loyalty.

Hypothesis 6c. Time cost has a positive impact on switching costs.

37.2.3.3 Hospital Image

It is generally believed that the brand image is "consumer's overall perception and views of the brand", which influences consumers' purchasing and consumption behavior of the brand. In this paper, hospital's brand image is generated by a combination reflection of the value of the hospital and its medical services to its patients. All those things was approved including the extent of the hospital, visibility, credibility of this hospital and so on. Although the concept of brand image dimensions has different views, but most of the views have emphasized the psychological mechanism to consumer's brand association, while brand image also has a significant effect on consumer usage behavior. Researcher also used typical correlation analysis confirmed that the store image and customer loyalty have correlation between two variables, and that brand image can be used to predict customer loyalty.

Along with the improvement of people's living standard, people's requirement about services, facilities and equipment are getting higher and higher, and they pay more attention on the service environment, especially in a hospital which has good facilities and equipment, and a good medical care environment is one aspect of the performance of its strength. At the same time a good environment is benefit to a better recovered for patients, and the length of recovery period has an impact on loyalty.

Inference theory suggests that people can infer unknown things from the clues of the available information [13]. The hospital environment provides a lot of information clues which are available to patients to infer hospital-related services. The high quality of services of the hospital would help to improve the perceived value. In other empirical studies have confirmed that the perceived value has a significant positive effect on customer loyalty.

Therefore, we obtain the following assumptions:

- Band image

Hypothesis 7a. Hospital band image has a positive impact on inpatient loyalty.

Hypothesis 7b. Hospital band image has a positive impact on switching costs.

- Facilities and equipments

Hypothesis 8a. Hospital facilities and equipments has a positive impact on hospital band image.

Hypothesis 8b. Hospital facilities and equipments has a positive impact on inpatient loyalty.

Hypothesis 8c. Hospital facilities and equipments has a positive impact on switching costs

37.2.4 Structural Models Results and Hypothesis Testing

In order to obtain the best inpatients-doctor loyalty model which can reflect the characteristics of medical service, we applied generation model-based analysis to build and analyses model. The so-called generation model analysis is to propose one or more basic models at first, then check whether these models fit the data, find out the poorly fitted part on the base of theoretical or sample data, modify models, and then check the modified model's goodness of fit. The entire analysis process aims to produce a best model. By using of this best model, not only parameter estimation of the model can be known, but goodness of fit between survey sample data and models can be found out as well. The most important is that some valuable conclusions could be gained on the base of the relationship and its intensity among variables related to the structure.

Table 37.2 The results of the multiple-group SEM analysis

Model	Amends	df	χ^2	RMSEA	NFI	CFI
M 11	Initial model	332	677.32	0.074	0.93	0.96
M 12	GA(3,3)free	323	680.92	0.074	0.93	0.96
M 13	GA(1,1) free	324	677.49	0.073	0.93	0.96
M 14	GA(4,3)+GA(2,1) free	326	681.27	0.073	0.93	0.97

The output displayed that factor loadings, factor covariance between the error variance t-tests of model M14 are significant, and a variety of fit indices are statistically significant and thus M14 is a reasonable estimate.

Comparing the models above, we find that the best model is model M14 and its resulting parameter estimates for the standardized solution are shown in figure.

37.3 Results of Analysis

1. Doctor service quality, time cost, auxiliary service quality, facilities and equipments have a significant impact on the factor of brand image, while the nursing service quality's influence on brand image is not significant. Among the significant influence factors, doctor service quality has the greatest impact on brand image which indicates that patients of West China Hospital firstly take the level of doctors' skill and professionalism into consideration to judge the brand image.

Table 37.3 Regression paths of the model

Hypotheses	Regression paths coefficient	Critical ratio (t-value) p	Support of hypotheses
Hypothesis 1a	Nursing service quality→inpatient loyalty	5.546	*** Supported
Hypothesis 1b	Doctor service quality → inpatient loyalty	3.056	*** Supported
Hypothesis 2a	Nursing service quality→ hospital band image	3.663	*** Not Supported
Hypothesis 2b	Doctor service quality → hospital band image	6.259	*** Supported
Hypothesis 3a	Nursing service quality→ switching costs	1.382	Not supported
Hypothesis 3b	Doctor service quality → switching costs	4.404	*** Supported
Hypothesis 4a	Auxiliary service quality→ inpatient loyalty	1.738	** Supported
Hypothesis 4b	Auxiliary service quality → hospital band image	4.998	*** Supported
Hypothesis 4c	Auxiliary service quality→ switching costs	2.413	** Supported
Hypothesis 5	Switching costs→ inpatient loyalty	4.066	*** Supported
Hypothesis 6a	Time cost → hospital band image	0.854	Not Supported
Hypothesis 6b	Time cost→ inpatient loyalty	3.775	*** Supported
Hypothesis 6c	Time cost → switching costs	1.956	** Supported
Hypothesis 7a	Hospital band image→ inpatient loyalty	2.611	** Supported
Hypothesis 7b	Hospital band image→ switching costs	1.246	Not Supported
Hypothesis 8a	Hospital facilities and equipments → hospital band image	1.956	** Supported
Hypothesis 8b	Hospital facilities and equipments → inpatient loyalty	2.350	** Supported
Hypothesis 8c	Hospital facilities and equipments → switching costs	0.478	Not Supported

*p < .05, **p < .01, ***p < .001.

Time cost, as the second important factor, demonstrates that the operational efficiency of the medical service system has become an important criterion to make time cost become a separated factor different from band image. The auxiliary service quality becomes the third impact factor of the brand image with a small gap indicates that auxiliary service sectors has become an important elements of brand image.

2. Auxiliary service quality, doctor service quality and brand image have a significant impact on switching costs, while the nursing service quality and time cost's influence on brand image are not significant. The impact of switching costs is mainly from the secondary service quality which further reveals the service links play an important role in the patient's loyalty building. And the time cost's influence on brand image is not significant that further proves the independent study of time cost is correct.
3. Auxiliary service quality, switching costs, doctor service quality, brand image, nursing service quality, time cost and facilities and equipment all have a significant impact on inpatient loyalty. Descending by influence coefficient, auxiliary service quality, switching costs, doctor service quality, brand image round out the top four. Integrated direct and indirect effects, auxiliary service quality together

with the doctor service quality impact inpatient loyalty of West China Hospital as the most important factors.

4. Particularly, the quality of service of nurses has a significant effect on inpatients loyalty, but the impact on brand image and switching costs are not significant, and its impact on inpatient loyalty is also relatively small. This shows that the nursing service quality has become the short-board of inpatients loyalty building of West China Hospital.
5. The factor of facilities and equipments has a significant effect on brand image and inpatients loyalty, but influence intensity is very small. This shows that patients choose medical treatment would take facilities and equipments of the hospital into consideration, but not as the major factor.

37.4 Discussion

The service quality has significantly and strongly direct effected on inpatient loyalty indicating that service quality serves an important role in the proposed model. The results imply that how to manage:

1. To improve the service quality of nurses. In fact, the relationship at the contact point has a greater emphasis on physician-patient relationship, while the patients in hospital have the largest number of contacts with the nurses. It is necessary to strengthen the normative operation of nurses, standard-type, timeliness to improve the physician-patient relationship, and the most important thing is to enable nurses to take care of patients better. The patient may be in irritable mood when they are sick, the patient may made radical act in some cases, which needs nurses to be more patience and careful and good psychological quality. Hospitals should strive to improve the overall quality of the nurses of the hospital will help improve patient loyalty.
2. To improve the quality of service of doctors. From the above analysis we knew that the most important factors affecting outpatient loyal is the service quality of doctors. In the hospital, the doctors play a leading role. Doctor's services, including skilled services and human caring are of vital importance to loyalty. Therefore, improving the service quality of doctors has a good reason to increase loyalty.
3. To improve the quality of other services. Other quality of service including medical technical staff attitude and inquiries service attitude is that the main auxiliary services to patients in the process of accessing to be recovered. The good performance of these auxiliary services can ease the anxiety of patients, allowing patients to relieve feelings in the process of waiting and in the early stage of the process of medical treatment, which may cause patients to wait patiently for receiving medical treatment.
4. To improve the hospital facilities and equipment.
5. To shorten the time of taking medicine from the hospital dispensary. Layout rational the auxiliary equipments like dispensary, charges room to shorten waiting

time for the patients. Consumer behavior researchers have documented the vital role of service quality in a variety of customer loyalty model. However, medical service loyalty model have received little attention from scholars and practitioners, the integrated model and empirical studies containing mediation effect from switching costs and time cost in medical service environment, is also little. With empirical data and formally statistical test we verified that the proposed service quality and loyalty model is acceptable and found that doctors service quality, auxiliary service, hospital brand image and switching costs almost completely affect inpatient loyalty. The findings constitute a contribution to, and extension of, the literature in patient behavior and medical service management and the mediating role of switching costs and hospital band image in an integrated model as well.

37.5 Conclusion

The empirical analysis of inpatients loyalty of West China Hospital shows that China's medical service is gradually entering an era of full-service market competition. Whether it is an extension of service or improving the service efficiency of the hospital has become an important source of the core competitiveness. The hospital building should gradually shift its concerns to improve full-service system and service efficiency on the base of the consolidation of medical technology and the construction of facilities and equipments.

Acknowledgements This research is supported by National Natural Science main project fund NO. 71131006.

References

1. Cartwright A (1964) Human relations and hospital care. Routledge and Kegan Paul, London
2. Cartwright A (1967) Patients and their doctors: A study of general practice. Routledge and Kegan Paul, London
3. Abramowitz S, Cote A, Berry E et al (1987) Analyzing patient satisfaction: A multianalytic approach. Quality Review Bulletin 13:122–130
4. Risser N (1975) Development of an instrument to measure patient satisfaction with nurses and nuring care in primary care setting. Nuring Research 24:45–52
5. Van MHT (1984) Evaluation of nursing care: quality of nursing evaluated within the context of health care and examined from a multinational perspective. Churchill Livingstone, Edinburgh
6. McDougall GHG, Levesque T (2000) Customer satisfaction with services: Put-ting perceived value into the equation. Journal of Service Marketing 14:392–410
7. Ryan MJ, Rayner R, Morrison A (1999) Diagnosing customer loyalty drivers. Marketing Research 11:19–26

8. Christina G, Hailin Q (2008) Examining the structural relationships of destination image, tourist satisfaction and destination loyalty: An integrated approach. Tourism Management 29:624–636
9. Parasuraman A, Zeithaml A, Berry LL (1994) Alternative scales for measuring service quality: A comparative assessment based on psychometric and diagnostic criteria. Journal of Retailing 70:201–230
10. Berry LL, Parasuraman A, Zeithaml VA (1988) The service-quality puzzle. Business Horizons 31: 35-43
11. Parasuraman A, Berry LL, Zeithaml VA (1993) More on improving service quality measurement. Journal of Retailing 69:140–147
12. Ruyter K, Wetzels M (1998) On the complex nature of patient evaluations of general practice service. Journal of Economic Psychology 19:565–590
13. Andreasen N (1991) Assessment issues and the cost of Schizophrenia. Schizophrenia Bulletin 17:475–481

Chapter 38
Different Effects of Monetary Policy on Rural and Urban Prices

Xu Zhao and Liuliu Kong

Abstract With VAR model and impulse response function, this paper measures the impact of monetary policy shocks on urban and rural prices and finds that significant different effects exist. The result shows that M0 has a long term lasting effect on rural consumer price index while M1 and M2 have no long term lasting effect on the index. At the same time, M0, M1 and M2 all have long term lasting impact on the urban consumer price index. The time lag of monetary policy on rural consumer price index is shorter than that of monetary policy on urban consumer price index. In addition, the impact of monetary policy on urban consumer price index is stronger than that on rural consumer price index. Finally, the paper explains the causes of the difference and makes some recommendations.

Keywords Monetary policy · Urban consumer price index · Rural consumer price index

38.1 Introduction

Monetary policy is a process by which the monetary authority of a country controls the supply of money, often targeting a rate of interest or rate of inflation for the purpose of promoting economic growth and stability. There are four goals of monetary policy including price stability, full employment, economic growth and balance of international payments. In different periods, same country may emphasize different goal of monetary policy. China rules its monetary policy goals as maintaining currency stability and then promoting economic growth in recent years. Since price stability is the essence of currency stability, it is always concerned by Chinese Central Bank. Since August 2007, in order to cope with the global financial crisis, Chinese

---

X. Zhao · L. Kong (✉)
Business School, University of Shanghai for Science and Technology, Shanghai 200093, P. R. China
e-mail: kongliuliu@yahoo.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_38,

government lowered the benchmark interest rate for four times and the deposit reserve ratio for three times from September to December in 2008. At the end of 2008, the government decided to invest four trillion RMB to stimulate economic growth. However, as time went on, both domestic and international economy environment has changed. China faces serious inflation pressure. For example, China's CPI rose 6.4% in June and rose 6.5% in July in 2011 compared with that of same period of last year. In response to the inflation, the Central Bank had to raise the deposit reserve ratio seven times and raise its benchmark interest rate four times from January 2010 to June 2011. It is noteworthy that the changes of urban CPI and rural CPI were not same during the same period. For example, the urban CPI rose 6.2% and the rural CPI rose 7.0% in June 2011. And the urban CPI rose 6.2% while the rural CPI rose 7.1% in July 2011. The data shows that money policy has different impact on urban and rural price. We try to measure and explain the different impact of monetary policy on urban and rural prices.

38.2 Literature Review

Monetary policy has asymmetric effects, of which studies can be divided into two aspects: the first is the monetary policy's time asymmetric effects; the second is the monetary policy's regional asymmetric effect. Scott found that America monetary policy had a clear time lag when it was transmitted from New York to other regions [1]. Toal, Garrison and Chang found that different regions in the United States had different sensitivities to monetary policy [2, 3]. Based on the UK data from 1970 to 1995, Ganley and Salmon found that monetary policy had asymmetric effects on the 24 industries with the use of VAR model, analyzing the companies' response in speed and extent to the unexpected tighten monetary policy in each industry [4]. Using data of 48 states of America, Carlino and DeFina showed that the Fed's monetary policy indeed had regional effects, and interest channel was main reason for the effects [5]. By studying data of Netherlands for the period 1973 to 1993, Arnold and Vrugt measured the impact of monetary policy shocks on regional and sectoral output [6]. They found that sectoral effects account for much more of the variation in interest sensitivity than regional effects. In recent years, there are also many studies in China. Ke Dongmei conducted a qualitative research on China's regional effects of monetary policy [7]. After that, many economists have conducted empirical analysis. Song and Zhong applied the theory of optimum currency areas to China, adopting VAR model and IRF, and verified that there existed manifest regional effects of monetary policy in the country [8]. By researching regions of China, Yu came to the conclusion that northeast and central regions' responses to monetary policy were close to the average level, and that of the eastern regions were much stronger than other regions [9]. Using VAR method for the 1980 to 2004 period, comparing M2 and interest rate, Kong et al found that M2 is a better indicator to explain the monetary policy in China and the coastal provinces response more to shocks in monetary policy than the inland provinces [10]. Through empirical testing of China's eight economic zones with SVAR model and IRF, Jiang and Zhang found that there is a clear regional effects of monetary policy and the differences of regional productivity levels are the long-term factors which affect regional effects of monetary policy. The previous studies on effects of China's monetary policy are mainly based on administrative regions in China [11]. However, as we all know, China is a typical dual economy, this article attempts to study monetary policy effects on urban and rural prices.

38.3 Model and Data

38.3.1 Model Selection

In this paper, a vector autoregressive (VAR) mode which was introduced by Sims in 1980 is used to measure the effects of monetary policy shocks on prices for both urban and rural sectors. VAR mode is often used to predict the time series of interconnected systems and analyze the effects of random disturbance on dynamic variable system. All the variables in a VAR are treated symmetrically; each variable has an equation explaining its evolution based on its own lags and the lags of all the other variables in the model. As a result, expert knowledge and structured model can be avoided. A VAR model can be put in the following mathematical form:

$$y_t = \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + Hx_t + \varepsilon_t, \tag{38.1}$$

where y_t, k dimensional column vector of endogenous variables; x_t, d dimensional column vector of exogenous variables; p, the lag order; t, the sample number. $k \times k$ dimensional matrix $\Phi_1, \ldots, \Phi_p$ and $k \times d$ matrix H are the coefficient matrix to be estimated. ε_t is the k dimensional disturbances column vector, and they can be correlated at the same period, but they can not be correlated with their own lagged values and can not be correlated with variables on the right hand side of the equation.

38.3.2 Variables Selection

It is known that money supply and interest rate are the main channels for monetary policy transmission. However, using money supply as only one measure to analyze monetary policy's effect is biased. On the other hand, simply using the benchmark interest rate as only measure to analyze monetary policy intentions will encounter the same problem like money supply. Therefore, this article will introduce both variables into the model as tools of monetary policy. In addition, in order to display the impact of money supply on the urban and rural areas more comprehensively, M0, M1 and M2 are used to analyze the impact of money supply on the urban and rural prices correspondingly.

38.3.3 Data Sources

In order to measure the impact of money supply on urban and rural prices, the paper selects the monthly data from January 1998 to December 2010. M0, M1 and M2 are selected as money supply, and the one-year benchmark lending interest rate (R) is selected as interest rate, and urban consumer price index (UCPI) and rural consumer price index (RCPI) are selected as price index of urban and rural residents. To eliminate heteroskedasticity, M0, M1, M2 and UCPI, RCPI, are all in logarithmic, and the result are named as LnM0, LnM1, LnM2 and LnUCPI, LnRCPI respectively. The original data are taken from the China statistical applications support system database and People's Bank of China's website.

Table 38.1 ADF test results

Variable	ADF values	Critical value (1%,5%,10%)	Test form (C,T,P)	Station-arity
LnM0	−6.110699	(−4.019151, −3.439461, −3.144113)	(C,T,2)	Y
LnM1	−1.467939	(−4.019151, −3.439461, −3.144113)	(C,T,2)	N
LnM2	−1.185106	(−4.019151, −3.439461, −3.144113)	(C,T,2)	N
LnRCPI	−1.859471	(−3.473382, −2.880336, −2.576871)	(C,0,2)	N
LnUCPI	−2.708876	(−4.019151, −3.439461, −3.144113)	(C,T,2)	N
R	−3.997274	(−3.473382, −2.880336, −2.576871)	(C,0,2)	Y
DLnM1	−7.386531	(−4.019561, −3.439658, −3.144229)	(C,T,2)	Y
DLnM2	−6.120323	(−4.019561, −3.439658, −3.144229)	(C,T,2)	Y
DLnRCPI	−5.281233	(−3.473672, −2.880463, −2.576939)	(C,0,2)	Y
DLnUCPI	−6.021130	(−4.019561, −3.439658, −3.144229)	(C,T,2)	Y

38.4 Empirical Testing and Analysis

38.4.1 Data Stationarity Test

First of all, time series LnM0, LnM1, LnM2, LnRCPI, LnUCPI and R should be conducted stationary test. If a variable can not pass the stationary test, the series must be differential sequentially until the result is stable. With the data acquired, applying the ADF-test yields results as in the Table 38.1. From Table 38.1, it can be seen that R and LnM0 are stationary time series at 1% significant level. After a differential treatment, time series DLnM1, DLnM2, DLnRCPI, DLnUCPI, the results of LnM1, LnM2, LnRCPI, and LnUCPI correspondingly, are also stationary time series at 1% significant level. In the results, "Ln" denotes the natural logarithm, "D" denotes first-order differential, C, T, P in test forms (C, T, P) represent constant, time trend and the lag order correspondingly. Y denotes yes, N denotes no.

38.4.2 VAR Model Analysis

Based on the stationary data, according to the AIC or SC criteria, six VAR equations are established. With the impulse response function analysis, the lag orders in equations are shown in Table 38.2.

Table 38.2 VAR equation form

Equation	Equation variables	Lag order	AIC values	SC values
A	(DLnRCPI,LnM0,R)	2	−9.029163∗	−8.601958
B	(DLnUCPI,LnM0,R)	3	−8.888811∗	−8.281268
C	(DLnRCPI,DLnM1,R)	2	−11.26896∗	−10.84176
D	(DLnUCPI,DLnM1,R)	2	−11.07223∗	−10.64503
E	(DLnRCPI,DLnM2,R)	1	−12.54441	−12.30029∗
F	(DLnRCPI,DLnM2,R)	3	−12.47117∗	−11.86087

According to the VAR equations, the corresponding impulse response graphs are drawn as below:

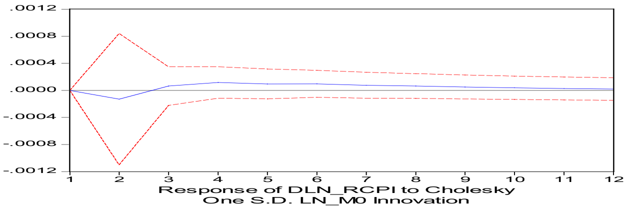


Fig. 38.1 Response of DLnRCPI to LnM0 in equation A

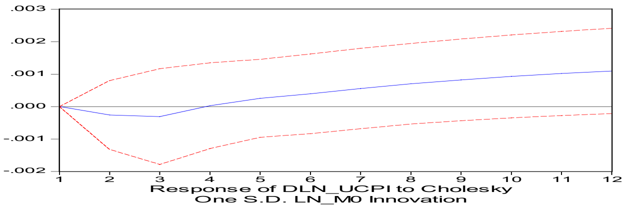


Fig. 38.2 Response of DLnUCPI to LnM0 in equation B

As we can see from Fig. 38.1 to Fig. 38.6, when LnM0, DLnM1 and DLnM2 are given one standard deviation shock, DLnRCPI and DLnUCPI response in very

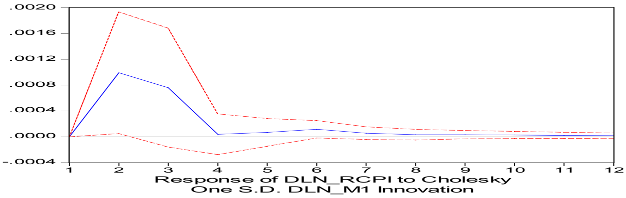


Fig. 38.3 Response of DLnRCPI to DLnM1 in equation C

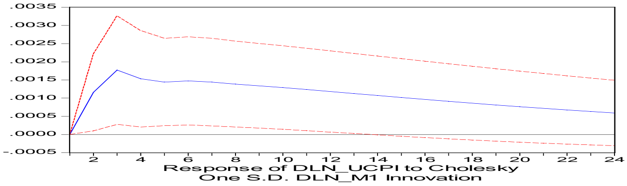


Fig. 38.4 Response of DLnUCPI to DLnM1 in equation D

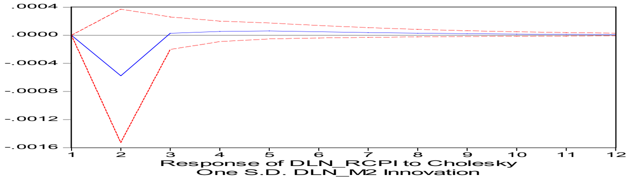


Fig. 38.5 Response of DLnUCPI to DLnM2 in equation E

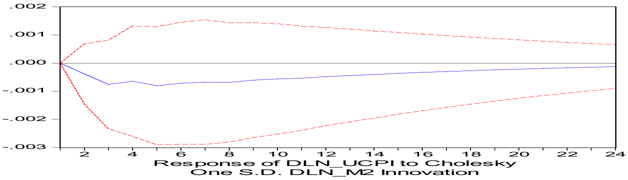


Fig. 38.6 Response of DLnUCPI to DLnM2 in equation F

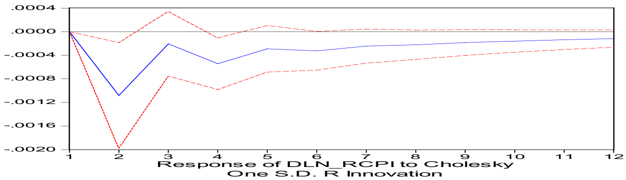


Fig. 38.7 Response of DLnRCPI to R in equation A

different ways. The responses of DLnRCPI to shocks of LnM0 and DLnM2 can reach maximum at the second period and gradually become small and stationary

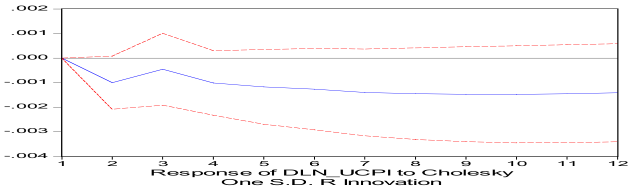


Fig. 38.8 Response of DLnUCPI to R in equation B

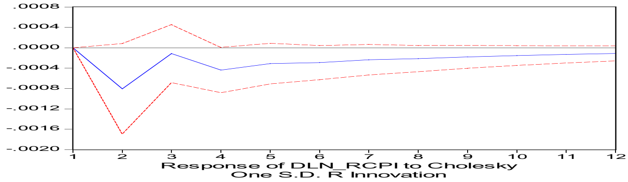


Fig. 38.9 Response of DLnRCPI to R DLnM1 in equation C

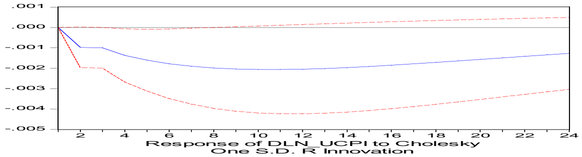


Fig. 38.10 Response of DLnUCPI to R in equation D

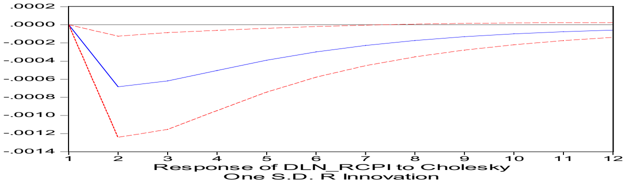


Fig. 38.11 Response of DLnRCPI to R in equation E

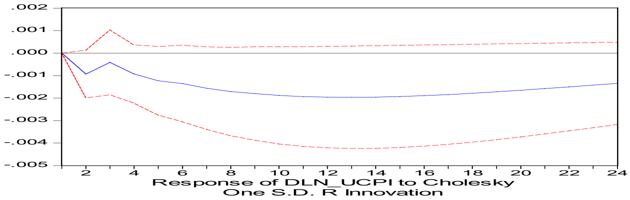


Fig. 38.12 Response of DLnUCPI to R in equation F

after the third period (see Fig. 38.1 and Fig. 38.5). When a standard deviation shock on DLnM1 is imposed, DLnRCPI can reach maximum at the second period as well, but becomes weak and stationary after the forth period (Fig. 38.3). In addition, the impact OF DLnM1 and DLnM2 on DLnRCPI will reduce to zero nearly after the peak a period of time, while LnM0 has lasting impact on it. On the other hand, when LnM0 and DLnM1 are given one standard deviation shock, the responses of DLnUCPI can reach maximum at the third period and becomes stationary from the forth period (Fig. 38.2 and Fig. 38.4). When a standard deviation on DLnM2 is imposed, DLnUCPI can reach maximum at the fifth period and then the effect gradually stabilizes (Fig. 38.6). It is not difficult to find that LnM0, DLnM1 and DLnM2 all have lasting effect on DLnUCPI. In addition, the responsing breadths of DLnUCPI to LnM0, DLnM1 and DLnM2 are greater than that of DLnRCPI obviously. As we can see from Fig. 38.7 to Fig. 38.12, when R is given one standard deviation shock, DLnRCPI and DLnUCPI also response in very different ways. The responses of DLnRCPI to shock of R can reach maximum at the second or third period and gradually become smaller and smaller after the peak (see Fig. 38.7, Fig. 38.9 and Fig. 38.11). In contrast, when a standard deviation shock on R is imposed, the responding of DLnUCPI will last a long time (see Fig. 38.8, Fig. 38.10 and Fig. 38.12).

38.4.3 The Explanation of Empirical Results

Firstly, the empirical test shows that only LnM0 has lasting impact on DLnRCPI, while the impacts of DLnM1 and DLnM2 on DLnRCPI reduces mostly to zero after the peak a period of time. The main reason of result is that cash still plays very important role in transactions in rural areas. That quasi-money has no lasting impact on rural consumer price index is mainly due to the undeveloped financial system in rural areas. In contrast, LnM0, DLnM1 and DLnM2 all have lasting impact on urban consumer price index (UCPI) indicating a relatively high level of developed financial system in urban areas where both cash and quasi-money can be traded in the monetary market. As a result, the money supply expands more largely in urban areas than that in rural areas under the same monetary policy and this mechanism promotes UCPI rising higher and higher. Secondly, the test result that responding lag of RCPI to monetary policy is shorter than that of UCPI shows that currency‘’s impact on the price of agricultural products is relatively straightforward. This difference may partially explain why rural consumer price index is occasionally higher than urban consumer price index. After rising of prices of agricultural products, the prices of industrial products which have to use agricultural products as raw materials go up, and as a result, UCPI goes up. So, follow-up conductive effect of prices plays a role in the whole price system. But in the long run, it is not difficult to find that urban consumer price index will be generally higher than rural consumer price index. In addition, the impact of interest rates on the urban price index is much greater than that on the rural areas. This is mainly because the credit economy is relatively much developed in the urban areas than in rural areas. In China, rural private enterprises usually depend on underground financial system in which the interest rates are much higher than that in banks, therefore, Central Bank‘’s interest rate policy has a very small effect on that system. As a result, the impact of changes in interest rates on urban prices is far greater than rural areas.

38.5 Conclusion and Recommendations

Previous studies on the effect of monetary policy focus on the regional difference and industrial difference. This paper argues that the different effects of monetary policy on urban and rural areas exist too. If the Central Bank takes inflation as intermediate target of monetary policy, the different effects of monetary policy on urban and rural areas may lead to the unexpected result if a same policy is executed. China is a typical dual economy, and the wealth gap between urban and rural is widening. In order to narrow the gap, monetary policy should give more supports to help the rural areas, such as increasing credit to farmers, increasing credit to enterprises in rural areas, etc. Further more, it is important to improve the quasi-currency market in rural areas and gradually weak the role of cash in transactions. In the long term, rural financial system should be strengthened and underground financial system in rural areas should be standardized and legalized.

38.6 Acknowledgements

The research is supported by The key Building Subject of Shanghai Board of Education — “The Operation and Control of Economics System” (J50504).

References

1. Scott Jr IO (1955) The regional impact of monetary policy. The Quaterly Journal of Economics 69:269–284
2. Toal WD (1977) Regional impacts of monetary and fiscal policies in the postwar period: Some initial tests. Working Paper, Federal Reserve Bank of Atalanta
3. Garrison CB, Chang HS (1979) The effects of monetary forces in regional economic activity. Journal of Regional Science 19:15–29
4. Ganley G, Salmon C (1997) The industrial impact of monetary policy shocks; some stylised facts. Bank of England Working Paper, No. 68
5. Carlino G, DeFina R (1999) The differential regional effects of monetary policy: Evidence from the US States. Journal of Regional Science 39:339–358
6. Arnold IJM, Vrugt EB (2002) Regional effects of monetary policy in the Netherlands. International Journal of Business and Economic 1:123–134
7. Dongmei K (2001) The theory of optimum currency areas and its reference to Chinese monetary policy. Journal of Central University of Finance and Economics 1:28–32 (In Chinese)

8. Wang S, Zhengsheng Z (2006) The existence and origin of regional effects of monetary policy in China — An analysis based on the theory of optimum currency areas. Economic Research Journal 3:46–58 (In Chinese)
9. Ze Y (2006) Analysis on the regional effects of Chinese monetay policy. Management World 2:118–22 (In Chinese)
10. Danfeng K, Cortes BS, Dazhong Q (2007) Regional effects of China's monetary policy: 1980-2004. Journal of Financial Research 12:17–26
11. Jiang Y, Zhang C (2009) An empirical study of regional effect of monetary policy under SVAR model: 1978-2006. Journal of Financial Research 4:180–195 (In Chinese)

Chapter 39
Safety Assessment of Crane based on FTA and ANP

Jian Zhang, Yuanrong Zhang, Chao Ji and Yudong Li

Abstract A new approach towards safety assessment on the cranes in service was proposed in this paper. The Fault Tree Analysis (FTA) was implemented to conclude common types of accidents and causations based on literature research and practical experience of special equipment safety assessment. Safety assessment indicators was extracted from the fault tree. Indicator system was organized by factors of human, equipment, management and environment. As the causations of accidents are mostly with dependence and feedback, analytical network process (ANP) is utilized to obtain the weights of indicators. The proposed approach provides a valuable reference for decision-making in crane risk assessment practice.

Keywords Crane · Safety assessment · Fault tree analysis (FTA) · Analytical network process (ANP)

39.1 Introduction

The cranes are widely used in ports, engineering construction, equipment manufacturing and other industries. Once accidents occur with cranes, casualties or economic losses would be enormous. Injuries caused by the operation of cranes pose a serious public problem [1]. Crane activities are responsible for most percent of machinery casualties in China [2]. China has stipulate crane as one of the 8 categories of special equipments to supervise its safety operation [3].

As cranes are so widely used and the complex of their components, accidents are likely to happen in operations. The study on safety assessment of cranes in China

---

J. Zhang (✉) · Y. Zhang
Fujian Special Equipment Inspection and Research Institute, Fuzhou 350008, P. R. China
e-mail: 32141081@qq.com

C. Ji · Y. Li
Business School, Sichuan University, Chengdu 610065, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_39,

is relatively poor and systematic safety evaluation application has not been implemented in special equipment inspection work yet. Xu and Fan used FAHP to evaluate the safety of bridge crane [4]. Qian, Li attempted to use neural network method to evaluate the safety statue of crane [5, 6]. Sun analyzed the fault tree of port lifting operation, and conducted an Analytical Hierarchy Process to obtain the weights of safety assessment indicators [7].

This article presents a safety assessment model on crane equipment by using Analytical Network Process (ANP). The index system was based on the causes of different kinds of accidents analyzed by Fault Tree Analysis (FTA). Indicators was extracted from the fault tree and organized by factors of human, equipment, management and environment. As the indicators are interdependence, Analytical Network Process was implemented to calculate the weights. The results present a useful reference for both safety management and supervision on cranes.

39.2 Fault Tree Analysis on Crane

The enormous static data of accidents caused by crane activities and literature review showed that accidents may be grouped in the following categories: falling loads, extrusion or collision, collapsing or overturning of cranes, and electrocution shock [8, 9].

Falling loads [10–12] was mainly caused by defective slings or spreaders and improper bundling. The lifting operation need strong collaboration between driver and rigging workers. But in actual work, commanders, drivers and rigging workers are constituted temporally. Operation mistakes are very likely to occur.

Extrusion or collision [13, 14] of equipment was mainly caused by working in the danger zone, waving loads or collapsing of cargoes. Electrocution shock usually happened in construction sites or harbors, where the operation sites were complex and with many high voltage lines. And collapsing or overturning of cranes mostly occurred in the mobile cranes and tower cranes.

The fault tree of cranes was presented in Fig. 39.1, based on literature research and safety supervision experience of the author.

39.3 Safety Assessment Index System on Crane

A systematic assessment of safety statue of equipment operation should take personal factors, equipment factors, managerial factors and environmental factors into consideration. By grouping the bottom events into these four categories, the index system was shown in Fig. 39.2.

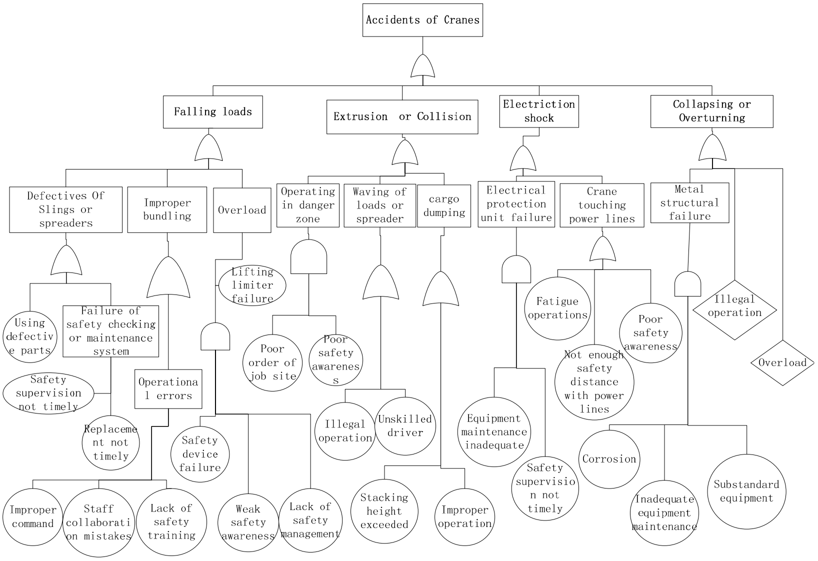


Fig. 39.1 Fault tree of cranes

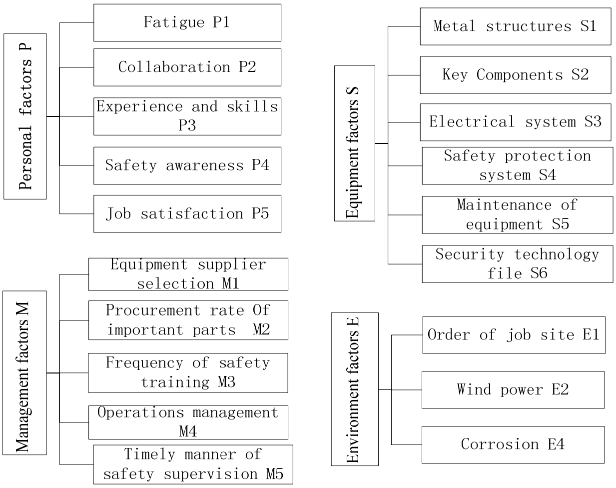


Fig. 39.2 Index system for crane equipment safety assessment

39.4 Analytical Network Process

Analytical Network Process (ANP) was presented by Saaty [15] to resolve decision making problems with dependence and feedback. A hierarchical framework with a linear top-to-bottom form is not appropriate for complex systems. In addition to the merits of AHP, the ANP provides a more generalized model in decision-making without making assumptions about the independency of the higher-level elements from lower-level elements and also of the elements within their own level [16].

The system was divided into control hierarchy and network hierarchy in ANP [17]. The control hierarchy includes the decision-making goal and criteria. All the criteria should be dependent and only dominated by the goal. Weights of criteria can be obtained by implementing Analytic Hierarchy Process. The network hierarchy was organized by clusters of decision indicators.

39.4.1 Construction of ANP Model

According to the index system established, strategy subjects, indicators and alternatives were used to construct the ANP model shown in Fig. 39.3. The arrows demonstrates the interdependency of each dimension. If factor A have an effect on factor B, then an arrow points from A to B was drawn in Fig. 39.3. The interdependency of each indicators was shown in Table 39.1. Number 1 demonstrates that column factor have an effect on the row factor, while number 0 demonstrates they have no relationship.

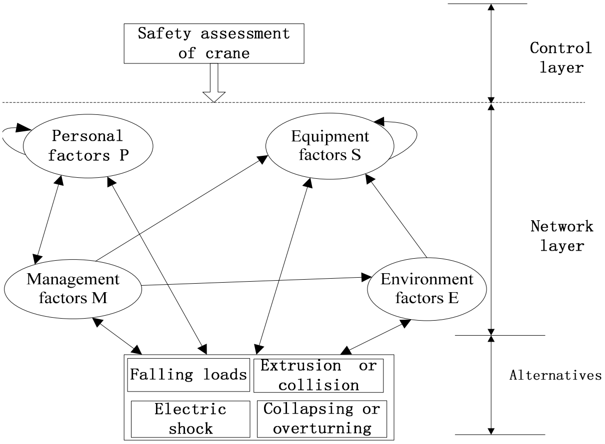


Fig. 39.3 ANP model for crane equipment safety assessment

Table 39.1 Relationships among indicators

	P1	P2	P3	P4	P5	S1	S2	S3	S4	S5	S6	M1	M2	M3	M4	M5	E1	E2	E3	A1	A2	A3	A4
P1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
P2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
P3	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1
P4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1
P5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
S1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	1
S2	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0
S3	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0
S4	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1
S5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1
S6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1
M1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
M2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
M3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
M4	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0
M5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1
E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
A1	1	1	1	1	1	0	1	0	1	0	1	0	1	0	1	1	1	0	0	0	0	0	0
A2	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	0	0	0
A3	1	0	1	1	1	0	0	1	1	0	1	0	1	0	1	1	1	0	0	0	0	0	0
A4	1	0	1	1	1	1	1	0	1	0	1	0	1	0	1	1	1	0	1	0	0	0	0

39.4.2 Supermatrix of Unweighted Priorities

Supermatrix of unweighted priorities was composed of local priority vectors obtained by pairwise comparisons. Safety is the only criterion in Model of this study. When doing pairwisely comparisons, criterion of the sub net in the control layer should be taken as the main criterion, and a certain indicator of the sub net should be taken as the secondary criterion. Comparison matrix could be constructed by the degree of influence, which was same with the AHP. The relative importance values are determined on a scale of 1-9 recommended by Satty [18], implications of each degree was shown in Table 39.2.

This study conducted a questionnaire research towards a grope of relevant experts to construct the comparison matrix. Questions were asked in the questionnaire such as: concerning the safety statue of crane, as to element A, comparing elements B and C, which element is influenced more by element A. By reviewing the questionnaires, geometric mean was obtained and transformed into the comparison matrix.

Local priority vectors W_{ij} was obtained by using the eigenvector method. All the consistency ratios (CR) were less than 0.1. The supermatrix of unweighted priorities was organized as the following form, and the supermatrix was shown in Table 39.3.

Table 39.2 The fundamental scale for making judgments

1	Equal Importance
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very, very strong
9	Extreme importance
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i

39.4.3 Supermatrix of Weighted Priorities

The weights of clusters could also be obtained from the comparison matrix. Define U_{ij} as the weight that cluster i affects cluster j, then $\bar{W}_{ij} = U_{ij} * W_{ij}$, the supermatrix of weighted priorities should be organized as the following form. The supermatrix of weighted priorities with normalized column was shown in Table 39.4.

39.4.4 Limit Supermatrix

The limit supermatrix can be calculated from the supermatrix of weighted priorities. When $\bar{w}^{\infty} = \lim_{t \to \infty} w^t$ exits, the final priorities of elements could be found in the corresponding columns in the limit supermatrix [19]. And if there are more than one criterion in the control hierarchy, other supermatrix should be obtained and additional calculation should be made to get the final priorities.

In this study, as there are 19 indicators and 4 alternatives, the calculation of limit supermatrix could be very complex. The calculation in this study was with the help of Super Decision software. Super Dcision is an expert software developed by T.L. Satty. Once model was constructed and comparisons of nods and clusters was made, the calculation results of limit supermatrix could be easily obtained. Calculation results of limit supermatrix in this study was listed in Table 39.5.

39.4.5 Results

According to the limit supermatrix, the normalized weight vector of four categories of accidents on crane is (0.43794,0.23301,0.15900,0.17005), which means that the frequency of occurrence on the four categories. The normalized priorities of each indicators was listed in Table 39.6. The results shows that experience and skills,

Table 39.3 Supermatrix of unweighted priorities

	P1	P2	P3	P4	P5	S1	S2	S3	S4	S5	S6	M1
P1	0	0	0	0	0	0	0	0	0	0	0	0
P2	0.297	0	0	0	0.750	0	0	0	0	0	0	0
	0.077	0.077										
P3	0.540	0	0	0	0.250	0	0	0	0	0	0	0
P4	0	0	0	0	0	0	0	0	0	0	0	0
P5	0.163	0	0	0	0	0	0	0	0	0	0	0
S1	0	0	0	0	0	0	0	0	0	0.107	0.212	0.122
S2	0	0	0	0	0	0	0	0	0	0.415	0.294	0.246
S3	0	0	0	0	0	0	0	0	0	0.185	0.225	0.082
S4	0	0	0	0	0	0	0	0	0	0.293	0.270	0.155
S5	0	0	0	0	0	0	0	0	0	0	0	0
S6	0	0	0	0	0	0	0	0	0	0	0	0.395
M1	0	0	0	0	0	0	0	0	0	0	0	0
M2	0	0	0	0	0	0	0	0	0	0	0	0
M3	0	0	0	0	0	0	0	0	0	0	0	0
M4	0	1.000	0	0	0	0	0	0	0	0	1.000	0
M5	0	0	0	0	0	0	0	0	0	0	0	0
E1	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	0	0	0	0	0	0	0	0	0	0	0
A1	0.274	1.000	0.424	0.481	0.525	0	0.540	0	0.467	0	0.141	0
A2	0.517	0	0.263	0.295	0.244	0	0.163	0	0.277	0	0.141	0
A3	0.117	0	0.202	0.131	0.131	0	0	1.000	0.160	0	0.263	0
A4	0.092	0	0.110	0.092	0.101	1.000	0.297	0	0.095	0	0.455	0

	M2	M3	M4	M5	E1	E2	E3	A1	A2	A3	A4
P1	0	0	0	0	0	0	0	0.129	0.209	0.239	0.117
P2	0	0	0	0	0	0	0	0	0.305	0.122	
	0.077	0.077									
P3	0	0.250	0	0	0	0	0	0.209	0.349	0.259	0.221
P4	0	0.750	0	0	0	0	0	0.258	0.209	0.314	0.431
P5	0	0	0	0	0	0	0	0.099	0.110	0.111	0.155
S1	0	0	0	0	0	0	1.0000	0	0	0	0.257
S2	0.300	0	0	0	0	0	0.000	0.443	0	0	0
S3	0.098	0	0	0	0	0	0	0	0	0.311	0
S4	0.159	0	0	0	0	0	0	0.169	0	0.000	0.126
S5	0.443	0	0	0	0	0	0	0.387	0	0.493	0.391
S6	0	0	0	0	0	0	0	0	0	0.196	0.226
M1	0	0	0	0	0	0	0	0.084	0	0	1.000
M2	0	0	0	0	0	0	0	0.273	0	0.169	0
M3	0	0	0	0	0	0	0	0.152	0	0.261	0
M4	0	0	0	0	0	0	0	0.263	1.000	0.451	0
M5	0	0	0	0	0	0	0	0.228	0	0.119	0
E1	0	0	1.000	0	0	0	0	1.000	0.750	0	0.750
E2	0	0	0	0	0	0	0	0	0.250	0	0
E3	0	0	0	0	0	0	0	0	0	1.0000	0.250
A1	0.800	0	0.451	0.333	0.227	0	0	0	0	0	0
A2	0	0	0.261	0	0.424	1.000	0	0	0	0	0
A3	0.200	0	0.169	0.140	0.227	0	0	0	0	0	0
A4	0	0	0.119	0.528	0.122	0	1.000	0	0	0	0

Table 39.4 Supermatrix of weighted priorities

	P1	P2	P3	P4	P5	S1	S2	S3	S4	S5	S6	M1	M2	M3	M4	M5	E1	E2	E3	A1	A2	A3	A4
P1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.058	0.131	0.107	0.052
P2	0.115	0	0	0	0.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.136	0.076	0.035	0.034
P3	0.115	0	0	0	0.29	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0.094	0.218	0.116	0.099
P4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0.116	0.131	0.14	0.193
P5	0.063	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.044	0.069	0.05	0.069
S1	0	0	0	0	0	0	0	0	0	0.107	0.063	0.122	0	0	0	0	0	0	0.2	0	0	0	0.073
S2	0	0	0	0	0	0	0	0	0	0.415	0.087	0.246	0.057	0	0	0	0	0	0	0.125	0	0	0
S3	0	0	0	0	0	0	0	0	0	0.185	0.067	0.082	0.019	0	0	0	0	0	0	0	0	0.088	0
S4	0	0	0	0	0	0	0	0	0	0.293	0.08	0.155	0.03	0	0	0	0	0	0	0.048	0	0	0.036
S5	0	0	0	0	0	0	0	0	0	0	0	0	0.085	0	0	0	0	0	0	0.11	0	0.14	0.111
S6	0	0	0	0	0	0	0	0	0	0	0	0.395	0	0	0	0	0	0	0	0	0	0.055	0.064
M1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.014	0	0	0.164
M2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.045	0	0.028	0
M3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.025	0	0.043	0
M4	0	0.209	0	0	0	0	0	0	0	0	0.163	0	0	0	0	0	0	0	0	0.043	0.228	0.074	0
M5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.037	0	0.019	0
E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.147	0	0	0	0	0.106	0.111	0	0.079
E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.037	0	0
E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.106	0.026
A1	0.168	0.791	0.424	0.481	0.322	0	0.54	0	0.467	0	0.076	0	0.647	0	0.385	0.333	0.227	0	0	0	0	0	0
A2	0.317	0	0.263	0.295	0.149	0	0.163	0	0.277	0	0.076	0	0	0	0.223	0	0.424	1	0	0	0	0	0
A3	0.072	0	0.202	0.131	0.08	0	0	1	0.16	0	0.142	0	0.162	0	0.144	0.14	0.227	0	0	0	0	0	0
A4	0.056	0	0.11	0.092	0.062	1	0.297	0	0.095	0	0.246	0	0	0	0.101	0.528	0.122	0	0.8	0	0	0	0

Table 39.5 Limit supermatrix

	P1	P2	P3	P4	P5	S1	S2	S3	S4	S5	S6	M1	M2	M3	M4	M5	E1	E2	E3	A1	A2	A3	A4
P1	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
P2	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
P3	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
P4	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066
P5	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
S1	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
S2	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
S3	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
S4	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
S5	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
S6	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
M1	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
M2	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
M3	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
M4	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
M5	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
E1	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
E2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
E3	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
A1	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194
A2	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
A3	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
A4	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074

safety awareness, collaboration, operations management and key components are the most important factors affecting the safety operation of cranes.

Table 39.6 The weight of indicators

		Priorities from Limiting Matrix	Priorities Normalized by Cluster			Priorities from Limiting Matrix	Priorities Normalized by Cluster
P	Fatigue P1	0.064734	0.145508	M	Equipment supplier selection M1	0.026595	0.161095
	Collaboration P2	0.09182	0.206391		Procurement rate of important parts M2	0.019047	0.115374
	Experience and skills P3	0.122314	0.274935		Frequency of safety training M3	0.014015	0.084894
	Safety awareness P4	0.118306	0.265926		Operations management M4	0.089993	0.545118
	Job satisfaction P5	0.047709	0.107239		Timely manner of safety supervision M5	0.015439	0.093519
S	Metal structures S1	0.02562	0.089856	E	Order of job site E1	0.081232	0.774339
	Key Components S2	0.083524	0.29294		Wind power E2	0.006845	0.06525
	Electrical system S3	0.028646	0.100469		Corrosion E3	0.016828	0.160412
	Safety protection system S4	0.049295	0.17289				
	Maintenance of equipment S5	0.072051	0.252701				
	Security technology file S6	0.025987	0.091143				

39.5 Conclusions

This paper proposed a new approach to establish the safety assessment index system of cranes in service. Literature research has been taken to summarize the categories of accidents on cranes and the main causes of accidents. Fault Tree Analysis (FTA) was implemented to make an information support for constructing the assessment index system. The proposed model contains four dimensions, human, equipment, management and environment. By a round of focus group meeting with experts in this field, the analytical network process (ANP) is utilized to obtain the weights of indicators.

The calculation results show that people is the major dimension of concern. Other dimensions sorted by decreasing weights are equipment, management and environment. The priorities showed in Table 39.6 could provide a good reference for both crane equipment safety management and safety assessment.

39.6 Acknowledgements

This research is funded by the large-scale technology projects of Fujian Special Equipment Inspection and Research Institute, “Research on special equipment hidden dangers of accidents classification and grading methods and mechanism of scientific investigation and management”, the National Nature Science Foundation of China (71131006; 71020107027; 71192197), and the Foxconn Technology Group’s Talent Selection Research Program (11F81210101).

References

1. Aneziris ON, Papazogloufℓ IA, Mud ML et al (2008) Towards risk assessment for crane activities. Safety Science 46:872–884
2. Huang QP, Shi JY, Liu YQ (2006) Risk factors and security management of lifting machinery. Chinese Journal of Raremetal 30:146–149
3. Zhu RJ (2003) Special equipment safety supervision regulations. Hoisting and Conveying Machinery 1–6
4. Xu GN, Jiang F (2010) Safety assessment on the crane based on FAHP. Journal of Safety and Environment 10:196–200
5. Qian NJ, Cheng QP, Liu ZY (2011) Research on intrinsic safety assessment method for lifting appliances based on LMNN. Journal of Nanchang University (Natural Science) 35:197–200
6. Li B, Chen DF, Tao DX (2006) Crane safety evaluation based on artificial neural network. Hoisting and Conveying Machinery 52–55
7. Sun L, Wang MT, Ye SM et al (2010) Use of Analytic Hierarchy Process in the port lifting handling operation fault tree analysis. China Water Transport 10:190–193
8. Han SX (2008) Safety management on special equipment. Science and Technology Press 123–135
9. Bureau of General Administration of Quality Supervision (2008) Institute of special equipment, accident investigation and handling in Bureau of general administration of quality supervision, inspection and quarantine of the state, sets of typical accident cases for special equipment. Aviation Industry Press 159–193
10. Zhang ZX (2008) Accident analysis of hook-gliding of portal crane. Construction Mechanization 29:72
11. Li Y (2007) Accident tree analysis on crane load falling accident. Accident Tree Analysis on Crane Load Falling Accident 41–42
12. Mazzola A (2000) A probabilistic methodology for the assessment of safety from dropped loads in offshore engineering. Risk Analysis 20:327–337
13. Yu ZP, Lu YS, He HG (2006) Analysis on squeezing accidents of lifting operation and the prevention. Industrial Safety and Environmental Protection 32:56–58
14. Shi CX, Yang T (2006) Analysis on the typical model of the lifting injury accident tree. Sci-Tech Information Development & Economy 16:177–178

15. Satty TL (1996) The analytic network processRWS Publications, Pittsburgh
16. Xu PP, Chan EHW (1996) ANP model for sustainable Building Energy Efficiency Retrofit (BEER) using Energy Performance Contracting (EPC) for hotel buildings in China. Habitat International 1016:1–9
17. Guo JL, Jiang W (2009) Research on evaluation indices system of medical quality based on ANP. Chinese Journal of Medical Device 22:14–17
18. Satty TL (2004) Decision making — the Analytic Hierarchy and Network Processes (AHP/ANP). Journal of Systems Science and Systems Engineering 13:1–34
19. Du HB, Li H, Yuan LP et al (2010) Risk assessment model for air traffic control based on Fuzzy-ANP method. China Safety Science Journal 20:79–85

Chapter 40
The Study of the GDP Simulation Model based on 3SLS-PCA

Yue He, Qiuyan Guo and Niu Xie

Abstract Utilizing three-stage least squares method (3SLS) as basic algorithm, eventually establish a model which can clearly describe the development of Chengdu's GDP through data collection initial construction, application of principal component analysis (PCA) dealing with multicollinearity, parameter estimation as well as model validation and error analysis. The model can accurately simulate the relationship between development of Chengdu's GDP and the main economic variables in order to provide scientific support for government decision-making.

Keywords Economic simulation · Principal components analysis · 3SLS · GDP

40.1 Introduction

GDP is a core indicator that measures the economy development of a country and region, its importance makes it be hot spots for study. Around the GDP forecasts, scholars also carried out many studies using a variety of methods from different angles. Initially people used a single model to predict, such as regression analysis method, time series analysis method, Gray Prediction, Artificial Neural Networks and so on. But different prediction method has its limitation and it may affect the prediction results. For example, there may be co-linearity and over-fitting phenomenon in ARIMA model and it will affect the prediction capability of the model [1]; the results that different data of GMDH auto-regression model predicts by group is different, which lead to prediction results having biases [2]; Document [3] combining climate data and statistics data makes prediction model, which improves forecast accuracy, Document [4] combines each model using multiple linear regression on the basis of comparing and analyzing a few characteristics prediction

---

Y. He (✉) · Q. Guo · N. Xie
Business School, Sichuan University, Chengdu 610064, P. R. China
e-mail: heyue@scu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_40,

methods and get a better prediction result. These research achievements basically study based on regression model.

Complexity science believes that macro-economic system is a complex system, relationship between many factors is very complex, simulation method for complex system can be used to simulate the relationship between multiple factors of system, so as to make scientific predictions through the simulation model. Currently the domestic research on economic simulation mainly views the micro-economic subject as an object for study, such as enterprises and individuals in the economic environment, or a subdividing market, but the simulation study on Macro-economic is relatively less, this paper established Chengdu macroeconomic simulation models using three - stage least squares method and principal components analysis method to simulate the relationship between the main economic indicators and provide help for macro-economic decision-making. The GDP simulation model is a main model among them.

40.2 Basic Model Form

40.2.1 Economic Simulation

Economic simulation is a method that refers to Utilizing real-world economic environment and the characteristics of economic agents as prototype, abstracting economic systems as program model in the computer for calculations and simulating economic operation of reality [5]. We can simulate the changes of some economic variables in real-life by changing the settings of some parameters and observe the result that the program runs and utilize it as an assistant method of economic decision-making.

Economic simulation is based on the theory of Complex Adaptive System that John. Holland in Santa Fe Institute of USA produced in 1994 [6]. Complex Adaptive Systems is a theory concerning the mechanism of system complexity. The theory believes that the cause of system complexity is mainly from the internal and it results from a lot of adaptive agents. While the economic system is a typical complex adaptive system and its origin of the complexity is the adaptive agents, that is, human's interaction. Specifically, every entity (person) involves in an economic environment consisting of a large amount of other subject, they constantly interact with the surrounding subject and correct their behavior according to the result (i.e., adaptive). Thus, from the micro perspective, economic has great uncertainty and from the macro perspective, economic also has certain regularity.

For socio-economic system, it is difficult to conduct experiments in real economic system, even if it can be experimented, it will cost a lot of human, material and financial resources and time, only then can understand the consequences and impacts caused by the changing of economic system parameters [7]. While the simulation uses the model to realize the essential process occurred in the actual system and study the existed or the designing system through experiments on the system model. Therefore, in the study of the socio-economic system, simulation is a particularly effective method of research and there will be particularly important practical significance using simulation technology to study the social economy.

40.2.2 Three-stage Least Squares Method

It is necessary to establish a lot of model equations consisting of economic variables when studying economic systems, In the model equations some economic variables are exogenous variable, some economic variables are endogenous variable and besides some may also include early or lag variable, the estimates of the traditional ordinary least squares (OLS) related with explanatory variables and stochastic disturbance term are biased and inconsistent because of endogenous variable appearing in the right side of the model equations. Therefore, it need select other parameter estimation methods to determine the equation parameters of the simultaneous equation models.

Three-stage least squares method (3SLS) is a system estimation method, belongs to the categories of the equation system methods and can determine the parameters of each equation in a multi-equation model at the same time to obtain consistent and asymptotically efficient estimator [8]. According to the experiments and research on the two-stage least squares (2SLS) and the three-stage least squares (3SLS) for many times in the past, we found in most cases the estimates of standard errors of three-stage least squares (3SLS) are less than the estimates of standard errors of two-stage least squares (2SLS) and this is a reflection to the effectiveness of estimates of 3SLS. Of course, due to the three-stage least squares belonging to the categories of the equation system methods, therefore the deterministic error is relatively sensitive and this requires we should pay attention to the collection of variable data and ensure the observation error of variable data as small as possible, so as not to affect the parameter estimation results of the whole model in the practical application.

40.2.3 The Principal Components Analysis Method

The basic idea of the Principal component analysis is that according to using irrelevant variables to replace the more original variables and reflecting the information of the original multi-variable as far as possible, so as to achieve the effect of dimensionality reduction and the assignment of the weight of non-subjective indicators and can make the comprehensive evaluation measured by multiple indicators more objective and reasonable based on the correlation between variables.

The main steps of the principal components analysis method [10]:

1. The standardization of data processing. It is necessary to standardize the data because of the unit or measuring unit of it being different, like $X_{ij} = \frac{X_{ij}-\overline{X_{.j}}}{S}$, n is the sample size in $S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(X_{ij}-\overline{X_{.j}}\right)}$.
2. The judgment of correlation between indicators;
3. Determining the number of principal components m;
4. The expression equation of principal components Y_i;
5. Naming for principal components Y_i.

40.3 The Empirical Analysis

Establishing the GDP economic simulation model in Chengdu includes six main steps: collecting and processing the data; constructing model equations; eliminating multi-co-linearity; estimating the model's parameters; getting the initial model; model validation and error analysis.

40.3.1 Collecting and Processing the Data

All the original data are directly or indirectly from the Statistical Yearbook (1990-2007) of Sichuan Province and Chengdu when establishing the model of economic simulation system including that establishing the simulation model uses the time series data from 1990 to 2002 while the index series data from 2003 to 2007 are used to verify the simulation effect of the final simulation system model. The original data include a total of 58 economic variable indicators. These indicators refer to the indicators that the government of Chengdu hopes to focus on consideration and the variable indicators that these project experts suggest.

We have a pre-processing for the time series data of these 58 variable indicators that remove the dimensions of each original data series through chain relative ratio method before establishing the model equation, this process can avoid the phenomenon that the dimensions of indicator variables are inconsistent as well as the effects resulting from the large disparities between numerical magnitudes of each indicator variable and the unreasonable phenomenon [9] when analyzing the data. The indicator variables after dimensionless process can directly do some algebraic operations and other comprehensive analysis.

40.3.2 Constructing Model Equations

The variable indicator of the GDP economic simulation model equation in Chengdu is selected after the comprehensive consideration to the result through qualitative analysis and quantitative analysis. Qualitative analysis mainly utilize economic theory, economic law, modeling principle and so on as the basis of analysis and at the same time add the analysis research needs that the government of Chengdu proposed; quantitative analysis is that do the relevant test for the relationship between the indicator variables, remove the variable index whose correlation coefficient is lower and keep and pick out the economic index whose correlation coefficient is higher to enter the model as an analysis object through the correlation analysis. At the same time in order to improve the degree of fitting and the precision of model equations, we use the constant adjustment technology that introducing random constants in each model equation and these random constants can represent those economic phenomena which cannot be described and expressed by certain economic indicator, so as to make sure model equations contain overall economic information as possible and those factors which can not be counted or affect the economy slightly can be taken into account. Considering the above conclusion of analysis and eventually to determine the basic structure of the equation model and each variable of the model, as is shown in Table 40.1.

$$\begin{aligned}\mathrm{C\_GDP} = \; & c(1)*\mathrm{C\_CONS}+c(2)*\mathrm{C\_DI}+c(3)*\mathrm{C\_GDP2}+c(4)*\mathrm{C\_GDP3}\\ & +c(5)*\mathrm{C\_GFCF}+c(6)*\mathrm{C\_PCGDP}+c(7)*\mathrm{C\_RETAIL}+c(8)\\ & *\mathrm{CPI00}+c(9)*\mathrm{GDP00}+c(10)*\mathrm{C\_CG}+c(11)*\mathrm{C\_GDI}+c(12)\\ & *\mathrm{C\_GDP1}+c(13).\end{aligned}$$

40.3.3 Eliminating Multi-co-linearity by Using Principal Components Analysis Method

After constructing initial model equations, considering there is larger correlation between the variables in model equations and some independent variable in some equations can be expressed by the linear function of other independent variable approximately, that is to say there is proximate linear relationship between the independent variables and this is a common problem that we often meet when doing multiple regression analysis — multicollinearity.

This article uses principal components analysis to solve the problem of multicollinearity. On the one hand it can standardize the variable data, on the other hand it can eliminate the high co-linearity existing between variables [10].

We used SPSS to do principal components analysis and determined the principal components required. We found the cumulative contribution rate of the first five principal components reach the percentage of 98.480 and at the same time the

Table 40.1 The instruction of economic variable index

Variable's code	Variable's name	Variable's code	Variable's name
C_GDP	The city's GDP (current year, one hundred million Yuan)	C_RETAIL	Retail sales (current year, one hundred million Yuan)
C_CONS	Total consumption (current year, one hundred million Yuan)	CPI00	National consumer price index
C_DI	Total income(current year)	GDP00	GDP (current year, ten billion Yuan)
C_GDP2	Value-added of the second industry (current year, one hundred million Yuan)	C_CG	Government consumption (current year, one hundred million Yuan)
C_GDP3	Value-added of the third industry (current year, one hundred million Yuan)	C_GDI	Investment in fixed assets (current year, one hundred million Yuan)
C_GFCF	Gross fixed capital formation (current year, one hundred million Yuan)	C_GDP1	Value-added of the first industry (current year, one hundred million Yuan)
C_PCGDP	GDP per capita(current year)		

characteristic value of the five principal components is greater than or equal to 1, therefore, we use the five principal components to replace the 12 original variables. According to the data displayed by the software results, we got the expression equation formed by the five principal components through the linear combination of standardized variables, as is shown in Table 40.2.

Table 40.2 The relationship between principal components of equations and standardized variables

Variable	Principal component 1	Principal component 2	Principal component 3	Principal component 4	Principal component 5
C_CONS	0.100	0.146	−0.507	−0.174	−0.058
C_DI	0.090	−0.114	0.500	−1.070	−0.285
C_GDI	0.094	−0.143	0.763	0.438	0.040
C_GDP1	0.077	0.437	−0.101	−0.386	0.556
C_GDP2	0.104	0.071	0.425	0.241	−0.139
C_GDP3	0.096	−0.188	−0.652	−0.229	0.659
C_GFCF	0.099	−0.182	0.123	0.366	1.528
C_PCGDP	0.107	0.002	−0.121	−0.058	0.470
C_RETAIL	0.098	−0.249	−0.055	−0.093	−0.254
CPI00	0.071	0.485	0.066	0.535	0.026
GDP00	0.103	0.137	0.045	−0.118	−1.322
C_CG	0.092	−0.219	−0.467	0.570	−1.156

40.3.4 Estimating the Model's Parameters by Using Three-stage Least Squares Method

We use EVIEW software and the three-stage least squares method to estimate the model's parameters and get the Coefficients and random items of each principal component of equation model, as is shown in Table 40.3.

Table 40.3 The result of parameter estimates

The coefficients of principal components and random items	Prob. (P)
2.386	0.0000
0.593	0.0034
−0.926	0.0107
−0.818	0.0000
0.674	0.0098
112.249	0.0000

The value of R^2 is 0.9833 after the adjustment and the fitting degree of equations is obviously good. The significance of coefficients that equations contain is relatively high (the value of P is basically lower than the given significance level 0.05) and this proves the variables that equations contain are basically all the factors that have a significant impact on the studied objects. So the equation model becomes

$$\begin{aligned} C\_GDP = {} & 2.386 * \text{factor\_1} + 0.593 * \text{factor\_2} - 0.926 * \text{factor\_3} - 0.818 * \text{factor\_4} \\ & + 0.674 * \text{factor\_5} + 112.249. \end{aligned}$$

40.3.5 Simulation Models

We need to turn the principal component expressions of model equations into the model equations consisting of original independent variables. Putting the relationship between principal component factors and standardized variables into model equation expressions and then we can get the model equation that expressed by standardized variables [10]. It contains the information including mean (Mean), standard deviation (Std. Deviation) and number of cases (N) in the Descriptive Statistics analysis table of SPASS. The transform between the original independent variables and the standardized independent variables need use the two indicators of mean and standard deviation, the concrete relationship is:

$$\text{Std}X(X - \text{Mean})/\text{Std. Deviation}.$$

As standardized variable $X = (\text{the original}X - \text{Mean})/\text{standard deviation}$.

Thus, according to this formula and the results of previous modeling, we can turn the model equations that expressed by standardized variables in the previous step into behavior equations consisting of the original independent variables, as shown below:

$$
\begin{aligned}
\mathrm{C\_GDP} = {} & 0.118098 * \mathrm{C\_CONS} + 0.095575 * \mathrm{C\_DI} + 0.168656 * \mathrm{C\_GDP2} \\
& + 0.143922 * \mathrm{C\_GDP3} + 0.108141 * \mathrm{C\_GFCF} + 0.138517 * \mathrm{C\_PCGDP} \\
& + 0.108204 * \mathrm{C\_RE\ TAIL} + 0.270564 * \mathrm{CPI00} + 0.063256 * \mathrm{GDP00} \\
& + 0.04791 * \mathrm{C\_CG} + 0.04623 * \mathrm{C\_GDI} + 0.084313 * \mathrm{C\_GDP1} - 29.3978.
\end{aligned}
$$

40.3.6 Model Validation and Analysis

In order to verify the accuracy and simulation effect of equation models established previously, we use the total GDP collected from 2003 to 2007 in Chengdu to calculate and analyze the relative error between real values and simulated values.

Using the equation model to calculate the GDP simulated values from 2003 to 2007 in Chengdu and then comparing to the real value from 2003 to 2007 separately to calculate the relative error and error mean over the years. The concrete validation conclusion of the fitting effect of the model is shown in Table 40.4.

Table 40.4 The error analysis of the GDP simulation model from 2003 to 2007 in Chengdu

Year	The simulated value of GDP (one hundred million Yuan)	Thereal value of GDP (one hundred million Yuan)	The relative error (%)
2003	1864.155	1870.89	−0.36
2004	2188.571	2185.73	0.13
2005	2387.365	2370.77	0.07
2006	2755.981	2750.48	0.02
2007	3354.088	3324.17	0.09

The mean of the error absolute value from 2003 to 3007 is 0.134%, the analysis results show that the simulation effect of the model is very good and the model can basically describe the correlation and influence between GDP of Chengdu and other main economic variables.

Observing the model and we can find that the economic indicator variables having direct influence on GDP mainly contain C_CONS (total consumption), C_DI (total income), C_GDP2 (value-added of the second industry), C_GDP3 (value-added of the third industry), C_GFCF (gross fixed capital formation), C_RETAIL (retail sales), CPI00 (national consumer price index), GDP00 (GDP), C_CG(government consumption), C_GDI (investment in fixed assets), C_GDP1 (value-added of the first industry) and so on. The relationship between these economic indicator variables and are GDP is all positively related, that is to say if these economic indicator variables increase, the GDP will increase and on the contrary if these economic variables decrease, the GDP will decrease.

The GDP model equation itself contains several indicators data and can provide rich information, but several indicators will certainly increase the complexity and difficulty of the analysis, at the same time there is also certain correlation between these indicators, so if any of these variables changes, it can influence the change of other variables of the model equation, that is to say it is not a independent relationship between variables but can restrict and influence with each other.

40.4 Conclusions

This paper established the GDP economic simulation model in Chengdu through the six steps including collecting and processing the data, constructing model equations, eliminating multi-co-linearity, estimating the model's parameters, getting the initial model, validating the model and analysing the error combining quantitative and qualitative analysis methods, as long as we make the forecasts and judgments for the factors influencing GDP, we can make the forecast for the development trend of GDP in the future and we can seek for policy measures and adjustment means that can make the development of GDP in Chengdu better and faster to provide some valuable suggestion for government decision makers.

The factors influencing GDP are mainly the three aspects including investment, consumption, and exports, but it is very complex when it comes to the macro-economic indicators, so how to establish the relational model between GDP and other macro-economic indicators is the problem that we need to study deeply in the future.

Acknowledgements The authors acknowledge the financial support Humanities and social science planning fund project of the Ministry of education of China, project No. 11YJA630029. The author is grateful to the anonymous referee for a careful checking of the details and for helpful comments that improved this paper.

References

1. He Y, Bao A, He C (2004) Research on the self-organizing modeling method and the GDP growth model. The management science in China 12:139–142 (In Chinese)
2. He C(2005) The self-organizing data mining and economic forecast. Science Press, Beijing (In Chinese)
3. Feng Y, He Y(2010) Research on the GDP combination prediction model combining the climate index. Statistics and Decision 20:19–21 (In Chinese)
4. Zhang Y, He C (2007) The application and research of the total industrial profit at the aspects of combination and forecast in Sichuan province. Forum of Association for Science and Technology 6:124–125 (In Chinese)
5. Wang H (2002) Modeling and simulation. Science Press, Beijing (In Chinese)

6. Zhu J (2011) The simulation modeling and implementation of capital flow of multi-government fiscal behaviour. Shanghai Jiaotong University, Shanghai (In Chinese)
7. Alan A (2002) Categorical data analysis. Hoboken, N. J. John Wiley & Sons, Inc. US
8. Wang N, Li G (2001) The analysis of the case of econometric modeling test based on software EVIEWS. Research on Quantitative and Technical Economics 10:94–97 (In Chinese)
9. Shang H (2008) The comparison of China's tax revenue forecast model in 2005. Statistics and Information Forum 23:27–31 (In Chinese)
10. Yu C (2007) SPSS and statistical analysis. Publishing House of Electronics Industry, Beijing (In Chinese)

Chapter 41

System Dynamics Simulation Model for Port Economy Analysis

Daming Li and Xinqiao Wang

Abstract This paper looks into the dynamic effect of ports on urban economy. Analysis of port's influence on economy is conducted based mainly on system dynamics (SD), combining also input- output method, the Multiplier, and econometrics model. By applying the SD model in the port economic system of Zhuhai city together with performing both base simulation and policy simulation of such model, it concludes the dynamic impact of Zhuhai Port on urban economy by the year 2025 and puts forward suggestions for Zhuhai Port development.

Keywords System dynamic · Econometrics model · Simulation · Dynamic diversifications · Input-output method · Multiplier

41.1 Introduction

Use the template With the gradual recovery of the world economy, the cargo throughput of international shipment is on the rise. Port, as a connection point for surface transport, plays an important role in the transportation network. The entire port system is interdependent to the regional economies where the city is located, and it performs a dual function in the urban economy, i.e., the subordinate and the guide functions. The more developed the urban economy is, the greater its dependence is to the port system; the development of the urban economy in return further promotes the development of the port. Therefore, it is particularly important to conduct quantitative studies about the port contribution to the national economy and regional economy.

D. Li (✉)
School of Management, City University of Macau, Macau 999078, P. R. China
e-mail: 103v@163.com

X. Wang
Logistics Teaching-Research Section, Zhuhai City Polytechnic, Zhuhai 519000, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_41, © Springer-Verlag London 2013

As the port system is a nonlinear system, there are usually multiple feedback and long delays. It is hence quite difficult to apply theories, methods and static views of linear system to describe the port system, and there is no way to rely on intuitive experience to master and track developments and changes in the social system. According to the characteristics of the ports in China and based on the combination of system dynamics and input-output method [1, 2], the multiplier method [3] as well as the econometric models [4, 5], this article attempts to quantitatively study the dynamic impact of the ports to the socio-economy. Similar studies in both China and oversea are also known as the Port Economic Impact Studies.

41.2 Analysis of Port System

For the national economy and urban economy, the port system is one of its subsystems. Therefore, the establishment of the port system model should take into account the reasonability between urban economic structure and the port system structure, as well as the relevance among the subsystems [6].

The issues in port system are very complicated, but basically they can be described as:

1. Ports are part of the national economy and the regional economy, and they contribute to the national GDP and income same as the other industries. Moreover, ports provide employment opportunities and taxes for the central and local government.
2. Ports provide handling, storage and other related services for the industry, trading and other sectors. From the perspective of ports, they have a forward linkage effect with these sectors.
3. Ports themselves are also consuming the products and services offered by the local and foreign industry and trading. Hence, from the perspective of ports, they have a backward linkage effect with the industrial sector and the service sector.
4. Due to their unique geographical locations and functions, ports have the attractive, productive and cohesive function to the industry. They also can stimulate the population growth in the local area, and thus they play a very important role in the urbanization and industrialization of the regional economy.

According to the principles of determining the boundaries of the research system in system dynamics and research purposes, this article defines that the dynamic port economic impact model includes six state variables: Gross Domestic Product (GDP), the throughput of the port, port capacity, natural resources, pressure and port fixed asset investment. In addition, there are four auxiliary variables, i.e., port-led GDP, stimulated employment by port, port revenue and port investment. With these variables, the model diagram of port system dynamics Fig. 41.1 is obtained.

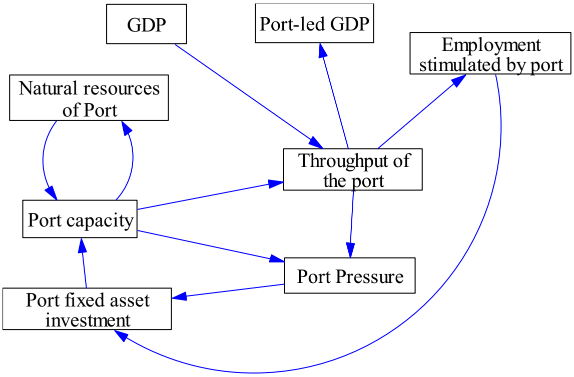


Fig. 41.1 The model diagram of port system dynamics

41.3 The Process of Establishing the Dynamic Port Economic Impact Model

This article established the above model by using VENSIM, Educational Version (see Fig. 41.2).

41.4 The Application of Dynamic Port Economic Impact Model in Zhuhai Port

There is no programming for VENSIM, and in fact this model is a set of differential equations. This model is applied to the city of Zhuhai Port, and the relationship between some of the main variables and the model values are as follows:

1. Port Contribution to the city = Port-led GDP/GDP (Dmnl).
2. Port fixed asset investment = INTEG (+ increased investment of fixed assets, the initial value of investment in fixed assets) (Ten Thousand Yuan).
3. Employment stimulated by port = throughput × Coefficient of port stimulated employment (Ten Thousand) 4) Port-led GDP = Throughput × Coefficient of Port-led GDP (Hundred Million Yuan).
4. Port Revenue = Throughput × Coefficient of throughput vs. port revenue (Ten Thousand Yuan).
5. Port Capacity = INTEG (+ Increased capacity, the initial capacity) (Ten Thousand Tons).
6. Port Throughput = INTEG (+ Increased throughput − Decreased throughput, initial throughput) (Ten Thousand Tons).
7. Port Pressure = INTEG (+ increased pressure, initial pressure) (Dmnl)
8. Increased pressure = Port Pressure × coefficient of pressure increment (Dmnl).

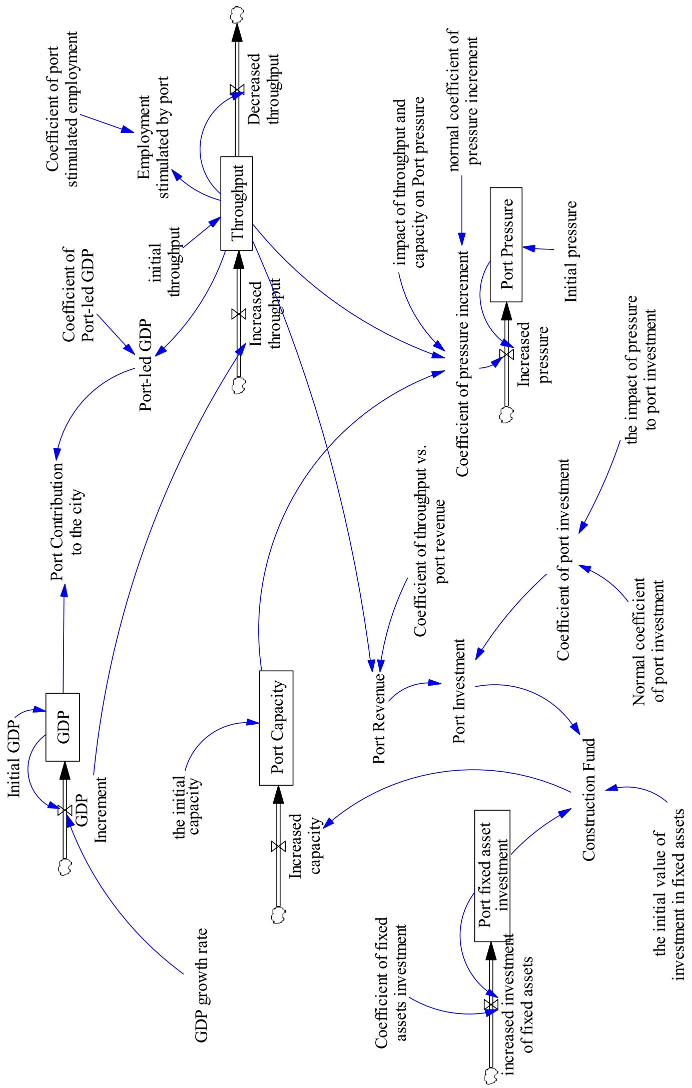


Fig. 41.2 The dynamic port economic impact model

9. Coefficient of pressure increment = normal coefficient of pressure increment × impact of throughput and capacity on Port pressure (Dmnl).
10. Port Investment = Port Revenue × Coefficient of port investment (Ten Thousand Yuan).
11. Coefficient of port investment = Normal coefficient of port investment × the impact of pressure to port investment (the change degree of port pressure) (Dmnl).

12. The increased investment of fixed assets = port investment of fixed assets × Coefficient of fixed assets investment (Ten Thousand Yuan/a).
13. Construction Fund = Port Investment of Fixed Assets − initial investment of fixed assets + Port Investment (Ten Thousand Yuan).
14. GDP = INTEG (+ GDP increment, Initial GDP) (Thousand Million Yuan).
15. GDP Increment = GDP × GDP growth rate

Basic Simulation and Policy Simulation are conducted for Zhuhai City by applying the Dynamic Port Economic Model.

It is very rare to set up a successful System Dynamic Model with just one simulation. It usually needs to be corrected for several times to reach the final completion. VENSIM provides methods like check model and units check, which allows model adjustment after equations are all established. The Basic Simulation cannot be conducted before all the checks are passed. The Basic Simulation does not consider the impact of joining CEPA (Closer Economic Partnership Arrangement), which is thus taken as zero in the model.

The Policy Simulation is an important analysis tool provided by System Dynamics. It analyses the impact of a specific policy on the system output by changing some of the policy variables in the system dynamics model.

There are three policy simulations implemented in this model:

1. Change the impact of joining CEPA (make the parameter to be 0.03) to simulate the changes in other variables after joining CEPA.
2. Add a pulse, 0.001 $*$ PULSE (2020, 5), to the reduction coefficient of the normal throughput. It means amplitude of 0.001 is added to the original base during 2020 and 2024, which will make the port competition becomes two times of the balance state.
3. Add a ramp function, RAMP (0.02, 2020, 2017), to the normal coefficient of pressure increment. It means the coefficient of pressure increment is gradually added with a ramp from 0 to 0.02 in Zhuhai Port between 2020 and 2025.

41.5 Result Analyses

The following conclusions are obtained by applying Dynamic Port Economic Model in Zhuhai City:

1. If the impact of joining CEPA is considered, according to the estimation of international organizations, i.e., GDP growth increased by 3%, the GDP of Zhuhai City will be 1,412.92 billion Yuan in 2025 − an increase of 66% compared to 850.03 billion Yuan in the planning. It proves that joining CEPA has made a substantial contribution to the economic development of Zhuhai City.
2. According to the results of the Basic Simulation, when general factors, joining CEPA, competitive factors and the port pressure are considered separately, the cargo throughput of Zhuhai Port in 2025 will be 4.75 times, 6.72 times, 3.38 times and 4.53 times comparing to that of 2007 respectively. After joining CEPA,

Table 41.1 Please write your table caption here

Year	Items	The model simulation results	The actual values	Relative error
2007	GDP/Hundred Million Yuan	1236	1235.64	0.03
	Port Throughput/Ten Thousand Tons	10046.8	10500	−4.32
	Port-led GDP/Hundred Million Yuan	146.7	156.03	−5.98
	Employment stimulated by port/Ten Thousand	26.9	28.14	−4.41
2008	GDP/Hundred Million Yuan	1384.3	1406.1	−1.55
	Port Throughput/Ten Thousand Tons	11190.7	11200	−0.08
	Port-led GDP/Hundred Million Yuan	166.3	166.432	−0.08
	Employment stimulated by port/Ten Thousand	30.0	30.016	−0.05
2009	GDP/Hundred Million Yuan	1550.4	1632.3	−5.03
	Port Throughput/Ten Thousand Tons	12471.9	12600	−1.02
	Port-led GDP /Hundred Million Yuan	188.6	187.236	−0.73
	Employment stimulated by port/Ten Thousand	33.4	33.768	−1.09
2010	GDP/Hundred Million Yuan	1836.5	1961.8	−6.39
	Port Throughput/Ten Thousand Tons	13906.9	14516.2	−4.00
	Port-led GDP/Hundred Million Yuan	213.9	215.71	−0.84
	Employment stimulated by port/Ten Thousand	37.3	38.9	−4.11

the cargo throughput in Zhuhai Port will increase by nearly 2-fold in 2025, which shows that joining CEPA will bring a tremendous growth in cargo throughput for Zhuhai Port. However, it is also found that the impact of port competition is much larger than the port pressure, which reminds Zhuhai City that the competition of surrounding ports needs to be fully considered in strategy planning. In order to reduce the negative impact of port competition, Zhuhai Port has to vigorously develop the modern port logistics and port industries and to improve the competitiveness by introducing advanced equipments, improving efficiency of port handling, adopting modern management skills, etc.

3. The basic simulation of the model gives that the port-led GDP of Zhuhai City will be 104.61 billion Yuan in 2025, seven times in 2007, indicating that with the development of the port, the related industrial chain is lengthening, and the ripple effect will generate more and more impacts. However, from the curve of the port contribution to the city (in this model, the port contribution to the city = port-led GDP / GDP) (Fig. 41.3), it is found that the contribution to the city

will reach 15% in 2020, and in 2021, the contribution will reach the highest rate – 15.2%. The contribution rate will decline after 2016. It is mainly because that the city is initially development by focusing on the port economy, and hence the port economy will take a very high proportion in the total economy. With the development of the other sectors, the percentage of the port economy will eventually decline. This also shows that other industries in Zhuhai Port are slowly increasing their contributions to the city, and that the competitiveness of Zhuhai Port City is being enhanced.

4. Joining CEPA, the impact of the port competitive factors and the impact of the port pressure will bring up the port-led GDP by 10 times, 5 times and 6.8 times in 2025 comparing to that of 2007 respectively. Same as the previous analysis, the impact of competition will be larger than the port pressure.
5. By introducing the impact of general factors, joining CEPA, the competitive factors and the port pressure separately into the simulation, it is shown that in 2025, the employment pulled by the port in Zhuhai Port is 4.75 times, 6.73 times, 3.4 times and 4.54 times comparing to that of 2007 respectively, from which, it is observed that the development of the port industry will greatly ease the overall employment situation in Zhuhai Port.

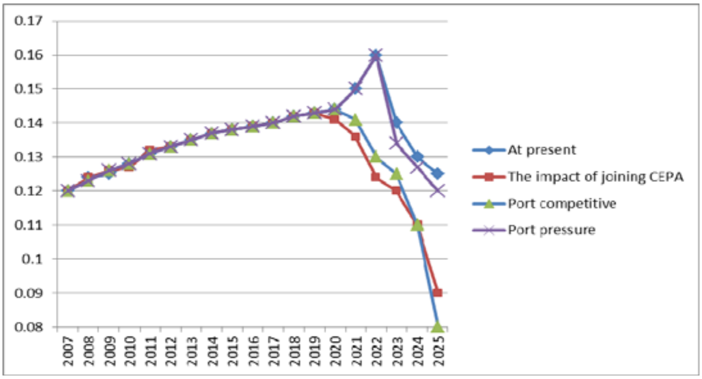


Fig. 41.3 Port contribution to the city

41.6 Test of Model Result

In order to test the model simulation accuracy, the model simulation results are compared to the actual values from 2007 to 2010, and it shows that they are basically consistent as in Table 41.1. Hence, the model is quite fine to simulate the port economic system.

As a preliminary study of dynamic changes of the port's impact to city economy, it is found out that by combining the system dynamics, input-output method and the econometric model, the impact of port competitive factors and port pressure factors on the port economy can be well simulated. This integrated method also can be used as the theoretical basis of policy simulation analysis. It has an irreplaceable function comparing to other methods.

References

1. Wang H, Luan WX (2001) Relationship between Dalian Port throughput and hinterland economy. China Harbour Engineering 20:34–36 (In Chinese)
2. Zhang YZ (2005) Analysis for the economic developmental situation of city B by using input-output method. Journal of Shenyang Architectural and Civil Engineering Institute 39:45–48 (In Chinese)
3. Pearson RL (1957) Measuring the impact of the waterborne commerce of the ports of Viginia on employment. Virginia State Ports Authority, University of Virginia. Bureau of Population and Economic Research
4. Wang QF (2009) System dynamics. Tsinghua University Press, Beijing (In Chinese)
5. Forrester JW (1969) Urban dynamics. MIT Press, Massachusetts
6. Hong CL (2007) Port planning and layout. Tsinghua University Press, Beijing (In Chinese)

Chapter 42
A Study on the Interactive Relationship between Regional Human Capital and Industrial Structure Adjustment in Shanghai

Feng Lin and Jinwen Chen

Abstract A national and regional levels of human capital have an important impact on the national and regional economic growth and industrial structure adjustment. This paper analyzes the influence of human capital on industrial structure adjustment with correlation data of Shanghai from 1978 to 2008. The result shows that human capital and industrial structure adjustment of Shanghai have a stable proportional relationship in a long term; in a short term, although the relationship between human capital and industrial structure adjustment is not as stable as that in a long term, the enhancement of human capital still does a great contribution to the adjustment of industrial structure. Based on this, some suggestions have been provided as following: to accelerate the value of human capital accumulation and structural optimization, to establish the strategic idea of upgrading the value of human capital in order to promote the upgrading of the industrial structure.

Keywords Human capital · Industrial structure adjustment · Cointegration analysis · Time series analysis · Empirical study

42.1 Introduction

Petty-Clark theorem states that the lower of a country's national per capita income, its agricultural labor force occupies the share relatively to be bigger and the secondary and tertiary industrial labor force occupies the share relatively to be smaller, and Vice versa [1]. Therefore the economic development must be accompanied by the transformation of industrial structure, and industrial structure is reasonable and related to the economic sustainability and coordinated development. Modern human capital theory argues that human capital investment and accumulation are necessary

---

F. Lin (✉) · J. Chen
School of Management, University of Shanghai for Science and Technology, Shanghai 200093, P. R. China
e-mail: linfeng@usst.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_42,

for a country's economy to maintain long-term stable growth. The new economic growth theory shows that to realize the transformation of economic growth, it should give full play to the advantage of human capital and its role in promoting economic growth. Then whether it will affect the level of human capital for industrial restructuring? What effect? Based on these understanding, we have analyzed the influence of human capital on industrial structure adjustment with correlation data of Shanghai from 1978 to 2008.

42.2 Literature Review

American scholars Schultz and Dennison had empirical analysis of economic growth of the United States from 1929 to 1957 successively, they drew almost the same conclusion that investment in human capital (education) contribute 20% to 33% to the economic growth rate [2]. After this, Lucas brought human capital into the model of economic growth successfully [3]. Ljungberg and Nilsson took Sweden as the example, researched the structure of human capital stock during the year of 1870 to 2000 and the relations with the economic growth, considering whether the human capital structure conforms to the current economic development is an important factor affecting economic growth [4]. Domestic research on human capital theory started later. Bao discovered that the correlation between the spatial gather of human capital and regional economic growth is strictly positive, and human capital has the obvious externalities and high output elasticity [5]. Chen believes the contribution of human capital to economic growth is greater than the inputs to increase the contribution to economic growth [6]. Guo and Xu judged Guangdong Province exists cointegration and dynamic correlation between the three: gross domestic product (GDP), gross capital formation and the time series of the total employed population [7]. Hu analyzes that human capital accumulation is convergent in itself and there is a positive correlation between the ratio of human capital accumulation and that of regional economic growth and at the same time, the level of human capital has double effects on regional economic growth which are direct convergence and indirect divergence [8]. Li suggests that effect of human capital on economic growth has a certain lag and phase, and the contribution of human capital and its investment are in asymmetric [9].

The current research literatures are mainly discussing the impact of human capital for economic development. Although studies on the relationship between human capital and economic growth involve mostly to human capital and industrial structure, that is, through the study of human capital on economic growth may indirectly obtain the preliminary relations between human capital and industrial restructuring. However what is the mechanism between the two factors did not answered, therefore this paper takes Shanghai as an example for empirical research, aims to establish a quantitative model of the level of human capital and industrial restructuring for Shanghai, to seek for the level of human capital to improve the quantitative impact of industrial restructuring.

42.3 Definition of Relevant Indicators and Data

This paper selects time-series data of two indicators between the year of 1978 to 2008 for empirical analysis: the level of human capital and conversion capabilities of the industrial structure for Shanghai (represented by X and Y respectively). The data mainly comes from each year's Shanghai Statistical annual, the partial data from China Labor statistics Yearbook. The following are the interpretation of the indicators.

42.3.1 Level of Human Capital

Up to now, there is not a feasible and effective method to accurately calculate a personal individual human capital stock. This paper uses the method of average educated years, that is using the average years of schooling to reflect the level of human capital, represented by the letters X, its computation formula is: $X = w \times a + j \times b + s \times c + h \times d + u \times e$, where w, j, s, h, and u respectively represent the working population of Shanghai "can not read or read very little", "primary School", "junior high school", "high school", "college and above" account for the percentage in the total employed population; a, b, c, d, e respectively represent average schooling years of each educational level, according to the actual situation respectively to its evaluation is 2, 6, 9, 12, 16. We take data for the recent six years in Shanghai as the example, to illustrate the calculation process, as shown in Table 42.1.

Table 42.1 Education level constitution and average years of schooling in working population in Shanghai from 2003 to 2008 (%)

Year	Can read very little	Primary School	Junior high school	High school	College and above	Average years of schooling
2003	0.01	0.057	0.369	0.361	0.203	11.26
2004	0.015	0.074	0.353	0.315	0.2436	11.33
2005	0.02	0.108	0.397	0.256	0.2199	10.85
2006	0.014	0.081	0.346	0.275	0.2832	10.85
2007	0.012	0.085	0.351	0.275	0.2766	11.42
2008	0.011	0.085	0.346	0.265	0.2921	11.50

Note: Data from *China labor statistics yearbook*

42.3.2 Industrial Structure Transforms Ability

There are basically two categories of indicators reflecting the restructuring of industries: one is the percentage of the labor force engaged in primary industry accounted for the total labor force. The smaller the proportion is, showed that the industrial structure more tends to be high-level. The other is the proportion of the primary industry accounted for gross domestic product. This paper mainly uses the first indicator to analyze the restructuring of industries, represented by the letters Y. Table 42.2 shows the percentage of the labor force in primary industry accounted for the total labor force.

Table 42.2 Percentage of the labor force in primary industry accounted for the total labor force in Shanghai from 2003 to 2009 (%)

Year	Y	Year	Y	Year	Y	Year	Y
1978	0.3438	1986	0.1424	1994	0.0898	2002	0.1133
1979	0.3155	1987	0.1301	1995	0.0924	2003	0.0956
1980	0.2902	1988	0.1176	1996	0.0926	2004	0.0829
1981	0.2731	1989	0.1130	1997	0.1271	2005	0.0714
1982	0.2544	1990	0.1108	1998	0.1194	2006	0.0625
1983	0.2298	1991	0.1035	1999	0.1381	2007	0.0613
1984	0.1956	1992	0.0959	2000	0.1307	2008	0.0551
1985	0.1635	1993	0.1156	2001	0.1251	2009	0.0456

Note: Data from *Shanghai Statistical Yearbook*

42.4 Interactive Relationship between Regional Human Capital and Industrial Structure Adjustment

42.4.1 Descriptive Analysis of the Sample Data

Before carrying out empirical analysis, descriptive analysis of sample data can visually reflect the characteristics of time series. In order to eliminate the heteroscedasticity of the data, it needs to take the natural logarithm to the two selection variables, respectively represented by LNX, LNY. At the same time, in order to investigate the stationary of the sample data of the two variables, we make LNX, LNY and its first order difference DLNX, DLNY brief chart separately, as shown in Fig. 42.1 and Fig. 42.2.

Fig. 42.1 shows that LNY overall assumes the declining trend and LNX upward trend, from which may determine initially, the two time series are non-stationary. Fig. 42.2 indicates that after first order difference, we may judge intuitively that the two variables are stable and can be used as modeling data.

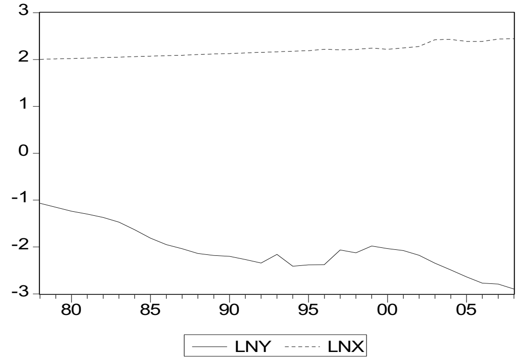


Fig. 42.1 Data LNX and LNY

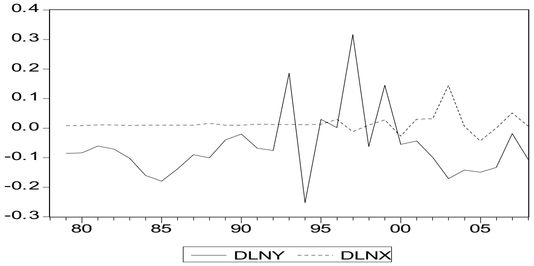


Fig. 42.2 Data DLNX and DLNY

42.4.2 Unit Root Test of the Sample Data

It is well known that OLS estimation with the non-steady sequence will present the false return, the regression coefficient estimator will lose the unbiasedness and its T-test values would be meaningless. But Macroeconomic variables are mostly not steady, they often manifested in the random walk. Through descriptive analysis of the sample data, we can preliminary determine that LNX, LNY are nonstationary series, while their first order difference sequence DLNX, DLNY are for steady. However, for rigorous consideration it is necessary to carry out unit root tests, that is if the variable sequence exist unit root, indicating it is non-stationary series, and vice versa. In this paper the unit root test uses ADF test methods completed by Eviews 3.0, the test results shown in Table 42.3.

Table 42.3 shows that compared ADF value with its critical value for the variable LNX and LNY, it cannot refuses the null hypothesis that they have the unit root under 5% and 10% significance levels, that is to say these two variable sequences are non-stationary. But for their first order difference sequence DLNX and DLNY, the ADF value's absolute value is bigger than its critical value's under 5% and 10% significance levels, namely it refuses the null hypothesis that these two sequences do not exist unit root. In other words, they are stationary ones.

Table 42.3 Unit root test results of LNX, LNY, DLNX and DLNY

Variable	ADF value	ADF critical value		Result
		5% critical value	10% critical value	
LNX	2.7205	−1.9526	−1.6216	Non stationary
LNY	2.5493	−1.9526	−1.6216	
DLNX	−4.2434	−1.9530	−1.6218	Stationary
DLNY	−4.0978	−1.9530	−1.6218	

42.4.3 Cointegration Test of the Sample Data

Cointegration is a characterization of the relationship between economic time series, the premise that two variables have cointegration relations is they are the same order integration. Learned by the above-mentioned variables stationarity test, the first order difference sequence of these two variables are stable, that is, two variables are integrated of order one.

There are many methods to test cointegration relationship, the paper selects Engel-Granger two-steptesting. It first uses OLS method to estimate the equation of the variables and calculate non-equilibrium error, next examines the single integrity of the error. If it is the stationary sequence, then the two variables exist long-term balanced relations, namely they are cointegrated. Here are concrete steps:

First, building regress model of LNX and LNY by the OLS method: supposes the regression model is $\mathrm{LNY}_t = a_0 + a_1\mathrm{LNX}_t + \mu_t$, according to the above data, estimating the parameters in the model by Eviews 3.0, thus resulting in the regression equation:

$$\begin{aligned} &\mathrm{LNY} = -2.960924\mathrm{LNX} + 4.407930 \\ &\qquad\quad (-8.291155) \qquad (5.638894) \\ &R^2 = 0.893304 \;\; DW = 1.932575 \end{aligned} \tag{42.1}$$

It can be seen from the regression equation: T values are very significantly, the goodness of fit is more satisfied and the residual sequence does not have the autocorrelation which can be seen from the DW value.

Second, examining the single integrity of the residual sequence: from regression results of Eviews, we can get residual sequence e_t, then testing unit root to e_t. The result is shown in Table 42.4.

Table 42.4 Unit root test result of residual sequence e_t

Variable	ADF value	ADF critical value		Result
		5% critical value	10% critical value	
e_t	−2.0068	−1.9526	−1.6216	Stationary

Table 42.4 shows the ADF value's absolute value of residual sequence e_t is bigger than its critical value's under 5% and 10% significance levels, indicating the residual sequence is stationary, namely variable sequence LNX and LNY are of (1.1) order cointegration. From this it is suggested that Shanghai's human capital and industrial structure transformation ability has the long-term stability proportional relationship. Because the variables are in logarithmic form, therefore the economic significance of the independent variable coefficients is the dependent variable to its elasticity coefficient, according to the cointegration equation we know that the long-term elasticity of the industrial structure transformation ability about the human capital level long-term elasticity is -2.960924.

42.4.4 Establishment of Error Correction Model

In order to further clarify the concrete function mechanism about the level of human capital regarding of the restructuring of industries, we have established the error correction model of the relations between human capital and the industrial structure transformation ability. According to the famous Granger representation theorem which proposed by Engel and Granger in 1987, if the two variables are cointegrated, the short-term equilibrium relationship between them can always stated by an error correction model (ECM). The main form of ECM was proposed by Davidson, Hendry, Srba and Yeo in 1978, called DHSY model, which can not only reflect the long-run equilibrium relationship between the different time series, but also can reflect the short-term deviation from the long-run equilibrium correction mechanism.

We can see from above, LNX and LNY have a long-term cointegration relationship. We take the error correction term, namely residual sequence e_t, as an explanatory variable, together with other explanatory variables that reflecting the short-term fluctuations, undertaking recursive an analysis on corresponding explanatory variables, then may obtain the error correction model, the general form is:

$$\Delta y_t = \alpha_0 \mathrm{ECM}_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta y_{t-i} + \sum_{j=1}^{n} \beta_j \Delta x_{t-j} + \mu_t, \qquad (42.2)$$

where ECM_{t-1} is unbalanced error term, namely the above e_t, μ_t is pure white noise error term, Δ represents difference sequence, α_0 is short-term adjustment parameter which represents the correction speed of error correction term to Δy_t, reflecting the influence of the long-run equilibrium on the short-term fluctuations. We can see from above that DLNX and DLNY are the first order difference sequences of LNX and LNY, and are stationary. We take Equation (42.2) as the regression model and select the lag period for 2 phases, the dynamic error correction model can be obtained by the OLS estimation on relevant data. As follows:

$$DLNY = \; -0.835743 \cdot ECM_{t-1} - 2.754722 \cdot DLNX + 1.414524 \cdot DLNX(-1)$$

$$\begin{array}{ccc} (-3.567234) & (-4.357132) & (2.837564) \\ +1.765421 \cdot DLNX(-2) & +1.176543 \cdot DLNY(-1) & -0.312451 \cdot DLNY(-2) \\ (1.145624) & (3.587982) & (0.245671) \\ R^2 = 0.745232 & DW = 1.914135 & \end{array} \qquad (42.3)$$

Under 5% significance level, ECM_{t-1}, DLNX, DLNX(-1) and DLNY(-1) all through the T test and goodness of fit R^2 has been satisfied. It can be seen from the model, the adjustment of y changes in period t is mainly according to the unbalanced error in period $t-1$, the level of human capital in period $t-1$ as well as y changes in period $t-1$.The coefficient of ECM_{t-1} in the model through the examination under a high confidence level, indicating that the level of human capital in Shanghai has a significant impact on the industry restructure for a long time. At the same time the coefficient of ECM_{t-1} reflects the intensity of correction deviated from the long-run equilibrium. From the coefficient value -0.835743, the correction intensity is relatively large.

42.5 Conclusion and Recommendation

We can see by the above empirical results.

42.5.1 Empirical Conclusions

(1) The level of human capital in Shanghai has the long-term stability proportional relationship with industry restructure.

Equation (42.2) shows the long-term elasticity of the industrial structure transformation ability about the human capital level long-term elasticity is -2.960924, indicating the level of human capital increases every one percent, the proportion of labor force engaged in primary industry in the total labor force will reduce 2.960924 percent, which illustrates it will promote the restructuring and upgrading of industrial structure of Shanghai by increasing the human capital investment and raising the level of human capital in the long term. Currently the proportion of tertiary industry in Shanghai is less than 60% of GDP, which still has a considerable distance to the goal of building a world-class metropolis. Therefore, in order to develop tertiary industry vigorously, it's necessary for Shanghai to increase the investment of human capital.

(2) In a short term changes in industrial structure conversion capabilities is also related to changes in the level of human capital.

Further observation in Equation (42.3), variable coefficient through the test of the level of human capital is negative or positive, which explains in different lag phase the relations is inconsistent between the level of human capital and the speed of industrial structure adjustment, and the intensity of the overall role is weakened to some extent. That is to say, the effects of human capital to industrial structure adjustment are not stable enough, which has a certain volatility and backwardness so that it is in a long time that its mechanism could be given full play. Therefore, the government must establish a long-term view instead of short-sighted in the promotion of education and improvement of the human capital investment.

Besides, since the coefficient of ECM_{t-1} in Equation (42.2) is bigger, it explains that the upgrading speed of the industrial structure has a great volatility.

42.5.2 Recommendations

Accordingly, the government should take appropriate control policies, accelerating the value of human capital accumulation and structural optimization and to promote the upgrading of the industrial structure. For example, intensify the development of tertiary industry, increase human capital investment, and promote the human capital value to a strategic altitude. Based on long-term, establish the strategic idea of upgrading the value of human capital to ensure economic stability and harmonious development in Shanghai.

42.6 Acknowledgements

This work is supported by National Nature Science Foundation under Grant No. 71171135.

References

1. Yu RG (1996) Review of petty — Clark theorem. Economic Perspectives 8:63–65 (In Chinese)
2. Liu XJ (1995) Measuration method of contribution of foreign investment in education on economic growth. Education & Economy 4:23–24 (In Chinese)
3. Lucas RE (1988) On the mechanics of economic development. Journal of Monetary Economics 22:41–42
4. Jonas L, Anders N (2009) Human capital and economic growth: Sweden, 1870–2000, Cliometrica. Journal of Historical Economics and Econometric History 3: vol.3
5. Bao YX, Wang HY, Li YJ (2010) An effect analysis of spatial concentration of human capital to Regional Economic Growth — With the sample of Shandong Province. Population & Economics 3:82–83 (In Chinese)
6. Chen HA, Li GP, Jiang RC (2010) Empirical analysis of the impact of human capital to economic growth in Beijing and Shanghai. Journal of East China Normal University 3:54–55 (In Chinese)
7. Guo HH, Xu L (2010) Cointegration analysis of human capital, capital formation and economic growth in Guangdong province. Special Zone Economy 2:31–32 (In Chinese)

8. Hu YY (2011) Analysis of simultaneous interaction between human capital and regional economic growth. China Population, Resources and Environment 12:153–157 (In Chinese)
9. Li JJ (2012) Analysis on the influence of human capital on economic growth. Science & Technology Economy Market 1:21–23 (In Chinese)
10. The Shanghai Bureau of Statistics (2003) Shanghai Statistical Yearbook, U. S. Department of Commerce, 2003-2010
11. National Bureau of Statistics of China (2003) China Labor Statistical Yearbook, U.S. Department of Commerce, 2003-2010

Chapter 43

Optimization Models for Shortest Path Problem with Stochastic Arc Lengths Taking Fuzzy Information

Wei Liu

Abstract Shortest path problem is a fundamental problem in network optimization and combinational optimization. The existing literature mainly concerned with the problem in deterministic, stochastic or fuzzy environments by using different tools. Different from the existing works, we investigate shortest path problem by regarding arc lengths as uncertain variables which are employed to describe the behavior of uncertain phenomena. According to different decision criteria, three concepts of path are proposed in uncertain environment, and three types of uncertain programming models are formulated. Furthermore, these models are concerted into deterministic optimization models in several special cases.

Keywords Uncertain programming · Shortest path problem · Uncertainty measure · Uncertain variable

43.1 Introduction

Shortest path problem concerns with how to find a path between two nodes such that the sum of the weights of its constituent edges is minimized. The sum of the weights may be distance, time, cost and so forth. It is one of core problems in networks and has been widely applied in practice. As a well-known combinational optimization problem, the shortest path problem has also been applied in the areas of operational research, computer science and so on. In the classical formulation, arc lengths representing traveling time, cost or distances are regarded as deterministic real variables. However, these quantities are difficult or impossible to be estimated precisely in real life. Therefore, uncertainty cannot be ignored.

W. Liu (✉)
Economics and Management department, Chengdu Sports University, Chengdu 610041, P. R. China
e-mail: liuweihua166@hotmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_43, © Springer-Verlag London 2013

Several researchers employed probability theory to study shortest path problem by assuming arc lengths are random variables and designed different algorithms to solve these stochastic versions such as [3, 4, 14, 15]. With the development of fuzzy set theory, several scholars thought the uncertainty should be interpreted as fuzziness not randomness. They pointed out that probability distributions of arc lengths are difficult to estimate due to lack of historical data. However, these quantities may be given by experienced experts by using membership functions. In this case, fuzzy set theory is a powerful tool to deal with this problem. To the best of our knowledge, fuzzy shortest path problem was first proposed by Dubois and Prade [2]. After that, fuzzy shortest path problem has been widely studied by many researchers such as [8, 10, 13, 16, 17]. [6] introduced new fuzzy programming models for shortest path problem based on credibility theory by defining a comparison index. Hernandes et al [5] proposes an iterative algorithm to solve fuzzy shortest path problem by assuming a generic ranking index for comparing the fuzzy numbers. Keshavarz and Khorram [7] concentrated on a shortest path problem on a network where arc lengths are fuzzy and costs are fuzzy intervals with increasing membership functions.

Recently, Liu [11] presented uncertainty theory to describe human decisions in the state of uncertainty. Up to now, several scholars have done many works surrounding the subject such as [1, 9, 12, 18, 19]. Different from the existing literature, we may assume that arc lengths are uncertain variables which are neither fuzzy nor stochastic. In the framework of uncertainty theory, this paper proposes three concepts of uncertain shortest path: expected shortest path, α-shortest path and the most shortest path which are defined through uncertainty measure. Based on these definitions, three mathematical models are formulated for uncertain shortest path problem by using uncertain programming techniques. The rest of the paper is organized as follows. For better understanding of basic knowledge of uncertainty theory, Sect. 43.2 introduces the relative concepts which will be used throughout the paper. In Sect. 43.3, three programming models are formulated for the proposed problem, which is the main part of this paper. Finally, some conclusions are drawn in Sect. 43.4.

43.2 Preliminaries

Let Γ be a nonempty set, and let $\mathscr{A}$ be a σ-algebra over Γ. Each element of $\mathscr{A}$ is called an event. A set function is called an uncertain measure [11] if and only if it satisfies the following four axioms

Axiom 1. (Normality) $\mathscr{M}\{\Gamma\} = 1$;

Axiom 2. (Monotonicity) $\mathscr{M}\{A\} \leq \mathscr{M}\{B\}$ whenever $A \subseteq B$;

Axiom 3. (Self-Duality) $\mathscr{M}\{A\} + \mathscr{M}\{A^c\} = 1$ for any event A;

Axiom 4. (Countable Subadditivity) $\mathscr{M}\{\cup_i A_i\} \leq \sum_{i=1}^{\infty} \mathscr{M}\{A_i\}$ for any countable sequence of events $\{A_i\}$.

Definition 43.1. [11] Let Γ be a nonempty set, and let $\mathscr{A}$ be a σ-algebra over it. If $\mathscr{M}$ is an uncertain measure, then the triplet $(\Gamma, \mathscr{A}, \mathscr{M})$ is called an uncertainty space.

Definition 43.2. [11] Uncertain variable ξ is defined as a measurable function from an uncertainty space $(\Gamma, \mathscr{A}, \mathscr{M})$ to the set of real numbers $\Re$. That is, for any Borel set B, we have:

$$\{\gamma \in \Gamma \mid \xi(\gamma) \in B\} \in \mathscr{A}.$$

Definition 43.3. [11] Let ξ be an uncertain variable. Then the expected value of ξ is defined as:

$$E[\xi] = \int_0^{+\infty} \mathscr{M}\{\xi \geq x\}dx - \int_{-\infty}^0 \mathscr{M}\{\xi \leq x\}dx$$

provided that at least one of the two integrals is finite.

Definition 43.4. [11] Let ξ be an uncertain variable, and $\alpha \in (0,1]$. Then

$$\xi_{\inf}(\alpha) = \inf\{r | \mathscr{M}\{\xi \leq r\} \geq \alpha\}$$

is called the $\alpha-$ pessimistic value of ξ.

Example 43.1. An uncertain variable ξ is called linear if it has a linear uncertainty distribution:

$$\Phi(x) = \begin{cases} 0, & \text{if } x \leq a \\ (x-a)/(b-a), & \text{if } a \leq x \leq b \\ 1, & \text{if } x \geq b \end{cases}$$

denoted by Ł(a,b) in which a and b are two real numbers with $a < b$. By the definitions of expected value and pessimistic value, we have $E[\xi] = (a+b)/2$ and $\xi_{\inf}(\alpha) = (1-\alpha)a + \alpha b$.

Example 43.2. An uncertain variable ξ is called zigzag if it has a zigzag uncertainty distribution:

$$\Phi(x) = \begin{cases} 0, & \text{if } x \leq a \\ (x-a)/2(b-a), & \text{if } a \leq x \leq b \\ (x+c-2b)/2(c-b), & \text{if } b \leq x \leq c \\ 1, & \text{if } x \geq c \end{cases}$$

denoted by $\mathscr{Z}(a,b,c)$ in which a,b and c are three real numbers with $a < b < c$. By the definitions of expected value and pessimistic value, we have $E[\xi] = (a+2b+c)/4$ and

$$\xi_{\inf}(\alpha) = \begin{cases} (1-2\alpha)a + 2\alpha b, & \text{if } \alpha < 0.5 \\ (2-2\alpha)b + (2\alpha-1)c, & \text{if } \alpha \geq 0.5. \end{cases}$$

Example 43.3. An uncertain variable ξ is called normal if it has a normal uncertainty distribution:

$$\Phi(x) = \left(1 + \exp\left(\frac{\pi(e-x)}{\sqrt{3}\sigma}\right)\right)^{-1}, \ x \in \Re$$

denoted by $\mathscr{N}(e,\sigma)$ in which e and σ are two real numbers with $\sigma > 0$. By the definitions of expected value and pessimistic value, we have $E[\xi] = e$ and $\xi_{\inf}(\alpha) = e + \frac{\sqrt{3}\sigma}{\pi}\ln\frac{\alpha}{1-\alpha}$.

Example 43.4. [18] An uncertain variable ξ is called lognormal if $\ln\xi$ is a normal uncertain variable $\mathscr{N}(e,\sigma)$ which implies a lognormal uncertain variable has an uncertainty distribution:

$$\Phi(x) = \left(1 + \exp\left(\frac{\pi(e - \ln x)}{\sqrt{3}\sigma}\right)\right)^{-1}, \; x \geq 0$$

denoted by $\mathscr{LOGN}(e,\sigma)$ in which e and σ are two real numbers with $\sigma > 0$.

Theorem 43.1. *(Linearity of Expected Value Operator, [11]) Let ξ and η be independent uncertain variables with finite expected values. Then for any real numbers a and b, we have $E[a\xi + b\eta] = aE[\xi] + bE[\eta]$.*

43.3 Models for Uncertain Shortest Path Problem

We consider a directed acyclic network $\mathscr{G} = (\mathscr{V},\mathscr{A})$ which is composed of a finite set of nodes $\mathscr{V} = \{1,2,\cdots,n\}$ and a set of arcs $\mathscr{A}$. Note that each arc may be denoted by an ordered pair (i,j) in which $(i,j) \in \mathscr{A}$. It is assumed that there is only one directed arc (i,j) from i to j, and the nodes in an acyclic directed network $\mathscr{G} = (\mathscr{V},\mathscr{A})$ can be renumbered so that $i < j$ for all $(i,j) \in \mathscr{A}$ (see [11]).

The path representation is as follows: $\boldsymbol{x} = \{x_{ij} | (i,j) \in \mathscr{A}\}$, where $x_{ij} = 1$ means that the arc (i,j) is in the path and $x_{ij} = 0$ means that the arc (i,j) is not in the path. In addition, we use the conclusion that $\boldsymbol{x} = \{x_{ij} | (i,j) \in \mathscr{A}\}$ is a path from nodes 1 to n in a directed acyclic graph if and only if:

$$\sum_{(i,j)\in\mathscr{A}} x_{ij} - \sum_{(j,i)\in\mathscr{A}} x_{ji} = \begin{cases} 1, & i = 1 \\ 0, & 2 \leq i \leq n-1 \\ -1, & i = n, \end{cases}$$

$x_{ij} = 0$ or 1 for any $(i,j) \in \mathscr{A}$.

As mentioned above, we assume that arc lengths ξ_{ij} are uncertain variables for all $(i,j) \in \mathscr{A}$. And write $\boldsymbol{\xi} = \{\xi_{ij} | (i,j) \in \mathscr{A}$. Then the total length of path $\boldsymbol{x}$ is $T(\boldsymbol{x},\boldsymbol{\xi}) = \sum_{(i,j)\in\mathscr{A}} \xi_{ij} x_{ij}$. By the operational law of uncertain variables, $T(\boldsymbol{x},\boldsymbol{\xi})$ is also an uncertain variable. Since it is meaningless to directly optimize an uncertain variable, we propose different decision criteria by using uncertain programming techniques and establish the corresponding optimization models in the following subsections.

43.3.1 Expected Value Model

The most commonly used criterion is expected value of uncertain variable, which represents the average value of uncertain variable in the sense of uncertain measure, and represents the size of uncertain variable. Before proposing the expected value model, we first give the following definition.

Definition 43.5. A path $\boldsymbol{x}$ is called expected shortest path if $E[T(\boldsymbol{x},\boldsymbol{\xi})] \le E[T(\mathbf{x}',\boldsymbol{\xi})]$ for all paths $\mathbf{x}'$ from nodes 1 to n in $\mathscr{G}$, in which $E[T(\boldsymbol{x},\boldsymbol{\xi})]$ is called expected shortest path length.

According to Definition 43.5, it is meaningful and reasonable to compare two uncertain arc lengths. Therefore, we can establish the following expected value model to find the expected shortest path,

$$\begin{cases} \min E\left[\sum\limits_{(i,j)\in\mathscr{A}} \xi_{ij}x_{ij}\right] \\ \text{s.t.} \begin{cases} \sum\limits_{(1,j)\in\mathscr{A}} x_{1j} - \sum\limits_{(j,1)\in\mathscr{A}} x_{j1} = 1 \\ \sum\limits_{(i,j)\in\mathscr{A}} x_{ij} - \sum\limits_{(j,i)\in\mathscr{A}} x_{ji} = 0,\ 2 \le i \le n-1 \\ \sum\limits_{(n,j)\in\mathscr{A}} x_{nj} - \sum\limits_{(j,n)\in\mathscr{A}} x_{jn} = -1 \\ x_{ij} \in \{0,1\},\ \forall (i,j) \in \mathscr{A}. \end{cases} \end{cases} \tag{43.1}$$

Further, we consider a special case in which arc lengths are all independent uncertain variables. It follows from linearity of expected value operator (i.e., Theorem 43.1) that

$$E\left[\sum \xi_{ij}x_{ij}\right] = \sum E[\xi_{ij}]x_{ij}.$$

Therefore, in this case, expected value model (43.1) can be converted into the following programming problem,

$$\begin{cases} \min \sum\limits_{(i,j)\in\mathscr{A}} E[\xi_{ij}]x_{ij} \\ \text{s.t.} \begin{cases} \sum\limits_{(1,j)\in\mathscr{A}} x_{1j} - \sum\limits_{(j,1)\in\mathscr{A}} x_{j1} = 1 \\ \sum\limits_{(i,j)\in\mathscr{A}} x_{ij} - \sum\limits_{(j,i)\in\mathscr{A}} x_{ji} = 0,\ 2 \le i \le n-1 \\ \sum\limits_{(n,j)\in\mathscr{A}} x_{nj} - \sum\limits_{(j,n)\in\mathscr{A}} x_{jn} = -1 \\ x_{ij} \in \{0,1\},\ \forall (i,j) \in \mathscr{A}. \end{cases} \end{cases} \tag{43.2}$$

Please note that $E[\xi_{ij}]$ is a crisp number. Thus, Model (43.2) is a deterministic optimization model of shortest path problem, and we can solve it by using classical algorithms or applied softwares.

43.3.2 Chance-Constrained Programming

The other commonly used criterion is critical value of uncertain variable. In fact, there are two kinds of critical values. In this work, we only employ pessimistic value criterion. The uncertain programming by using critical value criterion is called chance-constrained programming. First we give the following definition.

Definition 43.6. A path $\boldsymbol{x}$ is called α-shortest path from 1 to n if

$$\min\{\bar{T}|\mathscr{M}\{T(\boldsymbol{x},\boldsymbol{\xi})\leq\bar{T}\geq\alpha\}\leq\min\{\bar{T}|\mathscr{M}\{T(\mathbf{x}',\boldsymbol{\xi})\leq\bar{\mathbf{T}}\geq\alpha\},$$

for all paths $\mathbf{x}'$ from nodes 1 to n in $\mathscr{G}$, in which α is a predetermined confidence level.

Taking this concept into account, chance-constrained programming model for uncertain shortest path problem is formulated as follows,

$$\begin{cases}\min\bar{T}\\ \text{s.t.}\begin{cases}\mathscr{M}\left\{\sum\limits_{(i,j)\in\mathscr{A}}\xi_{ij}x_{ij}\leq\bar{T}\right\}\geq\alpha\\ \sum\limits_{(1,j)\in\mathscr{A}}x_{1j}-\sum\limits_{(j,1)\in\mathscr{A}}x_{j1}=1\\ \sum\limits_{(i,j)\in\mathscr{A}}x_{ij}-\sum\limits_{(j,i)\in\mathscr{A}}x_{ji}=0,\ 2\leq i\leq n-1\\ \sum\limits_{(n,j)\in\mathscr{A}}x_{nj}-\sum\limits_{(j,n)\in\mathscr{A}}x_{jn}=-1\\ x_{ij}\in\{0,1\},\ \forall(i,j)\in\mathscr{A},\end{cases}\end{cases}\tag{43.3}$$

where α is a confidence level which is in advance given by decision makers.

Next, we consider several cases in which Model (43.3) can be converted into deterministic optimization problem. If arc lengths $\xi_{ij}=\mathrm{Ł}(a_{ij},b_{ij})$ are independent linear uncertain variables, then $\mathscr{M}\left\{\sum_{(i,j)\in\mathscr{A}}\xi_{ij}x_{ij}\leq\bar{T}\right\}\geq\alpha$ holds if and only if $\bar{T}\geq(1-\alpha)\sum\limits_{(i,j)\in\mathscr{A}}a_{ij}x_{ij}+\alpha\sum\limits_{(i,j)\in\mathscr{A}}b_{ij}x_{ij}$ holds. Therefore, Model (43.3) can be converted into the following deterministic model,

$$\begin{cases}\min\,(1-\alpha)\sum\limits_{(i,j)\in\mathscr{A}}a_{ij}x_{ij}+\alpha\sum\limits_{(i,j)\in\mathscr{A}}b_{ij}x_{ij}\\ \text{s.t.}\begin{cases}\sum\limits_{(1,j)\in\mathscr{A}}x_{1j}-\sum\limits_{(j,1)\in\mathscr{A}}x_{j1}=1\\ \sum\limits_{(i,j)\in\mathscr{A}}x_{ij}-\sum\limits_{(j,i)\in\mathscr{A}}x_{ji}=0,\ 2\leq i\leq n-1\\ \sum\limits_{(n,j)\in\mathscr{A}}x_{nj}-\sum\limits_{(j,n)\in\mathscr{A}}x_{jn}=-1\\ x_{ij}\in\{0,1\},\ \forall(i,j)\in\mathscr{A}.\end{cases}\end{cases}\tag{43.4}$$

If $\xi_{ij}=\mathscr{Z}(a_{ij},b_{ij},c_{ij})$ are independent zigzag uncertain variables, then we have:

$$\bar{T} \geq \begin{cases} (1-2\alpha) \sum\limits_{(i,j)\in\mathscr{A}} a_{ij}x_{ij} + 2\alpha \sum\limits_{(i,j)\in\mathscr{A}} b_{ij}x_{ij}, & \text{if } \alpha < 0.5 \\ (2-2\alpha) \sum\limits_{(i,j)\in\mathscr{A}} b_{ij}x_{ij} + (2\alpha-1) \sum\limits_{(i,j)\in\mathscr{A}} c_{ij}x_{ij}, & \text{if } \alpha \geq 0.5, \end{cases}$$

which implied that if $\alpha < 0.5$, then the object is to minimize $(1-2\alpha) \sum\limits_{(i,j)\in\mathscr{A}} a_{ij}x_{ij} + 2\alpha \sum\limits_{(i,j)\in\mathscr{A}} b_{ij}x_{ij}$; otherwise, the object is to minimize $(2-2\alpha) \sum\limits_{(i,j)\in\mathscr{A}} b_{ij}x_{ij} + (2\alpha - 1) \sum\limits_{(i,j)\in\mathscr{A}} c_{ij}x_{ij}$. Thus, in this case, we replace the object function of Model (43.4) based on the given α.

If $\xi_{ij} = \mathscr{N}(e_{ij}, \sigma_{ij})$ are independent normal uncertain variables, then we have:

$$\bar{T} \geq \sum_{(i,j)\in\mathscr{A}} e_{ij} + \frac{\sqrt{3}}{\pi} \ln\left(\frac{\alpha}{1-\alpha}\right) \sum_{(i,j)\in\mathscr{A}} \sigma_{ij}.$$

And, if $\xi_{ij} = \mathscr{LOGN}(e_{ij}, \sigma_{ij})$ are independent lognormal uncertain variables, then we have:

$$\bar{T} \geq \exp\left(\sum_{(i,j)\in\mathscr{A}} e_{ij}x_{ij}\right) \left(\frac{\alpha}{1-\alpha}\right)^{\sqrt{3} \sum\limits_{(i,j)\in\mathscr{A}} \sigma_{ij}x_{ij}/\pi}.$$

In these cases, the object function of Model (43.4) is the right part of the above two inequalities.

43.3.3 Dependent-Chance Programming

In this part, we consider the last criterion which is called chance criterion. In practice, decision makers always predetermine a benchmark T_0 and wish the obtained result not to exceed the given value. In other words, decision makers want to maximize the uncertainty measure of satisfying $\{T(\boldsymbol{x}, \boldsymbol{\xi}) \leq T_0$. Based on this idea, we can establish dependent-chance programming for shortest path problem.

First, we give the following definition.

Definition 43.7. A path $\boldsymbol{x}$ is called the most shortest path from 1 to n if $\mathscr{M}\{T(\boldsymbol{x}, \boldsymbol{\xi}) \leq T_0\} \leq \mathscr{M}\{T(\mathbf{x}', \boldsymbol{\xi}) \leq \mathbf{T_0}\}$ for all paths $\mathbf{x}'$ from nodes 1 to n in $\mathscr{G}$, in which T_0 is a predetermined arc length.

If decision makers want to maximize the chance of achieving some object, then dependent-chance programming model for uncertain shortest path problem is formulated as follows,

$$\begin{cases} \min \mathscr{M}\left\{\sum\limits_{(i,j)\in\mathscr{A}} \xi_{ij}x_{ij} \le T_0\right\} \\ \text{s.t.} \begin{cases} \sum\limits_{(1,j)\in\mathscr{A}} x_{1j} - \sum\limits_{(j,1)\in\mathscr{A}} x_{j1} = 1 \\ \sum\limits_{(i,j)\in\mathscr{A}} x_{ij} - \sum\limits_{(j,i)\in\mathscr{A}} x_{ji} = 0,\ 2 \le i \le n-1 \\ \sum\limits_{(n,j)\in\mathscr{A}} x_{nj} - \sum\limits_{(j,n)\in\mathscr{A}} x_{jn} = -1 \\ x_{ij} \in \{0,1\},\ \forall (i,j)\in\mathscr{A}, \end{cases} \end{cases} \tag{43.5}$$

where T_0 is a confidence level which is given by decision makers.

Next, we take Model (43.5) into account in some special cases. We write I_A to represent the index function of event A. If $\xi_{ij} = \mathscr{L}(a_{ij}, b_{ij})$ are independent linear uncertain variables, then we have:

$$\mathscr{M}\left\{\sum_{(i,j)\in\mathscr{A}} \xi_{ij}x_{ij} \le T_0\right\} = \frac{T_0 - \sum\limits_{(i,j)\in\mathscr{A}} a_{ij}x_{ij}}{\sum\limits_{(i,j)\in\mathscr{A}} b_{ij}x_{ij} - \sum\limits_{(i,j)\in\mathscr{A}} a_{ij}x_{ij}} I_{\left\{\sum\limits_{(i,j)\in\mathscr{A}} a_{ij}x_{ij} \le T_0 \le \sum\limits_{(i,j)\in\mathscr{A}} b_{ij}x_{ij}\right\}} + I_{\left\{T_0 \ge \sum\limits_{(i,j)\in\mathscr{A}} b_{ij}x_{ij}\right\}}.$$

Replacing the right part of the above equation, we converted Model (43.5) into a deterministic optimization model. Similarly, we may obtain the following results. If $\xi_{ij} = \mathscr{Z}(a_{ij}, b_{ij}, c_{ij})$ are independent zigzag uncertain variables, then we have:

$$\mathscr{M}\left\{\sum_{(i,j)\in\mathscr{A}} \xi_{ij}x_{ij} \le T_0\right\} = \frac{T_0 - \sum\limits_{(i,j)\in\mathscr{A}} a_{ij}x_{ij}}{\sum\limits_{(i,j)\in\mathscr{A}} 2(b_{ij}-a_{ij})x_{ij}} I_A + \frac{T_0 + \sum\limits_{(i,j)\in\mathscr{A}} (c_{ij}-2b_{ij})x_{ij}}{\sum\limits_{(i,j)\in\mathscr{A}} 2(c_{ij}-b_{ij})x_{ij}} I_B + I_C,$$

in which $A = \left\{\sum_{(i,j)\in\mathscr{A}} a_{ij}x_{ij} \le T_0 \le \sum_{(i,j)\in\mathscr{A}} b_{ij}x_{ij}\right\}$, $B = \left\{\sum_{(i,j)\in\mathscr{A}} b_{ij}x_{ij} \le T_0 \le \sum_{(i,j)\in\mathscr{A}} c_{ij}x_{ij}\right\}$ and $C = \left\{T_0 \ge \sum_{(i,j)\in\mathscr{A}} c_{ij}x_{ij}\right\}$. If $\xi_{ij} = \mathscr{N}(e_{ij}, \sigma_{ij})$ are independent normal uncertain variables, then we have:

$$\mathscr{M}\left\{\sum_{(i,j)\in\mathscr{A}} \xi_{ij}x_{ij} \le T_0\right\} = \left(1 + \exp\left(\frac{\pi\left(\sum\limits_{(i,j)\in\mathscr{A}} e_{ij} - T_0\right)}{\sqrt{3}\sum\limits_{(i,j)\in\mathscr{A}} \sigma_{ij}}\right)\right)^{-1}.$$

Finally, if $\xi_{ij} = \mathscr{LOGN}(e_{ij}, \sigma_{ij})$ are independent lognormal uncertain variables, then we have:

$$\mathscr{M}\left\{\sum_{(i,j)\in\mathscr{A}}\xi_{ij}x_{ij}\le T_0\right\}=\left(1+\exp\left(\frac{\pi\left(\sum_{(i,j)\in\mathscr{A}}e_{ij}-\ln T_0\right)}{\sqrt{3}\sum_{(i,j)\in\mathscr{A}}\sigma_{ij}}\right)\right)^{-1}.$$

43.4 Conclusions

Shortest path problem is one of core problems in network optimization and combinational optimization, and it has been widely applied in real life. Up to now, shortest path problem has been investigated in deterministic, stochastic or fuzzy environments. In this paper, we considered uncertain shortest path problem in which arc lengths were assumed to be uncertain variables. By proposing three new concepts of path to formulate three decision criteria, we established three uncertain programming models for uncertain shortest path problem. And then, we converted these models into deterministic programming problems in detail.

In future, uncertain shortest path problem may be extended in several ways. First, we may design new algorithms to solve the proposed models for shortest path problem by integrating heuristic algorithm and uncertain simulation. Second, we may establish new models for shortest path problem by considering risk aversion of decision makers. Finally, we may extend the proposed models by relaxing some constraints or adding other constraint conditions and undertake sensitivity analysis.

References

1. Chen XW, Liu B (2012) Existence and uniqueness theorem for uncertain differential equations. Fuzzy Optimization and Decision Making, to be published
2. Dubois D, Prade H (1980) Fuzzy sets and systems: Theory and applications. Academic Press, New York
3. Frank H (1969) Shortest paths in probability graphs. Operations Research 17:583–599
4. Fu L, Rilett LR (1998) Expected shortest paths in dynamic and stochstic traffic networks. Transportation Sciences 32:499–516
5. Hernandes F, Lamata MT, Verdegay JL et al (2007) The shortest path problem on networks with fuzzy parameters. Fuzzy Sets and Systems 158:1561–1570
6. Ji X, Iwamura K, Shao Z (2007) New models for shortest path problem with fuzzy arc lengths. Applied Mathematical Modelling 31:259–269
7. Keshavarz E, Khorram E (2009) A fuzzy shortest path with the highest reliability. Journal of Compuational and Applied Mathematics 230:204–212
8. Klein CM (1991) Fuzzy shortest paths. Fuzzy Sets and Systems 39:27–41
9. Li X, Liu B (2009) Hybrid logic and uncertain logic. Journal of Uncertain Systems 3:83–94
10. Lin K, Chen M (1994) The fuzzy shortest path problem and its most vital arcs. Fuzzy Sets and Systems 38:343–353
11. Liu B (2007) Uncertainty theory. 2nd edn, Springer-Verlag, Berlin 2007.

12. Liu B (2009) Some research problems in uncertainty theory. Journal of Uncertain Systems 3:3–10
13. Moazeni S (2006) Fuzzy shortest path problem with finite fuzzy quantities. Applied Mathematics and Computaion 183:160–169
14. Murthy I, Sarkar S (1996) A relaxation-based pruning technique for a class of stochastic shortest path problems. Transportation Sciences 30:220–236
15. Ohtsubo Y (2008) Stochastic shortest path problems with associative accumulative criteria. Applied Mathematics and Computation 198:198–208
16. Okada S (2004) Fuzzy shortest path problems incorporting interactivity among paths. Fuzzy Sets and Systems 142:335–357
17. Okada S, Soper T (2000) A shortest path problem on a network with fuzzy arc lengths. Fuzzy Sets and Systems 109:129–140
18. Qin Z (2009) On lognormal uncertain variables. In: Proceedings of the Eighth International Conference on Information and Management Sciences 753–755
19. Qin Z (2009) Developments of conditional uncertain measure. In: Proceedings of the Eighth International Conference on Information and Management Sciences 782–786

Chapter 44

Technical Analysis and the Timing Strategies of Liquidity Providers: Evidence from China's A-Shares Stock Market

Wenfeng Li, Zhigang Wang and Yong Zeng

Abstract Liquidity providers have to consider a tradeoff between executive risk and adverse selection risk. In this paper we empirically research whether resistance and support levels can help liquidity providers to construct timing strategies. Using Chinese stock market high-frequency transaction data, we investigate the relations between resistance (support) level and several liquidity indicators, and we find that resistance and support levels are positively related to peaks in depth on the limit order book, and the Granger causality tests suggest that a large number of orders clustering at some prices leads to the creation of the resistance (support) level. The empirical results indicate that resistance (support) level can help liquidity providers to construct timing strategies.

Keywords Technical analysis · Liquidity provision · Timing strategies · Limit order book

44.1 Introduction

Technical Analysis (TA) is widely used in financial practice, practitioners use many different types of technical indicators to infer the direction of future prices, including moving average forecasts, support and resistance levels and so on, which involve the study of past price and volume data. However, Efficient Market Hypothesis (EMH) states that all available information must be reflected in security prices. As a consequence, Technical Analysis and Efficient Market Hypothesis appear to be at odds. Most of the existing researches on TA are focused on testing the predictability and profitability of TA.

W. Li (✉) · Z. Wang · Y. Zeng
School of Economics and Management, University of Electronic Science and Technology of China, Chengdu 610054, P. R. China
e-mail: i__promise@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_44, © Springer-Verlag London 2013

Despite both positive and negative evidences that TA can predict future prices had been provided [1], researchers have searched the theoretical basis of TA from different aspects. Based on rational expectations model with noise, Treynor and Ferguson [2], Brown and Jennings [3], Blume et al [4] demonstrate that technical indicators, involving the study of past price and volume data, provide relevant information to market participants and promote the revelation of private information. These findings provide the theory basis of market microstructure for the application of TA.

In subsequent researches, some researchers search richer relationships between TA and other market microstructure indicators. Donaldson and Kim [5], Osler [6] find some price barriers where price movements show specific patterns, for instance, trends tend to reverse course at price barriers, and trends tend to be unusually rapid after rates cross price barriers. Besides, these price movement patterns are related to limit order types and other market microstructure indicators. Moreover, Kavajecz and Odders-White [7], Harris and Panchapagesan [8] find the limit order book contains some information have not be reflected immediately in security prices. Furthermore, Kavajecz and Odders-White [9] investigate whether technical indicators can capture the useful information from limit order book. Using NYSE SuperDOT data, Kavajecz and Odders-White [7] find support and resistance levels are related to peaks in liquidity on limit order book. When the technical level is near the quotes, depth is concentrated near the quotes as well. This relationship indicates there are many shares standing ready at support and resistance levels to satiate liquidity demanders' trading needs, thereby support and resistance levels are likely to become an obstacle to achieving more extreme prices. Furthermore, they find the relationship between technical analysis and liquidity provision stems from the technical rules' ability to locate depth already in place on the book, which suggests liquidity providers placing large orders at some prices leads to the creation of support and resistance levels, instead they place limit orders referring support and resistance levels. At an order-driven market the liquidity is provided by limit orders, thereby this finding provides the important empirical evidence for us to understand the relation between TA and time strategies of liquidity providers.

At present, the application of TA on Chinese stock market focus on inferring the direction of future prices, no studies investigate the application of TA from the perspective of liquidity provision. Using Chinese stock market high-frequency transaction data, we research relations between technical indicators and several liquidity indicators, moreover, investigate whether TA is valuable for timing strategies of liquidity providers. Our empirical study represents support and resistance levels are related to peaks in liquidity on limit order book. When the resistance (support) level is near the quotes, depth is concentrated near the quotes as well, which suggests that many shares stand at or around support and resistance levels which are likely to become an obstacle to achieving more extreme prices. Furthermore, we research the causal relationship between resistance (support) level and liquidity provision, and find the aggregation of a large number of limit orders granger causes resistance and support levels, which suggests liquidity providers always place limit orders at some prices, the aggregation of limit orders leads to the creation of resistance and support levels. These empirical results are valuable for the timing strategy of liquidity providers, firstly, liquidity providers can locate the peak in depth with resistance and support levels, set their limit price equal to the resistance or support levels in order to maximally reduce adverse selection risk, moreover, in order to avoid a large number of limit orders gathering at resistance level or support level, liquidity providers can choose to place limit sell orders slightly below the resistance level or limit buy orders slightly above the support level.

The remainder of this paper is organized as follows. Sect. 44.2 and 44.3 describe the limit order book liquidity measures we employ and technical analysis rules we consider, as well as the data used in the analysis. Sect. 44.4 presents and interprets our result. Sect. 44.5 presents robustness test results. Sect. 44.6 concludes.

44.2 Data and Limit Order Book Liquidity Measures

We use Chinese stock market high-frequency transaction data for 90 stocks from January 2010 through June 2010. The data is sampled at 15 minutes intervals, and we get a total of 150,371 transaction records. These data are from CSMAR.

We consider four specific measures of depth on each side of the limit order book. Each measure captures somewhat different aspects of liquidity provision.

1. The first measure captures the price with the most shares on each side of the limit order book, and estimates the distance between this price and quoted midpoint. The price with the most shares are most likely to be the obstacle to achieving more extreme prices, if this price is near the quoted midpoint, depth is concentrated near the quotes as well, the market provides much more liquidity.
2. The second measure respectively estimates the distance between the best bid (ask) and quoted midpoint. If best bid (best ask), with the strongest wish to provide liquidity, is near the quoted midpoint, the market provides much more liquidity.
3. The third measure adds up all of orders on first five sell prices (buys prices).
4. The forth measure is define as the orders on best bid (best ask). The volume of orders is more, the market liquidity is better.

44.3 Technical Analysis Rules

This paper investigates support and resistance levels which are widely used. Each 15 minute, we compute the resistance and support levels using the bid and ask prices from the prior week (i.e., the 80 most-recent observations, sampled at 15 minute intervals). The resistance level is defined as the highest ask price attained during the last week, provided this maximum was achieved at least twice during that period and is undefined otherwise. We repeat this process at every 15 minute interval, using rolling on-week windows.

$$\begin{aligned}
\text{Resistance level}_{t+1} &= P_t^R \\
&= \begin{cases} \max(Ask_{t-w},\cdots,Ask_t), & \text{provided } P_t^R = Ask_t = Ask_j \\ & \text{for some } i,j \in (t-w,t) \\ \text{undefined}, & \text{otherwise.} \end{cases} \\
\text{Support level}_{t+1} &= P_t^S \\
&= \begin{cases} \min(Bid_{t-w},\cdots,Bid_t), & \text{provided } P_t^S = Bid_t = Bid_j \\ & \text{for some } i,j \in (t-w,t) \\ \text{undefined}, & \text{otherwise.} \end{cases}
\end{aligned} \tag{44.1}$$

Fig. 44.1 provides an illustration of the resistance level and the quoted midpoint. The chart covers a one-week period, February 22-26, 2010, for Shenzhen Energy (000027). As Fig. 44.1 illustrates, first, the resistance level tends to move with the quoted midpoint, second, resistance level can remain constant for substantial periods of time, and it is not always defined and can contain discrete jumps.

44.4 Results

In this section we focus on the first and third liquidity provision measures, the results related to the second and forth liquidity provision measures are presented in Sect. 44.5.

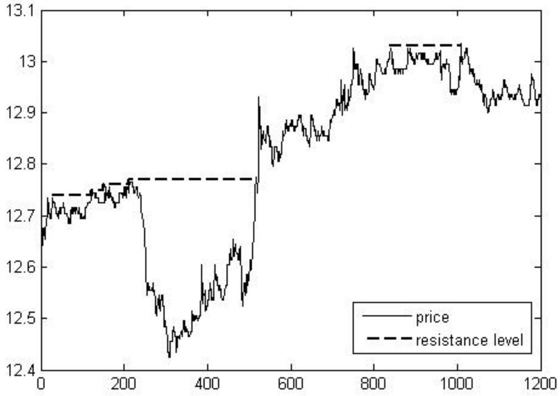


Fig. 44.1 Resistance level for Shenzhen energy

44.4.1 General Properties of Technical Analysis Rules and Liquidity Provision Measure

Table 44.1 displays statistics on the support and resistance levels we generate using Equation (44.1) for our entire sample, as well as the corresponding limit order book liquidity measures. Resistance level is defined for 56.99% of the observations in our sample and support level is defined for 59.91% of the observations in our sample. Panel A displays statistics on sell-side limit order book, panel B displays statistics on buy-side limit order book.

Table 44.1 Properties of technical analysis and limit order book measures

Liquidity provision	Variables	Mean	Median	Maximum	Minimum	Number of samples
Panel A: sell-side limit order book						
The first measure	Distance to qtd mdpt	0.0339	0.031	0.388	0.005	85693
	Distance to resistance level	0.6194	0.366	3.998	0.005	
The third measure	5 Depth	723557	156846	42302000	2069	85693
	Distance to resistance level	0.6194	0.366	3.998	0.005	
Panel B: buy-side limit order book						
The first measure	Distance to qtd mdpt	0.0325	0.031	0.391	0.005	90080
	Distance to support level	0.4375	0.299	3.999	0.005	
The third measure	5 Depth	806918	190676	34274957	1846	90080
	Distance to support level	0.4375	0.299	3.999	0.005	

*"Distance to qtd mdt" represents the distance between the price with most shares and quoted midpoint, which is our first liquidity provision measure, "5Depth" is defined as the sum of orders on first five sell prices or buys prices, which is our third liquidity provision measure. "Distance to resistance level" is the absolute value of the difference between the resistance level and the quoted midpoint. "Distance to support level" is the absolute value of the difference between the support level and the quoted midpoint.

44.4.2 Regression Analysis

In order to directly test whether resistance (support) level is related to liquidity provision on the limit order book, we regress the limit order book variables on the resistance (support) levels after subtracting the quoted midpoint from each series. Subtracting the quoted midpoint serves two purposes. First, it eliminates the non-stationarity that stems from the presence of unit roots in price series. Second, it removes the mechanistic part of the relationship that must exist between any functions of quoted prices and prices on the limit order book.

Table 44.2 and Table 44.3 show the regressions relating the different series. We regress the sell-side limit order book measures on the resistance level and the buy-side limit order book measures on the support level. In both cases we present results for univariate regressions and for multivariate regressions that control for current market conditions. The conditioning variables are those typically used in the literature to summarize the state of the market. We use the current quoted bid-ask spread and total quoted depth to control for the level of asymmetric information risk and inventory risk embedded into the quotes by liquidity providers. We also include the current (over the last 15 minutes) trading volume as well as net trade direction, which are defined as the difference between the number of buyer- and seller-initiated transactions in the given time intervals.

Table 44.2 Resistance and support level univariate regression

Dependent variable	*C*	Technical level-qtd mdpt	Medn adj.R2
Panel A: Sell-side limit order book measures regressed on resistance level			
Distance to qtd mdpt	−3.3496*** (−2669.4810)	0.0962*** −106.408	0.12
5 Depth	10.8240*** −2306.36	−0.6840*** (−202.3175)	0.32
Panel B: Buy-side limit order book measures regressed on support level			
Distance to qtd mdpt	−3.3261*** (−2434.5220)	0.0917*** −111.7388	0.12
5 Depth	10.7482*** −1906.195	−0.6683*** (−197.3130)	0.3

Technical resistance/support levels are defined in Equation (44.1) in the text. "Distance to qtd mdt" represents the distance between the price with most shares and quoted midpoint, which is our first liquidity provision measure, "5 Depth" is defined as the sum of orders on first five sell prices or buys prices, which is our third liquidity provision measure. Limit order book buy-side (sell-side) regressions use support (resistance) level technical measures. The value in parentheses is T-statistics measure, ***, **,*respectively represents 1%, 5% and 10% Significance level.

The univariate regression results demonstrate positive and significant relationships between the resistance (support) level and the prices with most shares (our first liquidity indicator). For our third liquidity indicator (the sum of orders on the first five prices), the coefficient is negative and significant in both sell-side and buy-side regressions. The univariate regression results suggest that when the resistance (support) level is near the quotes, depth is concentrated near the quotes as well. Analogously, when the distance between the resistance (support) level and the quotes is large, a substantial fraction of depth lies far from the quotes, near the technical level.

The multivariate regression results show that the technical variables remain important even after controlling for other market characteristics. Overall, Table 44.2 and 44.3 demonstrate the specific relationship between resistance (support) level and liquidity provision on the limit order book, that technical analysis resistance and support levels are related to peaks in liquidity on the limit order book. Moreover, the empirical results provide a practical guidance for investors, if the resistance (support) level is closer to the quotes, it may be easy to obtain a large block of stock, while if the technical level is far from the quotes, that same block of stock may be expensive to trade due to large price concessions.

Table 44.3 Resistance and support level multivariate regression

Dependent variable	C	Technical level-qtd mdpt	Qtoted spd	Tot qtd depth	volume	Net trd direction	Medn adj.R^2
Panel A: Sell-side limit order book measures regressed on resistance level							
Distance to qtd mdpt	−1.5205***	0.0503***	0.2516 **	0.0182***	−0.0737 **	−0.0087 **	0.33
	−74.4486	−40.7943	−94.1264	−11.3213	(−49.9155)	(−7.0448)	
5 Depth	−4.2981 ***	−0.2428***	−0.1729 **	0.7123 ***	0.2896 **	0.08679 **	0.8
	(−90.3323)	(−84.4726)	(−27.7642)	−189.8147	−84.1511	−30.1372	
Panel B: Buy-side limit order book measures regressed on support level							
Distance to qtd mdpt	6.8909***	0.9094***	0.2148 **	−0.3257***	0.0822 **	−0.1550 **	0.28
	−88.5717	−48.772	−18.3743	(−56.4303)	−14.0146	(−32.6734)	
5 Depth	−5.3340***	−0.3572 ***	−0.2498 **	0.8076***	0.2450 **	−0.0349 **	0.81
	(−108.0725)	(−124.6968)	(−36.7664)	−214.6404	−67.124	(−11.4624)	

Technical resistance/support levels are defined in Equation (44.1) in the text. "Distance to qtd mdt" represents the distance between the price with most shares and quoted midpoint, which is our first liquidity provision measure, "5 Depth" is defined as the sum of orders on first five sell prices or buys prices, which is our third liquidity provision measure. Limit order book buy-side (sell-side) regressions use support (resistance) level technical measures. "Qtoted spd", "Tot qtd depth", "volume" and "Net trd direction" are conditioning variables summarizing the state of the market. The value in parentheses is T-statistics measure, ***, **,*respectively represents 1%, 5% and 10% Significance level.

44.4.3 Granger Causality

We have represented resistance (support) level is related to liquidity provision in Chinese stock market, furthermore, this paper investigates underlying reason of the relationship between the resistance (support) level and liquidity provision.

According to the existing market microstructure theory and empirical research findings, we consider several possible explanations of this relationship.

The first explanation, a large number of orders clustering at some prices leads to the creation of the resistance (support) level. Specifically, informed traders, who are likely to have strong opinions as to the appropriate limit price, may have placed this collection of limit orders which leads to the creation of the resistance (support) level [10]. Alternatively, a liquidity trader may having placed a larger order at this price makes the creation of resistance (support) level.

The second explanation, traders make investment strategy with resistance (support) level. Specifically, traders place their limit orders near the resistance (support) level in order to profit, which results in that resistance and support levels relating to peaks in liquidity on the limit order book.

Finally, situations in the firth and second explanations both occur. For instance, resistance (support) level locates depth already in place on the book, liquidity providers subsequently place limit orders near the resistance (support) level [6].

Table 44.4 Granger causality between sell-side limit order book liquidity and resistance level

lags	The first liquidity measure		The third liquidity measure	
(15 min)	Depth does not Granger cause Resistance	Resistance does not Granger cause Depth	Depth does not Granger cause Resistance	Resistance does not Granger cause Depth
1	112.69***	4.39**	116.98***	5.76***
2	79.58***	2.24*	64.82***	2.29*
3	61.64***	2.10*	45.80***	1.93
4	51.42***	2.04*	35.53***	1.73
5	43.19***	2.11*	28.77***	1.79
6	37.04***	2.33**	24.28***	1.74
7	33.01***	2.96***	21.21***	1.66
8	30.00***	3.72***	18.76***	1.88
9	27.16***	3.74***	16.76***	1.22
10	25.32***	3.84***	15.39***	1.99
11	23.20***	3.86***	14.05***	1.92
12	21.91***	3.82***	13.01***	1.83
13	19.59***	3.72***	12.19***	1.82
14	18.82***	3.77***	11.39***	1.83
15	17.60***	4.05***	10.73***	1.99
16	17.08***	3.92***	10.53***	1.73

This table contains the sample period with resistance, a total of 85,693 observations. The values in the table is the *F* statistic measure, ***, **, * respectively represents 1%, 5% and 10% Significance level.

We determine the most reasonable one from the three explanations based on Granger causality tests. If the test result represents liquidity indicators cause the resistance (support) level, the first explanation is supported. If causality running from the resistance (support) level to liquidity indicators would suggest that limit orders are placed in response to resistance (support) level. Bidirectional causality would be consistent with the third explanation.

Table 44.5 Granger causality between buy-side limit order book liquidity and support level

Lags	The first liquidity measure		The third liquidity measure	
(15 min)	Depth does not Granger cause Support	Support does not Granger cause Depth	Depth does not Granger cause Support	Support does not Granger cause Depth
1	178.19***	48.10***	165.53***	7.58***
2	92.61***	16.05***	95.51***	1.16
3	60.08***	8.34***	64.05***	0.51
4	43.99***	5.53***	47.79***	0.14
5	35.29***	4.20***	38.04***	0.6
6	28.07***	3.86***	31.21***	0.41
7	24.45***	3.05***	26.13***	0.59
8	21.29***	2.83***	22.40***	1.01
9	18.34***	2.15**	19.39***	1.19
10	15.54***	1.72*	16.89***	0.7
11	14.43***	1.69*	15.04***	0.95
12	12.73***	1.56	13.55***	0.89
13	11.59***	1.48	12.45***	0.86
14	10.47***	1.32	11.32***	0.75
15	9.46***	1.38	10.53***	0.93
16	8.89***	1.26	9.92***	0.66

This table contains the sample period with support, a total of 90,080 observations. The values in the table is the F statistic measure, ***, **, * respectively represents 1%, 5% and 10% Significance level.

Table 44.4 displays the Granger test result between resistance level and liquidity provision on the sell-side limit order book, Table 44.5 displays the Granger test result between support level and liquidity provision on the buy-side limit order book. Table 44.4 and 44.5 demonstrate bidirectional causality running between liquidity indicators and resistance (support) level. However, liquidity indicators are more likely to Granger cause resistance (support) level than the reverse. Because liquidity indicators Granger cause resistance (support) level in all lags, while the results for causality running from resistance (support) level to liquidity indicators are not conclusive, especially, resistance (support) level no longer Granger causes our third liquidity indicator after the third lag.

In general, compared to causality running from resistance (support) level to liquidity indicators, the results of the Granger causality test support that liquidity indicators cause resistance (support) level. This finding means a large number of orders clustering at some prices leads to the creation of the resistance (support) level, which provides important empirical evidence for us to understand the relation between TA and time strategies of liquidity providers.

44.5 Robustness Test

Based on our second and forth liquidity provision measures, we investigate the relationship between resistance (support) level and liquidity indicators, so as to test the robustness of our findings. Table 44.6 shows the regression relating the differenced series.

Table 44.6 Granger causality between buy-side limit order book liquidity and support level

Dependent variable	C	Technical levelqtd mdpt	Qtoted spd	Tot qtd depth	volume	Net trd direction	Medn adj. R^2
Panel A: Sell-side limit order book measures regressed on resistance level							
Best sell -Qtd mdpt	0.0547 ** −18.2692	0.0012 ** −7.6748	0.0075 ** (14.2427)	0.0004 ** −4.064	−0.0015 ** (−10.4261)	−0.0001 ** (−5.0208)	0.37
Depth	−8.9082 ** (−57.550)	−0.2234 ** (−23.154)	−0.4040 ** (−21.8029)	0.9787 ** −79.956	0.1276 ** −11.6817	0.1136 ** −14.5174	0.75
Panel B: Buy-side limit order book measures regressed on support level							
Qtd mdpt -Best buy	0.0458 ** −19.7058	0.0024 ** −14.7331	0.0066 ** −15.3659	0.0002 ** −3.1077	−0.0011 ** (−10.0529)	0.0002 ** −6.4008	0.4
Depth	−9.4166 ** (−60.258)	−0.2921 ** (−33.594)	−0.4396 ** (−21.597)	1.0792 ** −88.5635	0.0476 ** −3.8093	−0.0154 ** (−1.9765)	0.77

Technical resistance/support levels are defined in Equation (44.1) in the text. “Best sell-Qtd mdpt” represents the distance between the best ask and quoted midpoint, “Qtd mdpt-Best buy” represents the distance between the best bid and quoted midpoint, which is our second liquidity provision measure, “Depth” is defined as the orders on the best ask or bid, which is our forth liquidity provision measure. Limit order book buy-side (sell-side) regressions use support (resistance) level technical measures. “Qtoted spd”, “Tot qtd depth”, “volume” and “Net trd direction” are conditioning variables summarizing the state of the market. The value in parentheses is T-statistics measure, ***, **,* respectively represents 1%, 5% and 10% Significance level.

Table 44.6 displays positive and significant relationships between the resistance (support) level and best ask (best bid), which is consistent with regress result based on our first liquidity indicator. For our forth liquidity indicator (orders on the best ask or best bid), the coefficient is negative and significant in both sell-side and buy-side regressions, which is consistent with regress result based on our third liquidity indicator. So our findings are robust.

44.6 Conclusion

Existing researches on technical analysis focus on the future price movements. We firstly investigate the application of TA on Chinese stock market from the perspective of liquidity provision. We find when the resistance (support) level is near the quotes, depth is concentrated near the quotes as well. Analogously, when the distance between the technical level and the quotes is large, a substantial fraction of depth lies far from the quotes, near the technical level. The empirical results provide a practical guidance for investors, if the resistance (support) level is closer to the quotes, it may be easy to obtain a large block of stock, while if the technical level is far from the quotes, and the impact cost will be higher.

We consider several possible explanations of this relationship between liquidity provision and resistance (support) level on Chinese stock market, based on Granger causality test we find a large number of orders clustering at some prices leads to the creation of the resistance (support) level. These findings provide a practical guidance for liquidity providers. Liquidity providers infer peaks in depth on the limit order book with resistance (support) level, and then subsequently place limit sell orders slightly below the resistance level or limit buy orders slightly above the support level. This strategy can effectively reduce adverse selection risk, as well as reduce executive risk from a large number of orders clustering at resistance (support) level.

According to our findings, in future we can estimate transaction probabilities of limit orders in different price ranges below (above) resistance (support) level in order to weight the tradeoff between executive risk and adverse selection risk. If the price of limit sell orders (limit buy orders) is higher (lower), their transaction probability is lower; on the contrary, if the price of limit sell orders (limit buy orders) is lower (higher), their transaction probability is higher. Thereby, liquidity providers can use market order price as the benchmark price, and then determine the optimal price to place limit orders based on the principle of maximizing the expected revenue relative to the benchmark price.

References

1. Park C, Irwin S (2007) What do we know about the profitability of technical analysis? Journal of Economic Surveys 21:786–826
2. Treynor J, Ferguson R (1985) In defense of technical analysis. Journal of Finance 40:757–775
3. Brown D, Jennings R (1989) On technical analysis. Review of Financial Studies 2(4): 527–551
4. Blume L, Easley D, O'Hara M (1994) Market statistics and technical analysis: The role of volume. Journal of Finance 49:153–181
5. Donaldson R, Kim H (1993) Price barriers in the dow jones industrial average. Journal of Financial and Quantitative Analysis 28:313–330
6. Osler C (2003) Currency orders and exchange rate dynamics: An explanation for the predictive success of technical analysis. Journal of Finance 58:1791–1819
7. Kavajecz K, Odders-White E (2001) An examination of changes in specialists' posted price schedules. Review of Financial Studies 14:681–704

8. Harris L, Panchapagesan V (2005) The information content of the limit order book: Evidence from NYSE specialist trading decisions. Journal of Financial Markets 8:25–67
9. Kavajecz K, Odders-White E (2004) Technical analysis and liquidity provision. Review of Financial Studies 17:1043–1071
10. Bloomfield R, O'Hara M, Saar G (2005) The "make or take" decision in an electronic market: Evidence on the evolution of liquidity. Journal of Financial Economics 75:165–199

Chapter 45
Customer Satisfaction: A Comparison of Public and Private Banks of Pakistan

Waqarul Haq and Bakhtiar Muhammad

Abstract The purpose of conducting this research is to compare public and private sector banks of Pakistan by evaluating their customer satisfaction. This research is mainly based on primary data which has been collected through a well-structured questionnaire (adapted from three different studies). The questionnaire has been distributed to 351 different respondents on different chosen locations. This paper makes a useful contribution as there are very low number of studies has been conducted in Pakistan on such areas like price, technology, reliability, customer service, location and infrastructure. This research shows that customer satisfaction varies from person to person and, bank managers need to conduct more researches in order to evaluate customer satisfaction more strongly.

Keywords Customer satisfaction · Customer services · Technology · Reliability

45.1 Introduction

Customer Satisfaction: is a measure of how products and services provide by any organization meet the expectations of a customer. It varies from person to person and service to service.A customer can be defined as a user or potential user of banking services. A customer would include an account holder, or a person carrying out casual business transactions with a bank. The efficiency of a banking sector depends upon how best it can deliver services to its target customers. In order to survive in this competitive environment and provide continual customer satisfaction, the banking services providers are required to frequently increase the quality of services. In banking business it is seen that only 5% increase in customer retention can extend 35% profitability.

W. Haq (✉) · B. Muhammad
Management Science Department, Shaheed Zulfikar Ali Bhutto Institute of Science and Technology, Islamabad, Pakistan
e-mail: mwaqarulhaq@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_45,

45.2 Literature Review

45.2.1 Entrance of Technology

Private sector Banks seem to have satisfied its customers with good services and they have been successful in retaining their customers by providing better facilities than Public sector Banks. But, still Private Banks need to go a long way to become customer's first preference. In an economy of innovative technologies and changing markets, each and every service quality variable has become important. New financial products and services have to be continuously introduced in order to stay competent and Private Banks need to concentrate more on their credit facilities and insurance services since customers do not have a very good opinion about these facilities being offered by Private Banks also public sector banks enjoy the trust of the customers, which they have been leveraging to stay in the race however they need to improve their service quality by improving their physical facility, infrastructure and giving proper soft skill training to their employees [13].

In the banking sector it is necessary to increased adoption of technology to better meet customer requirements, improve efficiencies, reduce costs and ensure customer delight and it was the private sector and foreign banks which established the technological revolution in Indian banking and considering the fact that in the new economy, mind share leads to market share and mind share is influenced not only by the promotions and advertisements but more importantly on favorable customer perception which in turn is based on satisfaction with regard to products, services and interaction [1].

The private sector banks are providing more satisfied ATM services then public sector banks and the customer perception about Productivity, Security and Sensitivity, Cost Efficiency, Problem Handling, Compensation and Contact services related to ATM service is very less in both the public sector and privates sector banks, Therefore both kinds of banks should be aware about these facets of ATM service to improve customers' satisfaction [18].

The entry of information technology into the banking industry has created a revolution and it has prompted commercial banks of India to design world-class customer service systems and practices, to meet the growing customer needs. It is interesting to note that the results are consistent with the previous studies conducted on customer service aspects, and it has been observed that the foreign and the new generation private sector banks are serving the customers better [15].

45.2.2 Customers Perceptions and Expectations

Quality expectation and the valuation of services received are slightly more in the private sector banks as compared with the public sector banks. The effects for tactic since sectorial differentiation become very blurry as a result of increasing correspondence between services and struggle from linked and additional industries [12].

Service quality is one of main elements of customer satisfaction and their intention to purchase. However, the customers of public and private sector banks different in terms of their perception of service quality. Private Banks have been observed to be higher on dimensions of service quality: effectiveness and convenient while, the nationalized banks are better on the dimensions of price and consistency [19].

Private bank customers are more satisfied with the services then public banks. Managers in the banking sector undertake significant efforts to conduct customer satisfaction surveys and it is appears that customers are saying that they expect good products and quality to their banks and that may the only thing important to them [9].

45.2.3 Image and Reputation of Banks

Some publicly owned banks are scoring well among customers but overall analysis shows that satisfaction rate in customers of private banks is much higher than public sector banks and people will continue the mortgage with private banks then public because they're impressed by the level of honesty of private banks [3].

45.2.4 Performance of Banks

After the privatizations of state-owned banks, their performances in comparison with other banking groups have increased by 95%. The performance of private banks after privatization of state banks had significant reduces and this reduction indicates that the share of the market of newly privatized state-owned banks increased. Although the performance of privatized state banks after privatization has increased significantly [7].

The economic reforms and the entry of private players have cause nationalized banks to revamp their services and product portfolios to incorporate new, innovative customer-centric schemes. Nowadays, due to the rise in competition, customer satisfaction is considered to be the most important thing in retail services but there is no noteworthy difference in customer satisfaction of public sector and the private sector banks.

45.2.5 Price and Packages

Cheque deposits and cheque clearing are most common services used by customers, the charges levied by the bank on these services are higher in private and foreign banks then in nationalized banks. Their study also shows that the customers of public banks were not much satisfied with the behavior of employee and infrastructure, while customers of private and foreign banks were not much satisfied with high charges, approachability and communication. They have also suggested that training on stress management and public dealing should be imparted to the employees of nationalized banks and nationalized banks need to improve their infrastructure and ambience to compete with private and foreign banks in India.

Credit cards have become a part of life. In recent years there was a lot of demand has been shown for credit cards and there is a lot of scope for credit cards business in India. The credit card holders consider eleven 'very important' variables which "Satisfied" them are: Joining Fee, Annual fee, Minimum payment due, Cash withdrawal possibility, Availability of ATMs, Life Insurance Cover, Card replacement fee, Air insurance, Baggage cover, lost card liability-after losing the card and lost card liability-before losing the card [2].

45.2.6 Location and Infrastructure

Good sites and suitable site of the branch are essential for bank branches for smooth operation of banking business. When the private banks were compared with public banks, all the private banks have excellent locations from business point of view compared to public banks in India and for providing better service to customers proper training should be given to the staff by the banks also public sector banks should invest and concentrate more on staff development where as private sector gives more priority on infrastructural aspects. The rigid policy of public banks creates more dissatisfaction among the customers while for private banks mostly the value of service is the key factor of satisfaction [17].

45.2.7 Quality of Customer Services

First dimension of customer satisfaction for nationalized banks is Service Orientation but, for private banks Service orientation appeared as second dimension and they focuses more on customer satisfaction and nationalized banks give more importance to Flexibility in Use of Services, Vision and Competency. Also customers of nationalized banks had not been given much importance by the executives. On the other hand customers of private banks had been offered these services right from the beginning therefore, customers of private banks more satisfied [5].

The consumers of nationalized banks are more satisfied with service quality, than private banks and it's required to ascertain the key success aspects in the industry, in terms of satisfaction of customers by keeping in view the growing market size and the strong competition [14].

The Private Banks came to existence within the last ten years with the objective of to limit the government intervention in banks and from since then they try hard to obtain customer satisfaction even after a short period of existence. According to a survey the result shows that private sector banks are more popular to obtain customer satisfaction than the public sector banks [4].

Satisfaction of customers is the most important forecaster of service quality of banking sector. Management of banks should confirm that the banking atmosphere should focus on quick and fair services to their customers. Public sector banks are contributing more credit facility to fishermen and farmers than private banks and the State Government announcement of giving the agricultural loan has given more satisfaction to the consumers of public banks [11].

The effort towards ease of banking and accessibility is preferred by the customer who is more seen in private banks then public and customer care and customer retention programs should take into consideration by public banks.In Kuwait Muslim customers are satisfied more with accessibility of ATM machines in multiple locations,funds safety, ease to use ATM machines and service quality provided,but the worse element which has been noticed in this study was that the interest rate on loans, which was the indicator of that the most of customer in Kuwait give more intention to loans [3].

Service quality is an important feature of customer satisfaction in Indian banking industry irrespective of public sector and the private sector banks and Customer satisfaction is found to be strongly associated with propensity to recommend [8].

Some of the respondents choose the SBI bank is because the bank is proving more ATM facility to the customers and many of the respondents are saying the reason to choose the services of the SBI bank is because they are good in efficient customer service but many of the respondents are not aware of the many services provided by the SBI bank. The few are deposit of cash in ATM, request for cheque book in ATM, end of the day balance in mobile, etc. While some of the respondents choose the ICICI bank is because the bank is more reliable to the customers and many of the respondents are saying the reason to choose the services of the ICICI bank is because they are good in efficient customer service and efficient complaint handling. So finally both the banks are competing equally with each other but SBI bank is little bit below the line in customer complaints handling when compared to ICICI bank [10].

45.3 Research Framework

A research framework has been developed to compare customer satisfaction among private and public sector banks of Pakistan which includes research methodology, research model and questionnaire.

45.3.1 Methodology

A method has been designed to meet the objectives of research. For this purpose a questionnaire has been adapted from three different research studies [6, 20, 21] and circulated in 5 different cities of Pakistan (Sukkur, Lahore, Islamabad, Rawalpindi and Peshawar). This questionnaire consists of two different parts. The first part is showing respondents personal data such as gender, bank type, income, age, qualification and the second part asked respondent to rate their satisfaction level to their bank from "strongly agree" to "strongly disagree" on such variables which lead to build strong relationship with customers such as prices, reliability, technology, customer service, location and infrastructure etc. This questionnaire was given to 500 different respondents out of which 351 questionnaires were returned. Most of these responses were conducted myself and rest through the help of friends and family. The research model can be shown in Fig. 45.1.

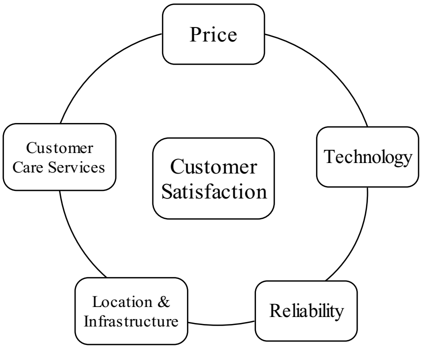


Fig. 45.1 Research model

45.3.2 Background of Respondents

The first part of this questionnaire was designed to collect personal information of respondents such as their gender, age, bank type, income and qualification and the investigation shows that 65% of the respondents are male and 35% are female of which, 42% of the respondents are having their account in public banks and 58% have their account in private banks. 72.6% respondents are from age group 18-25 years, 16.9% are from age group 26-33 years, 5.7% are from age group 34-41 years, 1.7% is from age group 42-50 years and 3.1% are from age group 51+ years. In terms of qualification only 0.6% are under matric, 1.6% have done matric, 4.4% respondents have done intermediate, 76.2% are graduated and 17% respondents are post graduated. In income segment 26% of the respondents having less than 20 thousand, 11.8% have 21-30 thousand, 18.5% earn 31 - 50 thousand, 33.5% earn 51-

100K and only 10.2% of the respondents earn more than 100 thousand per month.

Table 45.1 Mean std. deviation of each question

Questions	N	Minimum	Maximum	Mean	Std. Deviation
My bank gives me good compensation.	349	1.00	5.00	1.8195	1.10592
Services charges my bank imposes is competitive.	350	1.00	5.00	2.0514	.93188
My bank gives good interest rate on saving accounts.	349	1.00	5.00	2.1519	1.06262
My bank provides variety of service charges.	350	1.00	5.00	2.2000	1.07325
My bank provides good credit facilities.	346	1.00	5.00	2.2659	1.19120
My bank doesn't charge unnecessarily for not maintaining minimum balance in account.	346	1.00	5.00	2.3642	1.19917
My bank provides ATM service in multiple locations.	350	1.00	5.00	1.8971	1.05480
My bank provides good E-Banking service.	348	1.00	5.00	2.1810	1.05415
My bank provides Phone account service facilities.	346	1.00	5.00	2.1821	1.12357
My bank provides Internet banking service.	351	1.00	5.00	2.1368	1.14072
My bank provides safety for my funds.	349	1.00	5.00	1.9484	1.00440
My bank's image and reputation is good.	344	1.00	5.00	2.1686	1.11473
I have open account in this bank because for personal relationship with any of the employee.	350	1.00	5.00	2.2486	1.25921
Location of my bank is convenient.	348	1.00	5.00	2.0460	1.14543
My bank has multiple branches in Pakistan.	347	1.00	5.00	2.0259	1.09751
My bank provides good parking space facility.	347	1.00	5.00	2.1326	1.19718
Infrastructure of my bank is attractive and friendliness.	351	1.00	5.00	2.2393	1.19511
My bank staff attitude is friendliness.	350	1.00	5.00	2.0543	1.07587
My bank staff gives prompt attention to my needs.	345	1.00	5.00	2.0812	.98496
My bank staff understands my needs.	347	1.00	5.00	2.1729	1.06660
My bank staff handles my problems efficiently.	350	1.00	5.00	2.2000	1.13552
My bank provides me a good customer service.	347	1.00	5.00	2.1441	1.09491
My overall opinion about my bank is good.	348	1.00	5.00	2.1810	1.12810
I am satisfied with my bank.	345	1.00	5.00	2.1710	1.08493
I will not switch to any other bank.	348	1.00	5.00	2.3247	1.14170

45.4 Conclusion

Above analysis shows that customer satisfaction vary according to the nature of the services and in this case, highest customer satisfaction is shown in such areas like price charged by banks is nominal, convenient location of bank branches and staff attitude toward problem solving of customers. When the private sector banks are compared with public sector banks, private bank customers were more satisfied with their bank because of their multiple branches at convenient locations and technology (like check deposit machines, utility bill accepting machines etc.) which were not even seen in public sector banks. But when we talk about public sector banks customers of public sector banks were more satisfied with reputation, reliability and the prices which public sector banks impose on services like cheque/cash deposit and cheque/cash withdraw (it has been shown that price charges are lower in public sector banks than in private sector). When we compare both types of banks in terms of customer care service, private sector banks are favored more than public sector banks. Although overall both public and private sector bank customers are satisfied with their banks but due to wide difference of response, both public and private sector banks should concentrate on their weak areas in order to meet their customer expectations and this study provides sort of guidelines to managers of banks to take suitable decisions to get more satisfied responses from their customers.

45.5 Limitations of the Study

Four limitations have been observed during this research. First, the research only focuses on public and private banks, other banks like Foreign and Micro financial institutions that also plays good role in Pakistani banking industry, has not been included in this research. Second, a limited number of cities were covered in this research (Sukkur, Lahore, Islamabad, Rawalpindi and Peshawar only). Third, the sample size and actual respondent numbers were limited because of limited time period. Finally, permission to carry out study inside and outside banks has not been given so I had to reach respondents individually which has consumed a lot of time as well.

References

1. Tiwary BK (2011) Consumer perception and satisfaction of banking products and services — A comparative study of select Indian public and private sector banks. Indian Streams Research Journal
2. Chennappa D, Eliat MJ (2009) Satisfaction of the credit card holders of the public, private and foreign sector banks. European Journal of Management 9
3. Colin B (2005) Private banks rate high in customer satisfaction. CRM Magazine
4. Farzad A (2009) A comparative study on service quality and customer satisfaction of public banks and private banks in Iran. In: Las Vegas International Academic Conference
5. Jitendra KM (2007) Constitute dimensions of customer satisfaction: A study of nationalized and private banks. The Young Economist Journal 1:40–47
6. KhaledAl H, Abdulrasoul HB (2008) Bank's customer satisfaction in Kuwait: An exploratory study. Open University Malaysia
7. Mohammad KV, ParinazK, Hassan KV et al (2012) The comparison of private state banks and other banks in Iran. European Journal of Social Sciences 27
8. Monica B (2010) An integrated framework for service quality, customer satisfaction and behavioral responses in Indian banking industry — A comparison of public and private sector banks. Journal of Services Research 10:157–172

9. Muhammad N (2009) Customer satisfaction in banking sector. National University of Modern Languages
10. Vidhyaa MJ (2009) A comparative study of customer services in ICICI (Industrial Credit And Investment Corporation Of India) and SBI (State Bank of India). ICFAI National College, Keelkattalai.
11. Senthikumar N, Ananth A, Arulraj A (2011) Impact of corporate social responsibility on customer satisfaction in banking service. African Journal of Business Management 5:3028–3039
12. Peter K, Vassilis V (1997) Private and public banks: A comparison of customer expectations and perceptions. International Journal of Bank Marketing 15:279–287
13. Puja K, Yukti A (2010) Comparative study of customer satisfaction in Indian public sector and private sector banks. International Journal of Engineering and Management Sciences 1:42–51
14. Pooja M (2009) Customer satisfaction with service quality: An empirical study of public and private sector banks. The IUP Journal of Management Research 9:7–17
15. Rengasamy E, Vijaya KG (2006) A comparative study on the service quality and customer satisfaction among private, public and foreign banks. The IUP Journal of Marketing Management
16. Surabhi S, Renu A (2011) A comparative study of banking services and customer satisfaction in public, private and foreign banks. Economics 2:45–56
17. Uma SM, Bibhuti BM, Swagat P et al (2011) CRM in banks: A comparative study of public and private sectors in India. European Journal of Social Sciences 24:
18. Vijay MK (2011) Service quality perception and customers satisfaction in internet banking service: A case study of public and private sector banks. Cyber Literature 4:21–30
19. Kamble SS, Dhume SM, Raut RD et al (2011). Measurement of service quality in banks: A comparative study between public and private banks in India. International Journal of Services and Operations Management 10:274–293
20. Khalid S, Mahmood B, Abbas M et al (2011). Customer satisfaction with service quality in conventional banking in Pakistan: The case of Faisalabad. International Journal of Marketing Studies 3:165
21. Mishra U, Mishra BB, Biswal SK et al (2010) Employee evaluations of customer satisfaction: A comparative study between public and private banks in India. International Research Journal of Finance and Economics 134–144

Author Index

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1,

Part V
Supply Chain Management

Chapter 46
Mathematical Models of Queues with Moving Servers — Simple Vertical Transportation Systems

Asaf Hajiyev, Narmina Abdullayeva and Turan Mammadov

Abstract In the paper various mathematical models of vertical (lift) transportation are constructed and investigated. For minimizing of a customer average waiting time before service and reducing energy expenses of the system the various control policy are introduced. The comparison of introduced control policies have done and advantage some of them have found. Various examples, demonstrating these results are given.

Keywords Vertical transportation systems · Queues · Mathematical models

46.1 Introduction

Systems with moving servers have different and rather complicated structures, because servers move in these systems and so there are observed complicated interactions between servers and customers. Although these problems could be formulated in the frames of classic models of the queuing theory, their research by common standard methods creates some issues. Hence, it is necessary to construct and develop the new mathematical models and new approaches for their research due to their complicated structure.

The typical examples of queues with moving servers are traffic, elevator systems and an important problem is a control by them. The USA invests about 10% of its

---

A. Hajiyev (✉)
Institute of Cybernetics, Azerbaijan National Academy of Sciences, Baku AZ1141, Azerbaijan
Baku State University, Baku AZ1141, Azerbaijan
e-mail: asaf@baku-az.net

T. Mammadov
Institute of Cybernetics, Azerbaijan National Academy of Sciences, Baku AZ1141, Azerbaijan

N. Abdullayeva
Azerbaijan Tourism Institute, Baku AZ1072, Azerbaijan

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_46,

GDP in traffic systems. This branch of investigation is very important today and many books, monographers [1, 2] and special scientific journals (Transportation Science, Transportation and Communication and others) are being published in this field.

In 1953, there was an opening ceremony of the new building of Lomonosov Moscow State University. It was introduced there control policy, where in one of the elevator hall some elevators went up to $1,2,\cdots n/2$ floors (n is a number of the floors) and others went up to $1,(n/2)+1,(n/2)+2,\cdots,n$ floors. The great A.N.Kolmogorov, who participated in the opening ceremony immediately pointed out, that it is the wrong control policy and instead of this policy must be $1,2,\cdots 2n/3$ and $1,(2n/3)+1,(2n/3)+2,\cdots n$ correspondingly. Later on, with the use of the modeling of the behavior of elevator systems on the computer, was shown that the Kolmogorov's advice was true [3] and computer programs for confirmation Kolmogorov's hint have been prepared [4]. During our work in Moscow State University we met control policy of elevators that was run by cleaning service women, who actually improved (reduced an expectation of waiting time before service) service but could not explain how. If two elevators came to first floor at the same time, the cleaning women delayed one of the elevators for cleaning and only after they were done it was ready for use. This idea was used in [5, 6], where for wide class of queues it was derived that introduction of delays improve (reduce waiting time) service and for some systems the gain in the expectation of customer waiting time exceeds 10%. Interesting control policy was suggested in [7], which was used for crossing one line tunnel by cars in two directions.

One other interesting unofficial control policy was used in the students' dormitory of Moscow State University, which was called "higher-lower". There were 18 floors in the student dormitory and four elevators operated between the 1st to 12th, 14th, 16th and 18th floors (for the elevators to work more rapidly they skipped the odd numbered floors, after 12th), there was another elevator hall for service between the 1st-10th floors. If an elevator came to the first floor and the first student yelled the word "HIGHER" then the elevator would be used for going up only to the higher floors (16th and 18th) and next elevator will give service to the 12th, 14th and other floors. If the first call would have been "LOWER", then the elevator would operate between the lower floors (12th, 14th and afterward other floors).

The mathematical models and modeling this strategy on a computer, which confirmed an advantage of the "higher-lower" strategy were constructed and investigated [3]. Other control policies by elevator system can be found in [4]. There is also another control policy by elevators system "EVEN-ODD", when one elevator gives service only for "EVEN" and other for "ODD" floors. Comparing of "HIGHER-LOWER" with "EVEN-ODD" in [3] showed an advantage of "HIGHER-LOWER" control policy.

46.2 Construction of the Mathematical Models

Consider a system of two lifts with unbounded volume, which services customers on n floors. At each floor a stationary flow of customers arrives for service. Introduce the matrix $\Lambda = /\lambda_{j_1 j_2}/$ with non-negative elements $\lambda_{j_1 j_2}$, which are the intensity of customers, which are going from j_1^{th} to j_2^{th} floor. It is assumed that arriving flow of customers is Poisson with intensity $\lambda_{j_1 j_2}$, $j = 1,2,\cdots,n$.

We will consider different cases:

1. Loading regime, when the first row of the matrix is nonzero, other elements equal to zero;
2. Unloading regime, when the first row of the matrix is zero, other elements are not equal to zero;
3. Mixed regime, when $\lambda_{j_1 j_2} \neq 0,\ j_1 \neq j_2$, i.e., all no diagonal elements of the matrix Λ takes nonzero values.

We assume that in all regimes $\lambda_{jj} = 0$, because there are no customer who is needed to go from j^{th} to j^{th} floor.

Loading regime corresponds to a situation in a living building, when people come back home (in the evening) or in the office buildings when they go to their offices (in the morning). However, unloading regime corresponds to a situation when in the living buildings people go to their offices (in the morning) and in the office buildings they go home (in the evening).

In this paper we consider simplest systems with 1 or 2 lifts and different control policies.

There exist different efficiency indexes for such systems. One of them is a customer average service time, which is defined as an interval from customer arriving instant into the system until the instant when a customer gets service, i.e., leaves lift. This efficiency index includes two components: w_1 is a customer average waiting time before beginning of service (i.e., interval from the customer arriving instant into the system until the instant when the lift arrives to the customer, i.e., to desired floor) and w_2 is a customer average service time (i.e., interval from the beginning of service instant until an instant when the customer leaves lift).

Another efficiency index is a lift energy expenses. This efficiency index includes also two components: the lift single race time (motion without customers) and customer race time (i.e., time interval when lift moves with customers).

A single race time is defined as the time interval when lift moves without customers (it does not matter up or down). For instance, if lift at the first floor and there is a customer at j^{th} floor then a single race time is defined as the time interval while lift moves from first floor to j^{th} without customers. Loaded race time (i.e., with customer) is defined as a time interval, while lift moves with customers from j_{th} floor to the first.

There are various control policies by such systems, which can be observed in the different buildings. For instance, using of two Independent Lifts (*IL*-system) in a building, i.e., if both lifts are not occupied, then both will arrive to first call. Another system, (without single race time *srt*) when both lifts are free and only the closer one to the call will arrive, will be called *DL*-system (Dependent Lifts), because motion of lifts will be dependent.

Introduce the following notations: $L_kF_nC_{xx}$ means system with k lifts, n floors and control policy xx, for instance, $L_2F_nC_{IL}$ means system with 2 lifts, n floors and control policy IL. The system $L_kF_nC_{nc}$ means k lifts, n floors, no control, i.e., each lift moves independently and that system coincides with the system $L_kF_nC_{IL}$.

Denote

$\mu(s)$: a customer average service time in the system (s), which is defined as a time interval from the instant of customer arriving into the system until the instant when customer will leave lift;

$h[j]$: time interval, for passing distance between k floors. For some cases we will assume $h[j] = (j-1)h_1$, where h_1 time interval for passing distance between two neighbor floors.

More complicated formula (systems with acceleration) also can be used. For each system a value of h_1 is given.

h_2 : stopping time interval at the floor (opening and closing a door);
$srt(s)$: single race time of the system (s);
n : number of the floors.

For each lift is defined a cycle time as an interval from an epoch when lift starts from the first floor (reaches the top floor) until the instant when it comes back to the first floor).

$T^U_{L_2F_nC_{UL}}$: a cycle time of upper lift in the system $L_2F_nC_{UL}$;
$T^L_{L_2F_nC_{UL}}$: a cycle time of the lower lift in the system $L_2F_nC_{UL}$. (i.e., cycle time from the first floor to k^{th} and back to the first floor);
$T^O_{L_2F_nC_{ORE}}$: a cycle time of an odd lift in the system $L_2F_nC_{OE}$;
$T^E_{L_2F_nC_{OE}}$: a cycle time of an even lift in the system $L_2F_nC_{OE}$;
$T_{L_2F_nC_{UL}}$: a cycle time for an arbitrary lift in the system $L_2F_nC_{UL}$.

As mentioned above, for simplicity we assume that lifts move without acceleration, i.e., $h[j] = (j-1)h_1$, although later on we will model systems with accelerations.

We consider systems with rare input flows i.e. $\lambda_{j_1 j_2}$ takes small values (denoted $\lambda_{j_1 j_2} \approx 0$). It means that at the next customer arrival instant the previous customer was already served and the lift is free.

This case faces difficulties during a simulation, because it needs a long simulation time, hence if it is possible we research that system by analytical approaches.

Other case, when intensities of input flows take large values, which means that at the each floor there are customers. Such systems are closed to deterministic cases, because at the each floor lift must stop for getting customers. For this case we assume that lift has unbounded capacity (volume).

$$\lambda_1 = \sum_{j=2}^{n} \lambda_{1j},\ \lambda_2 = \sum_{j=2}^{n} \lambda_{j1} \text{ and assume } \lambda_{j_1 j_2} = 0,\ j_1, j_2 \neq 1.$$

46.2.1 Systems with One Lift

$L_1F_nC_{IL}$ **(one lift, n floors, no control). Loading regime.**

$$\lambda_{12} = \lambda_{13} = \cdots = \lambda_{1n} \approx 0,\ \lambda_1 \approx 0,\ \lambda_{j1} = 0,\ j = 2,3,\cdots,n.$$

We assume that customer chooses j^{th} floor $(i = 2,\cdots,n-1)$ with probability $1/(n-1)$, i.e., according to discrete uniform distribution. In the end of each service lift occupies j^{th} floor with probability $1/(n-1)$, because customer takes any floor with the same probability. Thus, at the preceding of customer arriving epoch lift occupies j^{th} floor with the same probability (see Fig. 46.1), where:

□ : lift;
t_i^{j+} : arriving instant of i^{th} customer, which goes from the first floor to the up (to the j^{th} floor);
$t_i^{(s)}$: a service end instant of i^{th} customer;
t_i^{i+} : i^{th} arriving instant of lift to desired floor (to the customer);
$t_i^{(j-)}$: arriving instant of i^{th} customer, which comes down from j^{th} floor;
$t_i^{(k,a)}$: arriving instant of the k^{th} lift to i^{th} call;
$t_i^{(k,s)}$: i^{th} end of service instant of k^{th} lift;
$\left[t_k^{(a)} - t_k^{(\cdot+)}\right]$: a waiting time before service of k^{th} customer (single race time);
$\left[t_k^{(s)} - t_k^{(a)}\right]$: a spending time in the lift of k^{th} customer;
$\left[t_k^{(s)} - t_k^{(\cdot+)}\right]$: a service time of k^{th} customer;
(- - - -) : lift free time interval (no customers in the system)

Below a bold square means that lift is free.

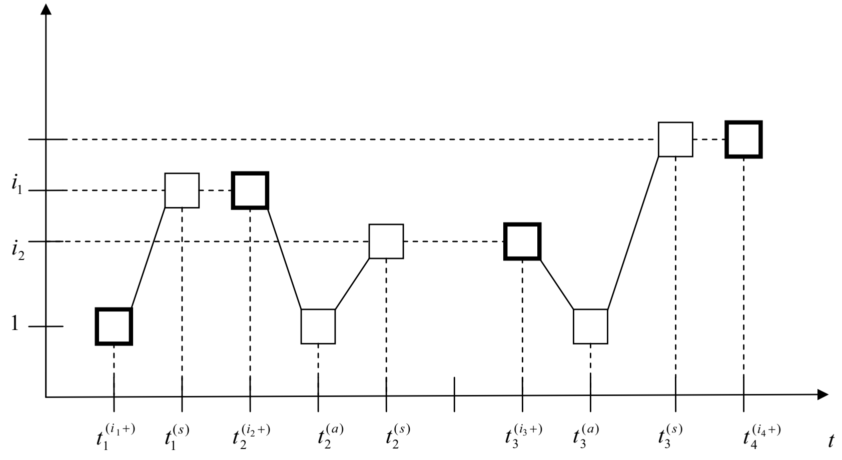


Fig. 46.1 Lift position at the different instants for the system $L_1F_nC_{IL}$

In Fig. 46.1, lift position at the different instants for the system $L_1F_nC_{IL}$ is shown. Below for simplicity we assume that n is even number. Hence,

$$\mu(L_1F_nC_{IL}) = (n-1)h_1 + h_2 \text{ and } srt(L_1F_nC_{IL}) = (n-1)h_1/2 + h_2. \quad (46.1)$$

(1) System $L_1F_nC_{xx}$ (One Lift, Control Policy xx, n-Floors)

Introduce control policy, which means that in the end of service lift immediately must go to the first floor. We denote such control policy as It is natural control, because there are only customers at the first floor. Thus, according to the control policy in the end of customer service lift must go to the first floor.

Hence, according to the control policy at the preceding customer arriving epoch lift must occupy first floor (see Fig. 46.2), where t^* is the instant when lift comes down to the first floor.

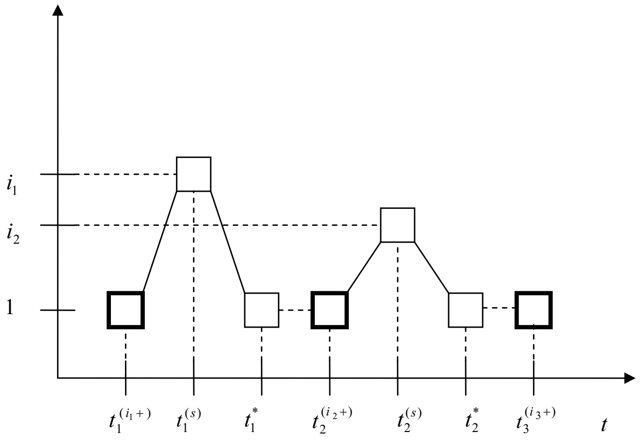


Fig. 46.2 Lift position at the different instants for the system $L_1F_nC_1$

In Fig. 46.2, there is shown lift position at the different instants for the system $L_1F_nC_1$. Hence,

$$\mu(L_1F_nC_1) = (n-1)h_1/2 + h_2 \text{ and } srt(L_1F_nC_1) = (n-1)h_1/2 + h_2. \quad (46.2)$$

Thus,

$$\begin{aligned} \mu(L_1F_nC_1)/\mu(L_1F_nC_{IL}) &= [(n-1)h_1/2 + h_2]/[(n-1)h_1 + h_2], \\ &= [h_1/2 + h_2/(n-1)]/[h_1 + h_2/(n-1)] \approx 1/2, \\ srt(L_1F_nC_1)/srt(L_1F_nC_{IL}) &= 1. \end{aligned} \quad (46.3)$$

For large values n the expression in (46.3) closed to $1/2$, i.e., other words by introducing such type of control policy we can decrease customer service time by two times but single race time is not changed.

Remark 46.1. In the case of system with one lift, *NC* means no control, in the case of two lifts without control means two independent lifts and it will be noted *IL*.

(2) System $L_1F_nC_{NC}$ (One Lift, n Floors, No Control)
Unloading regime.

$$\lambda_{12} = \lambda_{13} = \cdots = \lambda_{1n} = 0,\ \lambda_{21} = \lambda_{31} = \cdots = \lambda_{n1} \approx 0,\ \sum_{j=2}^{n} \lambda_{j1} = \lambda_2 \approx 0.$$

As all customers coming down from j^{th} $(i = 2, 3, \cdots, n)$ floor to the first floor, hence in the end of customer service lift always occupies first floor (see Fig. 46.3).

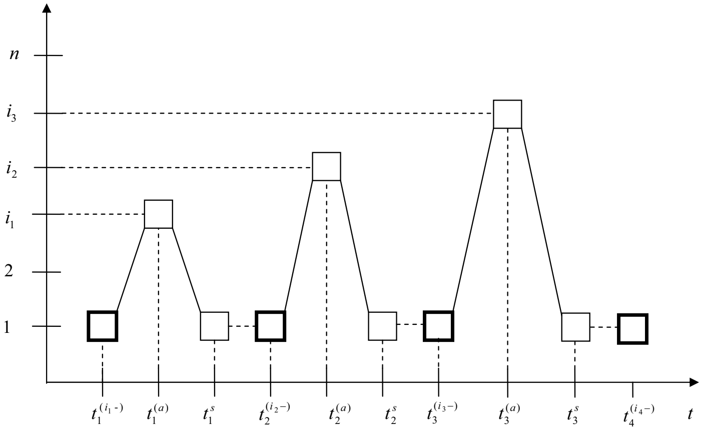


Fig. 46.3 Lift position at the different instants for the system $L_1F_nC_{NC}$

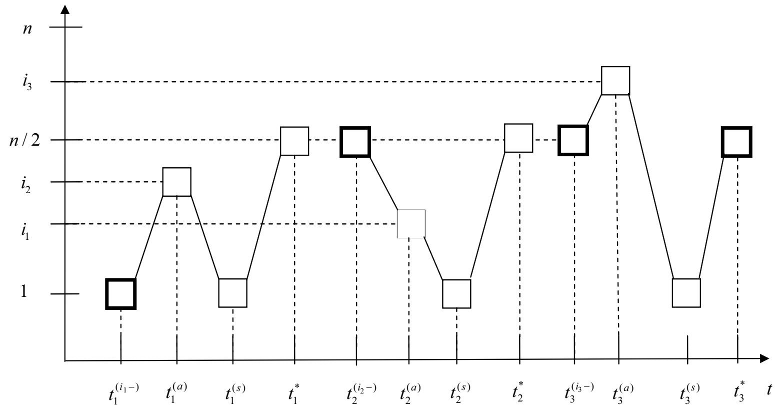
In Fig. 46.3, there is shown lift position at the different instants for the system $L_1F_nC_{NC}$.
(3) System $L_1F_nC_p$ (One lift, n Floors, p-Control Policy)
Unloading regime.

Control means that in the end of customer service lift immediately must go to the $(n/2)^{th}$ floor. Thus, at the preceding customer arriving instant lift must occupies $(n/2)^{th}$ floor, we call it as the control policy $C_{n/2}$ (see Fig. 46.4).

In Fig. 46.4, there is shown lift position at the different instants for the system $L_1F_nC_{n/2}$.

Example 46.1. It is shown that:

$$\mu(L_1F_nC_{n/2}) = 3(n-1)h_1/4 + h_2,\ srt(L_1F_nC_{n/2}) = 3(n-1)h_1/4 + h_2. \quad (46.4)$$



Note: Red C-40 Oepomo Method, and Green C-40 QR Method

Fig. 46.4 Lift position at the different instants for the system $L_1F_nC_{n/2}$

From Equations (46.1) and (46.4), we have:

$$\mu(L_1F_nC_{n/2})/\mu(L_1F_nC_{IL}) = [3(n-1)h_1/4+h_2]/[(n-1)h_1+h_2],$$
$$srt(L_1F_nC_{n/2})/srt(L_1F_nC_{IL}) = [3(n-1)h_1/4+h_2]/[(n-1)h_1/2+h_2].$$

Thus, customer service time in the $L_1F_nC_{n/2}$ system will be decreased by 25% but single race time will be increased by 25%.
(4) System $L_1F_nC_IL$ (One Lift, n Floors, No Control)
Mixed regime.

$$\lambda_{12} = \lambda_{13} = \cdots = \lambda_{1n} \approx 0, \lambda_{21} = \lambda_{31} = \cdots = \lambda_{n1} \approx 0, \ \sum_{j=2}^{n} \lambda_{j1} = \lambda_2 \approx 0.$$

If lift serves customers from first flow then in the end of service it occupies j^{th} floor ($j = 2,3,\cdots,n$) and if it serves customer from j^{th} floor ($j = 2,3,\cdots,n$) in the end of service lift occupies first floor. Probability to get lift at the first floor equals $\lambda_2/(\lambda_1+\lambda_2)$ and probability to get lift at the j^{th} floor ($j = 2,3,\cdots,n$) equals $\lambda_1/(\lambda_1+\lambda_2)$. Probability to have customer at the first floor equals $\lambda_1/(\lambda_1+\lambda_2)$ and to have customer at the others floor equals $\lambda_2/(\lambda_1+\lambda_2)$. Probability to have customer at the floors $2,3,\cdots,k$ equals $[\lambda_1/(\lambda_1+\lambda_2)][(k-1)/(n-1)]$. Using formula of complete probability we have.

Example 46.2. Let us calculate $\mu(L_1F_nC_{IL})$ for this case.

Each customer arrives to the first flow with probability $\lambda_1/(\lambda_1+\lambda_2)$ and to the j^{th} flow ($j = 2,3,\cdots,n$) with probability $\lambda_2/(\lambda_1+\lambda_2)$. Probability to have lift at the first flow equals $\lambda_2/(\lambda_1+\lambda_2)$ and to have at the j^{th} flow equals $\lambda_1/[(n-1)(\lambda_1+\lambda_2)]$. Using total probability formula and taking into consideration above mentioned facts we have:

$$\begin{aligned}
\mu(L_1F_nC_{IL}) = {} & \lambda_2/(\lambda_1+\lambda_2)\{[\lambda_1/(\lambda_1+\lambda_2)](n-1)h_1/2+2h_2+(\lambda_2/(\lambda_1+\lambda_2)) \\
& (n-1)h_1+2h_2\}+\lambda_1/(\lambda_1+\lambda_2)\{[\lambda_1/(\lambda_1+\lambda_2)][(n-1)h_1+2h_2] \\
& +(\lambda_2/(\lambda_1+\lambda_2)(1/(n-1)*\sum_{i=2}^{n}[(i-1)/(n-1)](i-1)+[(n-i)/ \\
& (n-1)][(n-i)+(i-1)]h_1+2h_2\} \\
= {} & [\lambda_1\lambda_2(n-1)/2+\lambda_2^2(n-1)+\lambda_1^2(n-1)+\lambda_1\lambda_2(5n^2-4n-3)h_1/ \\
& 6(n-1)]/(\lambda_1+\lambda_2)^2+h_2.
\end{aligned}$$

Similarly we have:

$$\begin{aligned}
srt(L_1F_nC_{IL}) = {} & \lambda_2/(\lambda_1+\lambda_2)[(\lambda_2/(\lambda_1+\lambda_2))(n-1)/2]h_1+\lambda_1/(\lambda_1+\lambda_2)\{[\lambda_1/(\lambda_1 \\
& +\lambda_2)][(n-1)/2+(\lambda_2/(\lambda_1+\lambda_2)(1/(n-1))h_1*\sum_{i=2}^{n}[(i-1)/(n-1)] \\
& (i-1)/2+[(n-i)/(n-1)][(n-i)/2]+h_2 \\
= {} & [\lambda_2^2(n-1)/2+\lambda_1^2(n-1)/2+\lambda_1\lambda_2(2n^3-8n^2+8n-9)/6(n-1)^2] \\
& h_1/(\lambda_1+\lambda_2)^2+h_2.
\end{aligned}$$

For large n we have:

$$\begin{aligned}
\mu(L_1F_nC_{IL}) &\approx [(\lambda_1^2+\lambda_2^2+4\lambda_1\lambda_2/3)]nh_1/(\lambda_1+\lambda_2)^2+h_2, \\
srt(L_1F_nC_{IL}) &\approx [(\lambda_1^2/2+\lambda_2^2/2+\lambda_1\lambda_2/3)]h_1n/(\lambda_1+\lambda_2)^2+h_2. \qquad (46.5)
\end{aligned}$$

Corollary 46.1. *If* $\lambda_1 = 0$*, then from Equation (46.5) it follows Equation (46.4) and if then from Equation (46.5) it follows Equation (46.1).*

(5) System $L_1F_nC_p$ (One Lift, n Floors and with p-Control Policy.)
Mixed regime.

$$\begin{aligned}
&\lambda_{12} = \lambda_{13} = \cdots = \lambda_{1n} \approx 0, \lambda_{21} = \lambda_{31} = \cdots = \lambda_{n1} \approx 0, \\
&\sum_{j=2}^{n} \lambda_{1j} = \lambda_1 \approx 0, \sum_{j=2}^{n} \lambda_{j1} = \lambda_2 \approx 0.
\end{aligned}$$

Let's introduce the following control. In the end of service the lift must go to k^{th} floor. What would be an optimal k, which minimizes value of w?

$$\begin{aligned}
\mu(L_1F_nC_k) = {} & \lambda_1/(\lambda_1+\lambda_2)[(k-1)+(n-1)/2]h_1+\lambda_2/(\lambda_1+\lambda_2)\{[(k-1)/ \\
& (n-1)][k-1]+[(n-k)/(n-1)](n-k+k-1)\}h_1 \\
= {} & [\lambda_2/(\lambda_1+\lambda_2)](k-1)^2/(n-1)++[\lambda_1/(\lambda_1+\lambda_2)-\lambda_2/(\lambda_1+\lambda_2)] \\
& (k-1)+(n-1)[\lambda_1/2(\lambda_1+\lambda_2)+\lambda_2/(\lambda_1+\lambda_2)]h_1+h_2. \qquad (46.6)
\end{aligned}$$

Example 46.3. Let us show that:
if $\lambda_2 = 0$, then $k = 1$, if $\lambda_1 = 0$, then $k = (n-1)/2$ (see Fig. 46.4),

if $\lambda_1 \geq \lambda_2$, then $\lambda_1 < \lambda_2$, then $k = (1 - \lambda_1/\lambda_2)(n-1)/2$.

Corollary 46.2. *If $\lambda_2 = 0$, then Equation (46.6) can be represented in the following form:*

$$\mu(L_1F_nC_k) = [(k-1) + (n-1)/2]h_1 + h_2. \tag{46.7}$$

If $k = 1$, then from Equation (46.7), it follows Equation (46.3).

Corollary 46.3. *If $k = 1$, then from Equation (46.6), we have:*

$$\begin{aligned}\mu(L_1F_nC_k) &= \{[(k-1)/(n-1)][k-1] + [(n-k)/(n-1)](N-k+k-1)\}h_1 + h_2 \\ &= [(k-1)^2/(n-1) - (k-1) + (n-1)]h_1 + h_2. \qquad (46.8)\end{aligned}$$

If $k = (n-1)/2$, then $\mu(L_1F_nC_{(n-1)/2}) = 3(n-1)h_1/4 + h_2$, i.e., from Equation (46.8), it follows Equation (46.4).

Corollary 46.4. *If $\lambda_1 = \lambda_2$, then*

$$\begin{aligned}\mu(L_1F_nC_{(n-1)/2}) = {} & \lambda_1/(\lambda_1+\lambda_2)[(k-1)+(n-1)/2]h_1 + \lambda_2/(\lambda_1+\lambda_2)\{[(k-1)/ \\ & (n-1)][k-1] + [(n-k)/(N-1)](n-k+k-1)\}h_1 + h_2 \\ = {} & [\lambda_2/(\lambda_1+\lambda_2)](k-1)^2/(n-1) + (n-1)[\lambda_1/2(\lambda_1+\lambda_2) \\ & +\lambda_2/(\lambda_1+\lambda_2)]h_1 + h_2 \\ = {} & [(k-1)^2/2(n-1) + 3(n-1)/4]h_1 + h_2 \qquad (46.9)\end{aligned}$$

and it follows from Equation (46.9), $k = 1$, $\mu(L_1F_nC_1) = 3(n-1)h_1/4 + h_2$.

Corollary 46.5. *If $\lambda_1 > \lambda_2$, then:*

$$\begin{aligned}\mu(L_1F_nC_1) = {} & \lambda_1/(\lambda_1+\lambda_2)[(k-1)+(n-1)/2]h_1 + \lambda_2/(\lambda_1+\lambda_2)\{[(k-1)/(n-1)] \\ & [k-1] + [(n-k)/(n-1)](n-k+k-1)\}h_1 + h_2 \\ = {} & \{[\lambda_2/(\lambda_1+\lambda_2)](k-1)^2/(n-1) + [\lambda_1/(\lambda_1+\lambda_2) - \lambda_2/(\lambda_1+\lambda_2)] \\ & (k-1) + (n-1)[\lambda_1/2(\lambda_1+\lambda_2) + \lambda_2/(\lambda_1+\lambda_2)]\}h_1 + h_2. \qquad (46.10)\end{aligned}$$

Hence, it follows from Equation (46.10):

$$k = 1,\ \mu(L_1F_nC_1) = (n-1)h_1/[\lambda_1/2(\lambda_1+\lambda_2) + \lambda_2/(\lambda_1+\lambda_2)] + h_2.$$

46.2.2 Systems with Two Lifts

(1) System $L_2F_nC_{IL}$ (two lifts, n floors, control policy - IL)
Loading regime.

$$\lambda_{12} = \lambda_{13} = \cdots = \lambda_{1n} \approx 0,\ \sum_{j=2}^{n} \lambda_{1j} \approx 0,\ \lambda_{21} = \lambda_{31} = \cdots = \lambda_{n1} = 0.$$

We assume that if both lifts are free then to the next customer call both lifts are going. Such situations can be observed in buildings where each lift has and individual call button and when those buttons are pushed simultaneously. Thus, both lifts will independently going to a call. Then, for that system at the preceding customer arriving instant one lift occupies the first floor, the other j^{th} $(i = 2, 3, \cdots, n)$ floor (see Fig. 46.5).

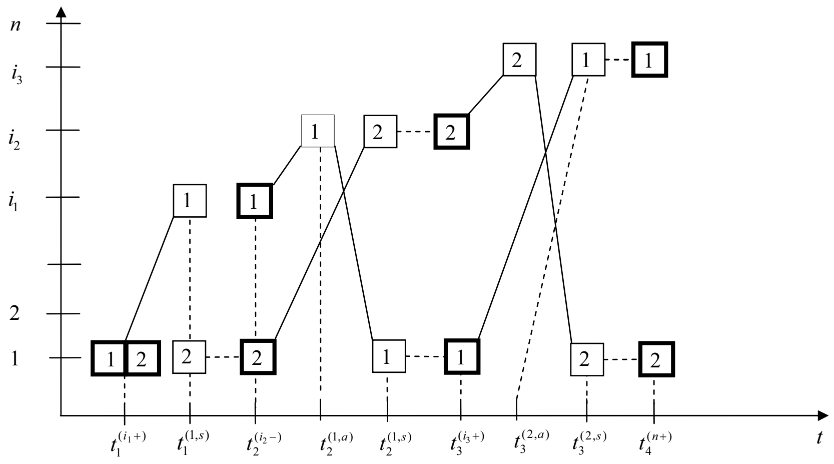


Fig. 46.5 Lifts positions at the different instants for the system

In Fig. 46.5, there are shown lifts positions at the different instants for the system. Hence,

$$\mu(L_2F_nC_{IL}) = (n-1)h_1/2 + h_2 \text{ and } srt(L_2F_nC_{IL}) = (n-1)h_1/2 + h_2. \quad (46.11)$$

Consider the system $L_2C_{DL}F_n$. For customer call only one lift is going, i.e., nearest lift. Then starting from third customer at the preceding of customer arriving instant with the same probability one lift occupies j_1^{th} $(j_1 = 2, 3, \cdots)$ floor another j_1^{th} $(j_1 = 2, 3, \cdots)$ floor (see Fig. 46.6). Hence, floor another j_2^{th} $(j_2 = 2, 3, \cdots)$ floor (see Fig. 46.6). Hence,

$$\lambda(L_2F_nC_{DL}) = (n-1)h_1 + h_2 \text{ and } srt(L_2F_nC_{DL}) = (n-1)h_1/2 + h_2. \quad (46.12)$$

Comparison of Equation (46.11) and Equation (46.12) shows that for small values of intensity the system preferable that the system $L_2F_nC_{DL}$ as $\lambda(L_2F_nC_{IL}) < \lambda(L_2F_nC_{DL})$, but single race time the same.
(2) System $L_2F_nC_{IL}$ (two lifts, n floors, no control)
Unloading regime.

$$\lambda_{12}=\lambda_{13}=\cdots=\lambda_{1n}=0,\ \lambda_{21}=\lambda_{31}=\cdots,\lambda_{n1}\approx 0,\ \sum_{j=2}^{n}\lambda_{j1}\approx 0.$$

Both lifts go to calls independently from each other. Then similarly as it was in the previous system at the preceding customer arriving instant one lift occupies first floor, another j^{th} $(j=2,3,\cdots,n)$ floor (see Fig. 46.5). Hence,

$$\begin{aligned}
\mu(L_2F_nC_{IL}) = {} & [1/(n-1)]\sum_{i=2}^{n}[(i-1)/2(n-1)](i-1)/2+[(i-1)/2(n-1)]\\
& (i-1)+(n-i)/(n-1)[(n-i)+(i-1)]h_1+h_2=[1/(n-1)]^2\\
& \left[\sum_{i=2}^{n}3(i-1)^2/4+(n-i)(n-1)\right]\\
= {} & [1/(n-1)]^2[3n(n-1)(2n-1)/24+(n-1)^2(n-2)/2]h_1+h_2,\\
srt(L_2F_nC_{IL}) = {} & \{[1/(n-1)]\sum_{i=2}^{n}[(i-1)/2(n-1)](i-1)/4+[(i-1)/2(n-1)]\\
& (i-1)/4+(n-i)/(n-1)[(n-i)/2]\}h_1+h_2=[1/(n-1)]^2\\
& \left[\sum_{i=2}^{n}(i-1)^2/4+(n-i)^2\right]h_1+h_2\\
= {} & [1/(n-1)]^2[n(n-1)(2n-1)/24+(n-1)(n-2)(2n-3)/6]h_1\\
& +h_2.
\end{aligned}$$

For large n we have:

$$\mu(L_2F_nC_{IL})\approx(3/4)nh_1+h_2,\ srt(L_2F_nC_{IL})\approx(5/12)nh_1+h_2. \tag{46.13}$$

For this case control policy will be introduced later.
(3) System $L_2F_nC_{IL}$ (two lifts, n floors, no control)
Mixed regime.

$$\lambda_{12}=\lambda_{13}=\cdots=\lambda_{1N}\approx 0,\textstyle\sum_{j=2}^{n}\lambda_j\approx 0,\lambda_{21}=\lambda_{31}=\cdots=\lambda_{n1}\approx 0,$$
$$\textstyle\sum_{j=2}^{n}\lambda_{j1}=\lambda_2\approx 0.$$

In this case at the preceding customer arriving instant one lift occupies first floor and another j^{th} floor $(j=2,3,\cdots,n)$. The probability to have customer at the first floor is $\lambda_1/(\lambda_1+\lambda_2)$ and at the other floor $\lambda_2/(\lambda_1+\lambda_2)$. Thus, customer average service time comes to:

$$\begin{aligned}
\mu(L_2F_nC_{IL}) = {} & \{(\lambda_1/(\lambda_1+\lambda_2)((n-1)/2)+(\lambda_2/(\lambda_1+\lambda_2))(1/(n-1))\left[\sum_{i=2}^{n}[(i-1)/\right.\\
& \left.2(n-1)](i-1)/2+[(i-1)/2(n-1)](i-1)\right]+(n-i)/(n-1)\\
& [(n-i)+(i-1)]\}h_1+h_2
\end{aligned}$$

$$= \left\{ (\lambda_1/(\lambda_1+\lambda_2))(n-1)/2 + (\lambda_2/(\lambda_1+\lambda_2))[1/(n-1)]^2 \right.$$
$$\left. \left[\sum_{i=2}^{N} 3(i-1)^2/4 + (n-i)(n-1) \right] \right\} h_1 + h_2$$
$$= \{(\lambda_1/(\lambda_1+\lambda_2))(n-1)/2 + +(\lambda_2/(\lambda_1+\lambda_2))[1/(n-1)]^2[3n(n-1)$$
$$(2n-1)/24 + (n-1)^2(n-2)/2]\}h_1 + h_2,$$
$$srt(L_2F_nC_{IL}) = \{(\lambda_2/(\lambda_1+\lambda_2))(1/(n-1)) \left[\sum_{i=2}^{n} [(i-1)/2(n-1)](i-1)/4 \right.$$
$$\left. +[(i-1)/2(n-1)](i-1)/4 \right] + (n-i)/(n-1)[(n-i)/2]\}h_1 + h_2$$
$$= \left\{ (\lambda_2/(\lambda_1+\lambda_2))[1/(n-1)]^2 \left[\sum_{i=2}^{n} (i-1)^2/8 + (n-i)^2/2 \right] \right\} h_1 + h_2$$
$$= (\lambda_2/(\lambda_1+\lambda_2))[1/(n-1)]^2[n(n-1)(2n-1)/48 + (n-1)(n-2)$$
$$(2n-3)/12]h_1 + h_2.$$

For large n we have:

$$\mu(L_2F_nC_{IL}) \approx (n/4)(2\lambda_1 + 3\lambda_2)h_1/(\lambda_1+\lambda_2) + h_2$$

and

$$srt(L_2F_nC_{IL}) \approx (5/24)nh_1(\lambda_2/(\lambda_1+\lambda_2)) + h_2.$$

Corollary 46.6. *If* $\lambda_1 = \lambda_2$*, then*

$$\mu(L_2F_nC_{IL}) \approx (5/8)nh_1 + h_2,\ srt(L_2F_nC_{IL}) \approx (5/48)nh_1 + h_2. \qquad (46.14)$$

(4) Two Lifts, n Floors, Control Policy xx

Mixed Regime.

Introduce the control policy, which means that at the preceding customer arriving instant one lift occupies j_1^{th} floor, another j_2^{th} floor. Our aim is to find k_1 and k_2, which minimizes the value of $\mu(L_2F_nC_{xx})$. Similarly (46.4), we have:

$$\mu(L_2F_nC_{k_1k2}) = \{(\lambda_1/(\lambda_1+\lambda_2)(k_1 - 1 + (n-1)/2) + (\lambda_2/(\lambda_1+\lambda_2))\{[(k_1-1)/$$
$$(n-1)](k_1-1) + [(k_2-k_1)/2(n-1)][(k_2-k_1)/2 + (k_1-1)]$$
$$+[k_2-k_1)/2(n-1)](k_2-1) + [(n-k_2)/(n-1)][(n-k_2)$$
$$+(k_2-1)]\}h_1 + h_2,$$
$$srt(L_2F_nC_{k_1k_2}) = (\lambda_1/(\lambda_1+\lambda_2)(k_1-1)h_1 + \lambda_2/(\lambda_1+\lambda_2))\{[(k_1-1)/(n-1)]$$
$$(k_1-1)/2 + [(k_2-k_1)/2(n-1)][(k_2-k_1)/2] + [(n-k_2)/$$
$$(n-1)](n-k_2)/2\}h_1 + h_2. \qquad (46.15)$$

Example 46.4. It can be shown that for large n

$$\begin{aligned} k_1 &\approx \max[1,(n/4)(1-3\lambda_1/\lambda_2)],\\ k_2 &\approx (k_1+2n)/3. \end{aligned} \qquad (46.16)$$

Using Equations (46.15) and (46.16), we have:

$$\begin{aligned} \mu(L_2F_nC_{k_1k_2}) = {} & \{\lambda_1[(k_1-1)+(n-1)/2]+(\lambda_2[3(k_1-1)^2\\ & +(n-k_1)(k_1+2n-4)]/3(n-1)\}/(\lambda_1+\lambda_2),\\ srt(L_2F_nC_{k_1k_2}) = {} & \{\lambda_1(k_1-1)+[\lambda_2/4(n-1)][2(k_1-1)^2+(k_2-k_1)^2\\ & +2(n-k_2)^2]\}/(\lambda_1+\lambda_2)\\ = {} & \{\lambda_1(k_1-1)+[\lambda_2/6(n-1)][3(k_1-1)^2+(n-k_1)^2]\}/\\ & (\lambda_1+\lambda_2). \end{aligned} \qquad (46.17)$$

Remark 46.2. If $\lambda_2 = 0$, then it follows from Equation (46.16), $k_1 = 1$. In this case, in fact only one lift operates, because in the end of service it comes to the first flow and there are no customers in another floor. Therefore, it does not matter location of the second lift. For large n, it follows from Equation (46.17) $\mu(L_2F_nC_{11}) \approx (n-1)/2$, $srt(L_2F_nC_{11}) = 0$.

Remark 46.3. If $\lambda_1 = 0$, then for large Nit follows from Equations (46.16) and (46.17).

$$k_1 = n/4, k_2 = 3n/4, \mu(L_2F_nC_{k_1k_2}) = 5n/8, srt(L_2F_nC_{k_1k_2}) = n/8. \qquad (46.18)$$

i.e., at the preceding customer arriving epoch one lift occupies $[n/4]^{th}$ floor another $[3n/4]^{th}$ floor (see Fig. 46.6).

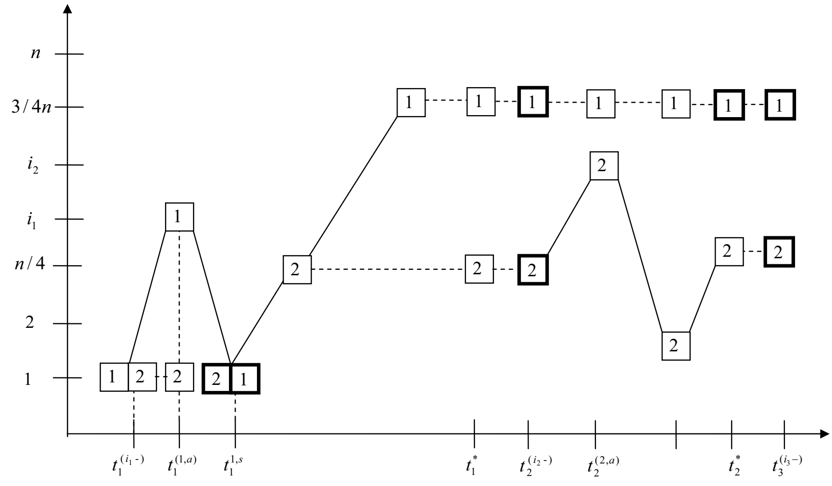


Fig. 46.6 Lifts positions at the different instants for the system $L_1F_nC_{n/4,3n/4}$

In Fig. 46.6, there are shown lifts positions at the different instants for the system $L_1F_nC_{n/4,3n/4}$. Comparison (46.17) and (46.18) shows that control gives the gain in the customer average service time 16% and in the *srt* 10%.

Remark 46.4. If $\lambda_1 = \lambda_2$, then for large n it follows from Equations (46.16) and (46.17)

$$k_1 = 1, k_2 = 2n/3,\ \mu(L_2F_nC_{k_1k_2}) = 7n/12,\ srt(L_2F_nC_{k_1k_2}) = n/12. \quad (46.19)$$

i.e., at the preceding customer arriving epoch one lift must occupy first floor another $2n/3$ floor, (see, Fig. 46.7). We assume that $2n/3$ is an integer number.

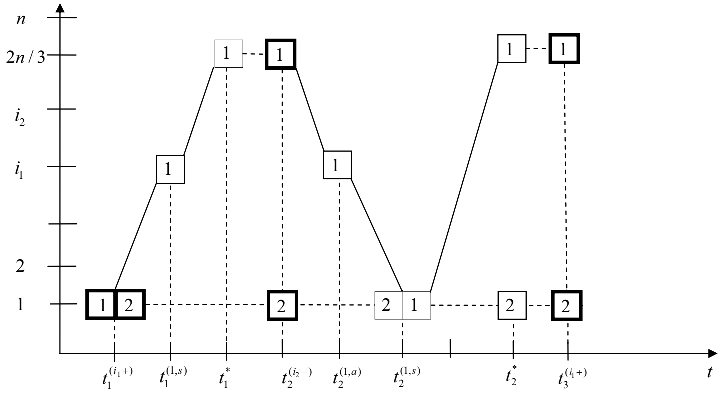


Fig. 46.7 Lifts positions at the different instants for the system $L_2F_nC_{1,2n/3}$

In Fig. 46.7, there is shown lifts positions at the different instants for the system $L_2F_nC_{1,2n/3}$. Comparison (46.19) with (46.14) shows that control gives the gain in the customer average service time 4% and in the single race time 2%.

Exercise 46.1. Consider the system $L_lF_nC_{k_1,k_2,\cdots,k_l}$, where l is a number of lifts in the system. Denote k_i the floor, which lift must occupy for an optimal service. We'll show that for the system $L_lF_nC_{k_1k_2,\cdots,k_l}$ in the mixed regime $k_1, k_2, \cdots, k_l$ satisfy to the following recurrent formulas (see Fig. 46.8)

$$\begin{cases} 2\lambda_1(n-1) + \lambda_2(3k_1 - k_2 - 2) = 0 \\ k_{s-1} - 2k_s + k_{s+1} = 0, \quad s = 2, 3, \cdots, l-1 \\ 2n - 3k_l + k_{l-1} = 0. \end{cases} \quad (46.20)$$

In Fig. 46.8, there are shown lifts positions at the different instants for the system $L_3F_nC_{k_1k_2,k_3}$, where t_i is customer arriving instant into the system, $l = 3$, k_1, k_2, k_3 satisfy to Equation (46.20).

According to optimal control at the each preceding customer arriving instant one lift must occupy j_1^{th} floor, another j_2^{th} floor and third lift j_3^{th} floor.

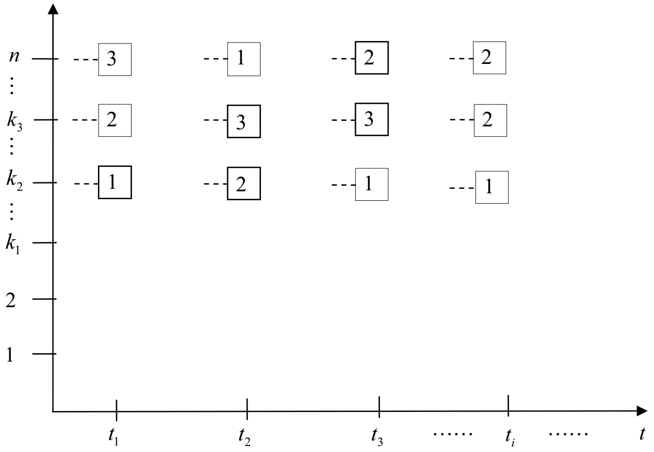


Fig. 46.8 Lifts positions at the different instants for the system $L_3F_nC_{k_1k_2,k_3}$

Example 46.5. Suppose that n takes large values. Show:

$$\begin{aligned}
k_1 =\ & \max\left[1, \frac{n\lambda_2 + (\lambda_2 - \lambda_1(n-1))(2l-1)}{2l\lambda_2}\right] = \max\left[1, \frac{n}{2l}\left(1 - \frac{\lambda_1}{\lambda_2}(2l-1)\right)\right], \\
k_s =\ & k_1 + 2(s-1)\frac{n-k_1}{2l-1} = k_1\left(1 + \frac{2(s-1)}{2l-1}\right) + \frac{2(s-1)}{2l-1}n \\
=\ & \frac{2(l-s)+1}{2l-1}k_1 + \frac{2(s-1)}{2l-1}n
\end{aligned}$$

is a unique solution of Equation (46.21).

Corollary 46.7. *Let $l = 3$ and $\lambda_1 = \lambda_2$. Then for large values n:*

$$k_1 = 1,\ k_2 = 2n/5,\ k_3 = 4n/5.$$

In Fig. 46.9, there are shown lifts positions at the different instants for the system $L_3F_nC_{k_1k_2,k_3}$.

46.2.3 Two Lifts, n Floors. Different Control Policies

System $L_2F_nC_{xx}$. Consider two lifts, which serves customers at the building with n-floors. Let us also assume, that each lift has a large volume (i.e., infinite volume, $m \to \infty$) and $1j \to \infty$ and each customer will choose a floor according to uniform distribution.Under these conditions such system closes to deterministic system and taking into consideration that the upward moving lift will stop on each floor (be-

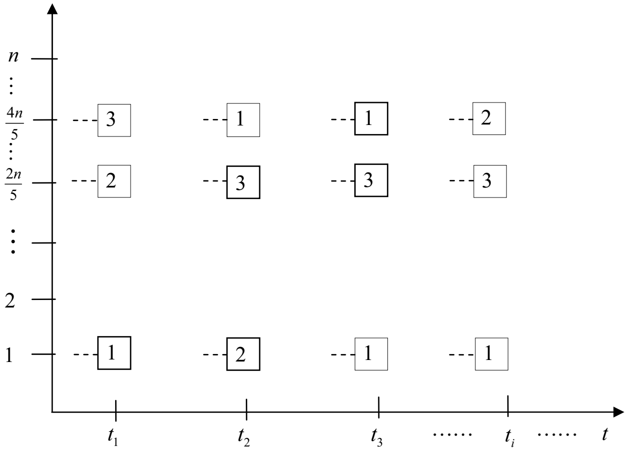


Fig. 46.9 Lifts positions at the different instants for the system $L_3F_nC_{k_1k_2,k_3}$

cause $\lambda_{1j} \to \infty$ and customer chooses a floor according to uniform distribution the following simple formulas are true:

$$T^L_{L_2F_nC_{UL}} = 2h[j-1] + (j-1)h_2, \quad T^U_{L_2F_nC_{UL}} = 2h[n-1] + h[n-j]h_2,$$
$$T^O_{L_2F_nC_{OE}} = 2(n-1)h[k] + lh_2, \quad T_{L_2F_nC_{UL}} = 2h[n-1] + (n-1)h_2.$$

We will call j an optimal floor separation for system $L_2F_nC_{Ul}$, if an expectation of waiting time of customer before service for customers who is going to the floors $2,3,\cdots,j$ coincides with an expectation of waiting time of customers that are going to the floors $j+1, j+2,\cdots,n$. Other words, it means that cycle time of lift "upper" and "lower" must be equal. Then j can be found from the equation:

$$T^U_{L_2F_nC_{UL_n}} = T^L_{L_2F_nC_{UL}},$$

i.e., j should be solution of the equation:

$$2h[j-1] + (j-1)h_2 = 2h[n-1] + (n-j)h_2.$$

If $h[k] = kh_1$, then for j we have $j = \{2nh_1 + (n+1)h_2\}/2\{h_1 + h_2\}$.

In the capacity of the efficiency index, we'll take cycle time of the lifts. Let's compare $L_2F_nC_{UL}$ and $L_2C_{OE}F_n$ systems. Consider

$$\lim_{n\to\infty}\left(1 - T^U_{L_2F_nC_{UL}} / T^O_{L_2F_nC_{OE}}\right) = 1 - [(2h_1 + h_2)^2/(h_1 + h_2)4(h_1 + h_2) \le 0.1.$$

Thus, in the case of a non-stochastic system comparison of $L_2F_nC_{xx}$ and $L_2F_nC_{UL}$ systems shows that for one cycle the gain is about 10%. It is clear, that we'll get a higher gain if we take the lift motion dynamic into consideration.

Consider a stochastic system, with calls on different floors. For such systems an average time of one cyclic can be represented as a double average time of the highest floor plus an expectation of waiting time of stops during one cycle. As the flow of customers is uniformly distributed on all floors then we have:

$$T^L_{L_2F_NC_{UL}} = \ (j-1)[1-(1-1/(j-1))^m]h_2+[2h[1]/(j-1)^m]\sum_{k=1}^{j-2}k^m,$$

$$T^L_{L_2F_NC_{UL}} = \ (n-j)[1-(1-1/(n-j))^m]h_2+[2h[1]/(n-j)^m]\sum_{k=1}^{n-j-1}k^m+2(j-1)h[1].$$

For the $L_2C_{UL}F_N$-system, we have:

$$T^L_{L_2F_NC_{UL}} = (n-2)[1-(1-2/(n))^m]h_2+2nh[1]-8h[1][2h[1]/n^m]\sum_{k=1}^{n/2-1}k^m.$$

For $L_2F_NC_{UL}$-system, we have:

$$T^L_{L_2F_NC_{UL}} = (n-1)[1-(1-1/(n-1))^m]h_2+(2h[1]/n^m)+(2h[1]/n^m)\sum_{k=1}^{n-1}k^m.$$

Comparison of $L_2F_NC_{UL}$ and $L_2F_NC_{OE}$ yields:

$$\lim_{N\to\infty}(1-T^O_{L_2F_NC_{OE}}/T_{L_2F_NC_{UL}}) = 1/[2(1+2h[1]/h_2)],$$
$$\lambda_{12}=\lambda_{13}=\cdots=\lambda_{1n}\approx 0,\ \lambda_1=\Sigma^n_{j=2}\lambda_{1j}\approx 0,\ \lambda_{j1}=0,\ j=2,3,\cdots,n.$$

Denote j_1,j_2 coordinates first and second lifts at the customer preceding instant into the system. As a customer from the first floor uniformly takes floors $2,3,\cdots,n$, then $j_1=1,j_2=j,j\neq 1$ or $j_1=j,j_2=1,j\neq 1$ with the same probabilities. Hence, $\mu(L_2F_NC_{1,j})$ and $w_1(L_2C_{1,j}F_N)=0$, where $srt(L_2F_NC_{1,j})=(n-1)/2h_1$ is the single race time and $w_1(L_2C_{1,j}F_N)$ is a customer waiting time.

For $L_2F_NC_{DL}$-system (without single race we have j_1,j_2 $(j_1,j_2\neq 1)$ or j_1,j_2 $(j_1,j_2\neq 1)$ with the same probabilities. Hence, $\mu(L_2F_NC_{IL})=[n(n+1)]/[3(n-1)]\approx n/3$. For $L_2F_NC_{DL}$-system, we have $j_1,j_2=2,3,\cdots,n$. Hence, $\mu(L_2F_NC_{DL})=n/2$.

So for this case (small intensity at the first floor and no customers at the other floors) $L_2F_NC_{IL}$-system is preferable than $L_2F_NC_{DL}$-system and it would be a right idea to keep always one lift at the first floor.

Unloading regime.

For the $L_2F_NC_{IL}$-system, we have $j_1=1,j_2=j,j=2,3,\cdots,n$ or $j_1=j,\ j_2=1,\ j=2,3,\cdots,n$ with the same probabilities. Hence, simple calculations yield $n/5<\mu(L_2F_nC_{IL})<n/4$, i.e., it means that in fact only one lift operates in this system. For $L_2F_NC_{DL}$-system, we have $j_1,j_2=2,3,\cdots,n$. Hence, $\mu(L_2F_nC_{DL})=n/2$, i.e., for this case $L_2F_nC_{IL}$ - system is preferable. Mixed regime $\lambda_1\approx 0,\lambda_2\approx 0,\lambda_1+\lambda_2\approx 0$. For $L_2F_nC_{IL}$ we have $j_1=1,\ j_2=j,\ j=2,3,\cdots,n$ or $j_1=j,\ j_2=1,\ j=2,3,\cdots,n$.

Simple calculations yield $\mu(L_2F_nC_{DL}) = (\lambda_1/(\lambda_1+\lambda_2))A$, where $n/4 < A < n/3$ and for $L_2F_nC_{DL}$-system, we have $\mu(L_2F_nC_{DL}) = [\lambda_1/(\lambda_1+\lambda_2)](n/3) + [\lambda_2/(\lambda_1+\lambda_2)](n/2)$.

It follows from formulas that for some cases $(\lambda_1 \approx 0,\ \lambda_2 \approx 0,\ \lambda_1+\lambda_2 \approx 0)$.

$L_2F_nC_{IL}$-system is preferable (expectation of customer service time is less, although that system spends more energy) than $L_2F_nC_{DL}$-system, but it is obviously that generally $L_2F_nC_{DL}$-system more effectively operates and moreover it spends less energy.

46.3 Conclusion

On a simple mathematical models of vertical transportation for different regime of work an advantage of some control policies are derived by analytical approach. For small intensity of input flow of customers it is shown that some introduced control policies give the gain in average service time of customers about 10% and at the same time an energy expenses of the system is reduced. Application of these control policies for practice allows to improve work of vertical transportation systems and save energy resources.

Acknowledgements Authors express their deep thanks to Professor Yu. K. Belyaev for discussion and useful advices during the preparation of this paper.

References

1. Newell G (1970) Elevators and Escalators. Willey
2. Haight F (1966) Mathematical theory of traffic flow. Mir
3. Belyaev Y, Gromak Y, Hajiyev A et al (1977) Comparison analysis of simple systems of vertical transportation. Soviet Journal of Computer and Systems Sciences 3:97–103
4. Belyaev Y, Hajiyev A, Dugina T (1981) Pack of programs for modeling of vertical transportation. Soviet State Fund of Algorithms and Programs. II002152
5. Hajiyev A (1985) Delays reducing the waiting time in systems with recurrent service. Scandinavian Journal of Statistics 12:301–307
6. Hajiyev A, Mammadov T (2009) Cyclic systems with delays. Doklady, Mathematics, Russian Academy of Sciences 426:303–306
7. Moeschlin O, Grycko E, Pohl K et al (2003) Experimental stochastics. Springer

Chapter 47

Coordination and Optimization of Short Life Cycle Product Supply Chain Channel under Sales Effort-Depended Demand

Hongying Xu, Can Zhang, Qiaoyun Ma and Dianli Cao

Abstract Based on the demand uncertainty and relevant with retailers' promotional effort level, this paper studies the short life cycle product supply chain contracts coordination problems. Through the three-stage modeling, firstly, analyzing the optimal decisions under integrated supply chain and decentralized supply chain without coordination. The result obtained is no contract, the retailer spread the best service level can't come to reach the best service level under the centralized system. Finally, constructing buybacks contract model based on rebate and penalty strategy, it can achieve the perfect coordination.

Keywords Short life cycle product · Channel coordination · Buyback contract · Rebate and penalty · Promotional effort

47.1 Introduction

Short life cycle product is one kind of product whose life cycle is short as a few months and not longer than three years. Such product is characterized by its best sales period is short and the final residual is low. Therefore, only in the best sales period enterprises can obtain profit. Otherwise, if it missed the best sales period, the enterprise will not only cannot obtain profit, but also cannot recovery R&D costs.

Because the market demand is difficult to grasp, the retailer is hard to make the optimal order plan. In addition, because the short life cycle of short life cycle product, retailers in order to prevent a loss, or recovery cost as soon as possible and even profitable, they should take a series of effective measures in the sales cycle, such as increased advertising, increased publicity, hire more sales staff to expand the marketing area and so on. However, these promotions need the cost, so that

---

H. Xu · C. Zhang · Q. Ma · D. Cao (✉)
Department of Information and Computational Science, Henan Agricultural University, Zhengzhou 450002, P. R. China
e-mail: caodianli6312@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_47,

between suppliers and retailers will have a mismatch phenomenon: no matter how hard retailers, suppliers all want retailers to work harder. As promotional activities are beneficial to the entire supply chain, but will increase the cost of the retailer, so retailers will choose the effort level to their advantage, the choice is often not achieve supply chain coordination. Therefore, how to balance the level of promotional efforts to make supply chain coordination are the concerns for research on supply chain model under effort-depended demand. Currently, the research of the coordination mechanism of the short life cycle product supply chain contract which is associated with retailers' promotional effort level. Zhang and Chen [1] used traditional newsboy model to analyze the supply chain coordination mechanism consider the retailer's marketing effort, and design a contract coordination mechanism based on complex assumptions. Ji [2] conducted a cost-sharing contract based on the buyback contract, which can coordinate the two-level supply chain of demand relevant with promotional efforts level, and compare supply chain performance levels between the three strategies; He established the quantity flexibility contract under uncertainty in demand related with effort level and retail price, by the introduction of rebate and penalty strategy to tackle the simple contract can not achieve supply chain coordination [3]; Xu [4] has proposed two restrictive buy-back contract, by limiting the number of buy-back products to achieve supply chain coordination; Cachon [5] found only the quantity discount contract could coordinate supply chain, The contract allows suppliers to receive a fixed percentage of expected sales, and retailers keep all sales revenue achieved, allowing retailers to optimize their level of effort to achieve supply chain coordination.

The study have shown that a single buy-back contract unable to achieve perfect coordination system considering demand under retailers promotional efforts, which must be combined with other contracts to solve new incentive inconsistencies caused by retailers promotional, to induce retailers invest more promotional efforts. But most research is based on the level of promotional efforts can be observed and verifiable, and determined a specific promotions, did not fully consider the impact of the actual demand of the market environment. In this paper, based on previous studies, propose a buybacks contract based on rebate and penalty strategy which without requiring vendors to verify the level of promotional effort, and giving the specific promotions. On the one hand, Inspirit retailers input best promotional into the supply chain to raise the level of profits, other suppliers provide certain compensation to retailers to make the supply chain to achieve performance. Thus achieve "win-win" and achieve the objective of suppliers and retailers share the market risk.

47.2 Symbols and Hypothesis

47.2.1 The Definition of Symbols

Let c be manufacturing cost per item, w is price per unit paid by the retailer to the supplier, p is selling price per unit by the retailer, g_1 is goodwill cost per unit due to stockout incurred by the retailer, g_2 is additional goodwill cost per unit due to stockout incurred by supplier, $g = g_1 + g_2$ is total goodwill cost, h is storage cost per unsold product unit, Q is amount ordered by the retailer from the supplier, e is level of effort made by the retailer and $G(e)$ is Retailer's effort cost function.

In this paper,the superscript I represents integrated supply chain, N represents decentralized supply chain without coordination and C represents decentralized supply chain with coordination.

47.2.2 Research Hypotheses

The paper consider from a single supplier and a single retailer consisting two-level supply chain, both are risk neutral and completely rational, and information is symmetric. Uncertain demand for short life cycle product, a shorter sales cycle, residual value is 0 and effected by the retailer's sales effort. Retailer decides two variables before the sales season: order quantity and sales effort. Assuming supplier's capacity is unlimited, according to retailer's decider to order the production, allowing only s single order.

Randomness in demand is sales effort independent and can be modeled either in an additive or a multiplicative fashion [6]. Specifically, demand is defined as $X = D(e) + x$, where $D(e) = \alpha + \beta e, \alpha, \beta > 0, x$ is can not eliminate random factors, the cumulative distribution function and the probability density function respectively is $F(x), f(x)$. The mean and variance respectively is μ, σ^2; α represents the basic demand of products, which is large relative to the popularity in the market; β represents the flexibility of sales effort level, the amount is usually according to sales history to forecast. Assume α, β are known for operators of products. However, due to the limited nature of potential customers, and efforts to affect activity is decreasing; the rate of increase in the demand function will gradually slow down and eventually tend to zero. That is $D'(e) > 0, D''(e) < 0$, Let effort cost function $G(e) = 0.5\rho e^2$, ρ is cost parameters [7].

Assume $p > w > c$, that supplier is rational; these parameters are larger than 0, and the system's initial inventory is 0.

47.3 The Design and Solution of the Joint Decision Model on Optimal Order and Effort Level

47.3.1 The Joint Decision under the Centralized System

In the centralized system, retailers and suppliers is a community of interests, in practice of it as a standard system to achieve perfect coordination. The profit for the system $PT^I(e,Q)$ is:

$$PT^I(e,Q) = -G(e) - cQ + \begin{cases} pX - h(Q-X), & X \leq Q \\ pQ - g(X-Q), & X > Q. \end{cases} \tag{47.1}$$

A convenient expression for this profit function is obtained by substituting $X = D(e) + x$ and defining $y = Q - D(e)$, we have:

$$PT^I(e,y) = -G(e) - c(y + D(e)) + \begin{cases} p(D(e)+x) - h(y-x), & x \leq y \\ p(y+D(e)) - g(x-y), & x > y. \end{cases}$$

Expected profit is:

$$\begin{aligned} EPT^I(e,y) = & -G(e) - c(y+D(e)) + \int_0^y [p(D(e)+x) - h(y-x)]f(x)\mathrm{d}x \\ & + \int_y^\infty [p(y+D(e)) - g(x-y)]f(x)\mathrm{d}x \\ = & -G(e) + (p-c)D(e) + (p+g-c)y \\ & + (p+g+h)\int_0^y xf(x)\mathrm{d}x - (p+g+h)yF(y) - g\mu. \end{aligned} \tag{47.2}$$

Lemma 47.1. *The whole supply chain system expected profit $EPT^I(e,y)$ to decision variables (e,y) respectively is concave.*

Proof. Consider the first and second partial derivatives of $EPT^I(e,y)$ taken with respect to y and e, we have: $\partial EPT^I(e,y)/\partial y = (p+g-c) - (p+g+h)F(y)$, because: $\partial^2 EPT^I(e,y)/\partial y^2 = -(p+g+h)f(y) < 0$, $EPT^I(e,y)$ is concave in y, Similarly also prove $EPT^I(e,y)$ is concave in e.

Lemma 47.1 shows that there is only variable group (e,y) makes the whole supply chain expected profit maximization. Although failed to prove $EPT^I(e,y)$, Lemma 47.1 shows that there is only variable group (e,y). However, due to the expected profit on the decision variables are concave, can be applied to iterative search algorithm to determine the optimal set of decision variables group (e,y).

By the first order necessary conditions for optimization we know the expectations of the whole supply chain system to achieve optimal profit when the order quantity y, and efforts e to promote standards must be met:

$$\begin{cases} \frac{\partial EPT^I(e,y)}{\partial y} = (p+g-c)-(p+g+h)F(y)=0 \\ \frac{\partial EPT^I(e,y)}{\partial e} = -\rho e - g\beta + (p+g+h)\beta F(y) = 0, \end{cases}$$

that is:

$$y^I = F^{-1}\left(\frac{p+g-c}{p+g+h}\right), e^I = \frac{\beta}{\rho}(p-c). \tag{47.3}$$

At this point the whole supply chain system optimal order quantity is $Q^I = y^I + D(e^I)$, the optimal expected profit is:

$$EPT^I(e^I,y^I) = -G(e^I)+(p-c)D(e^I)+(p+g+h)\int_0^{y^I} xf(x)\mathrm{d}x - g\mu. \tag{47.4}$$

The retailer's optimal expected profit is:

$$\begin{aligned} EPR^I(e^I,y^I) = -\ & G(e^I)+(p-w)D(e^I)+(p+g_1-w)y^I \\ +\ & (p+g_1+h)\int_0^{y^I}(x-y)f(x)\mathrm{d}x - g_1\mu. \end{aligned} \tag{47.5}$$

47.3.2 Retailer Optimal Decision in Decentralized System without Coordination

In decentralized system without contract, suppliers and retailers as the interests of two separate decision body, according to their own situation and make decisions to maximize their own utility. Retailers according to the supplier for their own wholesale price give the optimal order quantity maximizing expected profit and supplier in accordance with the order for production. Similar to the centralized model and conclusions, retailers expected profit in the decentralized system without contract is:

$$\begin{aligned} EPR^N = (e,y) = -\ & G(e)+(p-w)D(e)+(p+g_1-w)y \\ +\ & (p+g_1+h)\int_0^{y}(x-y)f(x)\mathrm{d}x - g_1\mu. \end{aligned} \tag{47.6}$$

Similarly, under the decentralized system without contract, retailers expected profit $EPR^N(e,y)$ to decision variables (e,y) respectively is concave. Retailers optimize expected profit when the order quantity y, and level e of promotional effort that must be met:

$$\begin{cases} \frac{\partial EPR^N(e,y)}{\partial y} = (p+g_1-w)-(p+g_1+h)F(y)=0 \\ \frac{\partial EPR^N(e,y)}{\partial e} = -\rho e - g_1\beta + (p+g_1+h)\beta F(y) = 0, \end{cases}$$

that is:

$$y^N = F^{-1}\left(\frac{p+g_1-w}{p+g_1+h}\right), e^N = \frac{\beta}{\rho}(p-w) \tag{47.7}$$

and the retailer's optimal order quantity is $Q^N = y^N + D(e^N)$.

Compared the centralized system optimal joint decision (47.3) to decentralized system without contract optimal decision (47.7), easy to know: $y^N < y^I, e^N < e^I$.

This indicates that there is not agreement in a decentralized system, the independent retailer's optimal order quantity and the average effort level of willing to pay to can not be achieved the centralized system optimal joint decision. This phenomenon is called double-marginalization, As long as two or more members to split the profits of the supply chain system, or as long as a member of the decision-making behaviour can affect demand, the total optimal decisions of individuals and the system optimal decision are inconsistency. Under the decentralized system without contract, the retailers and the system optimal expected profits are respectively:

$$\begin{aligned} EPR^N(e^N,y^N) = &\ -G(e^N) + (p-w)D(e^N) + (p+g_1+h)\int_0^{y^N} xf(x)\mathrm{d}x - g_1\mu, \\ EPT^N(e^N,y^N) = &\ -G(e^N) + (p-c)D(e^N) + (p+g-w)y^N \\ &+(p+g+h)\int_0^{y^N}(x-y^N)f(x)\mathrm{d}x - g\mu. \end{aligned}$$

47.3.3 Retailer Optimal Decision in Decentralized System with Coordination

The buyback contract is that supplier commits to give some compensation to retailer about unsold products, in order to stimulate the vendor orders to meet market demand, so that the risk of demand uncertainty generated by suppliers and retailers shared. But some scholars think that in considering the impact of buyback price to the effect level, as the buyback price fluctuations in demand to share the risks, thereby inhibiting the retailer's sales effort to improve motivation, which can not achieve coordination [8, 9]. To address the impact of market demand in the effort level, the individual can not be achieved the system coordination, this paper introduces the model of based rebate and penalty strategies on buyback contract.

The rebate and penalty strategy is that suppliers provide a sales target to the retailer,if the retailer to complete the task over, the excess will be rewarded, or did not complete the task will be part of punishment [10]. Suppose the given target is T, after the close of the sale, for the part more than T, supplier gives retailer τ feedback to per unit, for the part not complete task, supplier also gives retailer τ punishment per unit. In the sales end of the season, the supplier pays the buyback price for the unit unsold product is b, let $b < w$, the retailer can not profit from surplus stock. Under the introduction of rebate and penalty strategy in the buyback contract, the retailer's profit function is:

$$\begin{aligned} EPR^C(e,y) = -\ & G(e) + (p-w)D(e) + (p+g_1-w)y + (p+g_1+h-b) \\ & \times \int_0^y (x-y)f(x)\mathrm{d}x - g_1\mu + \tau[S(Q,e)-T], \end{aligned} \tag{47.8}$$

in which $S(Q,e)$ is expected sales, it means:

$$S(Q,e) = E\min(Q,X) = \begin{cases} X, & X \le Q \\ Q, & X > Q. \end{cases}$$

Take $y = Q - D(e)$ into above equation, we have:

$$S(Q,e) = \begin{cases} D(e)+x, & x \le y \\ y + D(e), & x > y, \end{cases}$$

$$S(Q,e) = \int_0^y [D(e)+x]f(x)\mathrm{d}x + \int_y^\infty [y+D(e)]f(x)\mathrm{d}x = y + D(e) + \int_0^y (x-y)f(x)\mathrm{d}x.$$

Let the above equation into Equation (47.8), we obtain:

$$\begin{aligned} EPR^C(e,y) = -\ & G(e) + (p-w+\tau)D(e) + (p+g_1-w+\tau)y \\ +\ & (p+g_1+h-b+\tau)\int_0^y (x-y)f(x)\mathrm{d}x - g_1\mu - \tau T. \end{aligned} \tag{47.9}$$

Under the contract concluded in a decentralized system [11], consider, the first and second partial derivatives of $EPR^C(e,y)$ taken with respect to y and e, because:

$$\begin{aligned} \frac{\partial EPR^C(e,y)}{\partial y} &= (p+g_1-w+\tau) - (p+g_1+h-b+\tau)F(y), \\ \frac{\partial EPR^C(e,y)}{\partial y^2} &= -(p+g_1+h-b+\tau)f(y) < 0, \end{aligned}$$

so retailers expected profit $EPR^C(e,y)$ to decision variables (e,y) respectively is concave.

Retailers optimize expected profit when the order quantity y, and level of promotional effort that must be met:

$$\begin{cases} \frac{\partial EPR^C(e,y)}{\partial y} = (p+g_1-w+\tau) - (p+g_1+h-b+\tau)F(y) = 0 \\ \frac{\partial EPR^C(e,y)}{\partial e} = -\rho e - g_1\beta + (p+g_1+h-b+\tau)\beta F(y) = 0, \end{cases}$$

that is:

$$y^C = F^{-1}\left(\frac{p+g_1+\tau-w}{p+g_1+h+\tau-b}\right), \quad e^C = \frac{\beta}{\rho}(p+\tau-w), \tag{47.10}$$

the retailer's optimal order quantity is $Q^C = y^C + D(e^C)$.

Assuming the stock does not consider the loss of supplier credit losses, that is $g_2 = 0$, so $g_1 = g$.

Comparison of Equation (47.3) and (47.10) shows that if the feedback factor and punishment factor and the buyback price to meet:

$$\tau^* = w - c, \quad b^* = \tau \tag{47.11}$$

and the order quantity and the effort level under the demand on retailer's effort level can achieve the optimal centralized system, also met:

$$\begin{cases} EPR^C(Q^C, e^C) > EPR^N(Q^C, e^C) \\ EPS^C(Q^C, e^C) > EPS^N(Q^C, e^C). \end{cases} \tag{47.12}$$

Therefore, the buyback contract based on rebate and penalty could achieve system perfect coordination.

Note that the supplier an a leader in the supply chain, in the dominant position of channel coordination, the supplier in accordance with Equation (47.11) to determine the wholesale price, buyback price and the feedback factor. The retailer in order to maximize their own revenue to determine the optimal order quantity and the level of promotional efforts, so as to achieve supply chain coordination and maximize profits. However, if satisfy Equation (47.11) but does not satisfy Equation (47.12), it must be through the conclusion of revenue sharing contract, to achieve the redistribution of the system expected profit.

As $EPT^C(Q^C, e^C) > EPT^N(Q^N, e^N)$, according to cooperative game theory [12], it is sure to find a set of parameters $(EPR^C(Q^C, e^C), EPS^C(Q^C, e^C))$, make benefits of the contract on both sides, that is:

$$\begin{cases} EPR^C > EPR^N(Q^N, e^N) \\ EPS^C > EPS^N(Q^N, e^N). \end{cases}$$

At this time, the profits of retailers and suppliers can be expressed as $EPR^C = EPR^N(Q^N, e^N) + \lambda[EPR^C(Q^C, e^C) - EPR^N(Q^N, e^N)]$, $EPS^C = EPS^N(Q^N, e^N) + \lambda[EPS^C(Q^C, e^C) - EPS^N(Q^N, e^N)]$. where $\lambda \in [0, 1]$ depends on the bargaining power of the suppliers and retailers.

47.4 Conclusions

In the premise of demand uncertainty has relevance with retailers' promotional effort level, through three stages of modelling, respectively analyzed retailers the optimal level of effort and the optimal order quantity under centralized system, decentralized system without contract and decentralized system with improved buyback contract. Been in retailer sales effort effects demand, achieving supply chain system coordination must meet two conditions: the level of effort and ordering quantity.

And traditional buy-back contract has been unable to achieve supply chain coordination. In this paper, by establishing the buyback contract based on feedback and punishment strategy not only achieve system coordination but also can achieve win-win, and the suppliers and retailers share the task of uncertain market demand. This contract does not require retailers to verify the premise of the promotional effort level, but in practical problems, the effort level is usually difficult to verify, or verification of the high cost, so the model established in this contract is more universal.

Acknowledgements This research is supported by the Soft-Science Foundation of Henan Province (No.102400440025; 102400440036).

References

1. Zhang J, Chen J (2011) A coordinating contract of supply chain with sale-effort dependent demand. Chinese Journal of Management Science 4:50–56 (In Chinese)
2. Ji X (2006) Supply chain contract designing with retailer promotional effort. Chinese Journal of Management Science 4:46–49 (In Chinese)
3. He Y, Yang D (2005) The return policy model with effort dependent demand. Systems Engineering-Theory Methodology Applications 6:568–571 (In Chinese)
4. Xu Z, Zhu D, Zhu WG et al (2008) Supply chain coordination under buy-back contract with sales efforts. Systems Engineering-Theory & Practice 1–11 (In Chinese)
5. Cachon G (2003) Supply chain coordination with contracts. Handbooks in Operation and Managements Science. Supply Chain Management: Design Coordination and Operation 229–339
6. Ye A (2009) Supply chain coordination contract of a two-stage perishable goods. Amoy University, Fujian (In Chinese)
7. Hu B, Wang X (2010) Supply chain revenue-sharing evolvement-contract with sales effort effects. Journal of Industrial Engineering and Engineering Management 2:33–38 (In Chinese)
8. Kandel E (1996) The right to returnJournal of Law and Economics 39:329–356
9. Padmanabhan V, PngI P (1997) Manufacturer's returns policies and retail competition. Marketing Science 1:81–94
10. Sun L (2008) On validity research of supply chain coordination with revenue-sharing contract. Beijing University of Chemical Technology, Beijing (In Chinese)
11. Cao D, Xia C, Cao J et al (2011) Studies on the comprehensive evaluation system of the green degree of green supply chain of fresh food. In: Proceedings of 2011 International Conference on E-Business and E-Government (ICEE)
12. Liu B, Chen J, Liu SF (2005) The joined decision model on ordering and pricing for a short-life-cycle product. In: Proceedings of 2005 IEEE International Conference on Service Operations and Logistics, and Informatics

Chapter 48

Production-distribution Planning in Supply Chain Management under Fuzzy Environment for Large-scale Hydropower Construction Projects

Muhammad Hashim, Muhammad Nazim and Abid Hussain Nadeem

Abstract In this paper, production-distribution planning in construction supply chain management is presented under fuzzy environment. This paper specifically addresses bi-level decision making problem with lower level corresponding to a plant planning problem, while the upper level to a distribution network problem. The main targets of the upper level are to minimize cost and maximize the satisfaction level for concrete mixing plants. The targets of the lower level are to maximize the profit and customer satisfaction level. The model is formulated in terms of fuzzy programming and the best solution is provided by using the fuzzy simulation and sensitive analysis is used to highlight the results. The Neelum Jhelum Hydropower Project is used as a real-world example to illustrate the effectiveness of the proposed approach.

Keywords Production-distribution planning · Supply chain management · Bi-level model · Fuzzy simulation

48.1 Introduction

Supply chain management (SCM) is the management of material and information flows both in and between facilities, such as venders, manufacturing and, assembly plants and distribution centers [1]. The main processes in supply chain are the production planning and control, and, the distribution and logistics. The production planning and control describes the design of process and management of entire manufacturing process, such as material handling, scheduling and inventory control, etc. The distribution and logistics process determines how products are retrieved and transported from the factory or warehouse to customers. This process includes the

---

M. Hashim (✉) · M. Nazim · A. Nadeem
Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, P. R. China
e-mail: hashimscu@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_48,

management of inventory retrieval, transportation, and final product delivery [2]. In that type of processes, production and distribution planning have a most important part to support global optimization in SCM, and it should be solved within the integrated planning structure.

Production and distribution (PD) planning in supply chain management for each type of construction project has an important role to play in the success of the entire project completed in-time and achieved the goals for supplier and customer. A significant number of research studies have addressed the importance of PD planning in supply chain management [3, 5, 41]. PD planning structure and different aspects has been discussed in a good manner [6–12]. In this paper, a production and distribution planning model is considered in construction supply chain (CSC) management for large scale Hydropower projects. For this purpose, a bi-level optimization model is developed. On the upper level, the construction department aims at obtaining the minimum level of purchasing inventory cost, transportation costs and maximizing the satisfaction level. On the lower level, supplier controls the production costs, transportation costs and maximize the customer satisfaction level. Yet, both cost and time are important in construction projects, especially in large-scale construction projects. In real conditions, there is enormous pressure to eliminate extra project expenses, with early arrival of materials shortening the completion time of construction project and improving construction efficiency [31]. Construction supply chain management is influenced by many factors like location of manufacturing plants or distribution centers [13], purchasing of raw material, manufacturing process, inventory control and the allocation of commodities [14]. To determine the regularity of PD planning is a major factor influencing the CSC management success [15–17].

Bi-level programming is used where two decision makers make decisions successively. In bi-level programming each decision maker tries to optimize their own objectives without considering the objective of other decision maker. Production and distribution (PD) can be presented as Leader-Follower or stacklberg game where the decision makers make the decision at two distinct levels with a hierarchical relationship. Bi-level programming (BLP) is an effective method to solve that type of optimization problem with two levels [18]. The upper level of the hierarchy is the behavior of the planner for minimizing the total cost for example transportation cost, inventory cost, storing cost and is influenced by the behavior of the lower level decision maker. The lower level of the hierarchy controls the production process and is limited by the decision of the first decision maker. Both, in general, do not cooperate because of different optimization strategies. Such characteristics render these problems unsuitable for modeling by standard mathematical programming. So in that type of problems bi-level modeling is more suitable than standard mathematical programming modeling.

Construction is often plagued by uncertainties [27], because of unforeseen factors such as changing weather, equipment breakdown, labor inefficiency, and lack of coordination among stakeholders [28]. In the real world decision making problems, one often needs to make a decision under uncertainty [29], because input data is usually uncertain due to incomplete or non-obtainable information. For instance production cost, inventory cost and transport cost will be around a value but not a certain value. So in that situation fuzzy variable is used rather than a constant. There is also an advantage of fuzzy approaches that it can measure the satisfaction level of each objective function explicitly and it is very useful for decision maker to make his final decision by choosing a best solution in accordance with the satisfaction level of each objective function. In PD planning, the fuzzy environment is often used including such factors as fuzzy raw material price and demand with Fuzzy programming and stochastic chance-constrained programming by Zhang et al [19], fuzzy-genetic approach to aggregate production-distribution planning in supply chain management by Aliev [20], fuzzy cost with A-cut of a fuzzy set by Avninder [22], fuzzy travel costs with Chance theory by Li et al [21], fuzzy demand and fuzzy yield rates with possibilistic linear programming by Kabak and lengin [24], fuzzy costs Zimmermann's approach by Bilgen [23], but no one use the bi-level modeling in his research. According to my point of view, to date there exists little research that addresses the PD planning with bi-level modeling in construction supply chain management under fuzzy environment.

This paper will consider a PD planing model and its application in construction supply chain management for large scale hydropower projects. In addition, fuzzy coefficients are used to describe the demand and cost which assists decision makers to make more effective and precise decisions. Supply chain management for hydropower construction projects can be presented as leader and follower where demander is upper level decision maker and supplier is lower level decision maker. In this study, an effort is made to develop a bi-level optimization model to improve a real world PD planning in the construction of Neelum Jhelum Hydropower Project.

The rest of this paper is further organized as follows: Sect. 48.2 presents the research problem and statement of the PD planning in CSC management for large scale hydropower construction projects under fuzzy environment; A bi-level programming model with EVM for PD planning problem is established in Sect. 48.3; Sect. 48.4 shows a case study at a Neelum Jhelum Hydropower project, GA and PSO algorithms discussed as solution approach and also a sensitivity analysis based on a fuzzy simulation; Finally the concluding remarks regarding the model of this paper are given in Sect. 48.5.

48.2 Problem Statement

In construction projects, especially large scale construction projects, the PD planning for supply chain management is most important. Usually, cost control and customer satisfaction level (time) are two key factors for measuring the level of a SCM. SCM is a flow of materials as they move in a process from manufacturer to wholesaler, and then to consumer (i.e., concrete mixing plants) Fig. 48.1. SCM involves coordinating and integrating that flow both within and among companies. Distributor will manage this supply chain in an cost effective and efficient manner because there is any delay in material transferring to project working places can create a problem for completing these projects in-time. The concrete issue is the coordination between two levels in production-distribution planning. In this paper, the proposed PD bi-level model will optimize the cost and service level at two separate levels for achieving the goals at both levels.

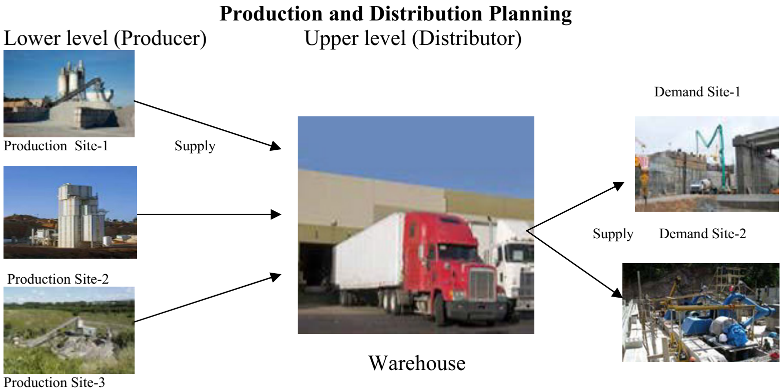


Fig. 48.1 An example of PD planning in CSCM

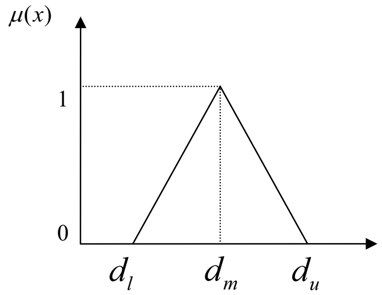
SCM in hydropower construction project consists of suppliers, construction project departments and material users. In construction project supply chain, the construction project departments that control the purchase and storage of raw materials are considered equivalent to distributors. The construction project department provides required materials and has uncertain demand with two goals to minimize the overall cost and maximize the satisfaction level. So there is a challenge for a decision maker (i.e., the construction project department) who takes the decision about construction materials to ensure that quantity will be delivered at the time of need and cost is not exceed the define limit. In other words, purchasing department determine where to buy it, how much to pay and ensure its availability by managing the contract and maintaining strong relationship with suppliers. The supplier will supplied the materials by using several manufacturing plants. The supplier takes the order from construction project departments and allocates the production to its plants. The main objectives of supplier are to maximize profit and customer satisfaction level.

In this paper, PD planning in SCM involves two kinds of decision makers that are supplier (producer) and distributor (construction project department) who have different objective functions. Obviously, it is suitable that the bi-level programming model is used for describing PD planning for SCM in hydropower construction projects. The upper-level decision maker takes the decision about the material storage level and distribution to concrete mixing plants whereas the lower level decision maker takes the decision about the amount assigned to them for processing the production order according to the upper level decision.

48.2.1 Motivation for Employing Fuzzy Variables for PD Planing in SCM

In practice decision making takes place in an environment where the objectives, constraints or parameters are not known precisely. These challenges increased the importance of stochastic programming and fuzzy mathematical programming in solving the real world problems where the data are not known precisely. Many researchers have developed stochastic SCM models that are closer to real situations. Most of them have modeled the SC uncertainty (e.g., uncertain demand) by using probability distribution that is usually predicted from historical data. Probability theory is a useful tool for dealing with uncertainty but sometimes it may not be suitable for new construction projects due to the lack of historical data. While it may be easy to estimate the probability distributions but it becomes difficult when the historical data is unreliable or even unavailable. In this case, it is usually difficult to do this for material demand, transportation cost and other important parameters in a new construction project, especially for PD planning in SCM for large scale hydropower projects. As different people have different feelings for uncertain demand and cost caused by the uncertain environment and there is no clear definition of this change. So in this situation, it can be characterized by uncertainty of fuzziness and stochastic models may not be the best choice. Fuzzy set theory may provide an alternative approach for dealing with the construction SCM uncertainty [39]. It is used to represents the fluctuated customers demand, uncertain processing time, and unreliable supply delivery time. Some scholars have observed this uncertainty and imprecision and fuzzy theory can deal them in an effective way [39, 40]. However, PD planning in construction SCM for large scale hydropower project is often faced with uncertain environment where fuzziness exists in a decision making process. Therefore, fuzzy variables that can take into account fuzziness are favored by decision-makers to describe the uncertainty and vague information.

Fig. 48.2 Triangular fuzzy variable



In this research, uncertain SC parameters (i.e., demand, production capacity, production variable cost and transportation cost) are represented by fuzzy variables that can be further characterized by triangular fuzzy numbers. Triangular and trapezoidal fuzzy numbers are most widely used in engineering and management fields due to their computational efficiency. In practice, in order to collect the data, investigations and surveys were made to different experts. The experts usually can not give an exact expression for each uncertain variable. So in this situation, triangular fuzzy numbers are more suitable to explain uncertainty in these parameters such as customer demand is about d_m, but definitely not less than d_l and grater than d_u (see Fig. 48.2). The further details will be provided in next heading.

48.2.2 Dealing with Fuzzy Variables

As we all know, it is very difficult to handle a multi-objective problem when it involves uncertain information, so it is necessary to transform the fuzzy numbers into a determinate form. Expected value operator (EVO) is a tool that can transform fuzzy uncertainty into crisp or determinate form. In this paper, expected value model (EVM) is proposed to solve this problem. For calculating the expected value of the above triangular variables, a new fuzzy measure with an optimistic-pessimistic adjusting index is introduced to characterize the real life problems. The definition of this fuzzy measure Me can be found in [4].

Let $\tilde{k} = (\gamma_1, \gamma_2, \gamma_3)$ denotes a triangular fuzzy variable. In fact, in large scale world problems, especially the retrial problem in large-scale construction projects, the case often encountered when $r > 0$. Based on the definition and properties of expected value operator of fuzzy variable using measure Me [4], if the fuzzy variable $\tilde{k}$ is transformed into the triangular fuzzy variable $\tilde{k} = (\gamma_1, \gamma_2, \gamma_3)$, where $\gamma_1, \gamma_2, \gamma_3 > 0$, then the expected value of $\tilde{k}$ should be:

$$E^{Me}[\tilde{k}] = \frac{1-\lambda}{2}(\gamma_1 + \gamma_2) + \frac{\lambda}{2}(\gamma_2 + \gamma_3). \tag{48.1}$$

Based on the above method, the expected values of the triangular fuzzy variables involved in each objective function and state equation can be calculated as follows:

$$\begin{aligned}
E^{Me}[\widetilde{tr}_{jpk}] &= \frac{1-\lambda}{2}(\gamma_1 + \gamma_2) + \frac{\lambda}{2}(\gamma_2 + \gamma_3), && (48.2)\\
E^{Me}[\widetilde{tr}_{jip}] &= \frac{1-\lambda}{2}(\gamma_1 + \gamma_2) + \frac{\lambda}{2}(\gamma_2 + \gamma_3), && (48.3)\\
E^{Me}[\widetilde{D}_{jk}] &= \frac{1-\lambda}{2}(\gamma_1 + \gamma_2) + \frac{\lambda}{2}(\gamma_2 + \gamma_3), && (48.4)\\
E^{Me}[\widetilde{VC}_{ji}] &= \frac{1-\lambda}{2}(\gamma_1 + \gamma_2) + \frac{\lambda}{2}(\gamma_2 + \gamma_3), && (48.5)\\
E^{Me}[\tilde{a}_{ij}] &= \frac{1-\lambda}{2}(\gamma_1 + \gamma_2) + \frac{\lambda}{2}(\gamma_2 + \gamma_3), && (48.6)\\
&\lambda \in [0,1],\ \gamma_1 > 0,\ \gamma_2 > 0,\ \gamma_3 > 0.
\end{aligned}$$

48.3 Modelling

In this paper the problem is formulated as a bi-level optimization problem with fuzzy coefficients, in which the demander is taken as the upper-level decision maker (leader) and the supplier is taken as the lower-level decision maker (follower).

48.3.1 Model Assumptions and Notations

Following assumptions are assumed in this model:

1. Every supplier has the capacity to deliver the same goods.
2. The production and distribution systems considered are operationally connected with each other.
3. There is no inventory in the side of demander.
4. To facilitate the handling of the problem, in this paper the purchase and inventory problems of raw material did not consider in manufacturing plants cost.
5. Demand, production capacity, production variable cost and transportation cost are assumed to be uncertain and characterized by fuzzy numbers.

Suppose that there are I production sites, P distribution centers (Construction project department) and K concrete mixing plants. The task is to transfer products (material) from the plant (producer) to the distribution center and from distribution centre to concrete mixing plants to satisfy the demand.

Indices

Ω : set of production sites, i is an index, $i \in \Omega = \{1,2,\cdots,I\}$;
Φ : set of products, j is an index, $j \in \Phi = \{1,2,\cdots,J\}$;
Ψ : set of warehouses, p is an index, $p \in \Psi = \{1,2,\cdots,P\}$;
Υ : set of concrete mixing plants, k is an index, $k \in \Upsilon = \{1,2,\cdots,K\}$.

Parameters

$\widetilde{D}_{jk}$: demand of product j at concrete mixing plant k;
$\widetilde{tr}_{jip}$: unit transportation cost of product j from production site i to warehouse p;
$\widetilde{tr}_{jpk}$: unit transportation cost of product j from warehouse p to concrete mixing plant k;
$\widetilde{VC}_{ji}$: variable production cost of product j at production site i;
$\tilde{a}_{ji}$: capacity of product j at production site i;
T_{ip} : transportation time from production site i to warehouse p;
h_{jp} : inventory holing cost for product j at warehouse p;
U_{jip} : unit price of product j at production site i for warehouse p;
FC_{ji} : fixed production cost of product j at production site i;
TC^L : predetermined total cost (budget available) for lower level.

Decision variables

Y_{jpk} : upper level decision variable this variable denotes the quantity j transferred from warehouses p to concrete plant k;

X_{jip} : lower level decision variable this variable denotes the quantity j transferred from production site i to warehouse p.

48.3.2 Modeling Formulation

The proposed model is based on a bi-level decisions with distributor center (construction engineering project department) and producer (production sites) under a fuzzy environment. The upper level describes the behavior of minimizing cost and maximizing satisfaction level. The lower level describes the behavior of maximizing profit and customer satisfaction level.

48.3.2.1 Upper Level Decision Maker

In this paper the upper level decision maker of the bi-level programming model is to determine the optimal quantity from producer to make the total cost (fixed and variable) minimum and to meet the demands of different projects which are working at different places. It is usually difficult to obtain the exact minimum cost and the decision makers only require the minimum objective under a certain possible level.

An operating objective function of upper level is to minimize their material costs, which typically consists of its product purchasing, transporting and holding costs. The mathematical formulations of objective is as follows:

$$\min F_1 = \sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{p=1}^{P} U_{jip}X_{jip} + \sum_{j=1}^{J}\sum_{p=1}^{P}\sum_{k=1}^{K} h_{jp}Y_{jpk} + \sum_{j=1}^{J}\sum_{p=1}^{P}\sum_{k=1}^{K} E^{Me}(\widetilde{tr}_{jpk})Y_{jpk}. \tag{48.7}$$

To measure the customer satisfaction level of SCN, this paper employs the products rendered to customers within the stipulated access time T, which can be denoted by $\sum_{jpk} Y_{jpk} / \sum_{jk} E^{Me}(\widetilde{D}_{jk})$. Upper level will maximize the ratio of this function for achieving the maximum satisfaction level of concrete mixing plants.

$$\max F_2 = \sum_{j=1}^{J}\sum_{p=1}^{P}\sum_{k=1}^{K} Y_{jpk} \Bigg/ \sum_{j=1}^{J}\sum_{k=1}^{K} E^{Me}(\widetilde{D}_{jk}). \tag{48.8}$$

Generally speaking, some mandatory conditions must be satisfied when the demander makes the decision. They are listed as follows.

- Warehouse holding inventory for product j should meet the levels required at concrete mixing plant k:

$$\sum_{j=1}^{J}\sum_{p=1}^{P}\sum_{k=1}^{K} Y_{jpk} \geq \sum_{j=1}^{J}\sum_{k=1}^{K} E^{Me}(\widetilde{D}_{jk}). \tag{48.9}$$

- The ratio of the function F_2 should be greater than/equal to 1. Its mean supply is greater than/equal to demand.

$$\sum_{j=1}^{J}\sum_{p=1}^{P}\sum_{k=1}^{K} Y_{jpk} \Big/ \sum_{j=1}^{J}\sum_{k=1}^{K} E^{Me}(\widetilde{D}_{jk}) \geq 1. \tag{48.10}$$

48.3.2.2 Lower Level Decision Maker

The objective of lower decision maker is to maximize the profit and customer satisfaction level. For achieving the maximum profit, the decision maker should try their best to minimize the cost like manufacturing cost $(FC_{ji} + \widetilde{VC}_{ji})$ and transportation cost $(\widetilde{tr}_{jip})$.

The mathematical formulation of objective is as follows:

$$\begin{aligned}\max Z_1 = & \sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{p=1}^{P} U_{jip}X_{jip} - \sum_{j=1}^{J}\sum_{i=1}^{I} FC_{ji} - \sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{p=1}^{P} E^{Me}(\widetilde{VC}_{ji})X_{jip} \\ & - \sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{p=1}^{P} E^{Me}(\widetilde{tr}_{jip})X_{jip}.\end{aligned} \tag{48.11}$$

Furthermore the objective is to maximize the customer satisfaction. As we know, the customer satisfaction level is a key factor to decide whether to buy products from the producers. So the second objective function Z_2 will maximize the customer satisfaction level.

$$\max Z_2 = \sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{p=1}^{P} \xi_{ip}(T_{ip})X_{jip}. \tag{48.12}$$

From many literatures [24–26], the customer satisfaction level is usually measured by the service time, i.e., employing the rendering products to the demander from the suppliers within the stipulated access time. The membership function of fuzzy due time $\xi_{ip}(T_{ip})$ is used to measure the satisfaction level, which is as follows:

$$\xi_{ip}(T_{ip}) = \begin{cases} 0, & T_{ip} \leq ET_p \\ \frac{T_{ip}-ET_p}{ET_p^d - ET_p}, & ET_p < T_{ip} < ET_p^d \\ 1, & ET_p^d \leq T_{ip} \leq LT_p^d \\ \frac{LT_p - T_{ip}}{LT_p - LT_p^d}, & LT_p^d < T_{ip} < LT_p \\ 0, & T_{ip} \geq LT_p, \end{cases}$$

where ET_p and LT_p are the max time ranges for customer to tolerant, ET_p^d and LT_p^d are the expected time ranges of customer p. Fig. 48.3 presents the description of this function.

Since the production of all suppliers will be influenced by the amount from the demander, some limited conditions that should be satisfied are as follows.

- Production cost should not exceed the predetermined total cost (available budget)

$$\sum_{j=1}^{J} FC_{ji} + \sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{p=1}^{P} E^{Me}(\widetilde{VC}_{ji})X_{jip} \leq TC^{L}. \tag{48.13}$$

- Transferred quantity from the supplier site i should meet the levels required at the warehouse p

$$\sum_{i=1}^{I}\sum_{p=1}^{P} X_{jip} \geq \sum_{p=1}^{P}\sum_{p=1}^{P}\sum_{k=1}^{K} Y_{jpk}. \tag{48.14}$$

- Product j transported quantity should not exceed the capacity of supplier i

$$\sum_{i=1}^{I}\sum_{p=1}^{P} X_{jip} \leq \sum_{i=1}^{I} E^{Me}(\tilde{a}_{ij}). \tag{48.15}$$

As a complicated system, both the leader and the follower should simultaneously consider the objectives and constraints with each other and then make the decision. Therefore, from Equations (48.7) $\sim$ (48.15), the whole expected value bi-level optimization model under fuzzy environment should be given as follows:

$$\left\{\begin{array}{l}
\min E^{Me}[F_1] = \sum\limits_{j=1}^{J}\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} U_{jip}X_{jip} + \sum\limits_{j=1}^{J}\sum\limits_{p=1}^{P}\sum\limits_{k=1}^{K} h_{jp}Y_{jpk} \\
+ \sum\limits_{j=1}^{J}\sum\limits_{p=1}^{P}\sum\limits_{k=1}^{K} E^{Me}(\widetilde{tr}_{jpk})Y_{jpk} \\
\min E^{Me}[F_2] = \sum\limits_{j=1}^{J}\sum\limits_{p=1}^{P}\sum\limits_{k=1}^{K} Y_{jpk} \Big/ \sum\limits_{j=1}^{J}\sum\limits_{k=1}^{K} E^{Me}(\widetilde{D}_{jk}) \\
\text{s.t.} \left\{\begin{array}{l}
\sum\limits_{j=1}^{J}\sum\limits_{p=1}^{P}\sum\limits_{k=1}^{K} Y_{jpk} \geq \sum\limits_{j=1}^{J}\sum\limits_{k=1}^{K} E^{Me}(\widetilde{D}_{jk}) \\
\sum\limits_{j=1}^{J}\sum\limits_{p=1}^{P}\sum\limits_{k=1}^{K} Y_{jpk} \Big/ \sum\limits_{j=1}^{J}\sum\limits_{k=1}^{K} E^{Me}(\widetilde{D}_{jk}) \geq 1 \\
\left\{\begin{array}{l}
\max E^{Me}[Z_1] = \sum\limits_{j=1}^{J}\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} U_{jip}X_{jip} - \sum\limits_{j=1}^{J}\sum\limits_{i=1}^{I} FC_{ji} \\
- \sum\limits_{j=1}^{J}\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} E^{Me}(\widetilde{VC}_{ji})X_{jip} - \sum\limits_{j=1}^{J}\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} E^{Me}(\widetilde{tr}_{jip})X_{jip} \\
\max Z_2 = \sum\limits_{j=1}^{J}\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} \xi_{ip}(T_{ip})X_{jip} \\
\text{s.t.} \left\{\begin{array}{l}
\sum\limits_{j=1}^{J} FC_{ji} + \sum\limits_{j=1}^{J}\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} E^{Me}(\widetilde{VC}_{ji})X_{jip} \leq TC^{L} \\
\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} X_{jip} \geq \sum\limits_{p=1}^{P}\sum\limits_{p=1}^{P}\sum\limits_{k=1}^{K} Y_{jpk} \\
\sum\limits_{i=1}^{I}\sum\limits_{p=1}^{P} X_{jip} \leq \sum\limits_{i=1}^{I} E^{Me}(\tilde{a}_{ij}) \\
X_{jip} \geq 0,\ Y_{jpk} \geq 0,\ \forall i \in \Omega,\ j \in \Phi,\ p \in \Psi,\ k \in \Upsilon.
\end{array}\right.
\end{array}\right.
\end{array}\right.
\end{array}\right. \tag{48.16}$$

48.4 Case Study: Neelum Jhelum Hydropower Project

In this section, a practical application of proposed bi-level model for CSC management PD planning at Neelum Jhelum Hydropower Project is presented. Some analysis of this model is presented to provide some guidance for decision makers.

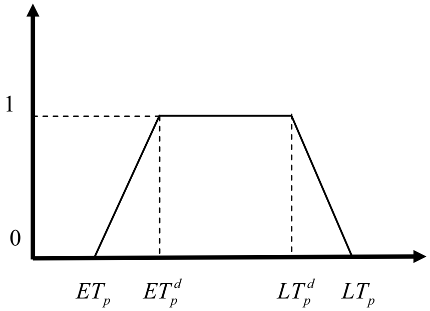


Fig. 48.3 The membership function $\xi_{ip}(T_{ip})$

48.4.1 Project Description

Neelum Jhelum Hydropower Project is one of the key projects for the hydropower development in Azad Jammu and Kashmir (AJK) Pakistan. The project was started in 2002 and will be completed in October 2015. The project is being constructed under the supervision of the Water and Power Development Authority (WAPDA). The contract for the construction of project was awarded to a Chinese contractor (CGGC-CMEC) in December 2007. It is being constructed over neelum and jhelum rivers in Azad Jammu and Kashmir near Muzaffarabad. It will produce 5.15 billion units of electricity annually and benefits of the project have been estimated at Rs.45 billion annually. Overall project estimated cost is Rs.130 billion. It is split into three main geographical areas:

- Nauseri Area (Also known as C1).
- Headrace tunnel (Also known as C2).
- Chattar kalas area (Also known as C3).

48.4.2 Presentation of This Case Problem

Neelum Jhelum Hydropower Project is an important hydraulic engineering project which will play a very important role in economic development. A concrete gravity

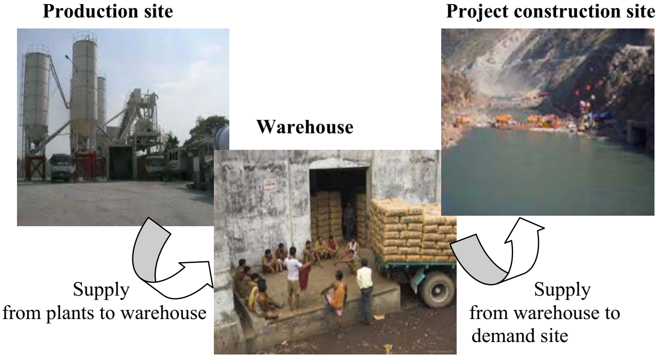


Fig. 48.4 Layout of PD planning in CSCM for Neelum Jhelum hydropower project

dam 135 m long and 47 m high will be constructed on Neelam River at Nauseri 41 Km East of Muzaffarabad. The catchment area upstream of the dam site at Nauseri is about 6680 km^2 and the average annual flow is 335 m^3/s. The Neelum River is characterised by the large quantities of sediment it carries, totalling an estimated 11.5 million tonnes/year, of which only about 0.05 million tones are during the dry season. In addition, about 3.5 million tonnes is carried as bed load. The Project is designed to operate as a peaking station during the low flow season. The live storage volume in the reservoir, 2.8 million m^3, is enough for generation at full power for 2.78 hours without any flow in the river [42]. PD planning in construction Supply chain management plays an important role in the success of the large scale hydropower project to complete it in estimated time and cost. So in such a large construction project, there is a need to ensure the construction project runs smoothly the material needs to be ordered in time and the cost of material should not exceed the estimated cost. Therefore, the SCM for materials in the construction of the Neelum Jhelum Hydropower Project is significant and needs to be addressed urgently.

Table 48.1 Production fixed cost, fuzzy variable cost and unit price (pkr/ton)

Product j	Fixed production cost (FC_{ji})	Variable production cost ($\widetilde{VC}_{ji}$)	Unit price U_{jip}
Cement	3400	(2050, 2100, 2150)	6800
Gravel	1100	(800, 850, 900)	3200
Sand	450	(550, 600, 650)	1500

48.4.3 Data and Computation

This case study considers a construction supply chain involving one demand site, one warehouse, three production sites and three kinds of materials i.e cement, gravel and sand with each kind having a different ingredient proportion. Because of space limitation here, only a part of data is presented for one month construction period. Because there is no actual data that are available, so due to this reason estimated data are considered. Table 48.1 shows Production fixed cost, fuzzy variable cost and the unit price of product j at production site i. Table 48.2 shows fuzzy transport cost from production site i to warehouse and warehouse to concrete mixing plant, for estimating the transportation cost it is supposed that every truck have a capacity of 6 tons for supply the material in one term. Table 48.3 shows warehouse inventory information, fuzzy demand and production capacity listed in Table 48.4 and Table 48.5 show the transportation time from supplier i to warehouse p and satisfaction level for customer (warehouse).

Table 48.2 Fuzzy unit transportation cost

Product j	Unit transportation cost from supplier site to warehouse ($\widetilde{tr}_{jip}$) (pkr/ton)	Unit transportation cost from warehouse to concrete mixing plant ($\widetilde{tr}_{jpk}$) (pkr/ton)
Cement	(200, 250, 300)	(100, 150, 200)
Gravel	(200, 250, 300)	(100, 150, 200)
Sand	(200, 250, 300)	(100, 150, 200)

48.4.4 Solution Approach

Particle swarm optimization (PSO) is a relatively new population-based evolutionary computation technique. It was proposed by Kennedy and Eberhart in 1995 as a global optimization approach for biomedical image registration [32]. PSO is a population-based search algorithm based on the simulation of the social behavior of animals such as fish schooling and birds flocking. Similar to other population-based algorithms such as evolutionary algorithms, PSO conducts its search using a population (i.e., a swarm) of individuals (i.e., paricles). It can be applied extensively to solve many complex problems and can solve a variety of difficult optimization problems but has shown a faster convergence rate than other evolutionary algorithms on some problems [33]. PSO is slightly influenced by the continuity of the objective function; it just uses the primary math operators, and receives good results in static, noisy and continuously changing environments [34]. Another advantage of PSO is that it has very few parameters to adjust, which makes it particularly easy to implement. Since PSO can be implemented easily and effectively, it has been applied in solving real-world optimization problems in recent years by some scientists [35–

37]. PSO has been proved more efficient than Genetic Algorithm (GA) in fuzzy problems [38].

Table 48.3 Warehouse holding cost and inventory capacity

Product j	Inventory holding cost (h_{jp}) (pkr/ton)	Maximum stock capacity (10^3 ton)
Cement	1400	8
Gravel	1000	12
Sand	1000	12

Table 48.4 Fuzzy demand and production capacity (10^3 ton)

Product j	Demand at concrete mixing plants ($\widetilde{D}_{jk}$)	Production capacity of supplier ($\tilde{a}_{ji}$)
Cement	(4,6,8)	(6,8,10)
Gravel	(8,10,12)	(10,12,14)
Sand	(8,10,12)	(10,12,14)

The GA is also a well suited algorithm and has been significantly applied to solve many complex optimization problems because it can handle any kinds of objective functions and constraints, i.e., discrete and continuous variables and, linear or nonlinear objective and constrain functions. It does not require the information expressed in terms of gradient of the optimization objective functions and can provide a number of potential solutions to a given problem, leaving the user to make the final decision. It has been employed considerable success in providing good solutions to many complex optimization problems containing fuzzy parameters [44, 45]. So GA is also a better choice for taking optimization problems containing fuzzy parameters. So taking into account the above, this paper proposed the both algorithms GA and PSO to optimize the considered production- distribution planning process in construction supply chain management. After that one most suitable optimal solution can be selected by comparing these two algorithm solutions with each other.

48.4.5 Sensitive Analysis

Some parameters, such as the demand, transportation cost, transportation time and so on are decided by the estimated data or historical data and experts advice to obtain different level solution. We can make the sensitive analysis by changing the decision makers confidence level. Global market is becoming more and more competitive day by day due to this reason manufacture face rigorous challenges for managing the supply chain in an efficient and cost effective manner. This paper presented

PD planning in construction supply chain management. The distributor is at upper level as a leader and producer is at lower level as a follower who owns several manufacturing plants. Every decision maker has their own objects. The distributor (construction project department) wants to minimize the over all material cost and maximize the satisfaction level than predetermine level. The supplier (producer) also wants to maximize their profit and customer satisfaction level than predetermine level. In real situation, it is very difficult for both decision makers to achieve the desirable level of objective functions due to uncertain environment. If the actual demand and supply is very close to the forecasted demand then the both decision maker can achieve the desirable satisfaction level. In a case, when the actual demand exceeds the forecasted one, the producer face losses in profit because of inability to sell end-product in excess and if it is lower than forecasted one, the producer also face losses in profit as of more expenses needed for storage. Experiment values in Table 48.6 show that a comparative or even higher profit and satisfaction level in this case can be got if the forecasted demand and cost are very close or equal to the actual demand and cost. Experiment values in Tab. 6 also shows the sensitivity analysis for the optimistic-pessimistic index of the decision maker. The results are obtained based on the following optimistic-pessimistic index, i.e., $\lambda = 0.5$.

Table 48.5 Transportation time and customer satisfaction level

Plants	Transportation time from Supplier i to warehouses $p(T_{ip})$	Customer satisfaction $\xi_{ip}(T_{ip})$				
		Maximum time ranges		Expected time ranges		Warehouse
		ET_p	LT_p	ET_p^d	LT_p^d	
1	14	10	16	12	14	1
2	15	10.5	16.5	12.5	14.5	0.75
3	15.5	11	17	13	15	0.75

In first case, both level decision makers achieved the optimal solutions. Upper level achieved the minimum level of cost function and maximum level of satisfaction and, lower level maximum level of profit and satisfaction. In second case, upper level cost increased because purchased quantity is increased from first case, due to this reason upper level will be increased the storage cost and the lower level increased the profit and satisfaction level. In third case, upper level increased more cost than second case because purchased quantity are increased from second case and also satisfaction level, due to this reason upper level will increased storage cost and the lower level increased the profit and satisfaction level. In a case, if upper level did not purchase the excess material than demand then lower level will face a loss in profit as of more expenses needed for storage. So the first case is an optimal solution for both decision makers.

Table 48.6 Experiment results

Cases	Upper level decision variable	Lower level decision variable
1	$Y_{jpk} = D_{jk}$ $Y_{jpk} = 260000$ $F_1 = 1201 \times 10^5,\ F_2 = 1$	$X_{jip} = Y_{jpk}$ $X_{jip} = 260000$ $Z_1 = 1830 \times 10^4,\ \ Z_2 = 650 \times 10^2$
2	$Y_{jpk} > D_{jk}$ $Y_{jpk} = 290000$ $F_1 = 1350 \times 10^5,\ F_2 = 1.1$	$X_{jip} > Y_{jpk}$ $X_{jip} = 290000$ $Z_1 = 2055 \times 10^4,\ \ Z_2 = 725 \times 10^2$
3	$Y_{jpk} > D_{jk}$ $Y_{jpk} = 320000$ $F_1 = 1499 \times 10^5,\ F_2 = 1.2$	$X_{jip} > Y_{jpk}$ $X_{jip} = 320000$ $Z_1 = 2430 \times 10^4,\ Z_2 = 800 \times 10^2$

48.5 Conclusion

In this paper, a bi-level multi-objectives programming model with fuzzy parameters is developed for solving the production-distribution problem in large scale hydropower projects. In BLP model the existing hierarchy is introduced where, producer at lower level and warehouse (construction project department) at upper level. Managing uncertainty is a main challenge within CSC management for large scale hydropower projects. This paper has demonstrated the effectiveness of a bi-level programming approach for PD planning in CSC management under uncertainty. This model has been tested by using estimated data for real-world PD planning in Neelum Jhelum Hydropower Project. The proposed fuzzy formulation is more effective than the deterministic methods for handling the real situations problems where precise or certain information is not available for PD planning in CSC management. The fuzzy simulationbased PSO and GA algorithms are proposed to solve the problem. Although the BLP model and PSO-base and GA-base fuzzy simulation algorithms discussed in this paper are helpful in solving real world problems.

References

1. Thomas DJ, Griffin PM (1996) Coordinated supply chain management. European Journal of Operational Research 94:1–15
2. Beamon BM (1998) Supply chain design and analysis: Models and methods. International Journal of Production Economics 55:281–294
3. Erenguc SS, Simpson NC, Vakharia AJ (1999) Integrated production/distribution planning in supply chains: An invited review. European Journal of Operational Research 115:219–236
4. Xu JP, Zhou XY (2011) Fuzzy-like multiple objective decision making. Springer-Verlag, Berlin
5. Hua G, Wang S, Chan CK (2009) A fractional programming model for internation facility location. Journal of Industrial and Management Optimization 5:629–649

6. Selim H, Araz C, Ozkarahan I (2008) Collaborative production-distribution planning in supply chain: A fuzzy goal programming approach. Transportation Research Part E: Logistics and Transportation Review 44:396–419
7. Liang TF (2008) Fuzzy multi-objective production/distribution planning decisions with multi-product and multitime period in a supply chain. Computers and Industrial Engineering 55:676–694
8. Lee YH, Kim SH (2002) Production-distribution planning in supply chain considering capacity constraints. Computers and Industrial Engineering 43:169–190
9. Averbakh I (2010) On-line integrated production-distribution scheduling problems with capacitated deliveries. European Journal of Operational Research 200:377–384
10. Bilgen B, Ozkarahan I (2004) Strategic, tactical and operational production-distribution models: A review. International Journal of Technology Management 28:151–171
11. Sarmiento AM, Nagi R (1999) A review of integrated analysis of production-distribution systems. IE Transactions 31:1061–1074
12. Vila D, Martel A, Beauregard R (2006) Taking market forces into account in the design of production distribution networks: A positioning by anticipation approach. Journal of Industrial and Management Optimization 2:255–268
13. Liu Q, Xu JP (2011) A study on facility location — Location problem in mixed environment of randomness and fuzziness. Journal of Intelligent Manufacturing 22:389–398
14. Xu JP, Zeng ZQ (2012) A discrete time optimal control model with uncertainty for dynamic machine allocation problem and its application to manufacturing and construction industries. Applied Mathematical Modelling 36:3513–3544
15. London KA, Kenley R (2001) An industrial organization economic supply chain approach for the construction industry: A review. Construction Management and Economics 19:777–788
16. Arbulu R, Tommelein I, Walsh K et al (2003) Value stream analysis of re-engineered construction supply chain. Building Research and Information 31:161–171
17. Cox A, Ireland P (2002) Managing construction supply chains: The common sense approach. Engineering, Construction and Architectural Management 9:409–418
18. Emam OE (2005) A fuzzy approach for bi-level integer non-linear programming problem. Applied Mathmatics and Computation 172:62–71
19. Zhang G, Shang J, Li W (2011) Collaborative production planning of supply chain under price and demand uncertainty. European journal of Operational Research 215:590–603
20. Aliev RA, Guirimov BG, Fazlollahi B et al (2007) Fuzzy-genetic approch to aggregate production-distribution planning in suplly chain management. International journal of Information Sciences 177:4241–4255
21. Li X, Qing Z, Yang L et al (2011) Etropy maximization model for the trip distribution problem with fuzzy and random parameters. Journal of Computational and Applied Mathmatics 235:1906–1913
22. Avinder G (2009) Determining loading dock requirements in production-distribution facilities under uncertianty. Computer and Industrial Engineering 57:161–168
23. Bilgen B (2010) Application of fuzzy mathematical programing approach to the production allocation and distribution supply chain network problem. Expert Systems with Applications 37:4488–4495
24. Stalk G (1988) Time-The next source of competitive advantage. Harvard Business Review 66:41–51
25. Mittal V, Kamakura WA (2001) Satisfaction, repurchase intent, and repurchase behavior: Investigation the moderating effect of customer characteristics. Journal of Marketing Research 38:131–142
26. Davis MM, Maggard MJ (1990) An analysis of customer satisfaction with waiting times in a two-stage service process. Journal of Operations Management 9:324–334
27. Tommelein ID (1998) Pull-driven scheduling for pipe-spool installation: Simulation of lean construction technique. Journal of Construction Engineering and Management 124:279–288
28. Zhang H, Tam CM, Shi JJ (2003) Application of fuzzy logic to simulation for construction operations. Journal of Computing in Civil Engineering 17:38–45

29. Katagiri H, Sakawa M, Kato K et al (2008) Interactive multi objective fuzzy random linear programming: Maximization of possibility and probability. European Journal of Operational Research 188:530–539
30. Xu JP, Liu QR, Zeng ZQ et al (2008) Multistage purchasing management for ready-mixed concrete with multiple objectives under fuzzy environment. International Journal of Project Management (submitted)
31. Xu JP, Tu Y, Zeng ZQ (2012) A nonlinear multi-objective bi-level model for minimum cost network flow problem in a large-scale construction project. Mathematical Problems in Engineering Doi:10.1155/2012/463976
32. Kennedy J, Eberhart RC (1995) A new optimizer using particle swarm theory. In: Proceeding of the Sixth International Symposium on Micro Machine and Human Science 39–43
33. Kennedy J, Eberhart R (2001) Swarm intelligence. Morgan Kaufmann Publishers
34. Song MP, Gu GC (2004) Research on particle swarm optimization: A review. In: Proceedings of 2004 International Conference on Machine Learning and Cybernetics 2236–2241
35. Sha DY, Hsu CY (2006) A hybrid particle swarm optimization for job shop scheduling problem. Computers & Industrial Engineering 51:91–808
36. Ling SH, Iu HHC, Chan KY et al (2008) Hybrid particle swarm optimization with wavelet mutation and its industrial applications. IEEE Transactions on Systems, Man, and Cybernetics B 38:743–763
37. Xu JP, Yan F (2011) Vehicle routing optimization with soft time windows in a fuzzy random environment. Transportation Research Part E 47:1075–1091
38. Eberhart RC, Shi YH (1998) Comparison between genetic algorithms and particle swarm optimization. In: Proceedings of the 7th International Conference of Evolutionary Programming 611–616
39. Zadeh LA (1978) Fuzzy sets as a basis for a theory of possibility. Fuzzy Sets and Systems 1:3–28
40. Su RH, Yang DY, Pearn WL (2011) Decision-making in a single-period inventory environment with fuzzy demand. Expert Systems with Applications 38:1909–1916
41. Handfield R, Warsing D, Wu XM (2009) (Q,r) inventory policies in a fuzzy uncertain supply chain environment. European Journal of Operational Research 197:609–619
42. Pakistan Water and Power Developement Authority (2008) Neelum Jhelum Hydropower Project. Inception Report V1
43. Aliev RA, Fazlollahi B, Aliev RR (2004) Soft computing and its application in business and economics. Springer-Verlag
44. Pedrycz W (1997) Fuzzy evolutionary computation. Kluwer Academic Publishers
45. Wang D, Fang SC (1997) A genetics-based approach or aggregate production planning in fuzzy environment. IEEE Transactions on Systems, Man, and Cybernetics 27:636–645

Chapter 49
Supply Chain Network Equilibrium Models with Stock-dependent Demand

Bing Xu and Yong Xiong

Abstract There widely exist brand-to-brand competition and channel-to-channel competition in supply chain network. Retailer's stock influences its demand, which is an important competition factor. For a supply chain network consisting of two manufacturers and two retailers with stock-dependent demand, this paper sets up three equilibrium models using the equilibrium theory such as the decentralized decision model when all agents make decisions to maximize their own profits, the brand-profit-maximum model when two dominant manufacturers make decisions to maximize the profits of their own brands, and the channel-profit-maximum model when two dominant retailers make decisions to maximize the profits of their channels. The order quantities and profits of two brands in the brand-profit-maximum model, and of two channels in the channel-profit-maximum model, are more than those in the decentralized decision model. So, two buy-back contracts are put forward to coordinate two decentralized retailers to choose the same decisions as in the brand-profit-maximum model and the channel-profit-maximum model respectively. A numerical example is taken to validate these models and contracts. It shows that supply chain coordination can promote the competitive ability of channel and brand.

Keywords Supply chain network · Stock-dependent demand · Equilibrium theory

49.1 Introduction

In many industries, the competition between firms has become chain-to-chain or brand-to-brand or channel-to-channel competition. Growing literature has addressed competition and coordination issues in supply chains. The majority of this literature concentrates on a single supply chain and inventory competition [1]. A coordination

---

B. Xu (✉) · Y. Xiong
Department of Management Science and Engineering, Nanchang University, Nanchang 330031, P. R. China
e-mail: xu_bing99@sina.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_49, © Springer-Verlag London 2013

mechanism is derived under credit period for a two-level supply chain that includes a single manufacturer and a single buyer for a single product, a centralized system is designed to minimize the total variable cost per unit time, theorems are developed to determine the optimal ordering policies and bounds are provided for credit period to develop an algorithm [2]. Xu and Zhu [3] set up three decentralized decision models of one manufacturer and one retailer by combining game theory with newsvendor model, and studies how to coordinate the supply chain under three situations that the markup in cost-plus retail price is constant, determined by retailer or manufacturer. Wu and Chen [4] studied the manufacturers' competition, the retailers' competition and the vertical interaction between them in a supply chain with multiple manufacturers selling differentiated products through multiple exclusive retailers, who are faced with fixed market prices but uncertain demands. The presence of retail inventory has a motivating effect on the customer. The class of inventory models with stock-, or inventory-level-, dependent demand rates has received considerable attention in supply chain competition [5]. Retailers can potentially increase their sales volume by increasing the amount of goods displayed on the shelf space. Wang and Gerchack [6] analyzed a decentralized manufacturer-retailer(s) supply chain with shelf-space dependent demand, recognizes the positive dependence of demand on the quantity displayed, shows that to coordinate the channel with one retailer, the manufacturer needs to augment the wholesale price lever by another-an inventory holding costs subsidy offered to the retailer, and studies retailers' Nash equilibrium and channel coordination when multiple retailers compete in that product's market. Parthasarathi et al [7] studied one manufacturer and two competing retailers who face price-sensitive, stock dependent and uncertain demand using the newsvendor framework, a combined contract model with returns policy plus quantity discounts is developed and sensitivity analysis is performed to analyze the impact of various parameters on supply chain coordination.

Variational inequality is efficient method to study the equilibrium model supply chain complex network consisting of multiple manufacturers, multiple retailers and so on. Xu and Zhu [8] used nested logit model to character the consumers' choice and puts forward the supply chain network equilibrium variational inequality model, under the assumption that the consumers are stochastic multi-criteria decision-makers, who firstly choose which retailer they transact with, and then make their consumption decisions with deficient information. Xu and Zhang [9] put forwards a variational inequality equilibrium model of closed-loop supply chain network, which can character the forward commodity flow from manufacturers to retailers then to end consumers, and the reverse used products flow from the owners of used products to recovery enterprises then to manufacturers. Boyaci and Gallego [10] considered three competition scenarios such as uncoordinated scenario, coordinated scenario and hybrid scenario between two supply chains at a same market, each consisting of one wholesaler and one retailer. In the uncoordinated scenario, individual members of both supply chains maximize their own profits by individually selecting their service and inventory policies. In the coordinated scenario, wholesalers and retailers of each supply chain coordinate their service and inventory policy decisions to maximize supply chain profits. In the hybrid scenario, competition is between one coordinated and one uncoordinated supply chain. Xu and Sun [11] investigated supply chain competition by examining the relationship between shelf-display-quantity and retail price in three settings: two decentralized supply chain, two centralized supply chains, and one decentralized vs. one centralized supply chain, and sets up three corresponding models such as EPEC (Equilibrium Problems with Equilibrium Constrains) model, Nash equilibrium model and MPEC (Mathematical Programs with Equilibrium Constrains) to characterize the supply chain competition. The upper layer is the competition equilibrium of two manufacturers and the lower layer is the competition equilibrium of two retailers.

We consider a supply chain network consisting of two manufacturers and two retailers with stock-dependent demand, put forward three equilibrium models using the equilibrium theory such as the decentralized decision model when all agents make decisions to maximize their own profits, the brand-profit-maximum model when two dominant manufacturers make decisions to maximize the profits of their own brands, and the channel-profit-maximum model when two dominant retailers make decisions to maximize the profits of their channels.

This paper is organized as follows. In Sect. 49.2, we present three competition models with supply chain network consisting of two manufacturer and two retailers. Each manufacturer sells his products through two retailers. We model the demand by a linear function of the inventory quantities. The models character three cases such as the decentralized decisions, brand-profit-maximum decisions and channel-profit-maximum decisions respectively. Sect. 49.3 puts forward two buy-back contracts, which can coordinate retailers' decentralized decisions just as in the brand-profit-maximum model and the channel-profit-maximum model respectively. A numerical example shows the validity of the models and contracts in Sect. 49.4. Sect. 49.5 concludes the paper.

49.2 Modeling the Competition Equilibrium of Supply Chain Network

49.2.1 Model Assumption

Consider a supply chain network consisting of two risk-neutral manufacturers and two risk-neutral retailers, who produce and sell homogeneous products at a same demand market. There exists a Stackelberg game between manufacturer $M_i (i = 1,2)$ and Retailer $R_j (j = 1,2)$: M_i put forward wholesale price w_{ij} of the brand product i to R_j, whose production cost per unit is c_i, satisfying $w_{ij} > c_i > 0$; R_j submits an order quantity, q_{ij}, to M_i; M_i produces and delivers to R_j before the single selling season; R_j sells product i with retail price $p_{ij} > w_{ij}$ during selling season. R_j earns $v_i < c_i$ per unit unsold at the end of season, where v_i is net of any salvage expenses. Assume that p_{ij} and v_i are exogenous variables, the inventory cost and penalty for loss of goodwill are not considered. Two retailers compete against each other in stock quantity. The stochastic demand D_{ij} of produce i at retailer R_j is affected by the stock of two kinds of products at two retailers, which can be denoted by a certain item d_{ij} relating to order vector $Q = (q_{11}, q_{12}, q_{21}, q_{22})$ and a stochastic item ξ_j, namely: $D_{ij}(Q) = d_{ij}(Q) + \xi_j = \left[a_j q_{ij} - b_j q_{3-i,j} - \frac{1}{2} e_{3-j}(q_{i,3-j} + q_{3-i,3-j})\right] + \xi_j$, $i, j = 1, 2$. Parameters a_j, b_j and e_{3-j} are positive constants. Let F_j be the distribution function of ξ_j and f_j its density function: F_j is differentiable, strictly increasing and $F_j(0) = 0$. Let F_j^{-1} is its inverse function. Denote $t_{ij} = (p_{ij} - v_i) f_j(q_{ij} - d_{ij})$.

Let $S_{ij}(Q)$ be expected sales and $I_{ij}(Q)$ be the expected left over inventory, we have:

$$S_{ij}(Q) = \int_0^{q_{ij}} x f_j(x - d_{ij})\mathrm{d}x + \int_{q_{ij}}^{+\infty} q_{ij} f_j(x - d_{ij})\mathrm{d}x = q_{ij} - \int_0^{q_{ij}} F_j(x - d_{ij})\mathrm{d}x,$$

$$I_{ij}(Q) = \int_0^{q_{ij}} (q_{ij} - x) f_j(x - d_{ij})\mathrm{d}x = \int_0^{q_{ij}} F_j(x - d_{ij})\mathrm{d}x.$$

Retailer R_j's profit function π_{R_j} and manufacturer M_i's profit function π_{M_i} are:

$$\pi_{R_j}(Q) = \sum_{i=1}^{2} (p_{ij} S_{ij} - w_{ij} q_{ij} + v_i I_{ij}) = \sum_{i=1}^{2} \left[(p_{ij} - w_{ij}) q_{ij} - (p_{ij} - v_i) \int_0^{q_{ij}} F_j(x - d_{ij})\mathrm{d}x\right],$$

$$\pi_{M_i}(w_{i1}, w_{i2}) = \sum_{j=1}^{2} (w_{ij} - c_i) q_{ij}.$$

The profit function of two production-sale channel realized by retailer R_j is:

$$\pi_j^R(Q) = \sum_{i=1}^{2} (p_{ij} S_{ij} - c_i q_{ij} + v_i I_{ij}) = \sum_{i=1}^{2} \left[(p_{ij} - c_i) q_{ij} - (p_{ij} - v_i) \int_0^{q_{ij}} F_j(x - d_{ij})\mathrm{d}x\right].$$

The profit function of brand product i is:

$$\pi_i^M(Q) = \sum_{j=1}^{2} (p_{ij} S_{ij} - c_i q_{ij} + v_i I_{ij}) = \sum_{j=1}^{2} \left[(p_{ij} - c_i) q_{ij} - (p_{ij} - v_i) \int_0^{q_{ij}} F_j(x - d_{ij})\mathrm{d}x\right].$$

49.2.2 Decentralized Decision Model

When this supply chain (SC) is decentralized SC, all agents make decisions to maximize their own profits. The decentralized decision model (MR model) is an EPEC model as following:

$$\begin{cases} (w_{11}^{MR}, w_{12}^{MR}) \in \underset{w_{11}\geq c_1, w_{12}\geq c_1}{\arg\max} & \pi_{M_1}(w_{11}, w_{12}, q_{11}^{MR}(w_{11}, w_{21}), q_{12}^{MR}(w_{12}, w_{22})) \\ (w_{21}^{MR}, w_{22}^{MR}) \in \underset{w_{21}\geq c_2, w_{22}\geq c_2}{\arg\max} & \pi_{M_2}(w_{21}, w_{22}, q_{21}^{MR}(w_{11}, w_{21}), q_{22}^{MR}(w_{12}, w_{22})) \end{cases} \tag{49.1}$$
$$\text{s.t.} \begin{cases} \pi_{R_1}(q_{11}^{MR}, q_{21}^{MR}, q_{12}^{MR}, q_{22}^{MR}) \geq \pi_{R_1}(q_{11}, q_{21}, q_{12}^{MR}, q_{22}^{MR}), \ \forall q_{11}, q_{21} \geq 0 \\ \pi_{R_2}(q_{11}^{MR}, q_{21}^{MR}, q_{12}^{MR}, q_{22}^{MR}) \geq \pi_{R_2}(q_{11}^{MR}, q_{21}^{MR}, q_{12}, q_{22}), \ \forall q_{12}, q_{22} \geq 0. \end{cases}$$

In this bi-level program, the upper layer problem is the competition equilibrium between two manufacturers; the lower layer is the competition equilibrium between two retails. At the same time, retailers' decisions of order quantity will affect the profits of two manufacturers, and manufacturers must consider the reaction of retailers when they make their own decisions.

Proposition 49.1. *The profit function $\pi_{R_j}(q_{1j}, q_{2j})$ is strictly differentiable and concave in (q_{1j}, q_{2j}).*

Proof. The Hessian matrix of $\pi_{R_j}(q_{1j}, q_{2j})$ is:

$$\begin{bmatrix} -(1-a_j)^2 t_{1j} - b_j^2 t_{2j} & -b_j(1-a_j)(t_{1j}+t_{2j}) \\ -b_j(1-a_j)(t_{1j}+t_{2j}) & -(1-a_j)^2 t_{2j} - b_j^2 t_{1j} \end{bmatrix}.$$

It is a negative matrix. Hence, $\pi_{R_j}(q_{1j}, q_{2j})$ is strictly differentiable and concave in (q_{1j}, q_{2j}).

According to Proposition 49.1, solve the first-order conditions of two retailers' profit functions:

$$\begin{aligned} \frac{\partial \pi_{R_j}}{\partial q_{ij}} = \ & (p_{ij} - w_{ij}) - (1-a_j)(p_{ij} - v_i) F_j(q_{ij} - d_{ij}) \\ & - b_j(p_{3-i,j} - v_{3-i}) F_j(q_{3-i,j} - d_{3-i,j}) = 0, \ i, j = 1, 2. \end{aligned}$$

We have:

$$q_{ij} - d_{ij} = F_j^{-1}(\lambda_{ij}^{MR}) = F_j^{-1}\{\frac{(1-a_j)(p_{ij} - w_{ij}) - b_j(p_{3-i,j} - w_{3-i,j})}{[(1-a_j)^2 - b_j^2](p_{ij} - v_i)}\}, \ i, j = 1, 2.$$

The competition equilibrium decisions of two retailers in Equation (49.1), $q_{ij}^{MR}(i, j = 1, 2)$, satisfy:

$$\begin{aligned} q_{ij}^{MR} = \ & \frac{(1-a_{3-j}+b_{3-j})[F_j^{-1}(\lambda_{ij}^{MR}) + F_j^{-1}(\lambda_{3-i,j}^{MR})] - e_{3-j}[F_{3-j}^{-1}(\lambda_{i,3-j}^{MR}) + F_{3-j}^{-1}(\lambda_{3-i,3-j}^{MR})]}{2\left[(1-a_j+b_j)(1-a_{3-j}+b_{3-j}) - e_j e_{3-j}\right]} \\ & + \frac{F_j^{-1}(\lambda_{ij}^{MR}) - F_j^{-1}(\lambda_{3-i,j}^{MR})}{2(1-a_j-b_j)}. \end{aligned} \tag{49.2}$$

49.2.3 Brand-profit-maximum Decision Model

When two manufacturers are dominant in this supply chain, they make decisions to maximize the profits of their own brands. The decision model of brand-profit-maximum (M model) is Nash equilibrium between two brands as following:

$$\begin{cases} \pi_1^M(q_{11}^M, q_{12}^M, q_{21}^M, q_{22}^M) \geq \pi_1^M(q_{11}, q_{12}, q_{21}^M, q_{22}^M), \forall q_{11}, q_{12} \geq 0 \\ \pi_2^M(q_{11}^M, q_{12}^M, q_{21}^M, q_{22}^M) \geq \pi_2^M(q_{21}, q_{22}, q_{11}^M, q_{12}^M), \forall q_{21}, q_{22} \geq 0. \end{cases} \tag{49.3}$$

According to this model, the profits of two brands are not affected by wholesale prices. Wholesale prices only affect the division of brand-profit between manufacturer and retailer.

Proposition 49.2. *The profit function* $\pi_i^M(q_{i1}, q_{i2})$ *is strictly differentiable and concave in* (q_{i1}, q_{i2}).

Proof. The Hessian matrix of $\pi_i^M(q_{i1}, q_{i2})$ is:

$$\begin{bmatrix} -(1-a_1)^2 t_{i1} - \frac{1}{4}e_1^2 t_{i2} & -\frac{1}{2}[e_2(1-a_1)t_{i1} + e_1(1-a_2)t_{i2}] \\ -\frac{1}{2}[e_2(1-a_1)t_{i1} + e_1(1-a_2)t_{i2}] & -(1-a_2)^2 t_{i2} - \frac{1}{4}e_2^2 t_{i1} \end{bmatrix}.$$

It is a negative matrix. Hence, $\pi_i^M(q_{i1}, q_{i2})$ is strictly differentiable and concave in (q_{i1}, q_{i2}).

According to Proposition 49.2, solve the first-order conditions of brand-profit functions:

$$\begin{aligned} \frac{\partial \pi_i^M}{\partial q_{ij}} = {} & (p_{ij} - c_i) - (1-a_j)(p_{ij} - v_i)F_j(q_{ij} - d_{ij}) \\ & -\frac{1}{2}e_j(p_{i,3-j} - v_i)F_{3-j}(q_{i,3-j} - d_{i,3-j}) = 0,\ i, j = 1, 2. \end{aligned}$$

We have:

$$q_{ij} - d_{ij} = F_j^{-1}(\lambda_{ij}^M) = F_j^{-1}\left\{ \frac{(1-a_{3-j})(p_{ij} - c_i) - \frac{1}{2}e_j(p_{i,3-j} - c_i)}{[(1-a_j)(1-a_{3-j}) - \frac{1}{4}e_j e_{3-j}](p_{ij} - v_i)} \right\}, i, j = 1, 2.$$

The competition equilibrium decisions of two brands in Equation (49.3), $q_{ij}^M (i, j = 1, 2)$, satisfy:

$$\begin{aligned} q_{ij}^M = {} & \frac{(1-a_{3-j}+b_{3-j})[F_j^{-1}(\lambda_{ij}^M) + F_j^{-1}(\lambda_{3-i,j}^M)] - e_{3-j}[F_{3-j}^{-1}(\lambda_{i,3-j}^M) + F_{3-j}^{-1}(\lambda_{3-i,3-j}^M)]}{2[(1-a_j+b_j)(1-a_{3-j}+b_{3-j}) - e_j e_{3-j}]} \\ & + \frac{F_j^{-1}(\lambda_{ij}^M) - F_j^{-1}(\lambda_{3-i,j}^M)}{2(1-a_j-b_j)}. \end{aligned} \tag{49.4}$$

49.2.4 Channel-profit-maximum Decision Model

When two retailers are dominant in this supply chain, they make decisions to maximize the profits of their channels. The decision model of channel-profit-maximum (R model) is Nash equilibrium between two channels as following:

$$\begin{cases} \pi_1^R(q_{11}^R, q_{12}^R, q_{21}^R, q_{22}^R) \geq \pi_1^R(q_{11}, q_{21}, q_{12}^R, q_{22}^R), \forall q_{11}, q_{21} \geq 0 \\ \pi_2^R(q_{11}^R, q_{12}^R, q_{21}^R, q_{22}^R) \geq \pi_2^R(q_{12}, q_{22}, q_{11}^R, q_{21}^R), \forall q_{12}, q_{22} \geq 0. \end{cases} \tag{49.5}$$

According to this model, the profits of two channels are not affected by wholesale prices. Wholesale prices only affect the division of channel-profit between manufacturer and retailer.

Substitute c_i for w_{ij} $(i = 1,2)$ in function $\pi_{R_j}(Q)$, we obtain function $\pi_j^R(Q)$. Similar to Proposition 49.1, Proposition 49.3 is held.

Proposition 49.3. *The profit function $\pi_j^R(q_{1j}, q_{2j})$ is strictly differentiable and concave in (q_{1j}, q_{2j}).*

According to Proposition 49.3, solve the first-order conditions of channel-profit functions:

$$\begin{aligned} \frac{\partial \pi_j^R}{\partial q_{ij}} = {} & (p_{ij} - c_i) - (1 - a_j)(p_{ij} - v_i)F_j(q_{ij} - d_{ij}) - b_j(p_{3-i,j} - v_{3-i}) \\ & F_j(q_{3-i,j} - d_{3-i,j}) = 0,\ i, j = 1,2. \end{aligned}$$

We have:

$$q_{ij} - d_{ij} = F_j^{-1}(\lambda_{ij}^{MR}) = F_j^{-1}\left\{\frac{(1 - a_j)(p_{ij} - c_i) - b_j(p_{3-i,j} - c_{3-i})}{[(1 - a_j)^2 - b_j^2](p_{ij} - v_i)}\right\},\ i, j = 1,2.$$

The competition equilibrium decisions of two channels in Equation (49.5), $q_{ij}^R (i, j = 1,2)$, satisfy:

$$\begin{aligned} q_{ij}^R = {} & \frac{(1 - a_{3-j} + b_{3-j})\left[F_j^{-1}(\lambda_{ij}^R) + F_j^{-1}(\lambda_{3-i,j}^R)\right] - e_{3-j}[F_{3-j}^{-1}(\lambda_{i,3-j}^R) + F_{3-j}^{-1}(\lambda_{3-i,3-j}^R)]}{2\left[(1 - a_j + b_j)(1 - a_{3-j} + b_{3-j}) - e_j e_{3-j}\right]} \\ & + \frac{F_j^{-1}(\lambda_{ij}^R) - F_j^{-1}(\lambda_{3-i,j}^R)}{2(1 - a_j - b_j)}. \end{aligned} \tag{49.6}$$

49.3 Coordinative Strategy Design

Compare Equation (49.2) with Equation (49.6), $q_{ij}^{MR} = q_{ij}^R$ only when $w_{ij} = c_i$, i.e., the wholesale price contract coordinates the supply chain realizing channel-profit-maximum only if two manufacturers use marginal cost pricing. Both manufacturers earn zero profit with marginal cost pricing, so the manufacturers clearly prefer a higher wholesale price. Hence, the wholesale price contract is generally considered a non-coordinating contract.

With a buy-back contract manufacturer M_i charges retailer R_j w_{ij} per unit purchased, but pays the retailer τ_{ij} per unit remaining at the end of the season. A retailer should not profit from left over inventory, so assume that $\tau_{ij} \leq w_{ij}$ is held.

Proposition 49.4. *In this supply chain network, when both manufacturers adopt the buy-back contract* (w_{ij}, τ_{ij})*, two retailers will choose the decisions of channel-profit-maximum and any division of the channel's profit is possible if* $\tau_{ij} = (1-\theta_j)(p_{ij} - v_i)$*,* $w_{ij} = (1-\theta_j)p_{ij} + \theta_j c_i$*,* $\theta_j \in (0,1) (i,j = 1,2)$*.*

Proof. With the buy-back contracts, the profit function of retailer R_j, $\overline{\pi}_{R_j}$, is:

$$\begin{aligned}\overline{\pi}_{R_j} &= \sum_{i=1}^{2}\left[(p_{ij}-w_{ij})q_{ij} - (p_{ij}-v_i-\tau_{ij})\int_0^{q_{ij}} F_j(x-d_{ij})\mathrm{d}x\right]\\ &= \theta_j \sum_{i=1}^{2}\left[(p_{ij}-c_i)q_{ij} - (p_{ij}-v_i)\int_0^{q_{ij}} F_j(x-d_{ij})\mathrm{d}x\right] = \theta_j \pi_j^R,\\ \pi_{M_i}(w_{i1},w_{i2}) &= \sum_{j=1}^{2}(w_{ij}-c_i)q_{ij} = \sum_{j=1}^{2}[(1-\theta_j)(p_{ij}-c_i)q_{ij}].\end{aligned}$$

It follows immediately that the competition equilibrium decisions of two retailers are unique and satisfy $\overline{q}_{ij}^{MR} = q_{ij}^R (i,j = 1,2)$, and any division of the channel's profit is possible. Note that there is a unique $\{w_{ij}, \tau_{ij}\}$ pair for any θ_j, and θ_j is retailer R_j's share of the channel's profit.

Compare Equation (49.2) with Equation (49.4), even when $w_{ij} = c_i$ is held, we still have $q_{ij}^{MR} \neq q_{ij}^M$. Hence, manufacturer can't use the wholesale price contract to coordinate retailer choosing the decisions of brand-profit-maximum.

Proposition 49.5. *In this supply chain network, when both manufacturers adopt the buy-back contract* $\{w_{ij}, \tau_{ij}\}$*, two retailers will choose the decisions of brand-profit-maximum if* $\tau_{ij} = (1-\theta_j)(p_{ij}-v_i)$*,* $w_{ij} = p_{ij} - \theta_j[(1-a_j)(p_{ij}-v_i)\lambda_{ij}^M + b_j(p_{3-i,j} - v_{3-i})\lambda_{3-i,j}^M]$*,* $\lambda_{ij}^M = \frac{(1-a_{3-j})(p_{ij}-c_i) - \frac{1}{2}e_j(p_{i,3-j}-c_i)}{[(1-a_j)(1-a_{3-j}) - \frac{1}{4}e_j e_{3-j}](p_{ij}-v_i)}$*,* $\theta_j \in (0,1)$ $(i,j = 1,2)$*.*

Proof. With the buy-back contracts, the profit function of retailer R_j, $\bar{\pi}_{R_j}$, is:

$$\bar{\pi}_{R_j} = \sum_{i=1}^{2}\left[(p_{ij}-w_{ij})q_{ij} - (p_{ij}-v_i-\tau_{ij})\int_0^{q_{ij}} F_j(x-d_{ij})\mathrm{d}x\right]. \tag{49.7}$$

Similar to Sect. 49.2.2, we can prove that $\overline{\pi}_{R_j}(q_{1j}, q_{2j})$ is strictly differentiable and concave in (q_{1j}, q_{2j}). Solve the first-order conditions of two retailers' profit functions, we have:

$$\overline{\lambda}_{ij}^{MR} = \frac{(1-a_j)(p_{ij}-w_{ij}) - b_j(p_{3-i,j}-w_{3-i,j})}{[(1-a_j)^2 - b_j^2](p_{ij}-v_i-\tau_{ij})} = \lambda_{ij}^M,\ \overline{q}_{ij}^{MR} = q_{ij}^M.$$

Note that there is a unique $\{w_{ij}, \tau_{ij}\}$ pair for any θ_j.

49.4 Numerical Example

Consider a supply chain network consists of two manufacturers and two retailers. By questionnaire survey, cost analysis and statistical analysis of production and sale data, we can obtain or estimate the parameters of models mentioned above: $a_1 = 0.2$, $a_2 = 0.15$, $b_1 = 0.08$, $b_2 = 0.06$, $c_1 = 30$, $c_2 = 25$, $e_1 = e_2 = 0.1$, $p_{11} = 60$, $p_{12} = 62$, $p_{21} = 54$, $p_{22} = 50$, $F_1(x) = F_2(x) = x/1000$. The meaning of these variables can be found in Sect. 49.2.1 and their units are out of consideration.

49.4.1 The Decisions of Supply Chain in Three Modes

1. MR model. Let wholesale price $w_{11} = w_{21} = 42.5$ and $w_{12} = w_{22} = 37.5$ in MR model, solve the problem of retailers' competition; obtain the decisions q_{ij}^{MR} and the profits of all agents (Tables 49.1 and 49.2).
2. M model. Solve the problem of brand competition in M model; obtain the decisions q_{ij}^{M} and the profits of two brands (Tables 49.1 and 49.2).
3. R model. Solve the problem of channel competition in R model; obtain the decisions q_{ij}^{R} and the profits of two channels (Tables 49.1 and 49.2).

It shows that the order quantities and profits of two brands in M model are more than those in MR model. So the control mode based on brand-profit-maximum decision can promote the development of brand. It shows that the order quantities and profits of two channels in R model are more than those in MR model. So the control mode based on channel-profit-maximum decision can promote the development of channel.

49.4.2 Validity Analysis of Coordinative Contracts

(1) Let $\theta_1 = \theta_2 = 0.3$ in the buy-back contract (w_{ij}, τ_{ij}) of Proposition 49.4, solve the problem of retailers' competition in MR model based on these contracts; obtain the decisions q_{ij}^{MR} and the profits of all agents (see Table 49.3).

Table 49.3 shows that the contracts can coordinate two decentralized retailers to choose the same decisions as in the channel-profit-maximum model. This decentralized supply chain is coordinated to the state of channel-profit-maximum model. By using these coordinative contracts, the profits of each manufacturer, each retailer and each channel are enhanced. So, supply chain coordination can realize win-win.
(2) Let $\theta_1 = \theta_2 = 0.3$ in the buy-back contract (w_{ij}, τ_{ij}) of Proposition 49.5, solve

Table 49.1 Order decisions in MR model, M model and R model

(λ_{ij}, q_{ij})	MR model		M model		R model	
	$j=1$	$j=2$	$j=1$	$j=2$	$j=1$	$j=2$
$i=1$	(0.39, 416)	(0.23, 317)	(0.78, 804)	(0.76, 857)	(0.76, 780)	(0.76, 809)
$i=2$	(0.32, 200)	(0.37, 374)	(0.82, 743)	(0.72, 697)	(0.78, 753)	(0.77, 686)

Table 49.2 Profits of all agents in MR model, M model and R model

π_i^M	$i=1$	$i=2$	Total	π_j^R	$j=1$	$j=2$	Total
MR model	17091	14720	31811	MR model	16967	14844	31811
M model	20625	18238	38863	R model	21015	18133	39148
MR model	π_{M_1} 11871	π_{M_2} 10153	π_{R_1} 5254	π_{R_2} 4533		Total 31811	

Table 49.3 Solutions of MR model based on coordinative contract of Proposition 49.4

(λ_{ij}, q_{ij})	$j=1$	$j=2$	π_{M_i}
$i=1$	(0.76,780)	(0.76,809)	14615
$i=2$	(0.78,753)	(0.77,686)	12788
π_{R_j}	6305	5440	
π_j^R	21015	18133	

Table 49.4 Solutions of MR model based on coordinative contract of Proposition 49.5

(λ_{ij}, q_{ij})	$j=1$	$j=2$	π_{M_i}	π_i^M
$i=1$	(0.78,804)	(0.76,857)	14227	20625
$i=2$	(0.82,743)	(0.72,697)	12307	18238
π_{R_j}	6900	5429		

the problem of retailers' competition in MR model based on these contracts; obtain the decisions q_{ij}^{MR} and the profits of all agents (see Table 49.4).

Table 49.4 shows that the contracts can coordinate two decentralized retailers to choose the same decisions as in the brand-profit-maximum model. This decentralized supply chain is coordinated to the state of brand-profit-maximum model. By using these coordinative contracts, the profits of each manufacturer, each retailer and each brand are enhanced. So, supply chain coordination can realize win-win.

49.5 Conclusions

Retailer's stock influences its demand, which is an important factor for supply chain competition. This paper studies the competitive equilibrium of supply chain network consisting of two manufacturers and two retailers under the assumption that retailer's product demand is affected by the stock of two kinds of products at two retailers. Two retailers compete against each other in quantity and two manufacturers compete against each other in wholesale price. At the same time, there exists a Stackelberg game between retailer and manufacturer. Firstly, an EPEC model is set up to character the decentralized decisions when all agents make decisions to maximize their own profits. Secondly, two Nash Models are put forward to character the brand-profit-maximum decisions when two manufacturers are dominant who make decisions to maximize the profits of their own brands, and the channel-profit-maximum decisions when two retailers are dominant who make decisions to maximize the profits of their channels respectively.

It shows that the order quantities and profits of two brands in brand-profit-maximum model are more than those in decentralized decisions model, the order quantities and profits of two channels in channel-profit-maximum model are more than those in decentralized decisions model. Supply chain contracts are valid method to coordinate supply chain. Two buy-back contracts are put forward to coordinate two decentralized retailers to choose the same decisions as in brand-profit-maximum model and channel-profit-maximum model respectively. Finally, a numerical example is put forward, which proves the correctness of the models and the validity of the coordinative contracts mentioned above.

There are some potentially interesting extensions such as supply chain network equilibrium with elastic demand, production capacity constraint, quality and price competition and. More research should be done on customer behavior, commitment, multiclass consume, and supply chain performance based on service level of supply chain. It will be more interesting and valuable to further study the competition of multiple SCs with multi-products.

Acknowledgements Research partially supported by National Natural Science Foundation of China (NSFC 70961006), China Postdoctoral Science Foundation (20100481186).

References

1. Cachon G (2001) Supply chain coordination with contracts, working paper. Wharton School of Business, University of Pennsylvania
2. Seyed R, Ali A, Taghi R (2009) Coordination mechanism for two-level supply chain with one manufacturer and one buyer under credit period. International Journal of Management Science and Engineering Management 4:39–48
3. Xu B, Zhu D (2008) Decision models and supply chain coordination under cost-plus pricing in retail market. In: Proceeding of the Second International Conference on Management Science and Engineering Management 122–129
4. Wu O, Chen H (2003) Chain-to-Chain Competition under Demand Uncertainty. Working paper, University of Michigan. http://webuser.bus.umich.edu/owenwu/academic/Chain-to-Chain_2.pdf
5. Timothy L (2005) Inventory models with inventory-level-dependent demand: A comprehensive review and unifying theory. European Journal of Operational Research 162:792–804

6. Wang Y, Gerchack Y (2001) Supply chain coordination when demand is shelf-space dependent. Manufacturing & Service Management 3:82–87
7. Parthasarathi G, Sarmah S, Jenamani M (2011) Supply chain coordination under retail competition using stock dependent price-setting newsvendor framework. Operational Resarch 11:259–279
8. Xu B, Zhu D (2008) A supply chain network equilibrium model with stochastic multicriteria decision. In: Proceeding of IEEE International Conference on Automation and Logistics 169–174
9. Xu B, Zhang X (2011) A closed-loop supply chain network equilibrium model based on variation inequality. In: Proceeding of the Fifth International Conference on Management Science and Engineering Management 3–7
10. Boyaci T, Gallego G (2004) Supply chain coordination in a market with customer service competition. Production and Operations Management 13:3–22
11. Xu B, Sun G (2011) Supply chain competition between two SCs and SC coordination modes for shelf-display-quantity. Journal of Industrial Engineering/Engineering. Management 25:197–202 (In Chinese)

Chapter 50

Optimal Manufacturing, Ordering, Pricing and Advertising Decisions in a Two-echelon Supply Chain System

Junping Wang and Shengdong Wang

Abstract This paper extends the existing models to the case where the random demand depending on advertising expenditure and selling price follows the additive form. The retailer's optimal ordering, pricing and advertising decision model and the manufacturer's optimal production decision model are respectively developed, and the closed-form solution to each model is provided as well. Moreover, we explore the effect of different forms of demand function (i.e., multiplicative form and additive form) on the decisions of the supply chain members. Our analysis suggests that the multiplicative form fits for depicting the demand of the branded products while the additive form is appropriate for the new or low brand recognition products. Finally, we implement a numerical study to illustrate the models.

Keywords Supply chain management · Manufacturing · Ordering · Two production modes · Additive demand form

50.1 Introduction

With the rapid improvement of technology, the lifecycles of products are becoming shorter and shorter. It leads many non-seasonal products like high-tech products (such as USB flash drivers, personal computers, mobile phones, etc.) to having the attributes of newsvendor-type or seasonal goods. For these newsvendor-type products, a second-order opportunity is more valuable since it can reduce the mismatches between the supply and demand dramatically. That is why in the past decades lots of research has been conducted on supply chain management issues for newsvendor-

---

J. Wang (✉)
School of Mathematics, Hefei University of Technology, Anhui 230009, P. R. China
e-mail: misswangjp@sina.com.cn

S. Wang
Department of Mathematics, Electronic Engineering Institute of PLA, Anhui 230037, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_50,

type products with two ordering opportunities. In general, this research mainly includes two streams as follows. The first stream is to discuss production/ordering decision issues from the perspective of operations management. This type of researches neglects the impact of pricing and/or advertising on market demand, see [4, 5, 15, 17, 18, 21]. The second stream is to study strategies of pricing, advertising and etc. from the perspective of marketing. A lot of models on this topic can be found in the literature, most of which, however, assumed that the mark demand was a random variable depending either on the advertising expenditure or on the selling price [1, 2, 6, 10–13, 17, 19].

Although the importance of the two streams mentioned above is widely investigated, few researches integrate them. In view of this gap in the literature, Wang et al [16] developed a more generalized supply chain coordination model than the existing related models. The generality of Wang et al [16] lies in the three aspects: (1) it incorporates pricing, advertising, production and ordering in one model; (2) it allows the manufacturer to use two production modes and not to follow the lot-for-lot policy; and (3) it employs an general function form to depict the expected market demand that is dependent on both the price and the advertising expenditure.

In the work of Wang et al [16], the demand function is modeled in a multiplicative form. Employing a multiplicative way by price and advertising expenditure to model market demand is commonly seen in the literature, such as [8, 9, 14, 18, 20] utilizing an additive way to model market demand, however, is rarely reported in the literature. This motivates us to further investigate the problem put forward by Wang et al [16]. Thus, several natural questions are: How do the channel members make their decisions under the case of additive demand form? Does there still exist a closed-form solution to the model with additive demand form since the model with additive demand form is more complex than the one with multiplicative demand form? What are the differences of the channel members' decisions under the two different demand forms? However, we are unable to have answers to these questions from Wang et al [16] and the existing literature. This paper is to cover this gap.

There are two main contributions in this paper. First, the retailer's optimal ordering, pricing and advertising decision model and the manufacturer's optimal production decision model are respectively developed, and the closed-form solution to each model is provided as well. Second, we explore the effect of different forms of demand function (i.e., multiplicative form and additive form) on the decisions of the supply chain members. Through a comparison of optimal policies between two demand cases, we find that the multiplicative form fits for depicting the demand of the branded products while the additive form is appropriate for the new or low brand recognition products.

The remainder of the paper is organized as the following. Sect. 50.2 introduces notations and assumptions. In Sect. 50.3, the retailer's optimal decision model is developed, and a comparison of optimal solutions between two demand cases is presented as well. The manufacture's optimal decision model is presented in Sect. 50.4. Numerical example is presented in Sect. 50.5. Conclusions are given in Sect. 50.6.

50.2 Notations and Assumptions

The following notations are used:

a : the advertising expenditure of the retailer (decision variable);
p : the retailer's unit sales price for the demand satisfied within the sales season (decision variable);
$D(a,p)$: the expected value of demand for the retailer;
ε : the positively random variable with mean equal to one, and CDF $F(\cdot)$ and PDF $f(\cdot)$;
c_s : the unit cost of the manufacturer when adopting slow production mode, which includes the cost of holding inventory before delivery and the cost of delivery itself;
c_f : the unit cost of the manufacturer when adopting fast production mode, which includes the cost of holding inventory before delivery and the cost of delivery itself, where $c_s < c_f$;
v : the salvage value per unit unsold product at the end of the season.
b : the retailer's unit backorder cost including the discount for delays;
Q : the retailer's (first) order quantity (decision variable);
M : the manufacturer's (first) production quantity (decision variable).

The following assumptions are used:
(1) The demand faced by the retailer is a random variable depending on the advertising expenditure and selling price. Similar to [16], the expected demand, $D(a,p)$, is assumed to satisfy: (i) $\partial D(a,p)/\partial a \geq 0$; (ii) $\partial^2 D(a,p)/\partial a^2 < 0$; (iii) $\partial D(a,p)/\partial p < 0$; $D(a,p) > 0, D(+\infty,0) = D_m$.

For convenience of analysis, the expected demand $D(a,p)$ is modeled in a multiplicative form in [16]. In this paper, however, we model the expected demand in an additive form, i.e.,

$$D(a,p) = D_m[\beta y(p) + (1-\beta)u(a)], \tag{50.1}$$

where D_m is the maximal potential demand faced by the retailer; $y(p)$ and $u(a)$ are normalization factors, i.e., $0 < y(p) < 1$, $0 < u(a) < 1$, which are used to evaluate the influence degree of the retail price and advertising expenditure on the expected demand, respectively; β and $(1-\beta)$ are the weight coefficients and $0 \leq \beta \leq 1$. Analogous to Wang et al [16], to provide the closed-form solutions to the models developed in this paper, we make the following assumptions:

First, $y(p)$ is a decreasing convex function and $py(p)$ a concave function with respect to p, i.e.,

$$y'(p) < 0, y''(p) \geq 0, 2y'(p) + py''(p) \leq 0. \tag{50.2}$$

Second, from from (i) and (ii), we assume that $u(a)$ satisfies:

$$\lim_{a \to +\infty} u(a) = 1, u'(a) \geq 0, u''(a) < 0. \tag{50.3}$$

Third, in order to reflect the uncertainty of the demand during the selling season, the practical demand, denoted by x, is defined as the product of $D(a,p)$ and ε, where ε is a positive random variable with mean equal to one, i.e., $x = D(a,p) \cdot \varepsilon$. Hence, the probability density function of practical demand, x, can be given by:

$$g(x,a,p) = \frac{1}{D(a,p)} f\left\{\frac{x}{D(a,p)}\right\}. \tag{50.4}$$

The Equation (50.4) describes the relative likelihood for the practical demand to occur at a given point in the observation space.
(2) The retailer has complete demand information before she places her second order and all excess demand (after the first order) is observed and completely backlogged.
(3) The manufacturer activates two different production modes in response to retailer's different requirements. The first production mode (a normal mode) is relatively cheap but requires a long lead time while the second (an urgent mode) is expensive but offers quick response.
(4) We assume the demand is never negative, and the distribution is continuous, invertible, and differentiable.

50.3 The Retailer's Optimal Decision Model

Consider a supply chain system composed of one manufacturer and one retailer. Before the start of the selling season, the retailer needs to determine the sales price, advertising expenditure, and the order quantity from the manufacturer. Due to the uncertainty of demand, the actual demand during the selling season may deviate from the ordered quantity. If the demand exceeds the ordered quantity by the end of the season, the retailer has an opportunity of placing an urgent order at a larger wholesale price from the manufacturer to meet all the excess demand. By adopting a similar analysis as that presented in [16], one easily derives the expected total profit of the retailer, $\Pi_b(Q,a,p)$, as:

$$\begin{aligned}\Pi_b(Q,a,p) &= (p-w_f-b)D_m[\beta y(p)+(1-\beta)u(a)]+(w_f+b-w_s)Q-(w_f+b-v)\\ &\quad \times D_m[\beta y(p)+(1-\beta)u(a)]\int_0^{\frac{Q}{D_m[\beta y(p)+(1-\beta)u(a)]}} F(x)\mathrm{d}x - a. \end{aligned}\tag{50.5}$$

Maximizing (Q,a,p) leads to the following Theorem 50.1.

Theorem 50.1. *The optimal selling price p^*, advertising expenditure a^* and ordering quantity Q^* can be given by:*

$$\beta[y(p^*)+(p^*-H)y'(p^*)]+(1-\beta)u(a^*) = 0, \tag{50.6}$$

$$D_m(1-\beta)(p^*-H)u'(a^*)-1 = 0, \tag{50.7}$$

$$Q^* = D(a^*,p^*)F^{-1}(\eta), \tag{50.8}$$

where $\eta = (w_f + b - w_s)/(w_f + b - v)$, $H = v + (w_f + b - v)(1 - \int_0^{F^{-1}(\eta)} xf(x)dx)$.

Proof. Since $\partial^2 \Pi_b(Q,a,p)/\partial Q^2 < 0$, then solving the first-order condition, i.e., $\partial \Pi_b(Q,a,p)/\partial Q = 0$ gives the optimal first-order quantity Q^* as:

$$F\left(Q^*/D(a,p)\right. = \eta \text{ or } Q^* = D(a,p)F^{-1}(\eta). \tag{50.9}$$

Substituting Equation (50.9) into Equation (50.5) gives the expected profit of the system as:

$$\Pi_b(a,p) = (p - H)D_m[\beta y(p) + (1-\beta)u(a)] - a. \tag{50.10}$$

By taking the second-order partial derivative of $\Pi_b(a,b)$ with respect to p, we have:

$$\partial^2 \Pi_b(a,p)/\partial p^2 = D_m\{\beta[2y'(p) + py''(p)] - \beta H y''(p)\}. \tag{50.11}$$

Since $\int_0^{+\infty} xf(x)\mathrm{d}x = 1$, one easily derives $H > 0$. This together with Equation (50.2) leads to $\partial^2 \Pi_b(a,p)/\partial p^2$, i.e., $\Pi_b(a,p)$ is a concave function with respect to p. Hence, the optimal selling price, p^*, can be obtained by solving the following first-order necessary condition:

$$\beta[y(p^*) + (p^* - H)y'(p^*)] + (1-\beta)u(a^*) = 0. \tag{50.12}$$

From Equations (50.2) and (50.12), we easily derive that $p^* > H$.

Substituting p^* into Equation (50.10), one has:

$$\Pi_b(a) = (p^* - H)D_m[\beta y(p^*) + (1-\beta)u(a)] - a. \tag{50.13}$$

Since $\Pi_b(a)$ is a concave function in a, then solving the first-order necessary condition gives the optimal advertising expenditure a^* as $D_m(1-\beta)(p^* - H)u'(a^*) - 1 = 0$. Hence, the proof of Theorem 50.1 is completed.

50.3.1 Comparison of Optimal Decisions between Two Demand Cases

In this subsection, we will make a comparison of the optimal policies between the two expected demand cases: multiplicative demand case and additive demand case.

From the Property 50.1 presented in [16] and Equation (50.8) given above, one can easily obtain the following property about the relationship among order quantity, selling price and advertising expenditure.

Property 50.1. No matter what form the expected demand has, multiplicative or additive, the more the centralized firm is willing to spend on advertising and/or the less she is in favor of charging the selling price, the more she will order.

Differentiating two sides of Equation (50.6) with respect to a, respectively, gives:

$$\frac{\partial p^*}{\partial a} = -\frac{u''(a)(p^* - H)}{[D_m(1-\beta)u'(a)]} > 0. \tag{50.14}$$

In [16], however, we have $\frac{\partial p^*}{\partial a} = 0$. This can be interpreted into the following property.

Property 50.2. With the increase of advertising expenditure, the optimal selling price remains unchanged in multiplicative expected demand case but increases in additive expected demand case.

It is interesting to observe from Property 50.2 that the influences of advertising investment on the pricing decision under the two demand cases are different. First, in the additive expected demand case, the greater the advertising investment, the larger the selling price set by the retailer. It seems consistent with our intuitive expectation, and also very common in practice. For example, in general, the market share of new or low brand recognition products is relatively small. Since advertising can bring more potential consumers to the stage of purchase desire and action, the retailer usually turns to advertise her products much more so as to broaden the market rapidly. However, to advertise needs massive capital investment. Thus, the retailer generally raises the retail price to balance an increase in advertising investment. This maybe can explain why the selling price increases with the advertising expenditure in additive expected demand case.

Second, in the multiplicative expected demand case, pricing decision of the retailer has nothing to do with the amount of capital invested in the advertisement, which seems to be out of our intuition. A possible explanation comes from branded products. As we know, branded products generally have received recognition from most of customers. For these products, the function of advertising is just to catch more customers' attention and to tell them what kind of brand name to have and where to purchase. So the effect of advertising on demand is very small. Thus, the selling price would become the key factor to stimulate consumer's buying behavior. Hence, the retailer's pricing decision may not depend on the advertising expenditure.

In terms of the above discussion, it is actually implied that the multiplicative expected demand form can be applied to the branded products while the additive expected demand form fits for the new or low brand recognition products.

50.4 The Manufacturer's Optimal Decision Model

In the two-echelon supply chain system, it is a typical Stackelberg game, with the retailer moving first by choosing Q, a and p and the manufacturer moving next by choosing the production quantity M. Since the retailer's optimal order quantity Q^* and optimal advertising expenditure a^* as well as the optimal selling price p^* have nothing to do with M, then, the manufacturer can decide on its optimal production quantity by taking Q^*, a^* and p^* as given. Consequently, the manufacturer's profits will be given by:

$$\Pi_m(x,M) = \begin{cases} w_s Q_d^* - c_s M + v(M - Q_d^*), & x \leq Q_d^* \\ w_s Q_d^* + w_f(x - Q_d^*) - c_s M + v(M - x), & Q_d^* < x \leq M \\ w_s Q_d^* + w_f(x - Q_d^*) - c_s M - c_f(x - M), & x > M. \end{cases}$$

Based on the above analysis, one can easily obtain the manufacturer's expected profit as:

$$\begin{aligned} \Pi_m(M) = \; & (w_f - c_f)D(a^*,p^*) + (w_s - w_f)Q^* + (v - w_f)D(a^*,p^*)\int_0^{\frac{Q}{D(a^*,p^*)}} F(x)\mathrm{d}x \\ & +(c_f - c_s)M - (c_f - v)D(a^*,p^*)\int_0^{\frac{M}{D(a^*,p^*)}} F(x)\mathrm{d}x. \end{aligned} \tag{50.15}$$

Maximizing subject to $M \geq Q^*$ will lead to the following theorem.

Theorem 50.2. *The unique optimal (first) production quantity, M^*, which maximizes the expected profit of the manufacturer, can be given by*

$$M^* = \begin{cases} Q^* & \frac{c_f - c_s}{c_f - v} \leq \xi \\ N \cdot D(a^*,p^*) & \textit{otherwise} \end{cases} \tag{50.16}$$

and $N = F^{-1}\frac{c_f - c_s}{c_f - v}$, $\xi = \frac{w_f + b - w_s}{w_f + b}$.

Proof. Taking the first- and second-order derivatives of $\Pi_m(M)$ in Equation (50.15) with respect to M gives respectively

$$\frac{\mathrm{d}\Pi_m(M)}{\mathrm{d}M} = (c_f - c_s) - (c_f - v)F\left(M\frac{M}{D(a^*,p^*)}\right), \tag{50.17}$$

$$\frac{\mathrm{d}^2\Pi_m(M)}{\mathrm{d}M^2} = -\frac{(c_f - v)f\left(\frac{M}{D(a^*,p^*)}\right)}{D(a^*,p^*)}. \tag{50.18}$$

From Equation (50.18), we know that $\mathrm{d}^2\Pi_m(M)/\mathrm{d}M^2 < 0$, i.e., $\Pi_m(M)$ is a concave function about M. Thus, the optimal production quantity of the manufacturer without considering the constraint will satisfy the first-order condition, i.e.,

$$F\left(\frac{M}{D(a^*,p^*)}\right) = \frac{(c_f - c_s)}{(c_f - v)}. \tag{50.19}$$

By taking into account the constraint $M \geq Q^*$, one can easily obtain that if $\frac{(c_f - c_s)}{(c_f - v)} \leq \xi$, $M^* = Q^*$; otherwise, $M^* = ND(a^*,p^*)$. Hence, the proof of Theorem 50.2 is completed.

Substituting Equation (50.16) into (50.15) will give the manufacturer's optimal expected profit $\Pi_m(M^*)$.

50.5 Numerical Study

In order to illustrate the model and gain more insights, we implement a numerical study.

The parameters of the model are listed below (most of them are kept the same as in [16]): $c_s = 2, c_f = 4, w_s = 6, c_f = 9, v = 0.5, b = 1, \theta = 0.05, \rho = 0.75, \beta = 0.75$, $D_m = 10000$, $\lambda = 0.001$. The influence factors of the selling price and advertising expenditure are assumed to be given by: $y(p) = 1 - \theta p$, $u(a) = 1 - \rho e^{-\lambda a}$, where θ and λ are positive constants, which denote the impact degree of selling price and advertising investment on the expected demand, respectively; $(1 - \rho)$ denotes influence factor without considering the advertising effect. Random variable is assumed to follow the uniform distribution in $[A, 2 - A]$, where $A = 0.6$ $(0 < A < 1)$.

Based on the solution procedure presented in this paper, one can obtain the following: the optimal policies of the retailer and the manufacturer are $p^* = 16.7$, $a^* = 2904.2$, $Q^* = 3419.4$, $M^* = 3858.5$ respectively, and the corresponding expected profits of the retailer and the manufacturer as well as the system are $\Pi_b = 32621.5$, $\Pi_m = 16240.3$, $\Pi_s = 48861.8$ respectively.

50.6 Conclusion

This paper extends the work of [16] by considering the additive demand form. The optimal ordering, pricing and advertising models for newsvendor-type products with additive demand form under centralized and decentralized decision systems are respectively developed, and the closed-form solutions to the models are presented as well. Through a comparison of optimal policies between the multiplicative demand case and additive demand case, we show that the multiplicative form depicts the demand of the branded products while the additive form depicts the demand of the new or low brand recognition products. Other possible extensions of the model include: considering multiple manufacturers, multiple retailers with price or quantity competition, random demand with unknown probability distribution, etc.

Acknowledgements This research was supported by the National Natural Science Foundation of P. R. China (Grant No. 71072165).

References

1. Arcelus F, Kumar S, Srinivasan G (2008) Evaluating manufacturer's buyback policies in a single-period two-echelon framework under price-dependent stochastic demand. Omega 114:808–824
2. Cachon G (2003) Supply chain coordination with contracts. In: Kok A, Graves S (eds) Handbooks in Operations Research & Management Science. Elsevier B.V. Press

3. Chen H, Chen J, Chen Y (2006) A coordination mechanism for a supply chain with demand information updating. International Journal of Production Economics 103:347–361
4. Choi T, Li D, Yan H (2006) Optimal two-stage ordering policy with bayesian information updating. Journal of the Operational Research Society 103:846–856
5. Donohue K (2000) Efficient supply contracts for fashion goods with forecast updating and two production modes. Management Science 1397–1411
6. Gerchak Y, Parlar M (1987) A single period inventory problem with partially controllable demand. Computers and Operations Research 14:1–9
7. Gurnani H, Tang C (1999) Note: Optimal ordering decisions with uncertain cost and demand forecast updating. Management Science 45:1456–1462
8. Jorgensen S, Zaccour G (1999) Equilibrium pricing and advertising strategies in a marketing channel. Journal of Optimization Theory and Applications 102:111–125
9. Jorgensen S, Zaccour G (2003) Channel coordination over time: Incentive equilibria and credibility. Journal of Economic Dynamics and Control 27:801–822
10. Khouja M (2000) Optimal ordering, discounting, and pricing in the single-period problem. International Journal of Production Economics 65:201–216
11. Li S, Zhu Z, Huang L (2009) Supply chain coordination and decision making under consignment contract with revenue sharing. International Journal of Production Economics 120:88–99
12. Petruzzi N, Dada M (1999) Pricing and the newsvendor problem: A review with extensions. Operations Research 47:183–194
13. Polatoglu L (1999) Optimal order quantity and pricing decisions in single-period inventory systems. International Journal of Production Economics 23:175–185
14. Szmerekovsky J, Zhang J (2009) Pricing and two-tier advertising with one manufacturer and one retailer. European Journal of Operational Research 192:904–917
15. Wang S, Zhou Y (2009) Single-manufacturer multi-buyer coordination model with twice ordering. Journal of Systems Engineering 24:423–429
16. Wang S, Zhou Y, Wang J (2010) Supply chain coordination with two production modes and random demand depending on advertising expenditure and selling price. International Journal of Systems Science 41:1257–1272
17. Webster S, Weng Z (2008) Ordering and pricing policies in a manufacturing and distribution supply chain for fashion products. International Journal of Production Economics 114:476–486
18. Xie J, Wei J (2009) Coordinating advertising and pricing in a manufacturer-retailer channel. European Journal of Operational Research 197:785–791
19. You P (2003) Dynamic pricing of inventory with cancellation demand. Journal of the Operational Research Society 54:1093–1101
20. Yue J, Austin, J, Wang MC et al (2006) Coordination of cooperative advertising in a two-level supply chain when manufacturer offers discount. European Journal of Operational Research 168:65–85
21. Zhou Y, Wang S (2009) Manufacturer-buyer coordination for newsvendor-type-products with two ordering opportunities and partial backorders. European Journal of Operational Research 198:958–974

Chapter 51
The Supply Chain Network Equilibrium Model with Direct Marketing under Random Demand

Zezhong Wu, Yuntao Hu and Bin Huang

Abstract A single-commodity equilibrium model of a competitive supply chain network with direct marketing in the case of random demands associated with the demand markets is developed. The network structure of the supply chain is identified and equilibrium conditions are derived. A finite-dimensional variational inequality formulation is established. A revised Quasi-Newton Method is built to solve the equilibrium model with direct marketing under random demands, and a numerical example is given.

Keywords Equilibrium model · Variational inequalities · Quasi-Newton method · Direct marketing · Random demand

51.1 Introduction

The topic of supply chain analysis is interdisciplinary by nature since it involves manufacturing, transportation and logistics, as well as retailing/marketing. It has been the subject of a growing body of literature [1] with the associated research being both conceptual in nature [2, 3], due to the complexity of the problem and the numerous agents such as manufacturers, retailers, and consumers involved in the transactions, as well as analytical [4–7].

Lee and Billington expressed the need for decentralized models that allow for a generalized network structure and simplicity in the study of supply chains [8].

Z. Wu (✉) · B. Huang
College of Mathematics, Chengdu University of Information Technology, Chengdu 610225, P. R. China
e-mail: zezhongwu@cuit.edu.cn

Y. Hu
College of Management, Chengdu University of Information Technology, Chengdu 610225, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_51, © Springer-Verlag London 2013

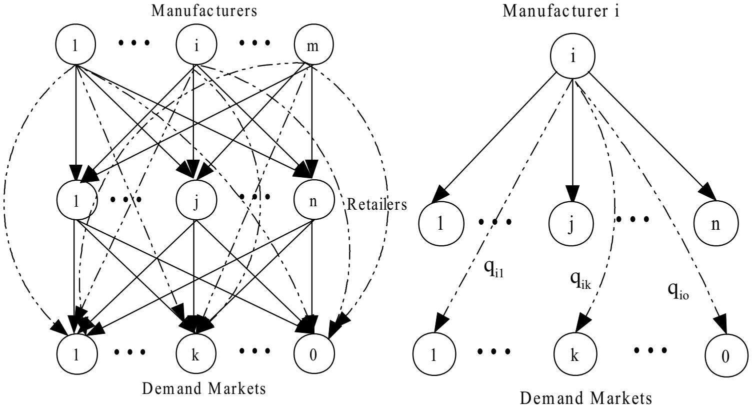
Anupindi and Bassok, in turn, addressed the challenges of formulating systems consisting of decentralized retailers with information sharing [9]. Lederer and Li, on the other hand, studied competition among firms that produce goods or services for customers who are sensitive to delay time [10]. Corbett and Karmarkar were concerned with the equilibrium number of firms in oligopolistic competition in a supply chain [11]. In order to allow for the closed form determination of the equilibrium number of firms they assumed that the firms in the same tier were characterized by identical linear production cost functions. Equilibrium models have a long tradition in transportation modeling as well as in economics [12, 13].

Many researchers, in addition to, practitioners, have described the various networks that underlie supply chain analysis and management [14–19]. The equilibrium model is drawn from economics and, in particular, from network economics [13]. Manufacturers are assumed to be involved in the production of a homogeneous product which is then shipped to the retailers. Manufacturers obtain a price for the product (which is endogenous) and seek to determine their optimal production and shipment quantities, given the production costs as well as the transaction costs associated with conducting business with the different retailers. Retailers, in turn, must agree with the manufacturers as to the volume of shipments since they are faced with the handling cost associated with having the product in their retail outlet. In addition, they seek to maximize their profits with the price that the consumers are willing to pay for the product being endogenous. Consumers determine their optimal consumption levels from the various retailers subject both to the prices charged for the product as well as the cost of conducting the transaction (which, of course, may include the cost of transportation associated with obtaining the product from the retailer). In this paper, we mainly consider a single-commodity equilibrium model of a competitive supply chain network with direct marketing under random demands associated with the demand markets. The network structure of the supply chain is identified and equilibrium conditions are derived by means of variational inequality. we solve the equilibrium model by a revised Quasi-Newton Method, and give a numerical example.

The paper is organized as follows. In Sect. 51.2, we present the competitive supply chain network model with direct marketing, derive optimality conditions for its decision-makers, and then present the governing equilibrium conditions. We also derive the finite-dimensional variational inequality formulation of the problem. In Sect. 51.3, we give the transformation form of equilibrium model in order to solve model. In Sect. 51.4, we provide the revised Quasi-Newton Method to solve model. In Sect. 51.5, we apply the algorithm to a numerical example to determine the equilibrium product flows and prices and also provide a discussion of the model and results. We conclude the paper with Sect. 51.6.

51.2 The Supply Chain Network Equilibrium Model

In this section, we develop the supply chain network model with manufacturers, retailers, consumers. The supply chain network structure with direct marketing at equilibrium, which we establish in this section is as depicted in Fig. 51.1 (A).



A: The overall structure B: The network structure of manufacturer i's

Fig. 51.1 The network structure of the supply chain at equilibrium

Specifically, we consider m manufacturers who are involved in the production of a product, which can be purchased by n retailers, also can be purchased by consumers of o demand markets. They make the product available to consumers located at o demand markets by k. We denote a typical manufacturer by i, a typical retailer by j, a typical demand market by k.

We first focus on the manufacturers. We then turn to the retailers and, subsequently, to the consumers. The complete equilibrium model is then constructed along with the variational inequality formulation of the governing equilibrium conditions.

51.2.1 The Behavior of the Manufacturers and Their Optimality Conditions

Let q_{ij} denotes that the manufacturer i ships the product to the retailer j. We group all q_{ij} into the column vector $Q^{11} = (q_{11}, q_{12}, \cdots, q_{1n}, \cdots, q_{m1}, \cdots, q_{mn})^T \in R^{mn}_{+}$.

Let q_{ik} denotes that the manufacturer i ships the product to the demand market k. We group all q_{ik} into the column vector $Q^{12} = (q_{11}, q_{12}, \cdots, q_{1o}, \cdots, q_{m1}, \cdots, q_{mo})^T \in R_+^{mo}$.

We assume that each manufacturer i is faced with a production cost function f_i, in general, on the entire vector of production outputs, that is, $f_i = f_i(Q^{11}, Q^{12}), i = 1,2,\cdots,m$.

We associate with each manufacturer and retailer pair (i, j) a transaction cost of the product denoted by c_{ij}. We consider the situation in which the transaction cost of the product between a manufacturer and retailer pair is given by $c_{ij} = c_{ij}(q_{ij})$ $i = 1,2,\cdots,m; j = 1,2,\cdots,n$. At the same time, we associate with each manufacturer and demand market pair (i,k) a direct transaction cost of the product denoted by c_{ik}. We consider the situation in which the direct transaction cost of the product between a manufacturer and demand market pair is given by $c_{ik} = c_{ik}(q_{ik})$ $i = 1,2,\cdots,m; k = 1,2,\cdots,o$.

To help fix ideas (cf. Fig. 51.1 (B)), and in order to facilitate the ultimate construction of the supply chain networks in equilibrium, we depict the manufacturer and retailers as nodes and the transactions between a manufacturer i and the retailers $j, j = 1,2,\ldots,n$, as links. We also depict the manufacturer and demand markets as nodes and the transactions between a manufacturer i and the demand markets $k, k = 1,2,\ldots,o$, as links.

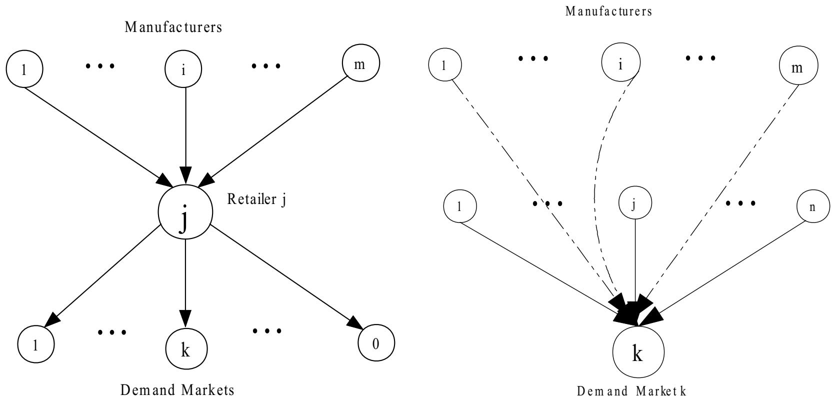
The total costs incurred by a manufacturer i for the product, thus, are equal to the sum of his production cost for the product plus the total transaction costs. His revenue, in turn, is equal to the price that the manufacturer charges for the product (and the retailers are willing to pay) times the total quantity obtained/purchased of the product from the manufacturer by all the retail outlets and all the demand markets. If we let ρ_{1ij} denote the price charged for the product by manufacturer i to retailer j (i.e., the supply price), and ρ_{1ik} denote the direct marketing price charged for the product by manufacturer i to demand market k, we have

$$\begin{cases} \max \sum\limits_{j=1}^{n} \rho_{1ij} q_{ij} + \sum\limits_{k=1}^{o} \rho_{1ik} q_{ik} - f_i(Q^{11}, Q^{12}) - \sum\limits_{j=1}^{n} c_{ij}(q_{ij}) - \sum\limits_{k=1}^{o} c_{ik}(q_{ik}) \\ \text{s.t.} \begin{cases} q_{ij} \geq 0, \quad q_{ik} \geq 0 \\ i = 1,2,\cdots,m; \ j = 1,2,\cdots,n. \end{cases} \end{cases} \tag{51.1}$$

Assuming that the production cost functions and the transaction cost functions for each manufacturer are continuous differentiable and convex. The optimal conditions of Equation (51.4) are equivalent to the form of the variational inequality as follows, $\forall (Q^{11}, Q^{12}) \in R_+^{mn+mo}$,

$$\sum_{j=1}^{n} \left(\frac{\partial f_i(Q^{11*}, Q^{12*})}{\partial q_{ij}} + \frac{\partial c_{ij}^*}{\partial q_{ij}} - \rho_{1ij}^* \right) \times (q_{ij} - q_{ij}^*) \geq 0, \tag{51.2}$$

$$\sum_{k=1}^{o} \left(\frac{\partial f_i(Q^{11*}, Q^{12*})}{\partial q_{ik}} + \frac{\partial c_{ik}^*}{\partial q_{ik}} - \rho_{1ik}^* \right) \times (q_{ik} - q_{ik}^*) \geq 0. \tag{51.3}$$



C: The network structure of retailer j's transactions

D: The network structure of consumers' transactions at demand market k

Fig. 51.2 The network structure of the supply chain at equilibrium

The optimality conditions are expressed by Equations (51.2) and (51.3) have a nice economic interpretation. Equation (51.2) represents that a manufacturer will ship a positive amount of the product to a retailer (and the flow on the corresponding link will be positive) if the price that the retailer is willing to pay for the product is equal to the manufacturer's sum of marginal production and transaction costs; if sum exceed what the retailer is willing to pay for the product, then the flow on the link will be zero. Similarly, Equation (51.3) represents that a manufacturer will ship a positive amount of the product to a demand market (and the flow on the corresponding link will be positive) if the price that the demand market is willing to pay for the product is equal to the manufacturer's sum of marginal production and transaction costs; if sum exceed what the demand market is willing to pay for the product, then the flow on the link will be zero.

We assume that the manufacturers compete in noncooperative fashion. Given that the governing optimization/equilibrium concept underlying noncooperative behavior is that of Cournot, Nash, which states that each manufacturer will determine his optimal production quantity and shipments, given the optimal ones of the competitors, the optimality conditions for all manufacturers simultaneously can be expressed as the following variational inequality.

Determine $(Q^{11}, Q^{12}) \in R_+^{mn+mo}$ satisfying:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\left[\frac{\partial f_i(Q^{11*}, Q^{12*})}{\partial q_{ij}} + \frac{\partial c_{ij}^*}{\partial q_{ij}} - \rho_{1ij}^*\right] \times (q_{ij}^l - q_{ij}^{l*})$$
$$+\sum_{i=1}^{m}\sum_{k=1}^{o}\left[\frac{\partial f_i(Q^{11*}, Q^{12*})}{\partial q_{ik}} + \frac{\partial c_{ik}^*}{\partial q_{ik}} - \rho_{1ik}^*\right] \times (q_{ik} - q_{ik}^*) \geq 0. \qquad (51.4)$$

51.2.2 The Behavior of the Retailers and Their Optimality Conditions

The retailers, in turn, are involved in transactions both manufacturers since they wish to obtain the product for their retail outlets, as well as with the consumers, who are the ultimate purchasers of the product. Hence, the network structure of retailer $j's$ transactions is as depicted in Fig. 51.2 (C). Thus, a retailer conducts transactions both with the manufacturers as well as with the consumers at the demand markets. Note the Fig. 51.2 (C) as did Fig. 51.1 (B), only depicts the network structure of the transactions involved. Later, we will also associate flows with the links as well as prices with the nodes.

A retailer j is faced with what we term a fuzzy handling cost, which may include, for example, the display and storage cost with the product. We denote this cost for the product by c_j and, in the simplest case, we would have that c_j is a function of $\sum_i^m q_{ij}$, that is, the handing cost of a retailer is a function of how much of the product he has obtained from the various manufacturers. However, for the sale of generality, and to enhance the modeling of competition, we allow the function to, in general, depend also on the amounts of the product hold by other retailers and, therefor, we may write $\tilde{c}_j = \tilde{c}_j(Q^{11}), \forall j$.

The retailers associate a price with the product at their retail outlet, which is denoted by ρ_{jk}, for retailer j. This price, as we will show, will also be endogenously determined in the model. Assuming, as mentioned in Sect. 51.1, that the retailers are also profit-maximizers, the optimization problem of a retailer j is given by

$$\begin{cases} \max \sum\limits_{k=1}^{o} \rho_{jk} q_{jk} - c_j(Q^{11}) - \sum\limits_{i=1}^{m} \sum\limits_{k=1}^{s} \rho_{1ij} q_{ij} \\ \text{s.t.} \begin{cases} \sum\limits_{k=1}^{o} q_{jk} \le \sum\limits_{i=1}^{m} q_{ij} \\ q_{ij} \ge 0,\ q_{jk} \ge 0, \forall i, j. \end{cases} \end{cases} \tag{51.5}$$

Objective function (51.5) expresses that the difference between the revenues minus the handling cost and the pay out to the manufacturers should be maximized. Constraint condition of Equation (51.5) simply expresses that consumers cannot purchase more from a retailer than is held in stock.

We denote the Lagrangian multiplier as: γ_j, $(j = 1, 2, \ldots, m)$, then the Lagrangian function is

$$L_j(\gamma_j) = \sum_{k=1}^{o} \rho_{jk} q_{jk} - c_j(Q^{11}) - \sum_{i=1}^{m} \rho_{1ij}(q_{ij}) + \gamma_j \left(\sum_{i=1}^{m} q_{ij} - \sum_{k=1}^{o} q_{jk} \right). \tag{51.6}$$

Assuming that the handling cost for each retailer is continuous differentiable and convex. Then the optimal conditions of Equation (51.6) are equivalent to the form of the variational inequality as follows,

$$\begin{cases} \left(\frac{\partial c_j(Q^{11*})}{\partial q_{ij}} + \rho^*_{1ij} - \gamma^*_j\right) \times (q_{ij} - q^*_{ij}) \geq 0 \\ (\gamma^*_j - \rho^*_{jk}) \times (q_{jk} - q^*_{jk}) \geq 0 \\ \left(\sum\limits_{i=1}^{m} q^*_{ij} - \sum\limits_{k=1}^{s} q^*_{jk}\right) \times (\gamma_j - \gamma^*_j) \geq 0. \end{cases} \tag{51.7}$$

The optimality conditions for all the retailers coincide with the solution of the variational inequality: Determin $(Q^{11*}, Q^{2*}, \gamma^*) \in R_+^{mn+no+n}$ satisfying

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\left[\frac{\partial c_j(Q^{11*})}{\partial q_{ij}} + \rho^*_{1ij} - \gamma^*_j\right] \times [q_{ij} - q^*_{ij}] + \sum_{j=1}^{n}\sum_{k=1}^{o}[-\rho^*_{jk} + \gamma^*_j]$$
$$\times [q_{jk} - q^*_{jk}] + \sum_{j=1}^{n}\left[\sum_{i=1}^{m} q^*_{ij} - \sum_{k=1}^{o} q^*_{jk}\right] \times [\gamma_j - \gamma^*_j] \geq 0. \tag{51.8}$$

We now highlight the economic interpretation of the retailers' optimality conditions. From the second term in inequality (51.8), we have that, if consumers at demand market k purchase the product from a particular retailer j, that is, if the q^*_{jk} is positive, then the price charged by retailer j, ρ^*_{jk}, is equal to γ^*_j, which, from the third term in the inequality, serves as the price to clear the market from retailer j. Also, note that, from the second term, we see that if no product is sold by a particular retailer, then the price associated with holding the product can the price charged to the consumers. Furthermore, from the first term in inequality (51.8), we can infer that, if a manufacturer transacts with a retailer resulting in a positive flow of the product between the two, then the price γ^*_j is equal to the retailer $j's$ payment to the manufacturer, ρ^*_{1ij}, plus its marginal cost of handling the product from the retailer.

51.2.3 The Equilibrium Conditions of Demand Markets with Random Demand

We now describe the consumers located at the demand markets. The consumers take into account in making their consumption decisions not only the price charged for the product by the retailers and manufacturer but also the transaction cost to obtain the product. We let c_{jk} denote the transaction cost associated with obtaining the product by consumers at demand market k form retailer j, c_{ik} denote the transaction cost associated with obtaining the product by consumers at demand market k form manufacturer i. We assume that the transaction cost is continuous, positive, and of the general form: $c_{jk} = c_{jk}(Q^2), \forall j,k$, where recall that Q^{2l} is the $nos-$dimensional column vector of product flows between the retailers and the demand markets, $c_{ik} = c^1_{ik}(Q^{12}), \forall i,k$.

In Fig. 51.2 (D), the network of transactions between the retailers and the consumers at demand market k is depicted, direct transactions between the manufacturers and the consumers at demand market k. Each demand market is represented by a node and the transactions, as previously, by links.

Let ρ_{3k} denote the price of the product at demand market k. Since the product demands of consumers vary with the price of the product ρ_{3k} changed, and thus the demand market is facing an uncertain market condition. We assume that the product demand $\hat{d}_k(\rho_{3k})$ is a random variable with a density function $g_k(x,\rho_{3k})$, with ρ_{3k} serving as a parameter. Hence, we assume that the density function may vary with the demand price. Let P_k be the probability distribution function of $\hat{d}_k(\rho_{3k})$, that is, $P_k(x,\rho_{3k}) = P(\hat{d}_k \leq x) = \int_0^x g_k(x,\rho_{3k})dx$.

Let $s_k = \sum_{i=1}^m q_{ik} + \sum_{j=1}^n q_{jk}$, in turn, denote the total supply at demand market k that he obtains from the all manufacturers and the all retailers. Then, the demand k can sell to the consumers no more than the minimum of his supply or his demand, that is, the actual sale of j cannot exceed $\min\{s_k,\hat{d}_k\}$. Let $\Delta_k^+ = \max\{0, s_k - \hat{d}_k\}, \Delta_k^- = \max\{0, \hat{d}_k - s_k\}$, where Δ_k^+ is a random variable representing the excess supply, whereas Δ_k^- is a random variable representing the excess demand.

Note that the expected values of excess supply and excess demand of the demand market k are scalar functions of of s_k and ρ_{3k}. In particular, let e_k^+ and e_k^- denote, respectively, the expected values: $E(\Delta_k^+)$ and $E(\Delta_k^-)$, that is:

$$\begin{aligned} e_k^+(s_k,\rho_k) &= E(\Delta_k^+) = \int_0^{s_k} (s_k - x) g_k(x,\rho_{3k})dx, \\ e_k^-(s_k,\rho_k) &= E(\Delta_k^-) = \int_{s_k}^{\infty} (x - s_k) g_k(x,\rho_{3k})dx. \end{aligned} \tag{51.9}$$

Assume that the unit penalty of having excess supply at the demand market k is λ_k^+ and that the unit penalty of having excess the demand is λ_k^-, where λ_k^+ and λ_k^- are assumed to be nonnegative. Then the expected total penalty of the demand market k is given by: $E(\lambda_k^+\Delta_k^+ + \lambda_k^-\Delta_k^-) = \lambda_k^+ e_k^+(s_k,\rho_k) + \lambda_k^- e_k^-(s_k,\rho_k)$.

Assuming, as already mentioned, that the demand markets are also profit-maximizes, the expected revenue of the demand market k is $E(\rho_{3k}\min\{s_k,\hat{d}_k\})$. Hence, the optimization problem of the demand market k can be expressed as:

$$\begin{cases} \max \begin{cases} E(\rho_{3k}\min\{s_k,\hat{d}_k\}) - E(\lambda_k^+\Delta_k^+ + \lambda_k^-\Delta_k^-) - \sum\limits_{i=1}^{m} c_{ik}^1(Q^{12}) \\ - \sum\limits_{j=1}^{k} c_{jk}(Q^2) - \sum\limits_{i=1}^{m} \rho_{1ik} q_{ik} - \sum\limits_{j=1}^{n} \rho_{jk} q_{jk} \end{cases} \\ \text{s.t. } q_{ik} \geq 0,\ q_{jk} \geq 0,\ \forall i,j. \end{cases} \tag{51.10}$$

Objective function (51.10) expresses that the expected profit of the demand market k, which is the difference between the expected revenues and the sum of the expected penalty, the handling cost, and the payout to the manufacturers and the retailers, should be maximized.

Applying the definition of Δ_k^+ and Δ_k^-, we know that $\min\{s_k,\hat{d}_k\} = s_k - \Delta_k^+$. Therefore, the objective function (51.10) can be expressed as

$$
\begin{aligned}
&E(\rho_{3k}(s_k-\Delta_k^{+}))-E(\lambda_k^{+}\Delta_k^{+}+\lambda_k^{-}\Delta_k^{-})-\sum_{i=1}^{m}c_{ik}^{1}(Q^{12})-\sum_{j=1}^{k}c_{jk}(Q^{2})-\sum_{i=1}^{m}\rho_{1ik}q_{ik}\\
&-\sum_{j=1}^{n}\rho_{jk}q_{jk}=\rho_{3k}s_k-(\rho_{3k}+\lambda_k^{+})e_k^{+}(s_k,\rho_{3k})-\lambda_k^{-}e_k^{-}(s_k,\rho_{3k})-\sum_{i=1}^{m}c_{ik}^{1}(Q^{12})\\
&-\sum_{j=1}^{k}c_{jk}(Q^{2})-\sum_{i=1}^{m}\rho_{1ik}q_{ik}-\sum_{j=1}^{n}\rho_{jk}q_{jk}.
\end{aligned}
\tag{51.11}
$$

Thus, the model can be expressed again:

$$
\begin{cases}
\max\begin{cases}\sum_{i=1}^{m}(\rho_{3k}-\rho_{1ik})q_{ik}+\sum_{j=1}^{n}(\rho_{3k}-\rho_{jk})q_{jk}-(\rho_{3k}+\lambda_k^{+})e_k^{+}(s_k,\rho_{3k})\\ -\lambda_k^{-}e_k^{-}(s_k,\rho_{3k})-\sum_{i=1}^{m}c_{ik}^{1}(Q^{12})-\sum_{j=1}^{k}c_{jk}(Q^{2})\end{cases}\\
\text{s.t. } q_{ik}\ge 0,\ q_{jk}\ge 0, \forall i,j.
\end{cases}
\tag{51.12}
$$

We make the following derivation:

$$
\begin{aligned}
\frac{\partial e_k^{+}(s_k,\rho_{3k})}{\partial q_{ik}}&=\frac{\partial\int_{0}^{s_{1k}}(s_{1k}-x)g_k(x,\rho_{3k})dx}{\partial q_{ik}}=P_k(s_{1k},\rho_{3k}),\\
\frac{\partial e_k^{-}(s_k,\rho_{3k})}{\partial q_{ik}}&=\frac{\partial\int_{s_{1k}}^{\infty}(x-s_{1k})g_k(x,\rho_{3k})dx}{\partial q_{ik}}=P_k(s_{1k},\rho_{3k})-1.
\end{aligned}
$$

Similarly, we can obtain:

$$
\frac{\partial e_k^{+}(s_k,\rho_{3k})}{\partial q_{jk}}=P_k(s_{2k},\rho_{3k}),\ \frac{\partial e_k^{-}(s_k,\rho_{3k})}{\partial q_{jk}}=P_k(s_{2k},\rho_{3k})-1,
$$

where $s_{1k}=\sum_{i=1}^{m}q_{ik}$, $s_{2k}=\sum_{j=1}^{n}q_{jk}$.

Assuming that the handing cost for each demand market is continuous and convex, then the optimality conditions for all the demand markets satisfy the variational inequality: determine $(Q^{12*},Q^{2*})\in R_{+}^{mo+no}$, satisfying:

$$
\begin{aligned}
&\sum_{i=1}^{m}\sum_{k=1}^{o}\Bigg[\lambda_k^{+}P_k(s_{1k},\rho_{3k})-\lambda_k^{-}(1-P_k(s_{1k},\rho_{3k}))+\frac{\partial c_{ik}^{1}(Q^{12*})}{\partial q_{ik}}+\rho_{1ik}-\rho_{3k}\\
&(1-P_k(s_{1k},\rho_{3k}))\Bigg][q_{ik}-q_{ik}^{*}]+\sum_{j=1}^{n}\sum_{k=1}^{o}\Bigg[\lambda_k^{+}P_k(s_{2k},\rho_{3k})-\lambda_k^{-}(1-P_k(s_{2k},\rho_{3k}))\\
&+\frac{\partial c_{jk}(Q^{2*})}{\partial q_{jk}}+\rho_{jk}-\rho_{3k}(1-P_k(s_{2k},\rho_{3k}))\Bigg][q_{jk}-q_{jk}^{*}]\ge 0.
\end{aligned}
\tag{51.13}
$$

We now highlight the economic interpretation of the demand markets' optimality conditions. In inequality (51.13), we can infer that, if a manufacturer i transacts with a demand market k resulting in a positive flow of the product between the two, then the selling price at the demand market k, ρ_{3k} with the probability of $1 - P_k(s_{1k}, \rho_{3k})$, that is, when the demand is not less then the total order quantity, is precisely equal to the demand market k payment to the manufacturer, ρ_{1ij}, plus his marginal cost of handling the product and the penalty of having excess demand with probability of $P_k(s_{1k}, \rho_{3k})$ (which is the probability when actual demand is less than the order quantity), subtracted by the penalty of having shortage with probability of $1 - P_k(s_{1k}, \rho_{3k})$ (when the actual demand is greater than the order quantity). The same reason can explain the second term of Equation (51.13).

51.2.4 The Equilibrium Conditions

We now turn to a discussion of the market equilibrium conditions. Subsequently, we construct the equilibrium conditions for the entire supply chain.

The equilibrium conditions associated with the transactions that take place between the demand market and the consumers are the stochastic economic equilibrium conditions, which, mathematically, take on the following form: For any demand market k, $k = 1, 2, \cdots, o$.

$$\hat{d}_k(\rho_{3k}^*) \begin{cases} = \sum_{i=1}^{m} q_{ik}^* + \sum_{j=1}^{n} q_{jk}^*, & \text{if} \quad \rho_{3k}^* > 0 \\ \leq \sum_{i=1}^{m} q_{ik}^* + \sum_{j=1}^{n} q_{jk}^*, & \text{if} \quad \rho_{3k}^* = 0. \end{cases} \tag{51.14}$$

Conditions (51.14) state that, if the equilibrium demand price at demand market k is positive, that is, $\rho_{3k} > 0$, then the quantities purchased by the demand market from the manufacturers and the retailers in the aggregate, that is, $\sum_{i=1}^{m} q_{ik} + \sum_{j=1}^{n} q_{jk}$, is equal to the demand, with exceptions of zero probability.

In equilibrium, condition (51.14) will have to hold for all demand markets k, and these, in turn, can also be expressed as a variational inequality problem, and given by: Determine $\rho^* \in R_+^o$ such that:

$$\sum_{k=1}^{o} \left[\sum_{j=1}^{n} q_{jk} + \sum_{i=1}^{m} q_{ik} - \hat{d}_k(\rho_{3k}^*) \right] \times [\rho_{3k} - \rho_{3k}^*] \geq 0, \forall \rho \in R_+^o. \tag{51.15}$$

51.2.5 The Equilibrium Conditions of the Whole Supply Chain

In equilibrium, we must have that the sum of the optimality conditions for all manufacturers, as expressed by inequality (51.4), the optimality conditions for all retailers, as expressed by inequality (51.8), the optimality conditions for all demand markets, as expressed by inequality (51.13) and the market equilibrium conditions, as expressed by inequality (51.15) must be satisfied. We state this explicitly in the following definition:

Definition 51.1. (The supply chain network equilibrium). The equilibrium state of the supply chain with direct marketing under random demand is one where the product flows between the distinct tiers of the decision-makers coincide and the product flows and prices satisfy the sum of the variational inequalities (51.4), (51.8), (51.13) and (51.15).

We now establish the equivalent form of supply chain network equilibrium as follows.

Theorem 51.1. *(The variational inequality formulation). The equilibrium conditions governing the supply chain model with competition are equivalent to the solution of the variational inequality problem given by: determine* $(Q^{11*}, Q^{12*}, Q^{2*}, \gamma^*, \rho^*) \in \Re$ *satisfying:*

$$\begin{aligned}
&\sum_{i=1}^{m}\sum_{j=1}^{n}\Bigg[\frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ij}}+\frac{\partial c_{ij*}}{\partial q_{ij}}+\frac{\partial c_j(Q^{11*})}{\partial q_{ij}}-\gamma_j^*\Bigg]\times(q_{ij}-q_{ij}^*)\\
&+\sum_{i=1}^{m}\sum_{k=1}^{o}\Bigg[\frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ik}}+\frac{\partial c_{ik*}}{\partial q_{ik}}+\lambda_k^+P_k(s_{1k},\rho_{3k})-\lambda_k^-(1-P_k(s_{1k},\rho_{3k}))\\
&+\frac{\partial c_{ik}^1(Q^{12*})}{\partial q_{ik}}-\rho_{3k}(1-P_k(s_{1k},\rho_{3k}))\Bigg]\times[q_{ik}-q_{ik*}]+\sum_{j=1}^{n}\sum_{k=1}^{o}\Bigg[\gamma_j^*+\lambda_k^+P_k(s_{2k},\rho_{3k})\\
&-\lambda_k^-(1-P_k(s_{2k},\rho_{3k}))+\frac{\partial c_{jk}(Q^{2*})}{\partial q_{jk}}-\rho_{3k}(1-P_k(s_{2k},\rho_{3k}))\Bigg]\times[q_{jk}-q_{jk*}]\\
&+\sum_{j=1}^{n}\Bigg[\sum_{i=1}^{m}q_{ij*}-\sum_{k=1}^{o}q_{jk*}\Bigg]\times[\gamma_j-\gamma_j^*]+\sum_{k=1}^{o}\Bigg[\sum_{j=1}^{n}q_{jk}+\sum_{i=1}^{m}q_{ik}-\hat{d}_k(\rho_{3k*})\Bigg]\\
&\times[\rho_{3k}-\rho_{3k}^*]\geq 0,
\end{aligned}\tag{51.16}$$

where $\Re \equiv \{(Q^{11*}, Q^{12*}, Q^{2*}, \gamma^*, \rho^*) \in R_+^{mo+no+mn+n+o}\}$.

Proof. We first establish that the equilibrium conditions imply variational inequality (51.16). Indeed, from the summation of Equations (51.4), (51.8), (51.13) and (51.15), we have Equation (51.16).

We now establish the converse, that is, that a solution to variational inequality (51.16) satisfies the sum of inequalities (51.4), (51.8), (51.13) and (51.15), and is, hence, an equilibrium according to Definition 51.1. To inequality (51.16) add the terms $-\rho_{1ik}^* + \rho_{1ik}^*$, $-\rho_{1ij}^* + \rho_{1ij}^*$ and $-\rho_{jk}^* + \rho_{jk}^*$. Such "terms" do not change the value of the inequality since they are identically equal to zero, with the resulting inequality of the form:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\Bigg[\frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ij}}+\frac{\partial c_{ij*}}{\partial q_{ij}}+\frac{\partial c_j(Q^{11*})}{\partial q_{ij}}-\gamma_j^*-\rho_{1ij}^*+\rho_{1ij*}\Bigg]\times(q_{ij}-q_{ij*})$$

$$
\begin{aligned}
&+\sum_{i=1}^{m}\sum_{k=1}^{o}\left[\frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ik}}+\frac{\partial c_{ik*}}{\partial q_{ik}}+\lambda_k^{+}P_k(s_{1k},\rho_{3k})-\lambda_k^{-}(1-P_k(s_{1k},\rho_{3k}))\right.\\
&\left.+\frac{\partial c^1_{ik}(Q^{12*})}{\partial q_{ik}}-\rho_{3k}(1-P_k(s_{1k},\rho_{3k}))-\rho_{1ik*}+\rho_{1ik*}\right]\times[q_{ik}-q_{ik*}]\\
&+\sum_{j=1}^{n}\sum_{k=1}^{o}\left[\gamma_j^*+\lambda_k^{+}P_k(s_{2k},\rho_{3k})-\lambda_k^{-}(1-P_k(s_{2k},\rho_{3k}))+\frac{\partial c_{jk}(Q^{2*})}{\partial q_{jk}}\right.\\
&\left.-\rho_{3k}(1-P_k(s_{2k},\rho_{3k}))-\rho_k^{l*}+\rho_{jk}^*\right]\times[q_{jk}-q_{jk}^*]+\sum_{j=1}^{n}\left[\sum_{i=1}^{m}q_{ij}^*-\sum_{k=1}^{o}q_{jk}^*\right]\\
&\times[\gamma_j-\gamma_j^*]+\sum_{k=1}^{o}\left[\sum_{j=1}^{n}q_{jk}+\sum_{i=1}^{m}q_{ik}-\hat{d}_k(\rho_{3k}^*)\right]\times[\rho_{3k}-\rho_{3k}^*]\geq 0. \qquad (51.17)
\end{aligned}
$$

It can rewritten as:

$$
\begin{aligned}
&\sum_{i=1}^{m}\sum_{j=1}^{n}\left[\frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ij}}+\frac{\partial c_{ij}^*}{\partial q_{ij}}-\rho_{1ij}^*\right]\times(q_{ij}^l-q_{ij}^{l*})+\sum_{i=1}^{m}\sum_{k=1}^{o}\left[\frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ik}}\right.\\
&\left.+\frac{\partial c_{ik}^*}{\partial q_{ik}}-\rho_{1ik}^*\right]\times(q_{ik}-q_{ik}^*)+\sum_{i=1}^{m}\sum_{j=1}^{n}\left[\frac{\partial c_j(Q^{11*})}{\partial q_{ij}}+\rho_{1ij}^*-\gamma_j^*\right]\times[q_{ij}-q_{ij}^*]\\
&+\sum_{j=1}^{n}\sum_{k=1}^{o}[-\rho_{jk}^*+\gamma_j^*]\times[q_{jk}-q_{jk}^*]+\sum_{j=1}^{n}\left[\sum_{i=1}^{m}q_{ij}^*-\sum_{k=1}^{o}q_{jk}^*\right]\times[\gamma_j-\gamma_j^*]\\
&+\sum_{i=1}^{m}\sum_{k=1}^{o}\left[\lambda_k^{+}P_k(s_{1k},\rho_{3k})-\lambda_k^{-}(1-P_k(s_{1k},\rho_{3k}))+\frac{\partial c^1_{ik}(Q^{12*})}{\partial q_{ik}}+\rho_{1ik}\right.\\
&\left.-\rho_{3k}(1-P_k(s_{1k},\rho_{3k}))\right][q_{ik}-q_{ik}^*]+\sum_{j=1}^{n}\sum_{k=1}^{o}\left[\lambda_k^{+}P_k(s_{2k},\rho_{3k})-\lambda_k^{-}(1-P_k(s_{2k},\rho_{3k}))\right.\\
&\left.+\frac{\partial c_{jk}(Q^{2*})}{\partial q_{jk}}+\rho_{jk}-\rho_{3k}(1-P_k(s_{2k},\rho_{3k}))\right][q_{jk}-q_{jk}^*]+\sum_{k=1}^{o}\left[\sum_{j=1}^{n}q_{jk}+\sum_{i=1}^{m}q_{ik}\right.\\
&\left.-\hat{d}_k(\rho_{3k}^*)\right]\times[\rho_{3k}-\rho_{3k}^*]\geq 0. \qquad (51.18)
\end{aligned}
$$

But inequality (51.18) is equivalent to the price and shipment pattern satisfying the sum of Equations (51.4), (51.8), (51.13) and (51.15). The proof is completed.

51.3 Model Transformation

In order to solve the variational inequality (51.16), we have to simplify model.

Let $X=(Q^{11},Q^{12},Q^{2},\gamma,\rho)^T$, $F(X)=(F^1(X),F^2(X),F^3(X),F^4(X),F^5(X))^T$, $F^1(X)=(\cdots,F^1_{ij}(X),\cdots)^T$, $F^2(X)=(\cdots,F^2_{ik}(X),\cdots)^T$, $F^3(X)=(\cdots,F^3_{jk}(X),\cdots)^T$, $F^4(X)=(\cdots,F^4_j(X),\cdots)^T$, $F^5(X)=(\cdots,F^5_k(X),\cdots)^T$. The five vector functions can be defined as follows,

$$
\begin{aligned}
F_{ij}^{1}(X) &= \frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ij}} + \frac{\partial c_{ij}^{*}}{\partial q_{ij}} + \frac{\partial c_j(Q^{11*})}{\partial q_{ij}} - \gamma_j^{*},\\
F_{ik}^{2}(X) &= \frac{\partial f_i(Q^{11*},Q^{12*})}{\partial q_{ik}} + \frac{\partial c_{ik}^{*}}{\partial q_{ik}} + \lambda_k^{+} P_k(s_{1k},\rho_{3k}) - \lambda_k^{-}(1-P_k(s_{1k},\rho_{3k}))\\
&\quad + \frac{\partial c_{ik}^{1}(Q^{12*})}{\partial q_{ik}} - \rho_{3k}(1-P_k(s_{1k},\rho_{3k})),\\
F_{jk}^{3}(X) &= \gamma_j^{*} + \lambda_k^{+} P_k(s_{2k},\rho_{3k}) - \lambda_k^{-}(1-P_k(s_{2k},\rho_{3k})) + \frac{\partial c_{jk}(Q^{2*})}{\partial q_{jk}}\\
&\quad - \rho_{3k}(1-P_k(s_{2k},\rho_{3k})),\\
F_j^{4}(X) &= \sum_{i=1}^{m} q_{ij}^{*} - \sum_{k=1}^{o} q_{jk}^{*},\\
F_k^{5}(X) &= \sum_{j=1}^{n} q_{jk} + \sum_{i=1}^{m} q_{ik} - \hat{d}_k(\rho_{3k}^{*}).
\end{aligned}
\tag{51.19}
$$

Thus, the variational inequality (51.16) can be written as:

$$F(X^*)^T(X-X^*) \geq 0, \ \ \forall X \in \Re_{+}. \tag{51.20}$$

The nonlinear complementary problem (NCP) of Equation (51.20) is: find $X^* \in R_+$, such that

$$F(X^*)^T X^* = 0, \quad F(X^*) \succeq 0. \tag{51.21}$$

By means of a merit function invented by Fischer [20], $\phi(a,b) = [\sqrt{a^2+b^2} - (a+b)^2] : R^2 \to R_+$, the relevant NCP formulation (51.21) can be equivalently transformed into an unconstrained continuously differentiable minimization formulation.

$$\min_{\bar{X} \in \Re^{mn+mo+no+n+o}} \Phi(\bar{X}), \tag{51.22}$$

where:

$$
\begin{aligned}
\Phi(\bar{X}) = &\sum_{i=1}^{m}\sum_{j=1}^{n} \Phi(q_{ij},\bar{F}_{ij}^{1}(\bar{X})) + \sum_{i=1}^{m}\sum_{k=1}^{o} \Phi(q_{ik},\bar{F}_{ik}^{2}(\bar{X})) + \sum_{j=1}^{n}\sum_{k=1}^{o} \Phi(q_{jk},\bar{F}_{jk}^{3}(\bar{X}))\\
&+ \sum_{j=1}^{n} \Phi(\gamma_j,\bar{F}_j^{4}(\bar{X})) + \sum_{k=1}^{o} \Phi(\rho_{3k},\bar{F}_k^{5}(\bar{X})).
\end{aligned}
\tag{51.23}
$$

51.4 Algorithm

By the above model transformation, the variational inequality (51.16) can be transformed unconstrained optimization problem (51.22). Thus, we consider solve Equa-

tion (51.22) by means of the Quasi-Newton algorithm. The detailed computation steps as following.
Step 1. Given starting point $x^{(1)}$, convergence tolerance $\varepsilon > 0$.
Step 2. Set $H_1 = I_n(unitmatrix)$, computing the gradient: $g_1 = \nabla\Phi(x^{(1)})$. Let $K = 1$.
Step 3. Let $d^{(k)} = -H_k g_k$.
Step 4. Starting from $x^{(k)}$, search step length factor λ_k along the direction $d^{(k)}$, such that $\Phi(x^{(k)} + \lambda_k d^{(k)}) = \min_{\lambda>0} \Phi(x^{(k)} + \lambda d^{(k)})$, set $x^{(k+1)} = x^{(k)} + \lambda_k d^{(k)}$.

Since the function $\Phi(x)$ is complex, exact search step length factor is very difficult, thus we search step length factor by means of Golden Section Method as follows.

1. Selecting the initial data. Determining the initial search interval $[a_1, b_1]$ and the accuracy $\delta > 0$. Computing the initial two test points $\lambda_1,\ \mu_1,\ \lambda_1 = a_1 + 0.382(b_1 - a_1),\ \mu_1 = a_1 + 0.618(b_1 - a_1)$, and $\Phi(\lambda_1),\ \phi(\mu_1)$. Let $k = 1$.
2. Comparing function. If $\Phi(\lambda_k) > \phi(\mu_k)$, then go (3); If $\Phi(\lambda_k) \le \phi(\mu_k)$, then go (4).
3. If $b_k - \lambda_k \le \delta$, then stop computation and output μ_k. Else, let $a_{k+1} = \lambda_k,\ b_{k+1} = b_k,\ \lambda_{k+1} = \mu_k,\ \Phi(\lambda_{k+1}) = \Phi(\mu_k),\ \mu_{k+1} = a_{k+1} + 0.618(b_{k+1} - a_{k+1})$. Computing $\Phi(\mu_{k+1})$, go (5).
4. If $\mu_k - a_k \le \delta$, then stop computation, output λ_k. Else, let $a_{k+1} = a_k,\ b_{k+1} = \mu_k,\ \mu_{k+1} = \lambda_k,\ \Phi(\mu_{k=1}) = \Phi(\lambda_k),\ \lambda_{k+1} = a_{k+1} + 0.382(b_{k+1} - a_{k+1}$. Computing $\Phi(\lambda_{k+1})$, go (5).
5. Let $k = k + 1$, go (2).

The insertion point of approximate optimal solution of $\Phi(x)$ is considered as step length factor λ_k by means of Golden Section Method.
Step 5. If $\| g_k = \nabla\Phi(x^{(k+1)}) \| \le \varepsilon$, then stop computation, output $x = x^{(k+1)}$. Else go Step 6.
Step 6. If $k = n$, then let $x^{(1)} = x^{(k+1)}$, go Step 2. Else go Step 7.
Step 7. Let $g_{k+1} = \nabla\Phi(x^{(k+1)}),\ S^{(k)} = x^{(k+1)} - x^{(k)},\ y^{(k)} = g_{k+1} - g_k$. Computing $H_{k+1}, H_{k+1} = H_k + \frac{S^{(k)}S^{(k)}T}{S^{(k)}TY^{(k)}} - \frac{H_k S^{(k)} Y^{(k)} H_k}{Y^{(k)} T H_k Y^{(k)}}$. Set $k = k + 1$, go Step 3.

51.5 Numerical Example

In this section, we apply the modified quasi-Newton method to a numerical example. We assumed that the demands associated with the demand markets followed a uniform distribution. Hence we assumed that the random demand, $\hat{d}_k(\rho_{3k})$, of the demand market k, is uniformly distributed in $\left[0, \frac{b_k}{\rho_{3k}}\right], b_k > 0; k = 1, 2, \cdots, 0$. Therefore, $P_k(x, \rho_{3k}) = \frac{x\rho_{3k}}{b_k}$, $g_k(x, \rho_{3k}) = \frac{\rho_{3k}}{b_k}$, $d_k(\rho_{3k}) = E(\hat{d}_k) = \frac{1}{2}\frac{b_k}{\rho_{3k}}$; $k = 1, 2, \cdots, o$.

Example 51.1. The numerical example, depicted in Fig. 51.3, consisted of two manufacturers, three retailers, two demand markets.

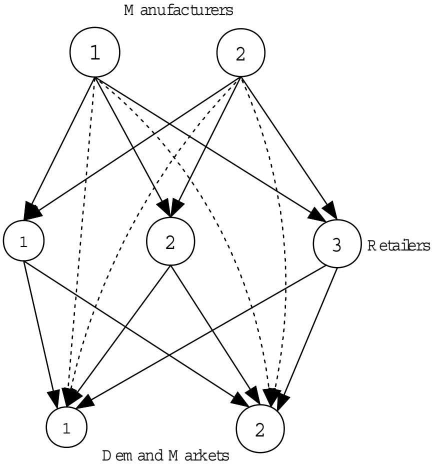


Fig. 51.3 The supply chain with two manufacturers, three retailers and two demand markets

Table 51.1 Manufacturer's production

Production	q
Manufacturer 1	0.321066
Manufacturer 2	0.321066

Table 51.2 Productions from manufacturers to retailers

	Retailer 1	Retailer 2	Retailer 3
Manufacturer 1	0.047602	0.047602	0.047602
Manufacturer 2	0.047602	0.047602	0.047602

Table 51.3 Productions from manufacturers to demand markets

	Demand Market 1	Demand Market 2
Manufacturer 1	0.08913	0.08913
Manufacturer 2	0.08913	0.08913

The data for this example were constructed for easy interpretation purposes. The production cost functions for the manufacturers for the product were given

Table 51.4 Productions from retailers to demand markets

	Demand Market 1	Demand Market 2
Retailer 1	0.047602	0.047602
Retailer 2	0.047602	0.047602
Retailer 3	0.047602	0.047602

by $f_1(q) = 2.5(q_1)^2 + q_1q_2 + 2q_1$, $f_2(q) = 2.5(q_2)^2 + q_1q_2 + 2q_2$, where, $q_1 = q_{11} + q_{12} + q_{13} + \hat{q}_{11} + \hat{q}_{12}$, $q_2 = q_{21} + q_{22} + q_{23} + \hat{q}_{21} + \hat{q}_{22}$.

The transaction cost functions faced by the manufacturers and associated with transacting with the retailers for the product were given by $c_{11}(q_{11}) = 0.5(q_{11})^2 + 3.5q_{11}$, $c_{12}(q_{12}) = 0.5(q_{12})^2 + 3.5q_{12}$, $c_{13}(q_{13}) = 0.5(q_{13})^2 + 3.5q_{13}$, $c_{21}(q_{21}) = 0.5(q_{21})^2 + 3.5q_{21}$, $c_{22}(q_{22}) = 0.5(q_{22})^2 + 3.5q_{22}$, $c_{23}(q_{23}) = 0.5(q_{23})^2 + 3.5q_{23}$.

The transaction cost functions faced by the manufacturers and associated with transacting with the demand markets for the product were given by $c_{11}(\hat{q}_{11}) = (\hat{q}_{11})^2 + 3.5\hat{q}_{11}$, $c_{12}(\hat{q}_{12}) = (\hat{q}_{12})^2 + 3.5\hat{q}_{12}$, $c_{21}(\hat{q}_{21}) = (\hat{q}_{21})^2 + 3.5\hat{q}_{21}$, $c_{22}(\hat{q}_{22}) = (\hat{q}_{22})^2 + 3.5\hat{q}_{22}$.

The transaction cost functions faced by consumers direct obtain the product from manufacturers were given by $c^1_{11}(\hat{q}_{11}) = 0.5\hat{q}^2_{11} + 5\hat{q}_{11}$, $c^1_{12}(\hat{q}_{12}) = 0.5\hat{q}^2_{12} + 5\hat{q}_{12}$, $c^1_{21}(\hat{q}_{21}) = 0.5\hat{q}^2_{21} + 5\hat{q}_{21}$, $c^1_{22}(\hat{q}_{22}) = 0.5\hat{q}^2_{22} + 5\hat{q}_{22}$.

The handling costs of the retailers for the product, in turn, were given by $c_1(Q^{11}) = 0.5(q_{11} + q_{21})^2$, $c_2(Q^{11}) = 0.5(q_{12} + q_{22})^2$, $c_3(Q^{11}) = 0.5(q_{13} + q_{23})^2$.

The transaction costs between the retailers and the consumers for the product at the demand markets were given by $c_{11}(\bar{q}_{11}) = \bar{q}^2_{11} + 5\bar{q}_{11}$, $c_{12}(\bar{q}_{12}) = \bar{q}^2_{12} + 5\bar{q}_{12}$, $c_{21}(\bar{q}_{21}) = \bar{q}^2_{21} + 5\bar{q}_{21}$, $c_{22}(\bar{q}_{22}) = \bar{q}^2_{22} + 5\bar{q}_{22}$, $c_{31}(\bar{q}_{31}) = \bar{q}^2_{31} + 5\bar{q}_{31}$, $c_{32}(\bar{q}_{32}) = \bar{q}^2_{32} + 5\bar{q}_{32}$.

We set the initial point $x^0 = (x^0_1, \cdots, x^0_j, \cdots, x^0_{21})^T$, $x^0_j = 10$, $j = 1, 2, \cdots, 21$. We take $b_k = 10$, $\Delta^+_k = 1$, $\Delta^+_k = 1$. The algorithm was implemented in MATLAB 7.1. The accuracy is taken as 10^{-8}. We can obtain the following results as Table 51.1 $\sim$ Table 51.3.

The demand price of demand markets: $\rho_{31} = 15.5723, \rho_{32} = 15.5723$.

The preceding example demonstrates the type of supply chain network problems that can be solved using the modified Quasi-Newton Method given in Sect. 51.4. We note that the example had nonlinear production costs associated with the manufacturers, nonlinear handling costs associated with the retailers, and nonlinear transaction costs between the manufacturers and the retailers.

51.6 Conclusion

In this paper, we have proposed a theoretically rigorous framework for the modeling and computation of solutions to supply chain network problems within an equilibrium context in the case of random demands associated with the demand markets. the equilibrium conditions were established, the modified Quasi-Newton Method was proposed for the computation of the equilibrium prices and product shipments. A illustrative supply chain network example was considered in the computations.

Acknowledgements The research was supported by the philosophy and Social Science Planning Projects of Sichuan Province (SC11B044), P. R. China; Bringing in qualified personnel projects of Chengdu University of Information Technology (KYTZ201203), P. R. China.

References

1. Stadtler H, Kilger C (2000) Supply chain management and advanced planning. Springer, Berlin
2. Poirier C (1996) Supply chain optimization: Building a total business network. Berrett-Kochler Publishers, San Francisco
3. Poirier C (1999) Advanced supply chain management: How to build a sustained competitive advantage. Berrett-Kochler Publishers, San Francisco
4. Federgruen A, Zipkin P (1986) An inventory model with limited production capacity and uncertain demands I: The average cost criterion. Mathematics of Operations Research 11:193–207
5. Slats P, Bhola B, Evers J et al (1995) Logistic chain modelling. European Journal of Operations Research 87:1–20
6. Hensher D, Button K, Brewer S (2001) Handbook of logistics and supply chain management. Elsevier, Oxford
7. Erengüc S, Simpson N, Vakharia A (1999) Integrated production/distribution planning in supply chains: An invited review. European Journal of Operations Research 115:219–236
8. Lee L, Billington C (1993) Material management in decentralized supply chains. Operations Research 41:835–847
9. Anupindi R, Bassok Y (1996) Distribution channels, information systems and virtual centralization. In: Proceedings of the Manufacturing and Service Operations Management Society Conference 87–92
10. Lederer P, Li L (1997) Pricing, production, scheduling, and delivery-time competition. Operations Research 4:407–420
11. Corbett C, Karmarkar U (2001) Competition and structure serial supply chains with deterministic demand. Management Science 47:966–978
12. Arrow K, Intrilligator M (1982) Handbook of mathematical economics. Elsevier, New York
13. Nagurney A (1999) Network economics: A variational inequality approach. 2nd edn, Kluwer Academic Publishers, Dordrecht
14. Nagurney A, Cruz J, Dong J et al (2005) Supply chain networks, electronic commerce, and supply side and demand side risk. European Journal of Operational Research 164:120–142
15. Nagurney A, Dong J, Zhang D (2002) A supply chain network equilibrium model. Transportation Research Part E: Logistics and Transportation Review 38:281–303
16. Nagurney A, Liu Z, Cojocaru M et al (2007) Dynamic electric power supply chains and transportation networks: An evolutionary variational inequality formulation. Transportation Research Part E: Logistics and Transportation Review 43:624–646
17. Nagurney A, Matsypura D (2005) Global supply chain network dynamics with multicriteria decision-making under risk and uncertainty. Transportation Research Part E: Logistics and Transportation Review 41:585–612
18. Nagurney A, Toyasaki F (2003) Supply chain supernetworks and environmental criteria. Transportation Research Part D: Transport and Environment 8:185–213
19. Nagurney A (2006) On the relationship between supply chain and transportation network equilibria: A supernetwork equivalence with computations. Transportation Research Part E: Logistics and Transportation Review 42:293–316
20. Fischer A (1992) A special Newton-type optimization method. Optimization 24:269–284

Chapter 52
The Impact of Clusters Characteristics on Supply Chain Performance in Cluster Networks

Lan Wang

Abstract This paper seeks to illustrate the advantages for firms who build local supplier and customer relationships in clusters. Specifically, supplier integration is proposed as a mediating strategic supply chain management behavior that may yield strategic advantages for supply chain partners. Using survey data from mainland China, the results show that cluster characteristics in terms of physical proximity and connectedness have a positive relationship with supplier integration which reveals that upstream and downstream partners may exist in cluster areas that can provide synergistic benefits more easily than firms in distant supply chain configurations. Theoretical and managerial implications are discussed.

Keywords Clusters characteristics · Information integration model · Supply chain performance model

52.1 Introduction

Clusters are currently recognized as an important instrument for promoting national economies and industrial development. Multinational supply chains is very popular as the development of information technology and high speed of transportation make it possible to communicate to suppliers and customers around the world almost as easily as with suppliers and customers next door. However, even in this age of unprecedented technologies, doing business locally also has numerous advantages [1]. Porter [2] suggests that the industrial environment outside a company plays a vital role in determining how a company creates competitive advantage. The repeated interactions among firms in clusters improve productivity, innovation

---

L. Wang (✉)
School of International Business, Beijing Language and Culture University, Beijing 100083,
P. R. China
e-mail: im2003@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_52,

and cooperation. Companies operating in a cluster can have the advantage of easily reach upstream and downstream supply chain members. Clusters in effect are closely knitted supply chain network in one location. However, previously few study empirically exams how cluster characteristics may influence supply chain management behavior and supply chain performance. To understand this, not only important for firms to enhance innovativeness but also enhance the sustainable competitive advantage of the clusters.

52.2 Literature Review and Hypotheses

A firm may obtain the advantages of linking with upstream and down stream suppliers in its local area which may reduce total supply chain costs compared with sourcing inputs globally [3]. This paper illustrates the linkages between supply chain management and Porter's cluster theory by examining the relative advantage of cluster theory and how this specific industrial environment affects supply chain management practices. Here in this article we focus on supplier integration. Supplier integration refers to long term oriented relationship with key suppliers [4], ranging from giving design suggestions to being responsible for complete development, design and engineering of a specific part of assembly.

(1) Physical Proximity and Supplier Integration

Currently, more and more managers employ supply chain management to improve customer service and reduce total costs. Geographic distance increases supply chain complexity and logistical costs in the supply chain because of transportation and inventory arrangements. Reputation is very critical factor for firms to survive in clusters [5], since the physical proximity facilitate the flowing of formal an informal information of suppliers' qualification and transaction history, which make the supplier is more likely to provide goods and product with consistent performance level without opportunism behavior [6]. Therefore, supplier integration is more likely to happen in clusters, which in turn enhance the supply chain performance. Therefore, we put forward the following hypothesis:

Hypothesis 1. Physical proximity is positively related with supplier integration.

(2) Connectedness and Supplier Integration

Firms in cluster with increased interdependence and mutual trust embedded in formal and informal connections create a tightly woven supply chain. The high level of connectedness may promote collaborative communication and enable supply chain partners to build stronger relational bonds with high level of trust and interdependence since they are very easy to get information of the transaction partner from direct tie or indirect tie [7]. In high level of inter-firm trust atmosphere, firms are more inclined to rely on norms for monitoring [8] and enforcing agreements to develop supplier integration activities [9]. Therefore, we put forward the following hypothesis:

Hypothesis 2. Connectedness is positively related with supplier integration.

(3) Cluster Characteristics, Supplier Integration and Supply Chain Performance

Supplier integration in purchasing functions has an important impact on the quality of final products, scheduling of producing, and innovation of products. Long term relationship makes supplier become part of a well-managed supply chain with providing goods and services in a consistent way. And also supplier integration facilitate effective communication to improve the quality of products, reduce customer response time and increase operational efficiency [10], which in turn positively influence supply chain performance. That is, the effects of these antecedent factors on supply chain performance are transmitted through supplier integration.

Hypothesis 3. supplier integration is positively related with performance.

Hypothesis 4a. supplier integration mediates the relationship between physical proximity and supply chain performance.

Hypothesis 4b. supplier integration mediates the relationship between connectedness and supply chain performance

52.3 Methodology

52.3.1 Sample and Data Collection

We developed a questionnaire on the basis of literature search and previous case studies. we collect data in Wenzhou area of mainland China from the early May of 2007 to the late November of 2007. 600 questionnaires were sent to the firms' managers from the city of Rui'an and Yueqing. When responding all questions about the business relationship, informants were asked to consider their relationship with a specific partner with whom the informant has done business regularly over the previous year. We received 280 responses, 86 pieces of returned questionnaires were incompletely filled or with self-evident mistakes, which were considered as unqualified questionnaires. Hereby, the returned valid questionnaires are 194 pieces, resulting in an effective respond rate of 32.3%. There were no significant differences between responding ventures and non-responding ventures in terms of venture size and age. Table 52.1 provides an overview of the relative distribution of respondents.

52.3.2 Measurement

As anticipated, most of the indicators loaded onto their underlying constructs during EFA using principal components method. The Eigen values for these factors were above the 1.0 cut-off point , while the percentage of variation was around 69%. The factor loadings were above the cut-off point and all above 0.70.The results of these analyses and reliability coefficients (Cronbach alpha) of variables are provided in

Table 52.1 Distribution of respondents

	N	%
Sales revenues (in million RMB)		
Less than	13	1.5
1-5	6	3.1
5-10	12	6.2
10-30	38	19.6
30-100	83	42.8
Above 100	52	26.8
Total	194	100
Business Types		
Manufacture	97	50.0
Manufacture and Distribution	63	32.5
Wholesale and Distribution	16	8.2
retailing	7	3.6
Other Services	11	5.7
Total	194	100

Table 52.2 Correlation matrix and summary statistics

Variables	1	2	3	4
1. Connectedness	1			
2. Physical proximity	0.187**	1		
3. Performance	0.210**	0.214**	1	
4. Supplier integration	0.257**	-0.026	0.210**	1
Mean	3.10	3.81	3.86	3.67
S.D.	0.82	0.89	0.57	0.68

Table 52.2. We controlled for the following variables, industry, business type, firm size, sale revenues, total asset and the district.

52.3.3 Model Testing Results

Two stepwise regression models were used to test the hypotheses, one with performance as the dependent variable (Model 1), the other one with supplier integration as the dependent variable (Model 2). The results of the analyses are presented in Table 52.3.

The relationship between physical proximity and performance was not significant ($\beta_{pp} = -061$; $p > 0.1$), So hypothesis 1 was not supported and also mediating effect of supplier integration (Hypotheses 4a) is not supported. The relationship between connectedness and performance was positive and significant ($\beta_{ct} = 0.252$; $p < 0.01$). The R^2 value increase attributable to adding connected-

Table 52.3 Correlation matrix and summary statistics

Variables	Model 1 Performance				Model 2 Supplier integration		
	Step1 Con.	Step2 IV1	Step3 IV2	Step4 mediator	Step1 Con.	Step2 IV1	Step3 IV2
	std. β	std. β	std. β	std. β	std. β	std. β	std. β
Industry	0.134 †	0.144 †	0.137 †	0.132 †	−0.008	−0.015	−0.035
business type	0.022	0.022	0.020	0.019	0.011	0.007	0.015
firm size	−0.064	−0.068	−0.058	−0.047	−0.032	−0.037	−0.064
sale Revenues	0.014	−0.041	−0.042	−0.035	0.003	−0.040	−0.037
total asset	0.024	0.049	0.045	0.031	0.045	0.069	0.079
district	0.127†	0.141†	0.140†	0.133†	0.029	0.036	0.041
connectedness		0.252***	.287***	0.256**		0.207**	0.177*
Physical proximity			−.062	−.096			0.185∗
Supplier integration				.176*			
R2	.035	0.109	0.113	0.141	0.003	0.046	0.076
Increase in R2	—	.074***	.004	.029*	—	.042**	.032*
F-value	1.035	3.009**	2.716**	3.113**	.081	1.162	1.801*

†$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed test).

ness to the model was statistically significant at the 1 percent level. Hypothesis 2 was supported.

To test Hypotheses 3 and 4, we use the independent variables predict supplier integration (the mediator). As Step 2 in Model 1 shows, since the relationship between supplier integration and supply chain performance was also positive and significant (Model 1, Step 5). Furthermore, the direct effect decreased from connectedness to performance, when considering the mediator, suggesting that the relationship is partially mediated. Hypotheses 3 and Hypotheses 4b were supported (see Table 52.3).

52.4 Discussion and Conclusion

This article highlights how clusters characteristics influence supply chain management behavior in clusters. We extend the stream of research in supply chain management by exploring a theoretical framework that relates cluster characteristics, supplier integration management and performance to illustrate the advantages for firms who build local supplier and customer relationships in clusters. Specifically, supplier integration management is proposed as a mediating strategic behavior that may yield strategic advantages for supply chain partners. Using survey data from a sample of 194 firms from mainland China, Our results provide strong support for the notion of supplier integration management as a mediator that enhances buyers' and suppliers' performance.

In summary, although global outsourcing helps a firm to obtain the complementary resources capabilities, clusters might provide a climate to achieve a lower total cost by better managing its supply chain. Firms considering relocation its business or make outsourcing decisions should analyze geographic regions that currently featured with the dimensions of cluster characteristics or that have emerging potential for developing clusters. Firms in cluster areas can improve both supply chain and firm performance though leveraging of complementary recourses and attracting other potential customers. Partners may exist in these areas that can provide synergistic benefits more easily than firms in non clusters areas [11]. Besides looking only for low cost advantage through distant outsourcing, the integration of cluster theory and supply chain management offers firms a way to build competitive advantage by pay more attention on local resources when selecting supply chain partners.

52.5 Limitation and Future Research

This study has several limitations that also suggest directions for future research. First, the use of self report data may pose such potential problems as the limited recall of the respondents, biased perceptions of past realities, and common method issues. However, although our post hoc examination and validation analysis indicated no serious common method problems, Further study should try to collect data from different parties (e.g., supplier or customer) to investigate the antecedents and outcomes of performance from multiple viewpoints. Since the supplier also plays a significant role in affecting the quality of the dyad, there is a need to examine the exchange relationship from the supplier's perspective as well. Second, we assessed mediate effect from supplier integration, this is central and important factors supply chain management, but still imperfect proxy. For example institutional factors may also influence strategic integration and capability development, so future research can attempt to add other variables to expand the model into multi-level framework.

Acknowledgements Lan Wang appreciates the support from National Science Foundation of China (No. 71002009). This paper is sponsored by China Nature Science Foundation (No. 710020-09).

References

1. Patti AL (2006) Supply chain management. An International Journal 3:266–270
2. Porter M (1998) Clusters and the new economics of competition. Harvard Business Review 76:77–90
3. Porter M (2000) Location, competition and economic development: Local clusters in a global economy. Economic Development Quarterly 14:15–34
4. Carr A, Pearson J (1999) Strategically managed buyer-seller relationships and performance outcomes. Journal of Operations Management 17:497-519
5. Bengtsson M, Sölvell Ö (2004) Climate of competition: clusters and innovative performance. Scandinavian Journal of Management 20:225–244

6. Wang L (2010) Supply chain uncertainty, relational behavior and innovation performance. In: Proceedings of 2010 International Conference on Management Science and Engineering Management
7. Powell W, Koput K et al (1996) Inter-organizational collaboration and the locus of innovation: Networks of learning in biotechnology. Administrative Science Quarterly 15:88–102
8. Wang L (2010) The role of relational governance in innovation performance in clusters. In: Proceedings of 2010 International Conference of Management and Service Science
9. Ganesan S (1994) Determinants of long-term orientation in buyer-supplier relationships. Journal of Marketing 58:1–19
10. Paulraj A, Chen IJ (2007). Environmental uncertainty and strategic supply management: A resource dependence perspective and performance implication. Journal of Supply Chain Management, 43:29–42
11. DeWitt T, Giunipero L, Melton HL (2006) Clusters and supply chain management: The Amish experience. International Journal of Physical 35:289–308

Chapter 53
Research on the Shape of the Dual-Core Supply Chain

Xigang Yuan and Zhigao Liao

Abstract The form of retailers and manufacturers as the core companies in supply chain are firstly summarized simply. Then, combined with previous researches, the mechanism of the shape of "dual core" enterprise supply chain is proposed. Meanwhile, the fact is pointed out that this form of supply chain is not suitable for all industries and only when manufacturers and retailers expands to a certain size, can such supply chain model emerge. Finally, factors of the shape of such supply chain mode are explained from the information-sharing, a certain firm size, control of the core enterprise and coordination mechanism.

Keywords Retailers · Manufacturers · Dual-core company

53.1 Introduction

Economies globalization urges the competition between supply chain to become increasingly fierce and the theory of supply chain management has become one of the hot points in the theories researches. A supply chain which is centered on core enterprise is a value chain formed from suppliers, manufacturers, retailers, distributors to ultimate customers, in which there are flows of information, logistics and capital.

In the supply chain, there is a core enterprise and others are in subordinate positions. The core enterprise determines the running rhythm, undertaking the task of interest's coordination and profit distribution among core enterprise determines the running rhythm, undertaking the task of interest's coordination and profit distribution among node enterprises. Thus, the core enterprise is extremely pivotal in supply chain. If the core enterprise had some problems in management, the operation of the

---

X. Yuan · Z. Liao (✉)
Logistics Simulation and Decision-making Laboratory, Management Department, Guangxi University of Science and Technology, Liuzhou 545006, P. R. China
e-mail: liaoxie_27@sina.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_53,

whole supply chain would probably break down. Therefore, the research on the core enterprise in supply chain bears important theoretical and practical significance.

Many scholars mainly focus on the researches of retailers-oriented supply chains and manufactures-oriented supply chains. Many researches are mainly concentrated on the shape of the two types of supply chains. For example, Zhou and Zhu [1], through the analysis of the commercial and manufacturing gross relation, holding that industry-commerce relations in china has entered into the commerce-oriented period and many large-scale commercials control and constrain manufacturing use of the ability to control the market. Guo [2] analyses from the aspects of manufactures, retailers and consumptions, that retail trades will dominate in the market gradually replacing manufactures. Wang and Li [3] illustrate from the aspects of the change of market environment, the scale of development, the development of information technology and the rise of commercial capital, that retailers will gradually take the lead in supply chain. Those scholars expound the reasons for the shape of "single core" enterprises supply chain from different perspectives. Some other scholars study the coordination of "single core" enterprises supply chain. Liu [4], through linear transfer payment contract, testifies that choosing appropriate reward and punishment factors and limiting the minimum sales scale in a certain range can coordinate supply chain. Cao and Lai [5] analyze that the coordination of supply chain system composed of one supplier and several Bertrand Competition retailers, and testify that when demand and production cost of suppliers are in turmoil, the integration of supply chain will achieve the coordination of supply chain. Meanwhile, an increasing number of scholars carry out abundant quantitative researches on cooperation mechanism of "single core" enterprises supply chain. Seyed et al [6] derived coordination under credit period for a two-level supply chain and they develop the optimal ordering policies and bounds are provided for credit period to develop an algorithm. As a result, they instructs their model are effective. Tiao and Dan [7] come up with two coordination mechanisms: an all-unit quantity discount and an incremental quantity discount. As a result, they think that this two mechanisms can make the total supply chain profit increasingly. Zhong and Si [8] develop retailer-dominant non-cooperative game models by introducing a sensitivity of retailer's order quantity to manufacturer's wholesale price then they analyze two cooperative scenarios in which the Nash bargaining model is utilized to implement profit sharing between the manufacturer and the retailer. Information sharing is also well worth studying. At present, many scholars have done lots of researches on information sharing of "single core" enterprise supply chain. For example, Borland, Bourland-Powell-Pyke Model, investigate that under the condition of a retailer and a manufacture, EDI (Electronic Data Interchange) can achieve the interchange of customers' information to meet purchasers' needs promptly [9]. D'Amours et al [10] advance the D'Amours-Montreuil-Lefrancois-Soumis model in which analyzing different degrees of customers' demand information sharing among each node of supply chain company and comparing the gross profit, they proved that information sharing has greeter value. Lee [11] advanced three information sharing models which are information transformation model, third-party information model and information neutralization model, making a great contribution to the research of demand information. Edwin and other scholars [12] testified that increasing the information sharing among members can achieve Pareto optimality according to the optimal inventory policy in different circumstances of information sharing. Seung put forward planning demand transferring method (PDTM) and Prediction of demand distribution method, evaluating the effect of supply chain information sharing [13]. Hau pointed out a general demand information model supposing that suppliers don't know retailers' demand information and investigated the influence of optimal smoothing parameters on the gross profit of supply chain [14]. In addition, the price of the node enterprises in supply chain also arouse many scholars' attention. Thus investigating the pricing policy of core enterprises in supply chain seems significant.

53.2 The Establishment and Description of the Model

Now an in-depth study on the two supply chain models is conducted from the form of supply chain model, the pricing strategy of core enterprise in supply chain, the coordination of supply chain, the information sharing of core enterprise and non-core enterprise. However, there are still some deficiency in current studies. On one hand, the researches on "single core" enterprise mostly focus on the "bi-level" supply chain of one core manufacture and one retailer or one core retailer and one manufacture. For example, only a pricing coordination model of "bi-level" supply chain under Game Theory Framework is studied in document and there are excessive assumptions in the research, which distorted the effect of model [14]. Only the coordination of two-stage supply chain system composed of one supplier and several competitive retailers is studied in Document [3]. Therefore, whether Linear Transfer Contract can be applied in the supply chain system composed of one core manufacture and several retailers is worthy of study. Whether the mentioned achievement of the researches on the "single core" company supply chain can be applied in multi-stage supply chain is also worthy of further study. On another hand, the research on "single core" company supply chain is mostly conducted by the application of quantitative method through the establishment of mathematical model. Excessive assumptions and the idealization of some assumptions make it hard to simulate some complex questions and to apply the conclusions in practice. Finally, what should be pointed out is that the retailer or the manufacture is regarded separately as the core enterprise of a supply chain, but the manufacture and the retailer are not taken together as the core enterprise of a supply chain to study on in most of current researches. Thus, it has great practical and theoretical significance to conduct an in-depth study on the backgrounds and reasons of the formation of "dual core" enterprise supply chain mode taking retailers and manufactures together as the core enterprise in supply chain, the allocation of profit among core enterprises, cooperative pricing strategy, the method of information sharing. Based on the deficiency in the researches, "dual core" enterprise supply chain mode is put forward and an in-depth description of the formation mechanism of such new supply chain model is done in this article.The formation mechanism of "dual core" enterprise supply chain as follows:

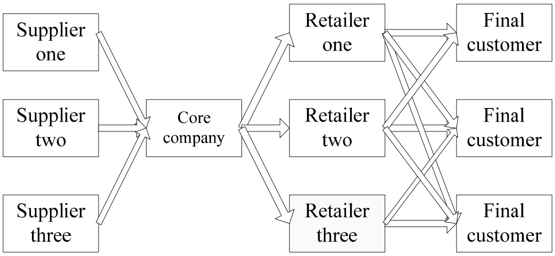


Fig. 53.1 The manufacture of the core company in the supply chain

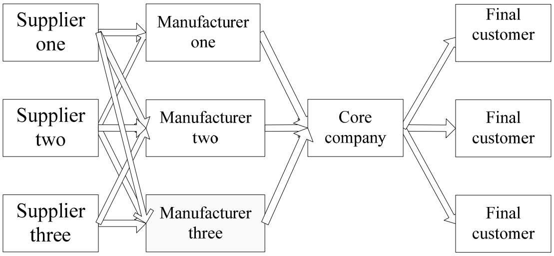


Fig. 53.2 The retailer of the core company in the supply chain

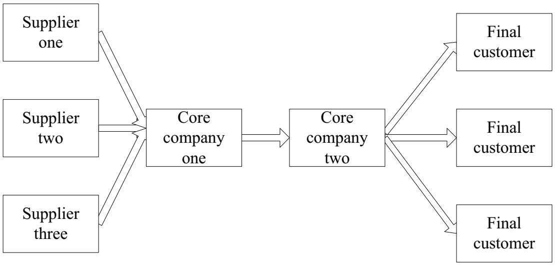


Fig. 53.3 The manufacture and the retailer of the core company in the supply chain

Supply chain has been regarded as a Dynamic Alliance, so an enterprise should be in the chief position. In Fig. 53.1, the manufacture is in the leader position and other node enterprise are in the subordinate. However, under this condition, the phenomenon of the big bullying the small or the strong domineering over the weak may occur. In the supply chain model of taking the manufacture as the core, the manufacture purchase raw materials from the original supplier in a very low price and then sell them to the retailers in a relatively high price to intensify the control over the original supplier and the subordinate retailer. In general, large manufacturers occupying a relatively large market share, having high credibility and strong competition, the suppliers and the retailers in a subordinate position are not willing to lose such large customers and such large suppliers. To maintain the survival, suppliers and retailers usually choose to maintain the relationship with core manufactures. When the relationship deteriorates, the core position of manufactures will be shaken and other node enterprises will seek new partners.

In Fig. 53.2, the retailer is in the leader position in supply chain and other node enterprises are in the subordinate. To obtain more benefits, the retailers will intensify the control over other node enterprises.Under this condition, the retailers purchase products from the manufacture in a relatively low price and then sell them to the customers in a relatively high price. In general, large core retailers occupying a relatively large market share and having high credibility, manufactures are not willing to lose such stable and large customers. Therefore, to reduce the control from large retailers, manufactures will cooperate with other retailers. When the manufacture separates itself from the supply chain, the core retailer will suffer great losses because of the loss of a stable supply.

Considering the problems in the "single core" enterprise supply chain, the "dual core" enterprise supply chain model shown in Fig. 53.3 is pointed out in this article. In such supply chain model taking manufactures and retailers together as the core enterprise, the large manufacture and retailer establish a marketing alliance, being the leaders in the supply chain and share information and risk. Manufactures have stable customers and retailers have stable supply so that they will not be generally separated from the supply chain.

The organization of such supply chain is formed when the retailers have equivalent strength with the manufactures. Supposing the strength of manufactures is stronger than that of retailers, the retailers will be under the leadership, constituting the supply chain model taking manufactures as the core shown in Fig. 53.1. In such model, manufactures are at the core deciding the running rhythm and direction of the supply chain and other enterprises are in subordinate positions. Besides, supposing the strength of retailers is stronger than that of manufactures, the manufactures will be under the leadership, constituting the supply chain model taking retailers as the core shown in Fig. 53.2. In such model, retailers are at the core deciding the running rhythm of the supply chain and mastering the core resources and other enterprises are in subordinate positions. Only when the two have equivalent strength can the "dual core" enterprise supply chain shown in Fig. 53.3 be composed, which is only suitable for industries of production and marketing alliance.

The most typical example of "dual core" enterprise supply chain in reality is the "Production and Marketing Alliance Supply Mode" of Wal-Mart store and P&D. It is well known that the two large retailers and manufactures, Wal-Mart store and P&D, get both greater development and profit through establishing new the production and marketing alliance. Two of them jointly determine the running rhythm and become the core enterprises in the supply chain.

53.3 Formation of Conditions

Some conditions for the formation conditions of "dual core" enterprise supply chain are needed to take the manufacture and retailer as the core compare in supply chain. Combined with the relative theories of the Synergetic Theory, the compare conditions are represented as the following aspects.

First of all, information sharing is the basis for the formation of "dual core" company supply chain. A high degree of mutual trust between manufactures and retailers is based on information sharing, including order information, stock information, the final demand information of customers and other information, which is usually related to whether the coordination of supply chain can be improved, whether the quality of products and service can be improved, whether the cost of supply chain can be reduced and whether the competition and information sharing can be strengthened. The information sharing among core enterprises and node enterprises in the whole supply chain can improve the coordination of the supply chain to meet customers' needs at a faster rate. Only highly shared information can reduce the Bullwhip effect, avoiding the higher cost and lower profit caused by information distortion.

Secondly, certain scale is a necessity of "dual core" enterprise supply chain. Only manufactures and retailers of a certain scale in the aspect of purchase, product, sale, management can attract other enterprises to share profit and bear risk driving the formation and development of the supply chain, such as Wal-Mart store, the largest retailer and P&D, the largest daily necessities manufacturer in the world. In the 514 million dollars value of sales of P&D in 2004, 8% is from Wal-Mart store, and in the 2,560 million dollars of Wal-Mart store, 3.5% is from P&D.(The data is from the research and survey of Bain& Co.)

In addition, the control over strategy, operation and manipulation is necessary. The core enterprise must notice the factors of supply chain to improve the ability of the supply chain to integrate resources. The manufacture and retailer must establish the platform of information sharing to ensure the smoothness of logistics and improve the quality of information transmission. The two core enterprises must have the ability of improving the control over the operation and manipulation to improve the competition of the whole supply chain.

Finally, effective coordination mechanism is significant for "dual core" enterprise supply chain. Coordination mechanism mainly includes interest coordination and operation coordination. The distribution of interests of manufactures and retailers, being the core enterprises, must be explicit and an effective pricing strategy should be established to ensure the effectiveness of coordination of interests. The effective coordination of manufactures and retailers can reduce the stock, cut the cost and improve the level of management and the efficiency of operation to improve the whole performance of the supply chain. At the same time, the internal activities of manufactures and retailers must achieve a certain degree of coordination to ensure the operational efficiency of the whole supply chain.

53.4 Comments

The form of retailers and manufacturers as the core enterprise in supply chain is first summarized simply. Then, combined with previous studies, the mechanism of "dual core" enterprise supply chain is proposed. Meanwhile, the fact is pointed out that this form of supply chain is not suitable for all industries and only when manufacturers and retailers expands to a certain size, can such supply chain model emerge. Finally, factors of the shape of such supply chain model is explained from the information-sharing, a certain firm size, control of the core enterprise and co-ordination mechanisms. Combined with the previous researches, only the definition and factors of formation of "dual core" enterprise supply chain is pointed out in this article. The aspects of whether such new supply chain is suitable for all the manufactures and retailers, what the internal mechanism and the influence on information will be when such supply chain occurs and what theoretical bases are need to be research further.

Acknowledgements This research was supported by the Doctor Foundation of Guangxi University of Technology (No. 11S03) and the Foundation of Research Projects of Department of Education of Guangxi (No. 200911MS117).

References

1. Zhou Q, Zhu Y (2005) Evolution of the relationship between manufacturing and commerce in China: Analysis of total. China Industry Economy 8:578–589
2. Guo J (2008) The reason of China's retail market buyer power. Economist 3:4578–4585
3. Wang F, Li X (2004) Position of retailers in supply chain evolution. Business Economy 6:5676–5683
4. Liu C (2007) Research on multi-retailer supply chain contract coordination problems. Journal of Management Science 4:1–5
5. Cao E, Lai M (2010) Requirement and costs at the same time disturbing when retailers supply chain coordination. Theory and Practice of systems engineering 10:1753–1761
6. Seyed R, Ali A, Taghi R (2009) Coordination mechanism for tow-level supply chain with one manufacturer and one buyer under credit period. International Journal of Management Science and Engineering Management 4:39–48
7. Tiao J, Dan Q (2009) Risk sharing and information revelation mechanism of a one-manufacturer and one-retailer supply chain facing an integrated competitor. European Journal of Operational Research 196:1076–1085
8. Zhong S, Si J (2008) Impacts of demand uncertainty on retailer's dominance and manufacturer-retailer supply chain cooperation. Science Direct 36:697–714

9. Bourland KE, Powell SG, Pyke DF (1996) Exploiting timely demand information to reduce inventories. European journal of erational Research 92:239–253
10. D'Amours S, Montreuil B, Lefrancois P et al (1999) Networked manufacturing: The impact of information sharing. International Journal of Production E-conomics 58:63–79
11. Lee H, Whang S (2000) Information sharing in a supply chain. International Journal of Technology Management 20:373–387
12. Yu Z, Yan H, Cheng T (2001) Benefit of information sharing with supply chain partnerships. Industrial Management 101:114–119
13. Seung-Jin R, Takahiro T, Hisashi O (2009) A study on evaluation of demand information-sharing methods in supply chain. International Journal of Production Economics 120:162–175
14. Hau L, Lee C (2009) Information sharing and order variability control under a generalized demand model. Management Science 10:781–798

Chapter 54
Uncertain Programming Models for Sports Supplier Selection with Cost Minimization

Wei Liu

Abstract In this paper, we consider three types of uncertain programming models for the purpose of selecting appropriate suppliers and allocating order quantities to them under under environment. The decision objective is to minimize the total cost incurred in the whole process, which is consisting of purchasing cost, holding cost and ordering cost. This paper chooses the case with multiple sources, multiple criteria and capacity constraints with uncertain parameters. In order to solve the proposed models, hybrid intelligent algorithm which integrating genetic algorithm by uncertain simulation is designed.

Keywords Supplier selection · Uncertain variable · Uncertain programming · Genetic algorithm

54.1 Introduction

For manufacturers, external purchase is a substantial expenditure, which takes up an important part of the value of products. In today's business world, outsourcing to external suppliers becomes a hot topic. For industrial companies, purchasing's share in the total turnover customarily ranges between 50% and 90% [16]. To our knowledge, several works have taken into multiple objective supplier selection account. These literature includes [3] and [18], in which objectives include net price, quality, delivery, performance history, capacity, communication system, service and so forth. The main aim is to choose appropriate suppliers which perform optimally on the desired dimensions.

The developments in supply chain management offer the opportunity for selecting suppliers with the minimal cost of ownership associated with purchasing pro-

---

W. Liu (✉)
Economics and Management Department, Chengdu Sport University, Chengdu 610041, P. R. China
e-mail: liuweihua166@hotmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_54,

cess. The method goes beyond price to consider all costs over the goods' whole life including quantities related to service, quality, delivery, administration, communication, failure, maintenance and so forth [4, 5]. For large companies with cost accounting systems, Timmerman [17] introduces the cost-ratio method to collect the costs related to quality, delivery and service. Monczka and Trecha [9] and Smytka and Clemens [14] employ a total cost approach with rating systems for criteria such as service and delivery performance.

Uncertainty and imprecision are inherit in real life. Several scholars dealt with uncertainty in their works. Soukoup [15] introduced a simulation-based approach to handle uncertainty in the demand or service purchased. The analytic hierarchy process is formulated to handle imprecision in supplier selection problem [1, 10, 11]. Ronen and Trietsch [13] developed a decision support system for supplier selection where the order lead time is assumed to be uncertain.

Fuzziness is another uncertainty in real life, and fuzzy methods have been applied to the field of finance and management. In particular, the quantities e.g. demand in supply chain management can be obtained by experts as fuzzy variables when there is no or not enough data. There are several works contributed to supply chain management in fuzzy environment by using credibility theory to deal with fuzziness, e.g., Qin and Ji [12] proposed a logistics network with product recovery in fuzzy environment. In order to model other imprecise quantities, Liu [8] presented uncertainty theory to describe human decisions in the state of uncertainty. Thus, we assume that the uncertain parameters are uncertain variables.

In this paper, we employ uncertain programming techniques to account for supplier selection problem in uncertain environment. The objective function is to minimize the total cost including order cost, holding cost and purchasing cost, and the capacity as the constraint. Long-term cooperation between manufacturers and suppliers is typically more important in the manufactory process. A minimum ordering rate is introduced to set in order to keep a relationship with all the suppliers. We assume that all the suppliers need be given the allocation at the minimum rate. The demand of the manufactory is confirmed by the retailers. The behavior of the manufacture is ahead of that of retail. The manufactory cannot obtain a precise amount when choosing the suppliers. Finally, we employ uncertain programming methods to model supplier selection problem. Considering the complexity, the traditional algorithms are impossible to be applied to solve the models. Therefore, we use so-called 99-method to solve the proposed models.

The rest of the paper is organized as follows. In Sect. 54.3, we briefly introduce the knowledge of uncertainty theory. Sect. 54.3 lists some symbols and notations used in this paper. Three optimization models named expected value model, α-cost minimization model and chance maximization model are established for supplier selection problem in Sect. 54.4. Sect. 54.5 introduces 99-method which can be used to numerically solve proposed models. Finally, remarking conclusions are listed in Sect. 54.6.

54.2 Preliminaries

Let Γ be a nonempty set, and let $\mathscr{A}$ be a σ-algebra over Γ. Each element of $\mathscr{A}$ is called an event. A set function is called an uncertain measure [8] if and only if it satisfies the following four axioms:
Axiom 1. (Normality) $\mathscr{M}\{\Gamma\} = 1$;
Axiom 2. (Monotonicity) $\mathscr{M}\{A\} \leq \mathscr{M}\{B\}$ whenever $A \subseteq B$;
Axiom 3. (Self-Duality) $\mathscr{M}\{A\} + \mathscr{M}\{A^c\} = 1$ for any event A;
Axiom 4. (Countable Subadditivity) $\mathscr{M}\{\cup_i A_i\} \leq \sum_{i=1}^{\infty} \mathscr{M}\{A_i\}$ for any countable sequence of events $\{A_i\}$.

Definition 54.1. [8] Let Γ be a nonempty set, and let $\mathscr{A}$ be a σ-algebra over it. If $\mathscr{M}$ is an uncertain measure, then the triplet $(\Gamma, \mathscr{A}, \mathscr{M})$ is called an uncertainty space.

Definition 54.2. [8] Uncertain variable ξ is defined as a measurable function from an uncertainty space $(\Gamma, \mathscr{A}, \mathscr{M})$ to the set of real numbers $\Re$. That is, for any Borel set B, we have $\{\gamma \in \Gamma \mid \xi(\gamma) \in B\} \in \mathscr{A}$.

Definition 54.3. [8] Let ξ be an uncertain variable. Then the expected value of ξ is defined as:

$$E[\xi] = \int_0^{+\infty} \mathscr{M}\{\xi \geq x\} dx - \int_{-\infty}^{0} \mathscr{M}\{\xi \leq x\} dx,$$

provided that at least one of the two integrals is finite.

Definition 54.4. [8] Let ξ be an uncertain variable, and $\alpha \in (0,1]$. Then:

$$\xi_{\inf}(\alpha) = \inf\{r | \mathscr{M}\{\xi \leq r\} \geq \alpha\} \tag{54.1}$$

is called the $\alpha-$ pessimistic value of ξ.

Theorem 54.1. *(Linearity of Expected Value Operator, [8]) Let ξ and η be independent uncertain variables with finite expected values. Then for any real numbers a and b, we have*

$$E[a\xi + b\eta] = aE[\xi] + bE[\eta].$$

54.3 Problem Formulation

Supplier selection problem concerns with how to choose appropriate suppliers and how to assign appropriate quantities to perform optimally for the desired purpose. Here, we list several symbols and notations which will be used in the rest of the paper. ξ is the annual demand (uncertain variable). Q is the ordered quantity to all suppliers in each period. H represents the inventory holding cost. n is the number of suppliers. O_i represents the ordering cost of the supplier $i = 1, 2, \cdots, n$ each period. C_i is the price of supplier $i = 1, 2, \cdots, n$. S_i is the capacity of supplier $i = 1, 2, \cdots, n$.

R is the minimum ordering quantity. D_i is the uncertain percentage of delayed delivery of supplier $i = 1,2,\cdots,n$. D represents the maximum accepted percentage of delayed delivery. P_i is the uncertain quality rate of supplier $i = 1,2,\cdots,n$. P represents the minimum accepted quality rate. X_i is the percent of Q assigned to supplier $i = 1,2,\cdots,n$ (decision variable).

We suppose that a buyer wants to give more quantities to the best supplier and gives minimum rate to the bad supplier from among the n vendors whose capacities are fixed. The buyer wants to minimize the annual total cost (C) including annual purchasing costs (P), ordering costs (O) and holding costs (H), subject to limitations on his/her budget, quality, service etc. In addition, the buyer needs to consider minimum quality rate, maximum delayed delivery and other constraints.

(1) Annual Purchasing Cost (C)

We suppose the purchased quantities from the supplier i are $X_i\xi$ and the unit price is C_i, the total purchasing cost (C) is:

$$C(\boldsymbol{x},\xi) = \sum_{i=1}^{n} C_i X_i \xi. \tag{54.2}$$

(2) Annual Ordering Cost (O)

To keep relationship with all the suppliers, The suppliers should be paid ordering cost each period. Therefore, the annual ordering cost is:

$$O = \frac{\xi}{Q}\sum_{i=1}^{n} O_i. \tag{54.3}$$

(3) Annual Holding Cost (H)

For supplier i, his/her average inventory is $X_i\xi/2$ and the inventory holding cost is HC_iX_i. Further, the holding cost is given as follows:

$$H(\boldsymbol{x}) = \sum_{i=1}^{n} (X_i Q/2) H C_i X_i = \frac{QH}{2}\sum_{i=1}^{n} X_i^2 C_i. \tag{54.4}$$

(4) Annual Total Cost (T)

Based on Equations (54.1), (54.2) and (54.3), we may derive the following annual total cost:

$$C(\boldsymbol{x},\xi) = P + O + H = \sum_{i=1}^{n} C_i X_i \xi + \frac{\xi}{Q}\sum_{i=1}^{n} O_i + \frac{QH}{2}\sum_{i=1}^{n} X_i^2 C_i. \tag{54.5}$$

It is worthwhile pointing out that both P and O are uncertain variables, since ξ is an uncertain variable. Further, the annual total cost is also an uncertain variable. Considering Q is the optimal order quantity, therefore, it can be derived by using the derivative of C. It follows from:

$$Q = \sqrt{2\xi(\gamma)\sum_{i=1}^{n} O_i \Big/ H\sum_{i=1}^{n} X_i^2 C_i},$$

that:

$$C(\boldsymbol{x},\xi) = \sum_{i=1}^{n} C_i X_i \xi + \sqrt{2\xi(\gamma)H\left(\sum_{i=1}^{n} O_i\right)\left(\sum_{i=1}^{n} X_i^2 C_i\right)}. \tag{54.6}$$

54.3.1 Constraints

Because of lack of resources, the supplier selection problem has several constraints, for example:

- Capacity constraint: $X_i\xi \le S_i$;
- Demand constraint: $\sum_{i=1}^{n} X_i = 1$;
- Quality constraint: $\sum_{i=1}^{n} X_i P_i \ge P$;
- Delayed delivery constraint: $\sum_{i=1}^{n} X_i D_i \le D$;
- Other constraint: $R \le X_i \le 1$.

Since the demand ξ is an uncertain variable, $X_i\xi \le S_i$ will become meaningless to compare a function with a real number. Uncertainty theory is useful to deal with this problem, and to formulate it as follows:

$$\mathscr{M}\{\gamma \in \Gamma | X \cdot \xi(\gamma) \le S_i\} \ge \alpha.$$

Furthermore, the constraint may be formulated as follows:

$$\begin{aligned} \mathscr{M}\{\gamma \in \Gamma | X \cdot \xi(\gamma) \le S_i\} \ge \alpha &\Leftrightarrow \mathscr{M}\{\gamma \in \Gamma | \xi(\gamma) \le S_i/X\} \ge \alpha \\ &\Leftrightarrow S_i/X \ge L(\alpha) \\ &\Leftrightarrow X \le S_i/L(\alpha), \end{aligned}$$

where $L(\alpha) = \{L | \mathscr{M}\{\gamma \in \Gamma | \xi(\gamma) \le L\} = \alpha\}$. We may obtain the crisp expressions of the value $L(\alpha)$ for several special uncertain variables, e.g. triangular, trapezoidal, normal uncertain variables and so on.

54.4 Mathematical Models

It is meaningless to minimize an uncertain variable. If we want to rank uncertain variables, we need to look for some indices such as expected value, critical values and so on. In this section, we employ uncertain programming techniques to model supplier selection problem. By using different criteria, we respectively propose three kinds of models including the expected value model, α-cost minimization model and chance maximization model.

54.4.1 Expected Value Model

The most used model is expected value model whose idea is to optimize the expected value of $C(\boldsymbol{x},\xi)$ subject to some expected constraints. Here, we formulate the expected value model for supplier selection with uncertain demand as follows:

$$\begin{cases} \min\limits_{\boldsymbol{x}} \mathrm{e}[C(\boldsymbol{x},\xi)] \\ \text{s.t.} \begin{cases} X_i \cdot \mathrm{e}[\xi] \leq S_i, \ i=1,2,\cdots,n \\ \sum\limits_{i=1}^{n} X_i = 1 \\ \sum\limits_{i=1}^{n} X_i P_i \geq P \\ \sum\limits_{i=1}^{n} X_i D_i \leq D \\ R \leq X_i \leq 1, \ i=1,2,\cdots,n. \end{cases} \end{cases} \tag{54.7}$$

54.4.2 α-Cost Minimization Model

Charnes and Cooper [2] initiated chance-constrained programming as a tool to model random decision systems. The main idea of chance-constrained programming is to optimize certain critical value at a predetermined confidence level given several chance constraints. According to the idea, α-cost minimization model for supplier selection with uncertain demand is proposed as follows:

$$\begin{cases} \min C \\ \text{s.t.} \begin{cases} \mathscr{M}\{\gamma \in \Gamma | C(\boldsymbol{x},\xi) \leq C\} \geq \alpha \\ X_i \leq S_i/L(\alpha), \ i=1,2,\cdots,n \\ \sum\limits_{i=1}^{n} X_i = 1 \\ \sum\limits_{i=1}^{n} X_i P_i \geq P \\ \sum\limits_{i=1}^{n} X_i D_i \leq D \\ R \leq X_i \leq 1, \ i=1,2,\cdots,n. \end{cases} \end{cases} \tag{54.8}$$

54.4.3 Chance Maximization Model

In some situations, decision makers want to maximize the chance of the event $C(\boldsymbol{x},\xi) \leq C^0$. In order to describe this case, Liu [6, 7] presented the dependent-chance programming. In this subsection, we employ the uncertain dependent-chance programming technique into the supplier selection area as follows:

$$\begin{cases} \max \mathscr{M}\{\gamma \in \Gamma | C(\boldsymbol{x},\xi) \le C^0\} \\ \text{s.t.} \begin{cases} X_i \le S_i/L(\alpha),\ i=1,2,\cdots,n \\ \sum\limits_{i=1}^{n} X_i = 1 \\ \sum\limits_{i=1}^{n} X_i P_i \ge P \\ \sum\limits_{i=1}^{n} X_i D_i \le D \\ R \le X_i \le 1,\ i=1,2,\cdots,n. \end{cases} \end{cases} \tag{54.9}$$

54.5 Hybrid Intelligent Algorithm

In Sect. 54.3, three models all contain uncertain parameter so that it is to solve these models by using classical methods. In order to solve the problem, Liu [8] proposed a 99-method to calculate the relative items. Here note that there is no difference between deterministic mathematical programming and uncertain programming except for that the latter has uncertain functions. Essentially, there are three types of uncertain functions in the above models, $U_1 : \boldsymbol{x} \to E[C(\boldsymbol{x},\xi)]$; $U_2 : \boldsymbol{x} \to \mathscr{M}\{C(\boldsymbol{x},\xi) \le C^0\}$; $U_3 : \boldsymbol{x} \to \min\{C | \mathscr{M}\{C(\boldsymbol{x},\xi) \le C\} \ge \alpha\}$.

Note that those uncertain functions may be calculated by the 99-method if the function C is monotone. In fact, it is easy to see that $C(\boldsymbol{x},\xi)$ is an increasing function of ξ.

Lemma 54.1. *[8] Let ξ be an uncertain variable with uncertainty distribution Φ, and let f be a strictly decreasing function. Then $f(\xi)$ is an uncertainty distribution with inverse uncertainty distribution*

$$\Psi^{-1}(\alpha) = f(\Phi^{-1}(1-\alpha)). \tag{54.10}$$

Based on this theorem, Liu [8] presented the following operational law.
99-Method Let ξ be an uncertain variable represented by a 99-table:

0.01	0.02	0.03	$\cdots$	0.99
x_1	x_2	x_3	$\cdots$	x_{99}

Then for any strictly decreasing function $f(x)$, the uncertain variable $f(\xi)$ has a 99-table:

0.01	0.02	0.03	$\cdots$	0.99
$f(x_{99})$	$f(x_{98})$	$f(x_{97})$	$\cdots$	$f(x_1)$

According the above 99-method, we can compute the discrete uncertainty distribution of $C(\boldsymbol{x},\xi)$ as the approximation. Then these three uncertain functions U_1, U_2 and U_3 can be obtained. Then we can find a numerical method for solving deterministic mathematical programming, for example, genetic algorithm, particle swarm optimization, or any classical algorithms. Then, for example, we may integrate the 99-method and the genetic algorithm to produce a hybrid intelligent algorithm for solving the above uncertain programming models:

Step 1. Initialize *pop_size* chromosomes whose feasibility may be checked by the 99-method.

Step 2. Calculate all the objective values for all chromosomes.

Step 3. Compute the fitness of all chromosomes.

Step 4. Select the chromosomes by spinning the roulette wheel.

Step 5. Renew the chromosomes by crossover and mutation operations in which the 99-method may be employed to check the feasibility of offsprings.

Step 6. Repeat the second to the fifth steps for a given number of cycles.

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

54.6 Conclusion

This paper used uncertain programming techniques to model supplier selection problem with uncertain demand. According to different criteria, expected value model, α-cost minimization model and chance maximization model were respectively established to choose the desired suppliers. These models have the following characteristics: (1) the total cost is composed of purchasing cost, ordering cost and holding cost; (2) keeping long-term relationship with the suppliers is considered; (3) three uncertain programming models may be used to solve different cases.

References

1. Barbarosoglu G, Yazgac T (1997) An application of the analytic hierarchy process to the supplier selection problem. Production and Inventory Management Journal 1st Quarter 14–21
2. Charnes A, Cooper W (1961) Management models and industrial applications of linear programming. Wiley, New York
3. Dickson GW (1966) An analysis of vendor selection systems and decisions. Journal of Purchasing 2:5–17
4. Ellram LM (1994) Total cost modeling in purchasing. Center for Advanced Purchasing Studies. Tempe, AZ
5. Ellram LM (1995) Total cost of ownership an analysis approach for purchasing. Journal of Physical Distribution and Logistics 25:4–23
6. Liu B (1997) Dependent-chance programming: A class of stochastic programming. Computers & Mathematics with Applications 34:89–104
7. Liu B (2002) Theory and practice of uncertain programming. Physica-Verlag, Heidelberg

8. Liu B. Uncertainty Theory, 3rd Edition.
http://orsc.edu.cn/online
9. Monczka RM, Trecha SJ (1988) Cost-based supplier performance evaluation. Journal of Purchasing and Materials Management 24:2–7
10. Narasimhan R (1983) An analytic approach to supplier selection. Journal of Purchasing and Supply Management 1:27–32
11. Nydick RL, Hill RP (1992) Using the Analytic Hierarchy Process to structure the supplier selection procedure. International Journal of Purchasing and Materials Management 28:31–36
12. Qin Z, Ji X (2012) Logistics network design for product recovery in fuzzy environment. European Jouranl of Operational Research, to be published.
13. Ronen B, Trietsch D (1988) A decision support system for purchasing anagement of large projects. Operations Research 36:882–890
14. Smytka DL, Clemens MW (1993) Total cost supplier selection model: A case study. International Journal of Purchasing and Materials Management 29:42–49
15. Soukup WR (1987) Supplier selection strategies. Journal of Purchasing and Materials Management 23:7–12
16. Telgen J (1994) Inzicht en overzicht: De uitdagingen van Besliskunde en Inkoopmanagement. Academical Address at the University of Twente, Enschede, the Netherlands
17. Timmerman E (1986) An approach to vendor performance evaluation. Journal of Purchasing and Supply Management 1:27–32
18. Weber CA, Current JR, Benton WC (1991) Vendor selection criteria and methods. European Journal of Operational Research 50:2–18

Chapter 55
The Role of Quick Response for Demand Driven Globalized Apparel Supply Chain Management

Md. Sanuwar Rashid

Abstract The purpose of this paper is to explore the impact of quick response (QR) issue on demand driven supply chain management (SCM) and to establish an objective measure for the implementation of QR in apparel supply chain to remain competitive in global fashion market. This research work is based on critical review and synthesis from prior conceptual paper to get a measure of QR. This paper fabricates the suitability of QR business strategy in SCM to cope with the changing behavior of consumer preference and to incline the business as per consumer requirement. To minimize the uncertainties and demand variation, this paper determines elements and dimension of QR by identifying the essential virtues of supply chain. This paper is also devoted to recommend the driver and tools to merge QR with demand driven apparel SCM. This work extends previous research on the importance of QR strategy in SCM and fills a gap in traditional framework of demand driven supply chain. It illustrates how this strategy empowers by its components and split up into different dimensions, virtues and elements that allow more customer-oriented SCM.

Keywords Quick response (QR) · Apparel supply chain · Supply chain management (SCM) · Globalization · QR drivers · Tools

55.1 Introduction

Developed countries belong to devolving countries for manufacturing product. Therefore, the various brands of developed countries emerge as branded marketer or brander retailer rather than branded manufacturer. So they needs to consider higher lead time to upload their product per season in retail shops. As the forecasting of demand trend is virtually impossible, there is a high risk of stock out of any par-

---

M. Rashid (✉)
Textile Engineering Department, Southeast University, Dhaka 1213, Bangladesh
e-mail: sanuwar.rashid@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_55,

ticular product rapidly for consumer preference. And if the replenishment requires long lead time, customer demand may not exist up to then. In this paradigm, Quick Response methodology shows us the way to overcome the barrier like lower service levels and ensure the fewer lost sales and better end of season markdown performance [3, 9].

The supply chain of fashion enterprise faces many challenges for shorter product life cycle, change of fashion trend overnight, higher SKU range. These characteristics make the fashion market volatile than ever. Therefore, QR, in whole or in part, has been accepted and implemented by many retailers to get in time delivery of stock out product from their vendor [9, 19]. To cope with the demand of fundamentally changing global competition, QR and supply chain partnering issues gaining attention [18]. Analysis by Robert O Knorr, on QR and supply chain excellence, emphasized on new kind of trust based relationship between the manufacturer and the retailer and on redesigned business processes throughout the entire supply chain. And the supply chain inspired by QR including Just in time (JIT) delivery concepts and flexible manufacturing of small lot of bulk production, will synchronized the flow of goods to retail consumer demand. Various studies have been conducted to indicate the components of quick response [8]. And insist on implementation of the key elements of QR methodologies by various organizations in supply chain [9].

A number of studies have investigated implementation of quick response (QR) concepts in the apparel industry [1, 9–17, 19, 20, 26]. However, there is a lack of research focusing on supplier perception of QR implementation (QRI). In this perspective, this paper work is devoted to represent the basis of an evolving and effective QR model for globalized apparel supply chain. The QR model in here is comprehended by its component and aimed to relate all prescribed dimension and key elements for a successful implementation. This model is interpretive and developed theoretically and oriented by its dimension, virtues and elements according to their driving power and dependence. The implementation process of QR is a prioritize matter of this paper which is fabricated by the value enhancement of globalized apparel supply chain.

55.2 The Literature Review

55.2.1 Today's Fashion Market

As we are now in twenty first century, all retail segments are facing new challenges: perhaps the fashion industries are going to face the most critical situation. Hot trends are created overnight; consumer preferences change frequently, moreover assortment and SKU maintain is the tough job but these are essential for remaining competitive in market.

The traditional method of marketing which was largely forecast based is no longer viable to us. Traditionally, what a apparel company sought to do is sort of plan ahead, pile up inventory and then just seat back and waiting for customer demand. But in this new environment the regular basis supply of product in market is emphasize enough to retain its sales opportunity every time. Non availability means that in the event of non supply the particular sales opportunity is lost forever [6]. Therefore over the time, evolvement of business process and its activities has gradually been inclining towards customer demand [19].

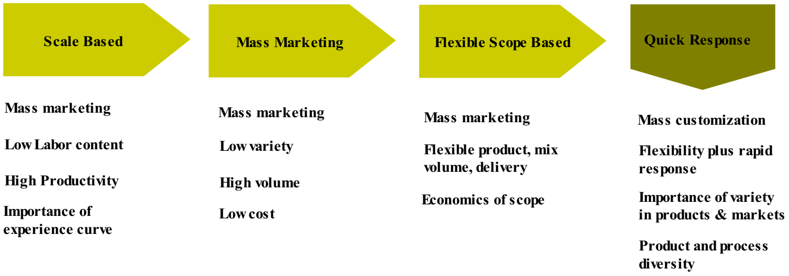


Fig. 55.1 Changes of marketing strategy in response to consumers' demand with the pace of time

Nowadays, in order to being able to realize the real value system of apparel Supply chain, we have to shift from the 'supply chain management' to 'demand driven supply chain management' [7]. Traditionally the value system was only designed with a chain of arrows horizontally from raw material to end consumer and feeding back an opposite arrows from end consumer to source for information flow (Fig. 55.2).

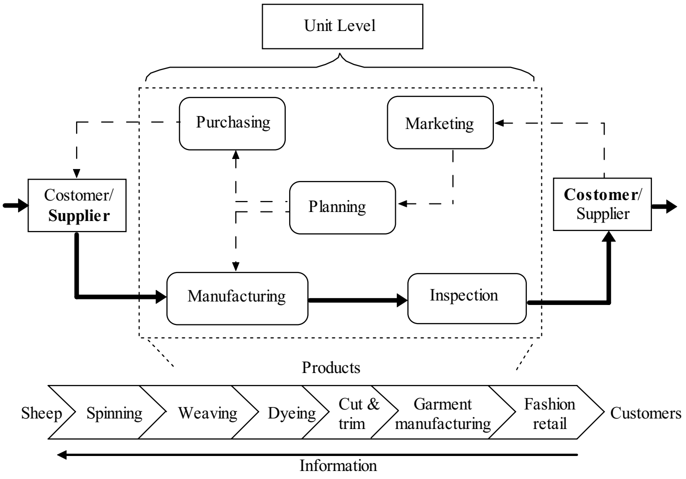


Fig. 55.2 Traditional supply chain as well as value system

Unlike the traditional business concept, nowadays branded marketer as well as branded retailer comes to developing country to manufacture their product. Therefore, every fashion company needs to count lead time to bring out the new product into market. To offer the right product at the right place to the right customer it is very necessary to shorten down the lead time. Therefore, the concept of vertical integration transform into virtual integration to manage the business process. In this paradigm, what we have to do is rearrange the supply chain. For example, the value system should slightly modify to prioritize the consumer preference where the demand side is represented by the retailers. Based on their experience and the assessment of consumer needs and desire, retailers performed the assortment planning, inventory management and the activities related with purchasing [19, 21]. Subsequently, the retailer would conduct his production in another country from sourcing to distribution and to integrate the distribution of product and purchasing activities-virtually while quick response comes in to action (Fig. 55.3).

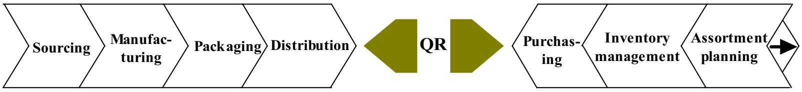


Fig. 55.3 Supply Chain tends to be demand driven to react quickly to consumer demand

55.2.2 Quick Response (QR) Strategy

In a demand driven supply chain perspective, quick response is suited for apparel sector to make the supply chain member and customer benefited while the same kind of benefit is taken from efficient consumer response (ECR) system for grocery sector [3]. Automatic replenishment (AR) is more commonly used strategy accepted by many firms in recent years. Based on point of sales data, AR triggers the restocking of inventory to avoid the lost sales and ensure the availability of demandable SKUs throughout the selling season. It made long range forecast and safety stock less viable [22].

QR is one type of AR system that has been widely adopted by fashion retailers and their suppliers in response to the fast fashion trend. It is a strategy which guide retailer to link up with their supplier to get a replenishment of stock out product. Therefore, the replenishment is free from prognosis error. Lowson et al [19] defined QR as: *A state of responsiveness and flexibility in which an organization seeks to provide a highly diverse range of products and services to a customer/consumer in the exact quantity, variety and quality, and at the right time, place and price as dictated by real-time customer/ consumer demand* .

Quick response is the combination of Just in time system and IT systems such as electronic point of sale (EPOS), Electronic data interchange (EDI), Computer aided design (CAD) and computer aided manufacturing (CAM) for enabling the supply chain to become more efficient [9]. Where production is demand driven rather than forecast based, there QR plays its ultimate role of information data sharing of retail store. Based on SKUs and specifications about order schedules and deliveries, QR strategy creates the field of buyer and supplier relationship.

According to the model induced by Fiorito et al [9], retailer collects information by evaluating his sales data which is mainly based on consumer needs and demand. Merchandise information, such as size, style, color and brand are collected through scanning barcodes. EDI is then subjected to transfer the information to vendor and based on this sales data of retail store, production is ordered for specific items to prevent the stock out of these products. It is important as I mentioned earlier that non availability means that in the event of non supply the particular sales opportunity is lost forever.

From the above figure it is clear to us that implementation of QR in reality is only possible through the development of IT. The firms which has wish to integrated itself virtually with upstream and downstream, needs to install information technology (IT) in their supply chain management procedure. According to [19], implementation of quick response is not something that deals with IT, but a strategy for information system (IS).

55.3 Discussion & Analysis

55.3.1 Generalization of QR System

The processes, components and systems of QR cannot and will not be applicable in a same manner to each SCM business process. It is, like its outcomes, flexible and contingent upon considerations of various perspectives. Therefore, it is not easy to implement QR in a business process while the retail shops are in Europe or USA and the manufacturer stay behind; may be somewhere in Asian country. So, QR should be supported by IS and by its component to create an uninterruptable network to respond to customer demand. Gunston and Harding [23] emphasize on the contribution of its component for a smooth flow of products: "*A mode of operation in which a manufacturing or service industry strives to provide products and services to its customers in the precise quantities, varieties and within the time-frames that those customers require*". Some of the components of QR system are listed below.
(1) Electronic data interchange (EDI)

EDI is the procedure of transferring the business data from a firm's computer system to the supplier computer system. Business data covers the purchase orders & confirmation, invoices, remittance advice, shipment releases, advance shipment notice and planning schedule which are effectively belongs to implementing QR.
(2) Bar-coded merchandise

Bar-coding is essential to get the information on SKUs volume and mixes. Here information means the accountability of transaction and remaining inventories. Bar-code basically an electrical safety mark and it demonstrates to everyone in supply chain. The record keeping system of inbound and outbound material can help them to calculate the waiting time and total time duration to receive the raw material as well as to deliver the product to the retail shop. So the partners of supply pipeline can go one step ahead in implementation of QR if they are adopted with the bar code facilities.

(3) PoS data sharing with customer

It is one kind of software covering the data of inventory values, remaining SKUs information rather than just recording of cash transaction. PoS have the significance of estimating reorder quantities for a particular time. By evaluating the point of sales data, we can easily identify the slow moving and fast moving goods of a retail shop. On the basis of this evaluation, we can take initiatives to minimize the lost sales as well as maximize the sell through percentage.

(4) Shared planning

Business partner should take part in a SCM process with shared degree of strategy and collaborative planning. Each partner should be updated about others' activity rather than being autonomous.

(5) Universal product codes (UPC)

UPC should be entitled to each and individual SKUs. And it should remain same throughout the SCM network. UPC plays an important role in identifying and tracking of bar code.

(6) Store ready deliveries

Direct store delivery with having price ticketing and final packaging as per retailer's specification will reduce the pressure of packing and repacking at DC and warehouse. Therefore, each delivery cycle will cause less time as the goods are ready to be placed on shelf once delivered.

There are some other components for a smooth generation of QR in supply chain like electronic reorder, continual and automatic replenishment, sales captured at item level, container shipping codes, electronic purchase order and invoicing, shared inventory management system, small batch orders, sharing product information with trading partners, modular or cellular manufacturing, joint product planning, consumer demographic information system and demand relationship [19].

55.3.2 Dimension

To cover the wider spread area of supply and demand chain, quick response enlarges its dimension or attribute in every possible way and Christopher expressed this matter as 4Rs. According to Christopher *"as we move rapidly into the era of supply chain competition, a number of principles emerge to guide ⋯. These can be conveniently summarized as the 4Rs of responsiveness, reliability, resilience and relationships"*.

(1) Responsiveness

The highly unpredictable demand creates volatility and causes high obsolete inventory, lost sales, and markdowns [21]. To ensure the material flow as per demand of upstream, quick response emphasized on responsiveness and flexibility [19]. Responsiveness ensures the effectiveness and efficiency of need for speed-to-market, flexibility and market orientation. Therefore, it is the ability to react purposefully and within an appropriate time-scale to consumer demand or change in fragmented marketplace while competitive advantage will be ensured and eventually this tactic will minimize the lost sales and markdowns [24]. In several ways, flexibility inclines toward the achievement of responsiveness within the defined supply chain parameters. The unpredictable change and volatility affect the supply chain flow and the concept of agility is come in action to minimize this problem [2]. Thus flexibility and agility reinforce the proposition of responsiveness being the one dimension of QR.

(2) Reliability

Reliability is something which is truly related with the quality or authenticity of supply chain management procedure and more importantly it ensures the continuous optimization of QR. The consumer driven approach of supply chain brings out the new perspective of quality - total quality management (TQM). It encompasses the core concepts which are known as the heart of quick response [19]: customer focus, error prevention, cost of quality, right first time or zero defects, acceptable quality level, competitive benchmarking, involvement to everyone, synergetic partnerships and team work etc. Youssef et al [25] argued that TQM is not only a quality related issue but it also measure the ability of firm to be a time based competitor. Therefore, TQM stimulates quick response culture through recognition, awareness, problem, ownership, and involvements which are known as core of developing reliability.

(3) Resilience

Risk management becomes the most prioritize area of every supply chain management business process. Supply chain; in general, use to experience continual turbulence, creating a potential for unpredictable disruption. The reason of experience the turbulence may vary from different perspective but causes complexity in supply chain. Therefore, the concept of resilience comes forward which measure the capacity of an enterprise to survive, adapt, and grow in the face of turbulent change. According to [5], *"resilience is the ability of a system to return to its original state or move to a new, more desirable state after being disturbed"*. For an effective and efficient quick response strategy in business process, value chain should be supported by adequate and sufficient resilience in terms of flexibility, redundancy, robustness and risk management. It is urgency to have sufficient resilient to resist disruptions, respond quickly and fulfill customer day to day demand changes to make quick response truly successful. In this sense, for managing and mitigating the vulnerability of supply chain, the concept of resiliency promoted as another dimension of quick response.

(4) Relationship

To be efficient and more structure oriented, the development of supply chain relationship is more emphasized by quick response perspective. And the relationship is mainly based on collaboration, partnerships, integrations and information sharing.

The performance of a supply chain depends much on alliances and relationships and mutual understanding or compromising ability of different role player. Competition is now between mutual networks rather than individual firms [4]. The co-ordination and relationships between these various entities is a matter for strategic consideration. From a QR perspective, the web of relationships and mutual networks upon which the organization depends, requires a professional management approach, and increasingly firms are devoting staff and other resources to this task [19]. Apparel manufacturers operate within a distribution channel with suppliers, retailers and consumers. Relationship in an apparel value chain could be inter-organizational at same or different levels (integration -horizontal or vertical respectively or collaboration), intra-organizational (collaboration based on organizational culture) or with customer (customer focus).

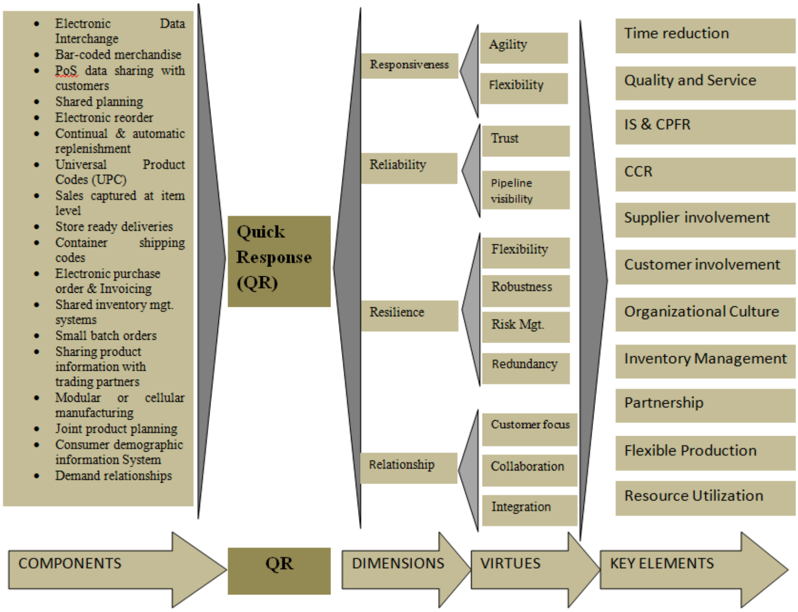


Fig. 55.4 QR strategy empowered by its components and headed towards customer response throughout its dimension, virtues and key elements

55.4 Quick Response Implementation

The volatility of today's fragmented and intensely competitive marketplace is the obstacle to understand the customer demand and offer them the right product at the right place. Even consumers have never been more sophisticated. They wish to be fully satisfied by purchasing an item. In this perspective, QR offers a wealth of opportunity to the partners of SCM but the matter is to be adopted with this systematic approach. Analysis of number of studies [9, 11, 13, 14, 19, 26] on implementation of QR in apparel supply chain shows that there are some drivers; (1) viable supply chain partnership (2) advanced manufacturing techniques (3) QR related information sharing (4) QR organization (5) Bar code technologies and electronic communication; which are successfully subjected for QR implementation (QRI). And each driver is constructed by their elements or tools to manage the customer-demand driven SCM. In the following figure it has been seen that the excellence of supply chain is inspired by five categories of QR where the ultimate outcome is customer satisfaction as well as financial benefits.

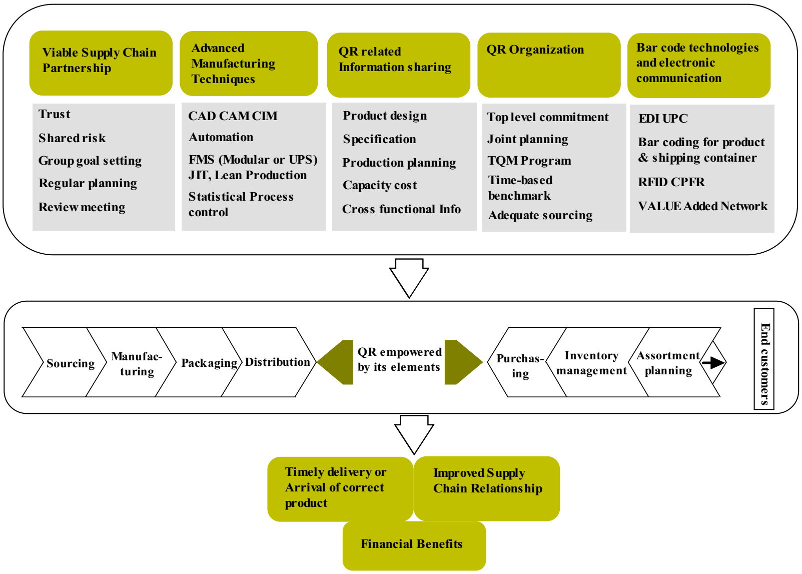


Fig. 55.5 Five basic drivers of QRI for apparel supply chain empowered by its tools

55.5 Conclusion & Further Work

This research work makes a sense of QR definition, its background and the area it covers under the paradigm of apparel supply chain. The findings can be summed up in some words: *a effective business strategy that works on wider spread area of marketing management and better suited on changing nature of competitive market place and generates responsiveness to customer demand, encourages business relationship and reliability with adequate resiliency of risk avoidance and ensures effec-*

tive use of resources and shortening the cycle of SCM business process. Therefore, this methodology consists of its components and split up into different dimensions, virtues and elements, allows more customer oriented SCM.

This research work struggled to comprehend theoretical frame work of QR and intended to show how an organization and its supply pipeline could adopted with its components and become benefited by practicing through different dimensions of QR.

Anyway, this research work needs further validation by empirical case studies conducted through various questionnaires and surveys. It is also essential to take a measure of time and expanses for the implementation procedure throughout the entire value chain.

References

1. Bertolini M, Bevilacqua M, Bottani E et al (2004) Requirements of an ERP enterprise modeller for optimally managing the fashion industry supply chain. Journal of Enterprise Information Management 17:180–189
2. Bernardes ES, Hanna MD (2009) A theoretical review of flexibility, agility and responsiveness in the operations management literature: Toward a conceptual definition of customer responsiveness. International Journal of Operations & Production Management 29:30–53
3. Birtwistle G, Fiorito S, Christopher M (2006) Supplier perceptions of quick response systems. Journal of Enterprise Information Management 19:334–345
4. Christopher M (2005) Logistics and supply chain management: Creating value-added networks. 3rdn, Pearson education
5. Christopher M, Lee H (2004) Mitigating supply chain risk through improved confidence. International Journal of Physical Distribution & Logistics Managemen 34:388–396
6. Debasis D (2003) Supply chain management: An integrated solution to apparel industry. Journal of Apparel Association, July-August
7. Ericsson D (2003) Supply/demand chain management: The next frontier for competitiveness. Waters D: Global Logistics and Distribution Planning
8. Fernie J, Azuma N (2004) The changing nature of Japanese fashion: Can quick response improve supply chain efficiency? European Journal of Marketing 38:790–808
9. Fiorito SS, May E, Straughn K (1995) Quick response in retailing: Components and implementation. International Journal of Retail & Distribution Management 23:12–21
10. Fiorito SS, Giunipero LC, He Y (1998) Retail buyers' perceptions of quick response systems. International Journal of Retail & Distribution Management 26:237–246
11. Giunipero LC, Fiorito SS, Pearcy DH et al (2001) The impact of vendor incentives on quick response. The International Review of Retail, Distribution and Consumer Research 11:359–376
12. Ko E, Kincade DH (1997) The impact of quick response technologies on retail store attributes. International Journal of Retail & Distribution Management 25:90–98
13. Ko E, Kincade D, Brown JR (2000) Impact of business type upon the adoption of quick response technologies: The apparel industry experience. International Journal of Operations & Production Management 20:1093–1111
14. KSA (1998) Response implementation: Action steps for retailers, manufacturers and suppliers. Kurt Salmon Associates, Atlanta, GA
15. KSA (1996) Floor-ready merchandise is a win-win. RIS News, March.
16. KSA (1997) Quick response mandate today. Apparel Industry Magazine, March
17. KSA (1997) Quick response: Meeting customer needs. Kurt Salmon Associates, Atlanta, GA

18. Knorr R, Neuman J (1992) Quick response technology: The key to outstanding growth. Journal of Business Strategy 13:61–64
19. Lowson B, King R, Hunter A (1999) Quick response: Managing the supply chain to meet consumer demand. Wiley, Chichester
20. Perry M, Sohal AS (2000) Quick response practices and technologies in developing supply chains. International Journal of Physical Distribution & Logistics Management 30:627–639
21. Wong CY, Hvolby H (2007) Coordinated responsiveness for volatile toy supply chains. International Journal of Production Planning & Control 18:407–419
22. Stank TP, Daugherty PJ, Autry CW (1999) Collaborative planning: Supporting automatic replenishment programs. Supply Chain Management 4:75–85
23. Gunston R, Harding P (1987) QR: US and UK experiences. Textile Outlook International 10:43–51
24. Kritchanchai D, MacCarthy BL (1999) Responsiveness of the order fulfilment process. International Journal of Production & Operations Management 19:812–833
25. Youseff MA, Boyd J, Williams E (1996) The impact of total quality management on firms' responsiveness: An empirical analysis. Total Quality Management 7:127–144
26. Perry M, Sohal A, Laney R (2002) An Australian quick response supply chain model. Department of Management, Faculty of Business and Economics, Monash University, Working paper

Chapter 56
The Development Trend and Strategy of Computer Industry based on SCP Analysis

Ke Liu

Abstract This paper analyzed the computer industry development trend based on SCP model in terms of the structure, conduct and performance. The finding shows that there are several product segments and also the technology is going onwards quite quickly which makes the prices go down quickly when the new, better products are introduced. Also smart phone markets and laptop markets are getting closer to each other. The emerging markets have more rapid economic growth than the developed ones and the computer sales are going hand in hand with the GDP. This would suggest that the growing markets will be very potential ones for the industry in the upcoming years.

Keywords Development trend · Computer industry · SCP analysis

56.1 Introduction

Computer industry includes not just only desktop Personal Computers and laptops that comes first in mind but also market segments including rack/blade servers, workstations, tablets, industrial computing, storage systems, networking equipment's, large amount of software and peripherals. Also handsets such as GPS devises and smartphones can be included as a market segment under the computer industry. Another significant market that should not be forgotten is the OEM products, where the customer uses parts of the computer firms' products creating its own end products. Typical example for this is medical equipment's, such as x-ray devices that are operated via computer.

K. Liu
School of International Business, Beijing Language and Culture University, Beijing 100083, P. R. China
e-mail: liukblcu@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_56, © Springer-Verlag London 2013

56.2 Computer Industry Overview

Computer industry is one of the fastest growing industries in the world, thus it will be interesting one for analyzing the current trends. The industry has reached its maternity and has not been influenced too much by the recent economic downfalls. PC's are the main tools for the employees in large amount of companies therefore they cannot work properly without them and are forced to buy new ones when the previous ones are getting too old to function properly or in other words, are not efficient enough for the employees to perform well in their work [1].

Many of the consumers especially in the developed countries are handling most of their important private life tasks with the computer and if the old one happens to break down or their find attractive discount, they might quite easily get new one. Also large market areas have developed quite quickly in the past few years and created higher market demand for computers. Especially China has been forecasted to be the major driver for the PC industry's growth for the next years.

Laptops are increasingly taking over the consumer market from desktops since they are quite flexible and easy to take along for the increasing amount of travelling that people do and the increasing amount of information that can be saved or searched via internet to one's computer. Especially among the younger consumers, laptops have replaced the function of TVs, DVD and music players as well as cell phones in a way for the cheap choice of communicating with friends.

Although mobile industry is getting closer to the computer industry by its new smart phones that allows consumers to do almost everything that you could do with mini laptops. Besides, mobiles are even handier to take along plus you can easily take pictures with them [2]. Anyhow, these two industries are still seen as separate ones with different producers, despite few trials for example when Nokia tried to start producing mini laptops couple years ago and Dell's recent try bring its own smart phone to the market. Either of them does not seem to have any comparative advantage on their new products and therefore it is most likely that the production costs will remain too high to enter the new market with fairly competitive prices. Another fact influencing the prices is that the value of the new products depreciates quite quickly since high speed of product development [3].

Since extend of the various products within the computer industry it is easier to describe the industry by segments.

56.3 SCP Model

The existence of a large domestic consumer base often helps to develop and distribute innovative products. When meeting the domestic customer's need a company can develop the products that can be marketed also internationally. Bigger company can easily attract local suppliers to meet the industry's growing needs. When located close they can easily exchange cost-saving ideas and inventions. If company has faced successfully competed in the domestic markets they have more strive to

Table 56.1 Top 5 vendors, worldwide PC shipments, third quarter 2011 (preliminary) (units shipments are in thousands)

Rank	Vendor	3Q11 Shipments	Market Share	3Q10 Shipments	Market Share	3Q11/3Q10 Growth
1	HP	16,652	18.1%	15,811	17.8%	5.3%
2	Lenovo	12,579	13.7%	9,242	10.4%	36.1%
3	Dell	11,007	12.0%	11,183	12.6%	−1.6%
4	Acer Group	9,207	10.0%	11,592	13.1%	−20.6%
5	ASUS	6,002	6.5%	4,610	5.2%	30.2%
	Others	36,432	39.7%	36,241	40.9%	0.5%
	All Vendors	91,879	100.0%	88,679	100.0%	3.6%

Source: IDC Worldwide Quarterly PC Tracker, October 12, 2011.

reduce costs, boost product quality, raise productivity and develop innovative products. On the other hand Apple has been very successful in its domestic markets and more likely will be gaining more market share globally [4].

Structure-Conduct-Performance model is established by industrial economist Bain and Scherer in Harvard University in the 1930s. This approach is developed to understand relationship among a firm's environment, behavior and performance.

56.3.1 Structure

Among the computer industry the competition is quite hard even though the market concentration ratio is quite, which means the Oligopolistic competition. Even if the top 5 companies share about half of the worldwide market share their products aren't that differentiated from each other that would allow them to charge higher prices in order to earn more profits. The name of the game seems to that the one that can reduce the production costs enough will gain the highest profit. Of course this does not really apply in Apple's case but it is not in the top 5 in the worldwide market shares yet. Its advantage is in the way it has differentiated its product rather by looks than content. There are no direct substitutes with the same look in the market, whereas other companies' products are looking more or less the same. Also Apple's customer base is bit different as it is mostly concentrated on the private consumers rather than companies unlike HP and Dell for example [5].

As a matter of fact HP announced it will quit producing laptops in the future and will concentrate on the servers where it is clear market leader at the moment. This decision makes sense since the profits from laptops where the competition is hard from the customer are quite low, whereas companies are still willing to pay more from bigger servers that are base for the whole IT and information flow and storage within a company [6]. There is clearly no use of doing almost zero profit sales with the laptops if it is possible to gain lot more with other products. Actually HP might have been one the reason itself why the prices have gone so low with its aggressive pricing. This is clearly good news for the other companies but we will see if the consumers will feel the same [7].

What is good thing is that the computer sales have been increasing quite fast every year so that there will be increasing demand for the products in the future which allows new companies to enter or the existing ones to produce more. The entry costs might be quite high since the research and development that the existing firms have already invested in it over the year.

56.3.2 Conduct

Conduct includes pricing, advertising, research and development investment, as well as decisions on product dimensions, merger and acquisition. Obviously computer companies are pricing their products differently for different customer based on their willingness to pay. Economically this is called price discrimination. In addition they will have different pricing strategies in different market areas and for different products. When some are easily sold with very little profit, the others are sold with higher prices. This is due to the fact than in other products the competition is very hard if there is no comparative advantage to sell it and then again if other products are not available from other suppliers the price can be less elastic. Good example is the good design from Apple that attracts some the consumers and some of the customized servers that only Dell can offer for its customers.

Marketing is part of the strategy that some companies are using more than the others. Especially Apple has done well with marketing its products and gained a good image for its products whereas Dell can be hardly ever seen advertised for consumer as its main focus is company customers. HP advantage has been its low price on the laptops but now that Acer also offers cheap laptops with even better performance, it must have taken some of the market share from HP. In the long run the product differentiation with price might not be the best solution but rather leads into price war with other producers. This on the other will not benefit anyone, maybe some producers will be pushed away from the markets and rest will earn very little profits. In a result, conduct can have effect into the market structure [8].

Conduct might also have effect on the performance depending on how much and how efficiently money is spent on the marketing and research & Development.

56.3.3 Performance

Performance analysis can be done in two levels: specific firm based in a similar way than SWOT analysis or in a society level. Competitive disadvantage, competitive parity and competitive temporary or sustained competitive advantage can be studied in the firm level. In a society level productive and allocative efficiency and level of employment can be studied.

The performance of an industry or firm is measured simplest by its profitability. It can be influenced through changing costs or prices or external shocks such as changing customer preferences or economic situation. Profitability can also be affected by a firm's ability to adjust, for example changes in market demand. Research and development, and availability of capital and resources are factors that greatly influence whether or not a firm is agile enough.

Apple is another success story here as its products account about 35% of its operating profits. None of the others gain even nearly as much profits.

56.3.4 Marketing Mix

The four P's for marketing mix is Product, Pricing, Promotion and Place. As mentioned earlier in the paper the components inside the computers are basically the same. What companies can do to differentiate their products is to change its design to be more appealing for the consumers. New light in weight and thin Apple laptops are obviously more attractive.

Dell tried to differentiate by the fact that customers are able to customize their products in the every single detail. Therefore Dell has no warehouses were there would products waiting for sales and suppliers are ordered to sign contracts that they have to deliver components within a short warning, therefore storage them close to Dell factories. Sometimes happens that they are not able to deliver the components after all and this might lead to extended delivery times. Actually delivery times are quite in the beginning with since the products are produced when ordered and nowadays mostly in China from the delivery takes a quite long time and it is not that cheap. Therefore even Dell has tried to promote few ready products in order to cut the costs and sell cheaper products as many others are doing.

HP and Acer on the other hand have quite similar products what it comes to the laptops so their strategy has been trying to produce and sell as low price as possible. This can be seen from the rather low profits once again. Since Acer has gained more of the market share and the competition with price is no longer reasonable, HP have decided to concentrate on the sales of servers where Dell has performed quite weakly in some market areas. It will be interesting to see if Lenovo and the others will come up with some new products ideas in the future that will allow them to capture more from the market share.

As for the pricing the basic economic assumption that can be applied also for oligopolistic markets is Nash equilibrium. In shortly it means that each firm is doing the best it can given what its competitors are doing. Because of that it is essential to understand opponent's point of view and to deduce their likely responses to one's own actions. In most cases the one that makes the first move has a clear advantage except in the market with differentiated products where the second mover has the possibility to undercut the price a bit and therefore to capture bigger market share.

Another fact should not be forgotten when doing pricing is to divide the customers in to correct segments as the pricing strategies, as well as the product preferences will obviously be quite different for the public customers and private consumers. Also customer preferences might vary among the different market areas due to cultural facts.

Pricing itself is not enough but the products should be promoted in efficient way that customers are aware of them. There are four elements in the promotion mix: advertising, personal selling, sales promotion and public relations. Marketing is considered to be the most important one. And as mentioned before, Apple has been quite successful with its message to the consumers whereas Dell is hardly advertising at all but concentrating highly on the personal sales. There is various ways of advertising via different Medias and second thing that needs to be decided whether the advertisements should be local or global ones. Personal selling creates more close relationship with the customer and as it can be imagined it is not profitable to sale this way for the every single customer. But this works when selling bigger amounts at the time for other companies no matter if they were public or private. Also in that the way the sales persons are very well aware of their own countries local culture, norms, customs and are gaining important knowledge about the market conditions. But still it is relatively high-costly strategy and as for Dell, they have tried to improve their e-commerce pages so that they could customize pages for the each customer to buy straight from there which makes more time for the sales persons to contact new customers instead of only dealing with existing ones. Also there are few local resellers around that are selling consumer products for the private people. But then again resellers always need their own profits so that the products cannot be sold with very high price on that channel.

Last P in the marketing mix was Promotion and that always works well in any industry. If you promote your products to sell them cheaper than normally, you will increase the revenue but once again, it is cut from the profit. Especially Dell has couple times a year email promotions during the lower sales months in order to increase the sales and/or attract new customers. There is also fair for the resellers in order to make them aware of the new products and how to sell them for the consumers.

56.4 Conclusions

Even if the market concentration rate would suggest that the computer industry is oligopolistic where higher profit should be earned this is not the whole truth. As we have seen there is several product segments and surely the profits can be earned some of them but all. Also the technology is going onwards quite quickly which makes the prices go down quickly when the new, better products are introduced. Also markets smart phone and laptop markets are getting closer to each other. For example there is new comer in the consumer markets seems to Samsung that has been so far producing smart phones. The growing computer industry is high likely to attract other smart phone producers to the market at some point.

The emerging markets have more rapid economic growth than the developed ones and as Deutche Banke's studies are showing the computer sales are going hand in hand with the GDP. This would suggest that the growing markets will be very potential ones for the industry in the upcoming years. Figure below illustrates the PC's per 1000 persons in different markets. The second one shows the percentage growth of the penetration among the region. We can see that the emerging markets are in a growth there.

Acknowledgements This paper is sponsored by Beijing Language and Culture University "Twelfth Five-year plan" project, No. 11GH05 (research on the internationalization of RMB).

References

1. Griffin R, Pustay M (2001) International business, a managerial perspective. 3rd edn, Prentice Hall, New Jersey
2. McWilliams A, Smart DL (1993) Efficiency v. structure-conduct-performance: Implications for strategy research and practice. Journal of Management 19:63–78
3. Pindyck R, Rubinfeld D (2010) Microeconomics. 7th edn, Pearson Education Asia Ltd, Beijing
4. Eisenhardt K (1995) Accelerating adaptive processes: Product innovation in the global computer industry. Administrative Science Quarterly 40:84–90
5. Berry T (2005) Entrepreneur: Conducting a market analysis for your business plan. http://www.entrepreneur.com/article/78002
6. Tabini M (2011) Macworld: Apple leads PC industry in profit share, analysts say. http://www.macworld.com/article/150051/2010/03/apple profit. html
7. Mayer K (2004) Learning to contract: Evidence from the personal computer industry. Organization Science 4:394–410
8. IDC (2011) Worldwide PC market grapples with slow growth in third quarter as Lenovo rises to number 2 position, according to IDC. http://www.idc.com/getdoc.jsp?containerId=prUS23087711

Part VI
Project Management

Chapter 57
Organizational Commitment and Counterproductive Work Behavior: Role of Employee Empowerment

Afsheen Fatima, Muhammad Zahid Iqbal and Rabia Imran

Abstract The current study was aimed at finding the role of employee empowerment in increasing organizational commitment and reducing counterproductive work behavior. A purposive sample of 302 respondents from the call centers of Pakistan was selected for the study. Structural equation modeling technique was used to test the hypotheses. The results exhibit that employee empowerment is significantly and positively associated with organizational commitment. The results also exhibit negative and significant impact of employee empowerment on counterproductive work behaviors. Implications of these findings are discussed, and suggestions are made for future research.

Keywords Employee empowerment · Organizational commitment · Counterproductive work behavior

57.1 Introduction

Empowerment is considered as a feeling of power and control within the person [63]. Empowerment when conceptualized in psychological aspect; is an individuals' inner and personal experience. Empowered individuals select their own ways,

---

A. Fatima (✉)
University Institute of Management Sciences, PMAS Arid Agriculture University, Rawalpindi 46000, Pakistan
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology (SZABIST), Islamabad 46000, Pakistan
e-mail: Afsheen@uaar.edu.pk

M. Z. Iqbal
COMSATS Institute of Information Technology, Islamabad 46000, Pakistan

R. Imran
University Institute of Management Sciences, PMAS Arid Agriculture University, Rawalpindi 46000, Pakistan

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_57, © Springer-Verlag London 2013

and remain committed to it. Scholars analyzed that empowered individuals prove themselves highly effective in their job, able to deal with adversity, more inclined to experience novel things, and ready to make important changes when asked to do so [21]. Employee empowerment can be defined as allowing people to participate in organizational decisions by increasing their autonomy in decision making [65]. It refers to "the breaking down of traditional hierarchical structures" [10]. Therefore, employee empowerment is described as shifting decision-making authority/power down hierarchical levels. It is not mere delegation but this transfer of authority is backed by providing the requisite resources, knowledge and skills for its effective implementation.

Empowered workers sense control over major portions of their job; therefore are more optimistic, concerned, and committed [63]. They are less likely to leave the job as compared to non-empowered employees [58, 66]. Organizational commitment is considered to be a main upshot of employee empowerment. Past researches reveal that individual's perceptions are attached to the anticipated value or incentives from the job [71]. Organizational commitment refers to "a psychological state that binds the individual to the organization". Individuals carrying greater degree of Organizational commitment are believed to be devoted and productive at work [64].

Employees enjoying higher autonomy on the job have little chance of being alienated [54] or withdrawn [1]. Counterproductive work behavior refers to practices that harm or intend to harm organizations and/or its people [56]. Such behaviors are "voluntarily acts that violate organizational norms, thereby, threatening the well-being of members and the organization itself" [47].

Past literature exhibits lack of empirical evidence on relationships between employee empowerment, organizational commitment and counterproductive work behavior. Therefore, the present study attempts to contribute toward theoretical developments by providing empirical evidence on posited relationships. Moreover, most of the existing work on organizational commitment has been carried out in the west [61]. The current study in an attempt to elucidate these constructs in an Asian context that is Pakistan, where a collectivist culture dominates [25]. The current study is important because of its indigenous nature as well. Culturally, Pakistan is one of the collectivist societies [25].

Yip [72] has pointed out that western and eastern societies differ in respect of perceptions regarding empowerment as the western culture advocate and promote democracy. Empowerment, however, is debatable in the Asian society, that conventionally promotes the culture of compliance, tolerance, and hierarchy and modesty, therefore, situating this study here is likely to reveal unusual findings. However, few studies have been carried out on organizational commitment [62] and counterproductive work behavior indigenously [13], but there is lack of significant work on these constructs together as well as in relation to employee empowerment. The main objective of the study is to analyze the (positive and negative) effects of empowerment on organizational commitment and counterproductive work behavior.

57.2 Literature Review and Hypothesis Development

57.2.1 Empowerment

Empowerment refers to the enrichment of individuals' autonomy in their jobs. It also refers to greater participation leading to increased decision making that is also beneficial for the organization [68]. It is the way through which individuals are equipped with the necessary assistance, direction and expertise to enable autonomous decision making [19]. Empowerment can be conceptualized in two different aspects, i.e., psychological empowerment and empowerment climate [59, 63]. Psychological empowerment is the psychological perception or feelings of workforce regarding their job and role in organization [59] whereas, empowerment climate is shared opinion regarding the degree to which organizations utilize their policies, practices and structures that facilitates in the workforce empowerment [52]. The concept of psychological climate has gained importance in the past few years. Literature [63] maintains that employees do not experience empowerment unless they feel that their actions have considerable weightage in organizational decision making.

Conger and Kanungo [15] have argued that without a feeling of self-belief in ones' own skills, employees cannot experience empowerment. When employees feel that they just have to work according to the instructions of their seniors they experience a lack of empowerment [67]. Empowerment was found to be associated with some of variables such as: customer service [29] and permanence of the job [17, 28]. However, it was found to play a mediating role in the relationship between work attitudes and organizational empowerment, as well as organizational environment and consequent behavior [32].

Thomas and Velthouse [63] have argued that recently employee empowerment has received attention, as organizations are making more and more efforts to compete in an increasingly competitive external environment. Brockner and Wiesenfeld [12] found that as organizations are following strategy of downsizing. They need to work with the few left ones. In such a situation, empowerment is found to be one of the powerful tools in utilizing employees' full potential.

57.2.2 Organizational Commitment

Organizational commitment has been conceptualized as "A psychological state that binds the individual to the organization" [2]. It is also described as worker's investment in the workplace in the form of the time, work amity, job-related expertise, and job effort [7]. Majority of scholars have attempted to find the outcomes of organizational commitment. For instance, it has been found to be a source of numerous positive outcomes including job performance and satisfaction [45]. Felfe et al [17] have found that highly committed individuals exhibit high level of organizational citizenship behavior to sustain their current employment status. Low organizational commitment leads to turnover, intention to leave; searching for alternatives outside of organizations [41]. It may also reduce organizational citizenship behavior [50, 70]; higher absenteeism and tardiness; increased turnover rate and turnover intention; inferior performance that has a negative impact on effectiveness and organizational efficiency [8, 38]. Organizational commitment was found to be low in temporary workers as compared to permanent individuals [28, 34]. Individuals with greater organizational commitment were found to be more satisfied and were more expected to take part in their organization's competitive advantage [44, 51, 71].

Keeping in mind its significance, few scholars have tried to explore the factors leading to organizational commitment. Organizational Commitment is composed of three factors; affective, normative and continuance commitments. Affective commitment refers to an emotional attachment; normative refers to obligation to remain with organization and continuance commitment refers to recognition of cost associated with leaving organization [42].

Organizational commitment is argued to be a key outcome that will be influenced by employee empowerment. Past studies on organizational commitment and empowerment have demonstrated that individual's perceptions are attached to anticipated value or incentives from the job [71]. Empowered workers sense control over major portion of their job; therefore are more sanguine, concerned, and committed and create increasing sense of self-efficacy or an admiration of their capabilities and expertise [63]. Empowered employees are found to be involved in several positive work attitudes like they are more committed, innovative, productive and satisfied. They have fewer turnovers as compare to non-empowered employees [58, 66]. A positive relationship was found to exist among empowerment, job satisfaction, and organizational commitment [36, 39]. Empowered and committed employees are considered to be an asset for the successful and effective functioning of contemporary organizations [29]. There are empirical evidences that empowered workforce is highly organizational committed [29]. Studies have shown that workforce having a "say" in their work were more committed and motivated to perform whatever was required [37]. From the reasoning above it is hypothesized that

Hypothesis 1. More is the empowerment higher is the organizational commitment.

57.2.3 Counterproductive Work Behaviors

Counterproductive work behavior is defined as "any act by a member of an organization that is very likely to do harm but no benefit to other members of the organization or the organization as a whole" [40]. In organizational context, behaviors have special place. If not dealt properly, they can have harmful effects in the form of counterproductive work practices that may badly hurt the organizations in terms of both cost and time and is a main issue in most of the organizations nowadays. Counterproductive work behavior includes acts such as theft [20], revenge [9], workplace violence and aggression [6, 27], sabotage [3], service sabotage [23] and incivility [4]. Organizations are aiming at developing strict rules to avoid such practices.

Employees exhibit counterproductive behavior through different ways, i.e., idleness, lethargy, taking long breaks than actually they are allowed to take, theft, sabotage, malingering, and other detrimental acts. These actions can potentially bring adverse consequences to the organization if not handled properly. Thus, while taking a managerial view, literature [9, 46] has highlighted the dysfunctionality of this behavior.

Counterproductive behavior is found to be linked with different nature of costs, such as; financial costs [46]; personal costs [49] and organizational costs [48]. Spector et al [57] have developed a taxonomy of CPWBs dividing counterproductive behaviors into: abuse-malicious actions affecting others; production deviance-intentionally doing incorrect work or letting blunders to transpire; sabotage-obliterate workplace property; theft-taking the goods of other employees or employer; and withdrawal-evading work. Employee's perception of work is significant as it affects the capability of the employees to have control of their job [5, 59]. Employee empowerment can increase an employee's sense of control and improve employee commitment [69]. Because a sense of empowerment helps individuals experience greater personal control over their own work, thus it assists them in reducing counterproductive work behaviors. It is therefore hypothesized that

Hypothesis 2. More is the empowerment less would be the counterproductive work behavior.

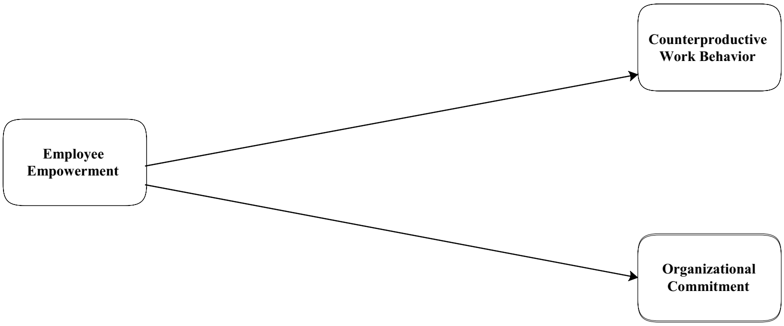


Fig. 57.1 The research model

57.3 Method

57.3.1 Participants and Procedures

A purposive sample of 302 respondents from call centers of Pakistan was selected for the study. Participants were approached after taking prior permission from their human resource departments. They were told that this task will not take more than 20 minutes. They were also briefed about the study objective, and ethical issues. The instrument contained two parts. The first part took responses from the employees on the study variables. However, the other part elicited demographic information. The sample constituted of 60 percent males and 40 percent females. Majority of respondents were from the age group of 18-35 years.

57.3.2 Measures

All items were scaled on five points, i.e., from strongly disagree = 1 to strongly agree = 5. Following measures were used for the study:

1. **Organizational Commitment**. An eight-items scale developed by Mayer and Allen [43] was used to measure the variable.
2. **Employee Empowerment**. Perceptions of empowerment were measured with a scale developed by Spreitzer [59]. The scale contained three items.
3. **Counterproductive Work Behaviors**. Eighteen-items scale developed by Spector et al [57] was used to measure the perceptions of counterproductive work behavior.

57.3.3 Data Analysis Approach

Structural equation modeling was used to conduct data analysis. This is a multivariate statistical technique employed to ensure the causal relations among latent constructs. The analysis was carried out in AMOS 18. Major benefits of using structural equation modeling are: attaining calculations on model fitness (means fit of the data to the theoretical model), demonstrating reliability and validity of the constructs, evaluating relations between observed and latent variables, and estimating the multiple relationships at one point in activity [24]. Structural equation modeling follows a two-step procedure [4] the measurement model with confirmatory factor analysis, and the structural model [35].

In the present study, prior to testing structural model, a measurement model was assessed to ensure the relationship between latent variables and the manifest items that serve as their indicators. The process of improvement indices was carried out through modification index in two steps. Firstly the items having insignificant values or having low loadings were deleted. Modification index was used to select indicator variables [26]. Through repeated filtering, some indicator variables were deleted on the basis of either their insignificance or low loadings. Secondly, modification indices were applied on the basis of co-variances.

57.3.4 Model Fitness

Dozens of model fit indices are available but applying all at one time is not recommended [30]. Therefore, the authors used model fit measures according to their general classification as: (1) absolute fit indices, (2) incremental fit indices and (3) parsimonious fit indices [24]. Table 57.1 reveals good and appropriate fit of the measurement and structural models respectively. Benchmarks for different model fit indices have also been in Table 57.1.

Table 57.1 Model fitness

Fit indices	Baseline Model	
	Measurement Model	Structural Model
Absolute Fit Indices		
χ^2 / df	1.683** (651.490/387)	1.698*** (612.807/361)
GFI	0.877	0.880
RMSEA	0.048	0.049
Incremental Fit Indices		
NFI	0.891	0.896
RFI	0.878	0.883
IFI	0.953	0.954
TLI	0.947	0.948
CFI	0.952	0.954

$*p < 0.05, **p < 0.01, ***p < 0.001$.

The benchmarks are: for $\chi^2/df(< 2, < 3, \text{or} < 5)$; for GFI, NFI, RFI, IFI TLI, and CFI (1 → perfect or exact fit, close to or > 0.90 or > 0.95 → good fit, and 0 → no or poor fit); for RMSEA (0 → perfect or exact fit, < 0.05 or between 0.05 to 0.08 → good fit, 0.08 to 0.10 → mediocre fit, and > 0.10 → poor fit) [14, 24].

57.3.5 Reliability and Validity

Cronbach's alphas and composite reliability coefficients were computed to confirm the inter-item consistency among the items. The reliability of three constructs was found to be acceptable, as the values were greater than 0.60 [60] and 0.70 [33] respectively. Convergent and discriminant validities were also computed to confirm the constructs' validity. Convergent validity was confirmed as all items significantly loaded on their respective construct. Discriminant validity was confirmed through the square root of each construct's average variance extracted ($\sqrt{AVE}$). The values of which, for all the three constructs were found to be greater than its correlations with other constructs [33]. Table 57.2 exhibits the descriptive statistics, reliabilities, validities, standardized loadings and correlations for all the three constructs of this study.

Table 57.2 Descriptive statistics, reliabilities, standardized loadings, validities, and correlations

Measures	M	SD	Cronbach's α	Standardized Factor Loadings*	Composite Reliability	Correlations		
						1	2	3
					N = 302			
Employee Empowerment	4.26	0.68	0.60		0.61			
EE1.				0.657^{***}				
EE2.				0.480^{***}				
EE3.				0.591^{***}				
Counterproductive Work Behaviors	1.72	0.90	0.95		0.96	-0.333^{***}		
CPWB1.				0.731^{***}				
CPWB2.				0.734^{***}				
CPWB3.				0.748^{***}				
CPWB4.				0.634^{***}				
CPWB5.				0.636^{***}				
CPWB6.				0.638^{***}				
CPWB7.				0.795^{***}				
CPWB8.				0.800^{***}				
CPWB9.				0.804^{***}				
CPWB10.				0.600^{***}				
CPWB11.				0.857^{***}				
CPWB12.				0.831^{***}				
CPWB13.				0.864^{***}				
CPWB14.				0.883^{***}				
CPWB15.				0.854^{***}				
CPWB16.				0.903^{***}				
CPWB17.				0.913^{***}				
CPWB18.				0.855^{***}				
Organizational Commitment	3.68	0.63	0.70		0.72	0.174^{**}	-0.037	
OC1.				0.429^{***}				
OC2.				0.464^{***}				
OC3.				0.430^{***}				
OC4.				0.463^{***}				
OC5.				0.433^{***}				
OC6.				0.632^{***}				
OC7.				0.427^{***}				
OC8.				0.460^{***}				
$\sqrt{AVE}$						0.580	0.788	0.472

$*p < 0.05, **p < 0.01, ***p < 0.001$.

57.3.6 Data Analysis Approach, Preparation, and Editing

The authors conducted preliminary data analysis including normality analysis, identified outliers, and ensured the sample adequacy, before analyzing the confirmatory and structural models [31]. All items provided the absolute value of kurtosis less than 10 [22], thus, satisfying the univariate normality assumption. The authors assessed the outliers through Mahalanobis D^2 statistic [14], however outliers were not found. The authors also satisfied the sample adequacy. Sekaran [53] suggested that a sample size greater than 50 and less than 500 is sufficient for the statistical analysis. Another recommended formula for the selection of sample size is $104+n[86]$, where n refers to number of independent variables, i.e., one in the present study [18].

57.4 Results

The authors examined the hypotheses using structural equation model exhibiting the effects of employee empowerment on organizational commitment and counterproductive work behaviors (Hypothesis 1 and Hypothesis 2 respectively). Table 57.3 shows the path coefficients for the hypothesized relationships. The hypotheses were tested by examining the completely standardized parameter estimates and their associated t-values. In general, estimates were consistent with expectation because both the hypothesized relationships were significant $(p < 0.001, p < 0.01$ and $p < 0.05)$ and in the expected direction. In sum, employee empowerment causes significant positive variation in organizational commitment, i.e., 27.6% (Hypothesis 1 is supported). On the other hand, employee empowerment explains significant negative variation in counterproductive work behaviors, i.e., −44.0% (Hypothesis 2 is supported). Thus, for the baseline model, overall results have managed to provide considerable empirical evidence on the proposed model.

Table 57.3 Results of hypotheses

Hypotheses	Relationships	Baseline Model
1. Organizational Commitment	← Employee Empowerment	$0.276**$
2. Counterproductive Work Behaviors	← Employee Empowerment	$-0.440***$

$*p < 0.05, **p < 0.01, ***p < 0.001$, ns = not significant.

57.5 Discussion

The aim of the study was to investigate the impact of empowerment on organizational commitment and counterproductive work behaviors. The present research has analyzed whether empowerment leads individuals towards organizational commitment or counterproductive work behaviors. Understanding the role of employee empowerment is essential for organizations in determining their employees' behaviors. Specifically, in current environment where managers are under pressure to involve their employees in decision making. Ken Blanchard, an American author and business maven suggest "as a manager the important thing is not what happens when you are there, but what happens when you are not there". Empowerment is considered as a feeling of power and control within the person that acts as a source of intrinsic task motivation for that person [63]. Power and empowerment are the related constructs. Scholars have maintained that empowerment efforts would work only when individuals have desire for [74]. Therefore, without having a desire to achieve power, empowerment efforts are useless. Employee empowerment means shifting decision-making authority down hierarchical levels while equipping individuals with the requisite resources, knowledge and skills. Only delegation does not produce empowerment when the individuals receiving the additional authority/power are not equipped. Therefore, preparing individuals to take responsibility is prior step to empowerment.

Empowered individuals select their own way; thus, remain committed to it because they themselves determined it. Scholars have analyzed that empowered individuals prove themselves highly effective in their job, able to deal with adversity, less disinclined to experience novel things, and ready to make important changes when asked to do so [21, 75].

First hypothesis anticipated a positive and significant impact of employee empowerment on organizational commitment. This hypothesis was substantiated as empowerment had a significant and positive impact on organizational commitment. This finding of the present research is in line with previous research studies [58, 66]. Empowered workers have control over job to a greater extent; thus are committed to have self-efficacy [63]. The current study was conducted on the employees of call centers. The service climate of call centers may greatly affect employee attitude and commitment to their call centers. Lux et al [76] suggest that service climate is closely related with an underlying emotional affective response, which in turn will shape service intentions and customer service behavior. Similarly, service climate facilitates the delivery of customer satisfaction through fostering higher levels of employee commitment. Therefore, it is in the interests of the call centers to empower employees and facilitate greater individual autonomy in the interests of boosting their service climate.

Second hypothesis anticipated a significant and negative impact of employee empowerment on counterproductive work behaviors. This hypothesis was also substantiated. Previous studies have considered managerial view towards such practices [9, 46]. While call centers can reduce the cost of existing functions, improve customer service facilities and offer new avenues of income generation. Anderson and

Jansson [73] concluded that the call centre industry is facing a poor reputation because of several reasons including low salary, tedious, boring, repetitive and droning work, high demands, low control, limited social support and few opportunities for participation and learning. Brown [77] suggests that the association between employees and the characteristics of work settings is not completely understood and given importance. Therefore, the present study also supports the idea of empowering employees in order to reduce counterproductive work practices.

57.5.1 Limitations and Future Research

The most obvious limitation of the current research is that it is limited by cost and time. Another limitation is the cross sectional design of the study. This study used one-dimensional measures of all the variables and should be viewed as a first step for future research that would be extended to employ different facets of these variables. In future impact of demographic variables impact may also be employed to examine the differences among different groups with respect to employee empowerment, organizational commitment and counterproductive work behaviors.

The above mentioned issues serve as suggestions for future research. There are several other characteristics of Human Resource Management, studying which in relation to employee empowerment, organizational commitment and spiritual leadership are equally beneficial. Several different moderating variables, e.g., transformational leadership, stress etc may also be made part of investigation of the present study's framework. For further research it is suggested to advance this study and examine this model by considering the dimensions of the current study's variables to have more in depth understanding of these constructs. In future, the best way to analyze these relationships would obviously be to conduct a longitudinal research design instead of cross sectional. This study may be replicated on other populations as this study was conducted on call center employees in Pakistan. In the current study data were collected from the single source it is suggested that to avoid the possibility of presence of common method variance, data may be collected by taking responses from both subordinates and supervisors.

57.5.2 Practical Implications

The findings of this study stress the importance of employee empowerment to enhance the organizational commitment of employees on the one hand, and diminishing counterproductive work behaviors on the other hand. This study has direct implications for keeping the employees committed. The employees should be trained about managing their stress while trusting their organizational leaders, owning their organizations and taking organizational problems as their own. This effort is expected to result in employees' satisfaction and increased organizational commitment at workplaces. Managers need to empower their employees and provide them with appropriate physical working environment in order to boost their commitment and minimizing the chances of their being involved in Counterproductive work practices. Productive behavior at work place is the most desirable behavior with reference to the Human Resources department of an organization. Productive work behavior may be encouraged by introducing incentives, additional benefit, salary raise, and promotions. Most employees do not know about counterproductive work behavior. In fact, they consider it as a normal behavior.

References

1. Abramson LY, Seligman ME, Teasdale JD (1978) Learned helplessness in humans: Critique and reformulation. Journal of Abnormal Psychology 87:49–74
2. Allen NJ, Meyer JP (1990) The measurement and antecedents of affective, continuance and normative commitment to the organization. Journal of Occupational Psychology 63:1–18
3. Ambrose ML, Seabright MA, Schminke M (2002) Sabotage in the workplace: The role of organizational injustice. Organizational Behavior and Human Decision Processes 89:947–965
4. Anderson JC, Gerbing DW (1988) Structural equation modeling in practice: A review and recommended two-step approach. Psychological Bulletin 103:411–423
5. Bandura A (1986) Social foundations of thought and action. Prentice-Hall, Englewood Cliffs, NJ
6. Barling J, Dupré KE, Kelloway EK (2009) Predicting workplace violence and aggression. Annual Review of Psychology 60:671–692
7. Becker HS (1960) Notes on the concept of commitment. American Journal of Sociology 66:32–40
8. Becker TE, Billings RS, Eveleth DM et al (1996) Foci and bases of employee commitment: Implications for job performance. Academy of Management Journal 39:464–482
9. Bies RJ, Tripp TM (2005) The study of revenge in the workplace: Conceptual, ideological, and empirical issues. Counterproductive Work Behavior: Investigations of actors and targets 65–81
10. Blanchard K (1997) Out with the old and in with the new. Incentive 171:59–61
11. Bowen DE, Lawler EE (1992) Total quality-oriented human resources management. Organizational Dynamics 20:29–41
12. Brockner J, Wiesenfeld B (1993) Living on the edge of social and organizational psychology: The effects of job layoffs on those who remain. In Murninghan JK (Ed.), Social Psychology in Organizations: Advances in Theory and Research. Prentice-Hall, Englewood Cliff, NJ
13. Bukhari Z, Ali U (2009) Relationship between organizational citizenship behavior and counterproductive work behavior in the geographical context of Pakistan. International Journal of Business and Management 4:85–92
14. Byrne B (2010) Structural equation modeling with AMOS: Basic concepts, applications, and programming. 2nd edn, Taylor and Francis, New York
15. Conger JA, Kanungo RN (1988) The empowerment process: Integrating theory and practice. Academy of Management Review 13:471–482
16. Cotton JL, Tuttle JM (1986) Employee turnover: A meta-analysis and review with implications for research. Academy of Management Review 11:55–70
17. Felfe J, Schmook R, Schyns B et al (2008) Does the form of employment make a difference? Commitment of traditional, temporary, and self-employed workers. Journal of Vocational Behavior 72:81–94

18. Gaur AS, Gaur SS (2009) Statistical methods for practice and research: A guide to data analysis using SPSS. Sage Publications
19. Geroy GD, Wright PC, Anderson J (1998) Strategic performance empowerment model. Empowerment in Organizations 6:57–65
20. Greenberg J (1990) Employee theft as a reaction to underpayment inequity: The hidden cost of pay cuts. Journal of Applied Psychology 75:561–568
21. Hardy C, Leiba-O'Sullivan S (1998) The power behind empowerment: Implications for research and practice. Human Relations 51:451–483
22. Harrington D (2009) Confirmatory factor analysis. Oxford University Press, New York
23. Harris LC, Ogbanna E (2002) Exploring service sabotage: The antecedents, types and consequences of frontline, deviant, antiservice behaviors. Journal of Service Research 4:163–183
24. Ho R (2006) Handbook of univariate and multivariate data analysis and interpretation with SPSS. CRC Press, New York
25. Hofstede G (2001) Culture's consequences: Comparing values, behaviors, institutions and organizations across nations. 2nd edn, Sage, London
26. Jöreskog KG, Sörbom D (1986) LISREL VI, analysis of linear structural relationships by maximum likelihood, instrumental variables, and least squares methods. 4th edn, Scientific Software, Mooresville
27. Kelloway EK, Barling J, Hurrell JJ (2006) Handbook of workplace violence. SAGE Publications, Thousand Oaks, CA
28. Kim J (2007) A comparison of organizational commitment, in-role, extra-role behavior of regular employees and irregular employees in hotel companies. Journal of Korean Academic Society of Hospitality Administration 39:61–79
29. Kirkman BL, Rosen B (1999) Beyond self-management: The antecedents and consequences of team empowerment. Academy of Management Journal 42:58–74
30. Kline RB (2005) Principles and practice of structural equation modeling. Guilford, New York
31. Kline RB (2011) Principles and practice of structural equation modeling. The Guilford Press, New York
32. Spence Laschinger HK, Finegan J, Shamian J et al (2001) Impact of structural and psychological empowerment on job strain in nursing work settings: Expanding Kanter's model. Journal of Nursing Administration 31:260–272
33. Lee CC, Liu HC, Yew MC et al (2007) 3D structure design and reliability analysis of wafer level package with stress buffer mechanism. IEEE Transactions on Component and Packaging Technologies 30:110–118
34. Lim H (2007) An empirical study on the effects of employment relations characteristics on organizational commitment with respect to employment status in K Broadcasting's employees. Journal of Korean Association of Human Resource Development 9:97–122
35. Lin C, Chen M (2004) Career commitment as a moderator of the relationships among procedural justice, perceived organizational support, organizational commitment, and turnover intentions. Asia Pacific Management Review 9:519–538
36. Liu C, Chang L (2006) Organizational and psychological empowerment on organizational commitment and job satisfaction among primary health professionals. Journal of Evidence-Based Nursing 2:5–13 (In Chinese)
37. Locke E, Schweiger D (1979) Participation in decision making: One more looks. Research in Organizational Behaviour 1:65–339
38. Lum L, Kervin J, Clark K et al (1998) Explaining nursing turnover intent: Job satisfaction, pay Satisfaction or organizational commitment? Journal of Organizational Behavior 19:305–320
39. Manojlovich M, Spence Laschinger HK (2002) The relationship of empowerment and selected personality characteristics to nursing job satisfaction. Journal of Nursing Administration 32:586–595
40. Marcus B, Schuler H, Quell P et al (2002) Measuring counterproductivity: Development and initial validation of a German self-report questionnaire. International Journal of Selection and Assessment 10:18–35

41. Mathieu JE, Zajac DM (1990) A review and meta-analysis of the antecedents, correlates and consequences of organizational commitment. Psychological Bulletin 108:171–194
42. Meyer JP, Allen NJ (1991) A three component conceptualization of organizational Commitment. Human Resources Management Review 1:61–89
43. Meyer JP, Allen NJ (1997) Commitment in the workplace: Theory, research, and application. Sage Publications, Thousand Oaks, CA
44. Meyer JP, Stanley DJ, Herscovitch L et al (2002) Affective, continuance, and normative commitment to the organization: A meta analysis of antecedents, correlates and consequences. Journal of Vocational Behavior 61:20–52
45. Meyer JP, Paunonen SV, Gellatly IR et al (1989) Organizational commitment and job performance: It's the nature of the commitment that counts. Journal of Applied Psychology 74:152–156
46. Robinson SL (2008) Dysfunctional workplace behavior. In Barling J, Cooper CL (Eds.), The Sage Handbook of Organizational Behavior, SAGE, Thousand Oaks, CA
47. Robinson SL, Bennett RJ (1995) A typology of deviant workplace behaviors: A multidimensional scaling study. Academy of Management Journal 38:555–557
48. Rogers KA, Kelloway EK (1997) Violence at work: Personal and organizational outcomes. Journal of Occupational Health Psychology 2:63–71
49. Schat A, Kelloway EK (2005) Workplace violence. In Barling J, Kelloway EK, Frone M (Eds.), Handbook of Workplace Stress, Sage, Thousand Oaks, CA
50. Scholl RW (1981) Differentiating organizational commitment from expectancy as a motivating force. Academy of Management Review 6:589–599
51. Schwepker CH (2001) Ethical climate's relationship to job satisfaction, organizational commitment, and turnover intention in the salesforce. Journal of Business Research 54:39–52
52. Seibert SE, Silver SR, Randolph WA (2004) Taking empowerment to the next level: A multiple-level model of empowerment, performance, and satisfaction. Academy of Management Journal 47:332–349
53. Sekaran U (2000) Research methods for business: A skill building approach. John Wiley & Sons, Inc
54. Seligman MEP (1975) Helplessness: On depression, development, and death. WH Freeman/Times Books/Henry Holt & Co
55. Sparrowe RT (1995) The effects of organizational culture and leader member exchange on employee empowerment in the hospitality industry. Hospitality Research Journal 18:95–109
56. Spector PE, Fox S (2005) The stressor-emotion model of counterproductive work behavior. In Fox S, Spector PE (Eds.), Counterproductive Work Behavior: Investigations of Actors and Targets. APA Press, Washington, DC
57. Spector PE, Fox S, Penney LM et al (2006) The dimensionality of counterproductivity: Are all counterproductive behaviors created equal? Journal of Vocational Behavior 68:446–460
58. Spreitzer G (1992) When organizations dare: The dynamics of individual empowerment in the workplace [disseration]. University of Michigan, Ann Arbor
59. Spreitzer GM (1996) Social structural characteristics of psychological empowerment. Academy of Management Journal 39:483–504
60. Tang YT (2008) The relationship between use of humour by leaders and R&D employee innovative behaviour: Evidence from Taiwan. Asia Pacific Management Review 13:635–653
61. Tayyab S (2006) Antecedents and consequences of organizational commitment in Pakistan. PhD thesis, Quaid-i-Azam University, Islamabad. http://eprints.hec.gov.pk/view/subjects/g16.html
62. Tayyab S (2007) An empirical assessment of organizational commitment measures. Pakistan Journal of Psychological Research 22:1–22
63. Thomas KW, Velthouse BA (1990) Cognition elements of empowerment: An "interpretive" model of intrinsic task motivation. Academy of Management Review 15:666–681
64. Ulrich D (1998) A new mandate for human resources. Harvard Business Review 76:124–135
65. Vogt P (1997) Transfer to power. Credit Union Management 20:44–45

66. Von Dran GM, Kappelman LA, Prybutok VR (1996) Empowerment and the management of an organizational transformation project. Project Management Journal 27:12–17
67. Wagner JA (1995) On beating dead horses, reconsidering reconsiderations, and ending disputes: Further thoughts about a recent study of research on participation. Academy of Management Review 20:506–509
68. Wall TD, Wood SJ, Leach DJ (2004) Empowerment and performance. International Review of Industrial and Organizational Psychology 19:1–46
69. Wayne SJ, Shore LM, Liden RC (1997) Perceived organisational support and leader member exchange: A social exchange perspective. Academy of Management Journal 40:82–111
70. Wiener Y (1982) Commitment in organizations: A normative review. Academy of management Review 7:418–428
71. Yang FH, Chang CC (2008) Emotional labour, job satisfaction and organizational commitment amongst clinical nurses: A questionnaire survey. International Journal of Nursing Studies 45:879–887
72. Yip K (2004) The empowerment model: A critical reflection of empowerment in Chinese culture. Social Work 49:479–487
73. Anderson E, Jansson A (2006) A call for learning — A model for developmental learning in call centres. Paper presented at the 6th UFHRD/AHRD Conference on Human Resource Development Research and Practice across Europe, Tilburg 23–25
74. Foster-Fishman PG, Keys CBG (1997) The person/environment dynamics of employee empowerment: An organizational culture analysis. American Journal of Community Psychology 25:345–369
75. Quinn RE, Spreitzer GM (1997) The road to empowerment: Seven questions every leader should consider. Organizational Dynamics 26:37
76. Lux DJ, Steve MJ, Curtiss PH (1996) Factors influencing employee perceptions of customer service climate. Journal of Market Focused Management 1:65–86
77. Brown SP (1996) A meta-analysis and review of organizational research on job involvement. Psychological Bulletin 120:235–255

Chapter 58

A Comparative Research on Competency and Competence, Competency Model and Competence Model

Yue Kou, Zhiyong Jia and Yihua Wang

Abstract This paper reviews the specific benchmark literature about the concepts of competence, competency model, occupational competence, competence at work and explores their logic relationship to one another. Based on this work, conceptual comparisons of competency and competence, competency model and competence model are presented. The comparative research clarifies some confusion surrounding the two pairs of concepts and emphasizes differences in their core connotations. Thus, the paper proposes that the two pairs of concepts should be distinguished in both narrow and broad senses, rather than being used alternately without distinction. We argue that the proposed distinction would be useful in establishing a coherent terminology, rather than a single terminology, e.g., competency.

Keywords Competency · Competence · Model · Comparative Research · Concept

58.1 Introduction

The research of competence and competence model plays an increasingly significant role in strategic human resource management fields. Although regarded by

---

Y. Kou (✉)
School of Economics and Management, Southwest Jiaotong University, Chengdu 610031, P. R. China
High Creation Management Consulting Co., Chengdu 610015, P. R. China
e-mail: byky7769@163.com

Z. Jia
School of Economics and Management, Southwest Jiaotong University, Chengdu 610031, P. R. China

Y. Wang
School of Economics and Management, Southwest Jiaotong University, Chengdu 610031, P. R. China
Sichuan Ya'an Branch of China Banking Regulatory Commission, Ya'an 625000, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_58,

some scholars [1] as a theoretical cornerstone of SHRM, competence remains a “Fuzzy Concept” [2] and arguments about its core connotation never come to an end. Just as Winterton noted,“There is such confusion and debate concerning the concept of ‘competence’ that it is impossible to identify or impute a coherent theory or to arrive at a definition capable of accommodating and reconciling all the different ways that the term is used [3].” Competence research in China began during the 1990s, and became particularly influential in recent years. The emergence and development of competence has passed through three stages: germination period (1998-1999), conceptual introduction period (2000-2003), tremendous growth period (2004-up to now) [4]. Although the number of related papers published in recent years increases rapidly, the theoretical grounding is still weak as a whole, especially in the introduction of concepts. On the one hand, the fore-mentioned conceptual confusion in China shows such a symptom that the apparently simple concept has become tangled and involved as a cluster of terminology. Researchers offer various explanations and Chinese translations for competence and competency, such as “competent characteristic” [1, 5] (individual underlying characteristic from a psychological perspective), “competent abilities” [6, 7] (job-related abilities from a functional perspective), “competent quality” [8, 9] (inherent traits and values from an ethical perspective), “qualification” [10, 11] (occupational qualification from an operational perspective), “competent capabilities” [12, 13] (multi-dimension complex from a holistic perspective). On the other hand, conceptual confusion in China is characterized by the misuse of competency and competence, competency model and competence model. Even in China’s mainstream academic periodicals like Nan Kai Business Review, misuse of these concepts are noticed in all of the three articles related to competence: The New Development of the Research of Competencies [5], Research on the Competency Model of Account Managers of Chinese Commercial Banks [13], A Study of Future HR Manager’s Competency Based on the Scenario Analysis Technique [12]. In the first article, albeit the two authors recognized and discussed the difference between competence and competency, they provided an ambiguous statement. One of the two authors, Shi suggested later that “competency”was a more rigorous term to unify different related concepts [1] In fact, his suggestion resulted in an apparently tautological definition that competency is a sub-set of itself. A glimpse at the titles of the last two articles mentioned left readers an impression that two different concepts of competency model and competency would be discussed, whereas a thorough reading of the papers enables the readers to realize that the research content of the two papers were exactly the same. Both articles in essence explored the same job-related competence and its framework, but they respectively employed the terms of competency model and competency, whose core connotations are completely different. One of the authors, Wei later substituted competency with competence in another job-related competence study [14], but the misuse of competence and competence model went on. This circumstance has imposed great obstacles to the follow-up researchers and the managers in practice. As Shi noted, “We need to have an agreement on conceptual definitions for the purpose of communicating on the same scientific platform [15].” However, a few international attempts to establish coherent terminology have hitherto had little impact, researchers in China have barely examined the differences in core connotations between competency and competence, competency model and competence model.

The purpose of this paper is to clarify the conceptual confusion in an attempt to establish a coherent terminology rather than a unified or single terminology like competency. In order to accomplish this, we will first review four specific benchmark literature about the concepts of competence, competency model, occupational competence, competence at work and explores their logic evolution relationship to one another. Based on this work, we will then present conceptual comparisons of competency and competence, competency model and competence model to identify their core connotations. Finally, we will put forward a suggestion that the two pairs of concepts should be distinguished in both narrow and broad senses, rather than being used alternately without distinction.

58.2 Literature Review

58.2.1 The Proposal of Competence

Competence as an academic concept was first proposed by psychological professor McClelland in 1973, [16] who raised questions and criticism against the validity of traditional intelligence tests. Based on abundant research fruits and empirical statistics, McClelland proved that "intelligence" couldn't effectively predict individual performance and occupational success. Repudiating the authority of traditional intelligence test, McClelland put forward a new directional proposition of testing "competence" in personnel selection. Although he confirmed that talents-selecting should test competence, McClelland subsequently described individual underlying characteristics of superior performer as "competency", and introduced competencies assessment methodology to a consulting firm that became Hay McBer.

McClelland and McBer undertook the first consulting project of competency testing for the Congress News Agency of the United States, to set up a standard of selecting service personnel to station abroad. In this project, McClelland determined for the first time the steps of implementing competency testing. Comparing the behavioral differences between persons with excellent performance and those with average performance and their respective events of success and failures, McClelland identified the key factors leading up to superior performance. Basing on CIT and TAT, McClelland designed behavioral events interview (BEI). He chose two groups of fifty persons with excellent performance and average performance as testing samples and asked each one of them to give three stories of both success and failure. By analyzing different behaviors arising from the total of 300 stories, McClelland refined the unique behavioral characteristics of excellent performance. He then defined these behavioral characteristics and provided each with a CAVE code, which enables the testers to work out the scores and analyze the frequencies. It is on the ground of these statistic analyses, McClelland derived a final three core competencies leading up to superior performance of news service personnel to station abroad, namely the Sensitivity of Cross-Cultural Communication, Political Judgment and Positive Expectations on Others.

In essence, the process of McClelland's analyzing competency and exploring the cause for excellent performance was a typical Abduction [17], namely an assumptive reasoning of certain facts. Even with abundant samples and close analysis, the "probability" of Abduction makes the "hypothesis" conclusion yet to be examined. In order to transform the hypothesis into a theory, McClelland and McBer had committed to transforming the simple quantitative induction into a qualitative refinement by accumulating empirical data.

58.2.2 Competency Model

As a renowned expert and president of McBer, Boyatzis published works [18] in 1982, which can be seen as a significant milestone for McBer's efforts stated above. The contribution of Boyatzis is reflected in two aspects. First, he made large-scaled and deep empirical research into the logic relations between competency and job performance. With managers as the research object and the combination of literature research and McBer's first-hand data, Boyatzis hypothesized 21 competencies related to management effectiveness. After sampling and analyzing the behavioral characteristics of 2000 managers holding 41 management jobs in 12 different industry organizations, Boyatzis confirmed 12 items of competencies closely related to management effectiveness, and proved the causal relations between competency and job performance. Second, Boyatzis further proposed the concept of competency model, by which he aims at integrating individual behavioral characteristic of superior performer into an acquirable and measurable behavioral standard needed by high performance.

Of the six principles and suggestions of competency testing proposed by McClelland in 1973, the first one pointed out that "the best test is criterion sampling", which implied that the purpose of competence testing is the acquisition of behavioral standard. McClelland considered the second principle "tests should be designed to reflect changes in what the individual has learned" as a corollary of the first [16]. In fact, people are always fascinated by successful persons and want to find out the paradigm for their success. Boyatzis's conception of competency model can be viewed as the interpretation and extension of McClelland's thoughts on competence. Competency model had a far-reaching impact on North America and made possible the transfer of competency from the academic world to the practical field of HRM.

58.2.3 Occupational Competence

In Britain, the campaign of competence in the 1980s was closely related to vocational education and training reform (hereinafter referred to as VET), initiated by the Thathcer's new vocationalism. In 1986, British Department of Education and Science and Department of Employment jointly issued "Work together: Education and Training White Paper", which promotes the construction of national vocational qualification system (hereinafter referred to as NVQS) to revive vocational education and training. In 1991, Gilbert Jessup, the authority of British NVQS, published works [19] to provide systematic clarification of the two achievements gained from British VET reform, namely national vocational qualification system and new model of education and training. He pointed out that NVQS radically reconstructed British vocational education and training, characterized by the booming of a new "learners-centered" model of education and training. On the one hand, the new model made it possible that the content and the goal of the learners originate from their practical work; on the other hand, it combined the assessment of learning with their vocational development. NVQ was the core of the new model, because it provided a basic standard for the ability needed by a certain professional field. The NVQ statement of competence was set up in a format which had three levels of detail: NVQ title, units of competence, elements of competence and performance criteria. Gilbert called the third level, namely elements of competence and performance criteria, the basic brick of NVQ, which showed that the core connotation of NVQ was competence. Nevertheless, this competence went beyond specific firms and specific jobs and represented occupational breadth, which was the so-called occupational competence by Gilbert Jessup.

Gilbert pointed out that, in spite of the long history of competence study in the U.S., the concept was adapted and expanded to a large extent in Britain and it became familiar to people in the development of NVQS. On the one hand, the adaptation was shown on the method that analyzed the functions of all kinds of occupations and all sorts of jobs level by level. Different from the traditional method in which was focused on "job responsibilities", NVQ adopted the method of "work role analysis" which denoted a more extensive connation. This was why Gilbert also called NVQ as functional competence or role competence. On the other hand, the adaptation was displayed on the connotation of competence. Occupational competence emphasized that it should be easy to develop through training and learning and should be also operational to assess the outcome. Therefore, occupational competence highlights the two prominent components of skills and knowledge, which explained why occupational competence was called occupational qualification standard in Britain.

In practical application, occupational competence was extended to the setting-up of the system of national vocational qualification certificate. The NVQs included the system of occupational qualification standard, curriculum system, educational training, appraisal accreditation, which displayed an inherent integration of occupational standard, training aim, outcome appraisal. Occupational competence was the foundation of curriculum designing and appraisal accreditation for individual study outcome, as well as the aim of individual study and educational training. Although the argument about NVQs has always been a hot topic in British academic field, the system did play a significant role in personnel training and skill improvement in various trades and organizations. The practical effect of the system also promoted the establishment of the Department of Education and Employment in 1995 which was renamed in 2001 as the Department of Education and Skill. In 2003, British issued “National Skill Strategy for the 21st Century”, which further stressed the close relationship between cultivating national competitiveness and promoting workers’ qualities based on occupational competence. The successful reform of British VET aroused great interests among the world. Establishing a framework of national occupation qualification and the new model of competence-based occupation education and training became the mainstream of occupational education reform in British Commonwealth, Europe even the world. Britain, as a result, became the major force pushing forward the global campaign of competence in 1990s.

58.2.4 Competence at Work

In 1990s, the US tradition based on Hay-McBer’s behavioral analysis, and the UK tradition based on NCVQ and MCI’s functional analysis, dominated international research and practice of competence [3]. Comparative study on the differences, advantages and disadvantages of the two traditional modes highlighted competence research. Burgoyne [20] distinguished “being competent” (meeting the job demands) from “having competencies”. Woodruffe [21] further stated that, competence referred to a cluster of competencies related to job, while competency referred to individual behavioral characteristics closely related to high performance. Tate [22] put forward the concepts of “input competencies” and “output competence”. Some scholars criticized the weakness of US and UK modes. Jacobs [23] considered Boyatzis’s model of manager competence too general and abstract. Holmes [24] pointed out the disadvantage of British NVQs was caused by the single method of functional analysis. Scholars like Attwell [25], Norris [26] and Sandberg [27] held that American and British rationalistic “operationalization” of attributes into quantitative measures often result in abstract and overly narrow and simplified descriptions that may not adequately represent the complexity of competence in work performance. Scholars such as Boak [28] believed that American and British methods actually complement for each other and they even attempted to create a holistic term. Veres [29] and other scholars tried to integrate many concepts by drawing on the strong points and overcoming the weaknesses.

In 1993, L. M. Spencer, president and director of research and technology department in Hay-McBer Group, published a monograph [30] on theoretical study and practical application of competence. Twenty years passed since McClelland’s proposal of competence and the foundation of McBer & Company. First-class research achievements, abundant practical experience and the challenges and weakness in application accumulated in these twenty years, needed to be sorted out and improved, which became the primary of the four goals the book intended for. The book consists of five parts, of which the first three review and summarize the research on competence focusing on competence at work. The last two parts of the book provide an all-around introduction to the various models of competence at work for occupational categories such as technological manufacture, marketing, customer service, functional management and decision-making. Applications of these models in various functional module of HR management are also included in the book. As is known to all, the greatest contribution of the book is the interpretation of "Iceberg Model" and "Onion Model", which systematically illustrates the connotation and structure of competence at work. His work has further laid a solid foundation in the development of competence research and application.

The "Iceberg" and the "Onion" model incorporated and summarized the key ideas and practical experience of international competence research. Based on the iceberg model, the concept of competence at work went beyond the traditional connotation of McBer's "competency" research and complemented the weakness of British "occupational competence" which overstressed knowledge and skill. In the middle and late years of 1990s, Holistic Approach [3] became popular in international competence research. Cheetham and Chivers [31] brought up a five-dimensional holistic framework of cognitive, functional, individual, ethics and meta competence. Scholars like Winterton [32] further proposed a four-dimensional framework to revise the former one. Sandberg [33] raised an interpretative method of "human competence at work". Based on specific work context, Nordhaug suggested a three-dimensional classificatory framework of competence [34]. Up till then, the conception of competence at work based on firm-specific work context gradually dominated modern competence research and practice.

58.3 Connotation and Identification of Concepts

58.3.1 Narrow-sensed Competency and Broad-sensed Competence

As to the connotation of competency, most of the scholars shared an agreement on Spencer's definition. The competency refers to underlying characteristics of people that are causally related to effective or superior performance in a job [30]. Three key terms of underlying characteristics, causal relation, criterion reference are included in the definition. (1) Underlying characteristics refer to the potential and stable characteristics deep inside an individual, including motive, traits, attitude and values. (2) Causal relation means that these underlying characteristics can stably predict the behavior and performance of an individual in complicated work contexts. (3) Criterion reference, in Spencer's view, is an important component of the connotation of competency. A characteristic can be called competency in that it is the root cause for distinctions between superior performance and average performance. Criterion references are usually some key performance indexes to identify individual distinctions.

In fact, most people ignored the word “a” in understanding Spencer’s “definition of a competency” [30]. Then, why did Spencer add “a” before “competency”? It was because the word “a” reflected the connotation and research method of competency is different from that of competence at work. The first step of competency research is to confirm the criteria reference for performance, by which the sampling group can be divided into superior performers group and average performers group. Secondly, according to behavioral differences, comparative analysis is made to identify unique characteristics possessed by superior performers. Finally, these characteristics are defined, tested and refined to derive a stable causal relationship with superior performance. In summary, competency research, as an Abduction from outcome to cause, needs to be attained and tested one by one. After 25 years, professor McClelland reaffirmed that the competency research method exploring the cause of individual worker’s superior performance is reliable and effective and BEI is the core of the method [35].

As stated above, Spencer put forward “competence at work” on the grounds of incorporating both American and British theoretical research and practical experience. The concept emphasized the connection with specific work context and displayed a holistic requirement needed from job-fit to superior performance. Thus, Competence at work is a sum of competencies. Competence at work consists of five basic elements, distributed on different levels and structures. Of the five elements, knowledge and skills are explicit. They directly affect job-fit and are easily developed and improved by education and training. Motive, traits and self-image are requirements at deeper levels. As the decisive factors leading to excellent performance, they are of great importance but are not so easily developed or improved through education and training. Competence at work features its definite object, clear structure and multiple layers. Definite object refers to the sum of competencies called for by a specific job. Clear structure means that competencies are arranged in the order of basic element-dimension-competencies. At present, the research on competence at work is focused on confirming the ”dimension” which varies according to different research subject. Finally, multiple layers refer to the onion characteristic which explains that the five basic elements of competence are distributed from the outer to the inner and developed from the easier to the more difficult.

In summary, the comparison and identification of competency and competence shows that the two concepts are evidently different in the core connotation and research method. Competency refers to individual’s inherent characteristics that are causally related to superior performance, while competence stresses a holistic complex of knowledge, skill and motive, attitude, needed from job fit to superior performance. In the research method, BEI is the core of the competency research. Competence research is based on the combination of BEI and functional analysis etc. So it is our suggestion to adopt “competency in narrow sense” to define the individual’s inner characteristics and behavioral characteristics that forms stable causal relationship with superior performance. We also propose to use “competence in broad sense" to define the sum of competencies with multiple dimensions needed by specific job-fit in organizations.

58.3.2 Narrow-sensed Competency Model and Broad-sensed Competence Model

As is mentioned above, the research on competency in narrow sense refers to the process of exploring the cause for excellent performance during which individual's behavioral characteristics are confirmed by BEI and are identified through comparative analysis. The causal relationship needs to be further tested and refined based on a series of empirical statistics and data accumulation from simple quantitative induction to the final qualitative refinement. It is on the basis of the accumulated raw data in McBer and the large-scaled and thorough empirical research on the causal relationship between competency and job performance, Boyatizs put forward the concept of competency model, with the aim of deriving a universal and measurable behavioral standard from individual's behavioral characteristics of superior performers. Therefore, competency model is the universal behavioral standard. Competency model includes three basic elements: the name of competency, definition of competency and the grading behavioral description of competency, see Table 58.1.

The grading behavioral description of competency is key to the modeling of competency. The critical behavior indexes often originate from BEI's large-scaled samples and need to be tested by empirical statistics. In general, critical behavior indexes of competency are the "meta-code" of the competency database in most of the management consulting companies engaged in the development of competence model. In 1993, a project-group led by Spencer through the raw-data of McBer created a database of 286 competency models. They identified 760 behavior indexes from the database, 360 of which frequently appear in 21 competencies, according to detailed and accurate analysis. Therefore, the 21 competencies and 360 critical behavioral indexes make up a competency dictionary of the McBer [30].

The model of competence refers to the cluster of competencies for a specific job, the grading behavior standard of each competency and its matching degree to a specific job. The first component of the concept is the specific job. Generally, even the behavior standard of the same competency varies according to different occupational background and firm context. Therefore, in order to make the model of competence fit for a specific job, the specific jobs should be categorized and picked out, which is often based on analyzing the core value chain of a given firm and clearly identifying occupational categories, occupational families, occupational grades, and occupational positions. The second component of the concept is the cluster of competencies that contains two meaning: the sum of competencies and the structural dimension of their distribution. Confirming the sum of competencies and the structural dimension of their distribution falls under the detailed task of competence modeling and will not be covered in the paper. The third component, the grading behavior

Table 58.1 Narrow-sensed competency model diagram

Subordinate Cultivation
Definition: promote the knowledge and skill of the subordinates step by step in a planned way. Draw lessons from experience and help the subordinates to form appropriate logic and behaviors and create opportunities for them to study and develop. Level I (1) Bear the shortcomings of the subordinates and encourage them to talk about their feelings. Analyze and summarize with them to improve gradually. (2) Give objective and accurate evaluation of subordinates' daily performance and make positive or negative judgment and provide suggestions for improvement. Level II (1) Be aware of both merits and demerits of the subordinates. Focus attention on the "less-advanced" ones and encourage them to grow with the team. (2) The evaluation of the subordinates involves the work and contribution as well as their shortcomings. Be good at encouraging in a positive way. Level III (1) Organize team members to communicate and demonstrate experience at regular intervals. Promote "knowledge sharing" and the growth of the whole team. (2) Analyze the performance and achievements of the subordinates and make objective and overall judgment. Provide the subordinates objective response of their performance. Keep abreast of the intentions and demands of the superiors and revise the goals and methods accordingly. Level IV (1) Pay close attention to cultivating capabilities of the subordinates and design training programs and plans corresponding to the development of each team member. (2) Conduct effective face-to-face communications with the subordinates about their performance and work out performance improvement schemes aiming at individual personality.

standard of each competency and its matching degree to the specific jobs, needs to be tested and revised through the combination of BEI data. The matching degree can be determined by mathematic tools such as structural equation modeling, as well as the importance, relevance and frequency analysis of the relations between competencies and job-fit.

In light of the differences in the core connotations of competency model and competence model, we argues that the two conceptions should be also distinguished from broad and narrow sense. The narrow-sensed competency model refers to the universal behavioral standard from individual's behavioral characteristics of superior performers, while the broad-sensed competence model includes the cluster of competencies needed for a specific job, the grading behavior standard of each competency and its matching degree to the job.

58.4 Conclusion and Discussion

This paper is a tentative effort to clarify the conceptual confusion about competency and competence, competency model and competence model. Based on the comparison and identification of concept, the final conclusion of the paper is that evident differences do exist in the core connotations of these concepts. Competency indicates the causal relation between individual inherent characteristics of superior performer and his successful and effective job performance, while competence emphasizes the connection between a holistic complex of knowledge, skill and motive, attitude etc. and a job-fit under the specific work context. In brief, competence is a sum of competencies. Meanwhile, competency model refers to standardizing individual behavior characteristics of superior performer, includes three basic elements: the name of competency, the definition of competency and the grading behavioral description of competency, while competence model includes the cluster of competencies needed for a job, the grading behavior standard of each competency and its matching degree to the jobs of the firm-specific work context. Therefore, we do not approve of treating the two pairs of concepts as synonymous ones being used alternatively without distinction.

Considering the differences in their core connotations, the paper proposes that the two pairs of concepts should be distinguished in both narrow and broad senses. We argue that the proposed distinction would be useful in establishing a coherent terminology, rather than a unified or single terminology like competency. Not only can the proposed distinction reveal the differences of their core connotations and features of respective method of research, but also it displays inherent logic relations between the two pairs of concepts. Research on the competency in narrow sense is the preliminary foundation for the formation and development of competence theory. Without competency in narrow sense and its research method, competence in broad sense would lose its theoretical support and expanding basis. In contrast, competence research in broad sense opens up a broader road from individual job-competence to organizational core competence.

Researchers in the strategy field increasingly center on core competence and emphasize "core competence" as a source to organizational sustained competitive advantage. While the majority of them universally recognize the inseparability of the organizational core competence and the individual abilities of the employees, the logic of competence is polarized into two distinct directions: macro-oriented approach, focusing on building the organizational core competence and micro-oriented approach, focusing on individual behavioral abilities development. This article presents a consistent and coherent conceptual foundation for the theoretical integration between organizational core competence and individual job-based competence, although it is limited in both breadth and depth and further research is required. In summary, if competence is important, it follows that its connotation is also important, since without a common understanding there is little chance of integration, alignment even development in theoretical or practical fields.

References

1. Shi K (2006) Human resource development based on competency model. Advances in Psychological Science 14:586–595 (In Chinese)
2. Boon J, Vander K (2002) Competencies: The triumph of a fuzzy concept. In: Proceeding of Academy of Human Resource Development Annual Conference, Honolulu
3. Francoise D, Jonathan W (2005) What is competence? Human Resource Development International 3:27–46
4. Xiao J, Zhao S (2008) The meta-analysis of the competency research in mainland China. Economic Management 10:73–78
5. Zhong L, Shi K (2003) The new development of the research of competencies. Nankai Business Review 6:4–8 (In Chinese)
6. Wu N, Xu F(2006) Competency model-design and application. Guang Dong Economy Publishing House, Guangzhou (In Chinese)
7. Luo S (2008) From competence to performance excellence. China Machine Press, Beijing (In Chinese)
8. Wang S (2005) Foundation of human resource management competency model. Journal of Capital University of Economics and Business 1:54–56 (In Chinese)
9. Yao K, Chen M (2009) Constructing training systems using competency model. Chinese Journal of Management 6:532–536 (In Chinese)
10. Sun J (2007) Competency model in ralents-management. Chinese Talents 7:30–32 (In Chinese)
11. Zhang W (2004) Competency-base and core of human resource management. Human Resource 3:34–35
12. Xiao J, Zhao S (2010) A study of future HR manager's competency based on the scenario analysis technique. Nankai Business Review 13:50–58 (In Chinese)
13. Wei J, Zhang D (2005) Research on the competency model of account managers of Chinese commercial banks. Nankai Business Review 8:4–8 (In Chinese)
14. Wei J (2009) Competence measurement model for credit examining and approving managers in commercial banks in China. Chinese Journal of Management 6:781–787 (In Chinese)
15. Shi K (2007) Competency model leadership research and its application in human resource development. Journal of Capital University of Economics and Business 6:13–19 (In Chinese)
16. McClelland D (1973) Testing for competence rather than for"intelligence". American Psychologist 28:1-14
17. Hanson N (1985) From patterns of discovery. Cambridge University Press, New York
18. Boyatzis R (1982) The competent manager: A model for effective performance. Wiley, New York
19. Gilbert J (1991) Outcomes: NVQs and the emerging model of education and training. The Falmer Press, London
20. Burgoyne J (1988) Competency based approaches to management development. Centre for the study of management learning, Lancaster
21. Woodruffe C (1991) Competent by any other name. Personnel Management 9:30–33
22. Tate W (1995) Developing managerial competence: A critical guide to methods and materials. Gower, London
23. Jacobs R (1989) Evaluating managerial performance: the need for more innovative approaches. In: Meeting of the European Foundation for Management Development, Knowledge as a Corporate Asset: An International Perspective
24. Holmes L (1992) Understanding professional competence: Beyond the limits of functional analysis. In: Proceedings of Course Tutors' Conference, Personnel Management at UMIST
25. Attewell P (1990) What is skill? Work and Occupations 4:422–448
26. Norris N (1991) The trouble with competence. Cambridge Journal of Education 21:1–11
27. Sandberg J (1991) Competence as intentional achievement: A phenomenographic study. In: Proceedings of the Tenth International Human Science Conference, Gotebory, Sweden

28. Boak G (1991) Developing managerial competences: The management learning contract approach. Pitman, London
29. Veres JG, Locklear TS, Sims RR (1990) Job analysis in practice: a brief review of the role of job analysis in human resource management. Human Resource Management: Perspectives and Issues 79–103
30. Spencer LM, Spencer SM (1993) Competence at work: Models for superior performance. John Wiley & Sons, Inc
31. Cheetham G, Chivers G (1996) Towards a holistic model of professional competence. Journal of European Industrial Training 20:20–30
32. Winterton J, Parker M, Dodd M et al (2000) Future skill needs of managers. Research Report RR182, Department for Education and Employment, Sheffield
33. Sandberg J (2000) Understanding human competence at work: An interpretative approach. Academy of Management Journal 43:9–25
34. Nordhaug O (1998) Competence specificities in organization: A classificatory framework. International Studies of Management & Organization 28:8–29
35. McClelland D (1998) Identifying competencies with behavioral-event interviews. Psychological Science 9:331–339

Chapter 59
Factors of Successful Relationship Management: Guanxi in China

Huiying Zhang and Shuang Lv

Abstract Guanxi, which is a concept in Chinese culture, has been paid extensive attention from scholars and managers in recent years. The purpose of this paper is to analyze the factors of successful relationship management in China and hope to be helpful for further study and practice. The studies of Guanxi in recent years are reviewed in the following content. And then, based on the clear definition of Guanxi which is given in the next part, analysis of its characteristics is summarized in Chinese cultural background. As a result, an integrated framework of Guanxi is proposed, which is a six-dimension model that includes common interest, communication, credibility, commitment, collaboration and compromise, and identify the key items of them.

Keywords Guanxi · Common interest · Communication · Credibility · Commitment · Collaboration · Compromise

59.1 Introduction

Relationship between people and organizations, which is called Guanxi in China, is a cultural characteristic that is the most common sense nouns. In our daily life, Guanxi is the most common phenomenon, which refers to every individual, family and organization. Chinese people and organizations establish, maintain and improve their Guanxi between each other energetically and subtly. Guanxi is an intricate and pervasive relational network that contains implicit mutual obligations, assurances, and understanding [40]. Guanxi has been the lifeblood of personal relationships and business conduct in Chinese society [55]. Nowadays, basing fast-changing Chinese environments, Guanxi has become particularly important for both interpersonal

---

H. Zhang (✉) · S. Lv
College of Management & Economics, Tianjin University, Tianjin 300072, P. R. China
e-mail: hyzhang@tju.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_59,

and interorganizational relationship. Therefore, It is critical for businesses in China, whether foreign or local, to understand contents of Guanxi and properly utilize it in order to survive and shore up the foundation for long-term development.

Although it is known that Guanxi is of vital importance to personal relationships and business conduct, which can conclude from previous studies, such as that Guanxi affects market benefits [14, 56], financial outcomes [30], competitive advantages [52, 57], and business performances [23], it is not easy to carry on the successful relationship management. Some scholars focus their research on influence factors of Guanxi utilization [8, 18, 40, 47], such as ownership, strategic orientation, enterprise scale, and so on.

However, this paper focuses on the factors of successful relationship management, which contain common interest, communication, credibility, commitment, collaboration and compromise which is an integrative framework called six-dimension model. This study tries to explore the factors influencing Guanxi in China. Next, in Sect. 59.2 we discuss the related studies and define Guanxi to identify particular characteristics of Guanxi in China; In Sect. 59.3, we suggest an integrated framework of Guanxi, which is a six-dimension model that includes common interest, communication, credibility, commitment, collaboration and compromise, and identify the key items of them; In Sect. 59.4, discussions and future research are presented.

59.2 Conceptual Background

59.2.1 Literature Review

In recent years, with the acceleration of reform and opening up and the development of the Chinese economy, more and more transnational group came to China to investment or founding factory. Therefore, scholars and managers have given more attention to Guanxi, which is a Chinese culture concept, to help enterprises to establish the competitive advantage, gain scarce resources, and so on.

The recent literatures about Guanxi are summarized in Table 59.1. Although it is a summary, we can clearly see the number of studies on Guanxi increased year by year and the extent refined.

We can see from the recent literatures, researchers not only concerned about impact of Guanxi on enterprise performance or cost, but also concerned about the key factors of Guanxi, which are more rooted in the concepts of structure of Chinese culture. Because it is a prerequisite for successful relationship management, which is also an important part of appropriate utilization of Guanxi in China. Next, we will give a clear definition of Guanxi and summary of characteristic of Guanxi for the following research.

Table 59.1 Summary of recent studies on Guanxi

Bala et al [4]	Trust and communication which are components of Guanxi are the two main channels of knowledge transfer.
Peter et al [45]	Government support and a shared mindset can only be secured when mutual trust is established, which is also key concepts in Guanxi.
Wang [54]	The underlying differences between Chinese Guanxi and Western relationship is trust or xinyong in long-term orientation.
Peter and Paul [43]	Guanxi has a significant influence on supply chain management.
Lu et al [29]	Guanxi and trust effectively reduce transaction costs in vegetable marketing in China.
Zhuang et al [59]	The impact of Guanxi on behaviors (such as power, conflict, and cooperation)among firms in a Chinese marketing channel
Robert and Gao [47]	Guanxi behavior as a type of personal social networking, it has its own antecedents, measures, and outcomes.
Chen and Wu [9]	Two types of Guanxi - with business partners and with government officials - affect corporate capabilities differently.
Yang and Wang [56]	Guanxi as a governance mechanism in business markets, is a fine balance among qing (emotion or feeling), li (reciprocity) and liyi (utilitarian benefits).
Shou et al [48]	Trusting relationship influences firm boundary agents' Guanxi behavior.
Bradley et al [6]	Ganqing (an affective element), renqing (reciprocation and favor), and xinren (personal trust), which are crucial dimensions for fostering Guanxi.
Henry [23]	The role of Guanxi in the relation between market orientation and business performance.
Nie et al [37]	Guanxi has its negative side and interorganizational trust and relationship specific investment, as two potential mediators, can enhance and amplify the eroding effect of Guanxi on firm performance.
Chen et al [9]	Guanxi can be viewed as a business relationship management strategy that is leveraged by organizations in response to environmental conditions.
Li and Sheng [28]	Under different competition and technology environment, effects of Guanxi on firm profitability are different.
Chen et al [11]	In the different stages during the buyer-supplier relationship lifecycle, effects of Guanxi practice on Chinese buyer-supplier relationships are different.
Leung et al [27]	Mianzi, Renqing, Ganqing, Xinyong, are all key elements of Guanxi establishing, and guide successful negotiation.
Chen [10]	Guanxi could be utilized either to lower the set-up cost as entrepreneurs or to secure jobs as workers.
Peter and Xiao [44]	Guanxi network closure increases propensity to stay, whose effects high-commitment human resource management reinforce.
Cheng [12]	Relational benefits and Guanxi between partners improve the negative effect of relational risk on knowledge sharing.

59.2.2 Defining Guanxi

Guanxi which is a complex, multidimensional, involving numerous theories concept, are the process of interperson and interorganization forming a link between each other.

According to Industry/Interaction Network Approach [22], which is developed from IMP-Group (International/Industrial Marketing and Purchasing Group), Guanxi which is hierarchical, connects activities, combines with actors, and forms the resource links [19, 21, 53]. Establishing and maintaining a Guanxi network between organizations is a process of interaction and mutual influence. This process is based on Guanxi between enterprises, which are interdependence between each other, and coordinate their behaviors between whiles. It is accomplished through interaction in the process of establishment and development of Guanxi. Interaction consists of two closely linked processes: first, Exchange, and second adaptation [22].

According to transaction cost theory, the market management takes saving transaction cost as the principle. Thus the appropriate, suitable utilization of Guanxi can reduce the opportunism behavior to reduce the transaction cost [10], and then maintain good cooperation. But excessive utilization of Guanxi can cause the enterprise operation cost arise [40].

According to resource dependence theory, Guanxi itself is a resource. In today's unprecedented fierce competitive environment, it is not sufficient for enterprise just focusing on a particular type of resources to establish sustainable competitive advantage. Hence it is necessary to develop Guanxi network between organizations with access to different resources. It can create competitive advantage through mutual cooperation between organizations and sharing each other's unique elements and resources [24].

According to social exchange theory [25], mutual exchanges of interests form a dynamic exchange of Guanxi. The main norms and rules of exchange process of interperson and interorganization, while establishing and developing Guanxi with each other, is reciprocity. The theory use the behaviorism perspective, focus on the psychological benefits of Exchange, emphasize the interaction of non-economic input and output, make the intangible exchange such as trust as much important as tangible benefit exchange. It can suitable explain the phenomenon such as trust and commitment which can not analysis by the economic theory [3, 18, 35].

Based on the above review and analysis, we summarize several characteristics of Guanxi:

(1) Guanxi is a process of change.

Guanxi, as the same with any organism, which is alive, is a process of change and development. In this world, Guanxi with invariant network will never have. Dynamic of Guanxi is absolute while static is relative. It is in a certain condition which is a process of unsteady, complex and tortuous change, whatever in any level such as interperson or interorganization. Therefore, it is not a once and for all according to building Guanxi, and it requires constant training and investment.

(2) Guanxi is valuable.

Guanxi, especially interorganization, is based on value exchange, which can be a tangible benefit or the intangible long-term emotional investment. However, compared with the pure emotional feelings between friends, it is more utilitarian, and more value-oriented.

(3) Guanxi is reciprocal.

In accordance with the social exchange theory, Guanxi is based on "reciprocal". Mutually beneficial concept not only exists in terms of tangible benefits, but also in trust and commitment which are invisible. For example, when A does B a favor, it is to say there is emotional investment from A to B. Maybe not now, but after a time, when A is in trouble, B will also help.

(4) Guanxi as a kind of resource, is able to exchange and transfer.

Guanxi as itself a kind of social capital, is also a unique resource of enterprise, and can be exchanged and transferred during the development of cooperation. Here is an example, there is a good co-operational relationship between A and B, and B and C are also good partners. As A and B between C and B cultivating Guanxi, A and C will become good partners some day in terms of their strength of the ties with B.

Precisely because Guanxi has all above characteristics, which make the concept of relationship has a different meaning in China, it can be appropriately use only when a clear understanding of Guanxi is well known.

59.3 A Six-dimension Model of Guanxi

59.3.1 Guanxi in the Transition Economy

Characteristics of the transition economy, are described as the traditional culture and the strong role of the government along with institutional defects and intense competition due to imperfect market economy. In transition economy country such as China, Guanxi is a typical process of doing business, through which organizations can significantly reduce transaction costs, seek government or political support, improve the business performance [51, 57]. Therefore, organizations in transition economy maintain Guanxi with customers, suppliers and competitors which are all market entities, and establish and keep Guanxi with government which has the right of scarce resource allocation in order to obtain legitimacy and the scarce resources in the market [38, 39].

59.3.2 A Six-dimension Model of Guanxi

According to the former studies, the conclusion about the mechanism of relationship and the performance of relationship sometimes are not coherent and the reason is the particular economic background of transition economy in China. Therefore, the factors of Guanxi must take the transition economy in consideration. And based on all of above, a six-dimension model of Guanxi is proposed. The six dimensions are Common interest, Communication, Credibility, Commitment, Collaboration and Compromise.

(1) Common interest

Guanxi as it is valuable and reciprocal, must take the common interest as the foundation in the hierarchy of interperson and interorganization [13, 41, 50], otherwise it can not be a long-time relationship or succeed. It may be successful, if there have had the common interest. But if the partners do not have common interest, they could not avoid finally separation, even if celebrate the establishment of Guanxi everyday. Moreover, the intense competition which is caused by the imperfect market economy make common interest become a more important factor that partners would like to consider before they cooperate. It includes following several essential elements: knowing exactly about oneself and the partners; setting common interest above oneself interest; preparing transformation of Guanxi once common interest vanishing.

(2) Communication

Anderson and Narus [3] defined communication as “the formal and informal sharing of meaningful and timely information between partners.” Communication which is indispensable is so important that no communication no actual Guanxi. With communication, information sharing and value exchanging could be achieved. And more dynamic the environment is, the more communication both formally and informally the organizations need. Because in the transition economy, the dynamic is remarkable but the information carrying capacity from market or government to the market entities is weak. Therefore, organizations would like to communicate with other market entities and government timely in order to hold the new and value information. Many scholars have made contributions in the measure of this factor [7, 18, 32–35]. The essential elements are summarized from communication quality and information sharing two aspects: knowing exactly about aim and objective; having formal and informal communication frequently; sharing information openly; offering valuable information forwardly if needed; solving problem/conflict through communication.

(3)Credibility

Credibility, another factor to the success of the relationship, is particularly important in commercial activities, especially in countries with a transition economy like China. Credibility means “mianzi” which is important in traditional culture in China and an intangible form of social currency and personal status, which is affected by one’s social position and material wealth [40]. It is imperative to maintain a certain level of “mianzi” in order to cultivate and expand a viable Guanxi network [57]. Therefore, building trust with clients or partners helps to enhance transaction performance and reduce the uncertainty in the relationship [26]. Integrated research achievements of the former researchers [1, 16, 18, 35, 36, 46], the key elements of credibility are: positive attitude of cooperation; trust of partners’ abiding by the contract; meeting the requirements of cooperation in technology and management;

considering our benefit by partners when when making important decisions; keeping vigilant because of partners' not always loyalty.

(4) Commitment

Commitment which is defined as "the affective willingness to maintain a relationship enhancing perception of future value" [15], is a key factor in long-term relationships and the need of keeping in a steady relationship. Commitment is also a basis for cooperation, and that is the key point difference between social exchange and economic exchange [17]. Moreover, commitment is the key factor to ensure the strength, stability, durability, and profitability of Guanxi. Especially, in a transition economy in China, commitment in contract buffers the dynamic environment and emotional commitment improves the Guanxi of partner even closer and deeper. Our research follows contribution of previous scholars and divides commitment into attitude and behavior, contains the following key elements [18, 20, 35]: willing to make a commitment to one's own duties and keep it; writing all commitments in the contract; concerning about the long-term co-operational goals; making the commitment of obligation and responsibility; training technician and improving equipment in order to in order to achieve cooperation.

(5) Collaboration

Collaboration, which is essential in Guanxi network, can keep consistency of goals of relationship. And it can promote trust and positive development between partners during the frequent collaboration. Anderson and Narus [3] defined collaboration as an cooperative activities that are taken by enterprises in an interdependent relationship to achieve common goals, and in this way, all of the participators benefit from the relationship. Not only that, inter-organizational collaboration also helps partners reduce even solution of organization resource exchange agent [5]. More obviously, scarce resource and sophisticated technology may not hold in one organization's hand in Chinese environment, enterprise must collaborate with each other in order to achieve a cooperative target. Integrated from previous studies about collaboration [2, 34, 49], we regard collaboration as the following elements: participating actively and continuously by all the partners; establishing a good relationship with other participants to avoid misunderstandings; accepting the rights/responsibilities; contacting partners to work together on issues and conflicts under the uncertain situation; knowing clearly about which decisions can be made by one's own and which can not.

(6) Compromise

It can not be maintained of relationship without compromise [31], in other words, Guanxi is a process of compromise. In Chinese culture, compromise, as it is used appropriately, could contribute to the further development of Guanxi. From another perspective, it is reflected that the partners have the high degree of recognition and long-term goals. Compromise, as a key factor of Guanxi, which is concordant with value of traditional harmonious concept in China, can minimize the inharmonious factors. At the same time, from the results, it can take the interests of all parties into account, which is the best way to resolve the conflict [42, 58]. Based on former study [58], we considered that compromise is comprised of the following elements: respecting for partners' culture and value; considering other partners' commercial and financial interests; striving to reach solutions that are equitable to all partners when differences arise.

The six dimensions and their items are shown in the Table 59.2 below.

Table 59.2 Six-dimension model of Guanxi

Dimensions	Items
Common interest	Knowing exactly about oneself and the partners Setting common interest above oneself interest Planning transformation of Guanxi once common interest vanishing
Communication	Knowing exactly about aim and objective Having formal and informal communication frequently Sharing information openly Offering valuable information forwardly if needed Solving problem/conflict through communication
Credibility	Positive attitude of cooperation Trust of partners' abiding by the contract Meeting the requirements of cooperation in technology and management Considering our benefit by partners when when making important decisions Keeping vigilant because of partners' not always loyalty
Commitment	Willing to make a commitment to one's own duties and keep it Writing all commitments in the contract Concerning about the long-term co-operational goals Making the commitment of obligation and responsibility Training technics and improving equipment in order to in order to achieve cooperation
Collaboration	Participating actively and continuously by all the partners Establishing a good relationship with other participants to avoid misunderstandings Accepting the rights/responsibilities Contacting partners to work together on issues and conflicts under the uncertain situation Knowing clearly about which decisions can be made by one's own and which can not
Compromise	Respecting for partners' culture and value Considering other partners' commercial and financial interests Striving to reach solutions that are equitable to all partners when differences arise

59.4 Discussion and Future Research

An integrated framework of Guanxi, which is a six-dimension model concludes the factors of Common interest, Communication, Credibility, Commitment, Collaboration and Compromise. These are essential factors in the process of establishing and improving Guanxi, and the relationship will disappear in the lack of any one. Especially in transition economy in China, enterprises no matter domestic companies or foreign-owned enterprises should all focus on these six factors and make more gains in successful utilization of Guanxi.

In future studies, further deepen research may follow the following aspects: empirical research on the six-dimension model summary in this article needs to be tested and verified; as Guanxi is a dynamic process, one particular dimension may be more important to the utilization of Guanxi in different stage, therefore, more dynamic method may be used to clarify the mechanism of Guanxi.

Acknowledgements This study was sponsored by the Science and Technology Development Strategy Program (10ZLZLZF02100): Evaluation of enterprises innovation capability in Tianjin. Thanks them for their assistance.

References

1. Andaleep S (1996) An experimental investigation and commitment in marketing channels: The role of trust and dependence. Journal of Retailing 72:77–93
2. Anderson E, Weitz B (1992) The use of pledges to bulid and sustain commitment in distribution channel. Journal of Marketing Research 24:85–97
3. Anderson J, Narus J (1990) A model of distributor firm and manufacturer firm working partnerships. Journal of Marketing 54:42–58
4. Bala R, Goh K, Matthew C (2006) Is Guanxi (relationship) a bridge to knowledge transfer? Journal of Business Research 59:130–139
5. Barney H (1994) Trustworthiness as a source of competitive advantage. Strategic Management Journal 15:175–190
6. Bradley R, Dorothy Y, Zhou L (2011) Investigating Guanxi dimensions and relationship outcomes: Insights from Sino-Anglo business relationships. Industrial Marketing Management 40:510–521
7. Cannon JP, Homburg C (2001) Buyer-Supplier relationships and customer firm costs. Journal of Marketing 65:29–43
8. Chen H, Alexander E, Yu T (2011) Manufacturer-supplier Guanxi strategy: An examination of contingent environmental factors. Industrial Marketing Management 40:550–560
9. Chen X, Jie W (2011) Do different Guanxi types affect capability building differently? A contingency view. Industrial Marketing Management 40:581–592
10. Chen Y (2011) A study on the role of Guanxi in entrepreneurship and employment. Economic Modelling 28:2049–2053
11. Chen Z, Huang Y, Brenda S (2011) Guanxi practice and Chinese buyer-supplier relationships: The buyer's perspective. Industrial Marketing Management 40:569–580
12. Cheng J (2011) Inter-organizational relationships and knowledge sharing in green supply chains-Moderating by relational benefits and Guanxi. Transportation Research Part E 47:837–849
13. Liu C, Yi M, Lee C (2011) The effects of relationship quality and switching barriers on customer loyalty. International Journal of Information Management 31:71–79
14. Davies H, Leung T, Luk S et al (1995) The benefits of Guanxi: The value of relationships in developing the Chinese market. Industrial Marketing Management 24:207–214
15. Dick A, Basu K (1994) Customer loyalty: Toward an integrated conceptual framework. Journal of the Academy of Marketing Science 22:99–113
16. Doney P, Cannon J (1997) An examination of the nature of trust in buyer-seller relationships. Journal of Marketing 61:35–51

17. Emerson H, Cook J, Polatajko H et al (1998) Enjoyment experiences as described by persons with schizophrenia: A qualitative study. Canadian Journal of Occupational Therapy 65:183–192
18. Fynes B, Voss C, De Burca S (2005) The impact of supply chain relationship quality on quality performance. International Journal of Production Economics 96:339–354
19. Gao H, David B, John G (2010) Paradoxes and Guanxi dilemmas in emerging Chinese-Western intercultural relationships. Industrial Marketing Management 39:264–272
20. Gundlach G, Ravi S, John T (1995) The structure of commitment in exchange. Journal of Marketing 59:78–92
21. Hakansson H, Ford D (2002) How should companies interact in business networks? Journal of Business Research 55:133–139
22. Hakansson H, Snehota I (1995) Developing relationships in business networks. Routledge, London
23. Henry F (2011) Market orientation, Guanxi, and business performance. Industrial Marketing Management 40:522–533
24. Jay B (1999) How do a firm's capabilities affect boundary decisions? Sloan Management Review 40:134–144
25. Kelley H, Berscheid E (1983) Close relationships. W. H. Freeman & Company, New York 72–75
26. Lee J, Kim Y (1999) Effect of partnership quality on IS outsourcing success: Conceptual framework and empirical validation. Journal of Management Information Systems 15:29–62
27. Leung T, Ricky Y, Lai K et al (2011) An examination of the influence of Guanxi and Xinyong (utilization of personal trust) on negotiation outcome in China: An old friend approach. Industrial Marketing Management 40:1193–1205
28. Li J, Sheng S (2011) When does Guanxi bolster or damage firm profitability? The contingent effects of firm- and market-level characteristics. Industrial Marketing Management 40:561–568
29. Lu H, Trienekens J, Omta S et al (2008) Influence of Guanxi, trust and farmer-specific factors on participation in emerging vegetable markets in China. NJAS-Wageningen Journal of Life Sciences 56:21–38
30. Luo Y, Chen M (1996) Managerial implications of Guanxi-based business strategies. Journal of International Management 2:193–316
31. MacDuffie J, Helper S (2006) Collaboration in supply chains with and without trust. In: The Firm as Collaborative Community, Re-constructing Trust in the Knowledge Economy, Oxford University Press, Oxford
32. Mohr J, Fisher R, John R (1996) Collaborative communication in interfirm relationship: Moderationg effects of integration and control. Journal of Marketing l:103–115
33. Mohr J, Nevin J (1990) Communication strategies in marketing channels: A theoretical perspective. Journal of Marketing 54:36–51
34. Mohr S (1994) Characteristics of partnership success: Partnership attributes, communication behavior, and conflict resolution techniques. Strategic Management Journal 15:135–152
35. Morgan R, Hunt S (1994) The commitment-trust theory of relationship marketing. Journal of Marketing 7:20–38
36. Moorman C, Gerald Z, Rohid D (1992) Relationship between provider and users of market research: The dynamics of trust within and between organizations. Journal of Marketing Research 29:314–328
37. Rui N, Zhong W, Jiang W et al (2011) A bittersweet phenomenon: The internal structure, functional mechanism, and effect of Guanxi on firm performance. Industrial Marketing Management 40:540–549
38. Peng M, Luo Y (2000) Managerial ties and firm performance in a transition economy: The nature of micro-macro link. Academy of Management Journal 43:486–501
39. Peng M (2003) Extending research on network strategy in emerging economics. In: Strategic Management Society Mini-Conference, The Chinese University of Hong Kong

40. Park S, Luo Y (2001) Guanxi and organizational dynamics: Organizational networking in chinese firms. Academy of Management Journal 22:455–477
41. Parsons A (2002) What determines buyer-seller relationship quality? An investigation from the buyer's perspective. Journal of Supply Chain Management 38:4–12
42. Perrone V, Zaheer A, McEvily B (2003) Free to be trusted? Organizational constraints on trust in boundary spanners. Organization Science 14:422–439
43. Peter K, Paul K (2007) The role of Guanxi in supply management practices. Production Economics 106:450–467
44. Peter W, Xiao Z (2011) Embedding social networks: How Guanxi ties reinforce Chinese employees' retention. Organizational Behavior and Human Decision Processes 116:188–202
45. Peter J, Jeremy C, Tan H (2006) Cultural awareness in knowledge transfer to China — The role of Guanxi and Mianzi. Journal of World Business 41:275–288
46. Pinto J, Slevin D (1989) Critical success factors in R&D projects. Research-Technology Management 1:31–35
47. Robert J, Jennifer H (2010) A research model for Guanxi behavior: Antecedents, measures, and outcomes of Chinese social networking. Social Science Research 39:1195–1212
48. Shou Z, Rui G, Zhang Q et al (2011) The many faces of trust and Guanxi behavior: Evidence from marketing channels in China. Industrial Marketing Management 40:503–509
49. Tjosvold D (1988) Cooperative and competitive interdependence. Group and Organization Studies 13:274–289
50. Tomaz C, Barbara C (2010) Product and relationship quality influence on customer commitment and loyalty in B2B manufacturing relationships. Industrial Marketing Management 39:1321–1333
51. Tsang E (1998) Can Guanxi be a source of sustained competitive advantage for doing business in China? Academy of Management Executive 12:64–73
52. Tsang W (1998) Can Guanxi be a source of sustained competitive advantage for doing business in China? Academy of Management Executive 12:64–73
53. Vargo S, Lusch R (2004) Evolving to a new dominant logic for Marketing. Journal of Marketing 68:1–17
54. Wang C (2007) Guanxi vs. relationship marketing: Exploring underlying differences. Industrial Marketing Management 36:81–86
55. Xin K, Pearce J (1996) Guanxi: Connections as substitutes for formal institutional support. Academy of Management Journal 39:1641–1658
56. Yang Z, Wang C (2011) Guanxi as a governance mechanism in business markets: Its characteristics, relevant theories, and future research directions. Industrial Marketing Management 40:492–495
57. Yeung Y, Tung R (1996) Achieving business success in confucian societies: The importance of Guanxi (connections). Organizational Dynamics 25:54–65
58. Zhang C, Sridhar V, John W et al (2011) The boundary spanning capabilities of purchasing agents in buyer-supplier trust development. Journal of Operations Management 29:318–328
59. Zhuang G, Xia Y, Alex S (2010) Power, conflict, and cooperation: The impact of Guanxi in Chinese marketing channels. Industrial Marketing Management 39:137–149

Chapter 60
Study on the Action Mechanism of Humanities and Social Sciences Education Division

Yongjie Wang and Zhixia Li

Abstract This article puts forward the concept of division of knowledge on the basis of analyzing the division of knowledge. Then, it discusses the mechanism of educational division from both the angles of "threshold knowledge" and "learning by doing". On the one hand, it gets the function model of specialization division that explains expression form of educational division of labor. On the other hand, it states the inherent self promoting mechanism of educational division of labor in detail. After the research of education division mechanism, it analyses the action mechanism of humanities and social sciences education division considering economy development, society progress and our county's practical condition. Finally, it comes to a conclusion that humanities and social sciences education division has effects in the follow three aspects: knowledge content innovation, knowledge structure innovation and knowledge organization innovation.

Keywords Humanities and social sciences · Division of knowledge · Educational division of labor · Education

60.1 Introduction

The division of labor in society brings division of knowledge, which then brings educational division of labor. One of its main performances is that humanities and social sciences education appeared and refined. The development of humanities and social sciences knowledge and education leads to social knowledge structure's improvement. At present, there are almost no scholars studying humanities and social science education from the perspective of educational division of labor. Therefore, this article puts forward a brand new concept of education division of labor. On that

---

Y. Wang (✉) · Z. Li
School of Public Management, Southwest Jiaotong University, Chengdu 610031, P. R. China
e-mail: wyj@home.swjtu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_60,

basis, the article analyses the performance and action mechanism of it. And then, the article discusses the action mechanism of Humanities and Social Sciences Education Division. It presents a new research perspective for theory studies of humanities and social science education field. At the same time, it analyses the action mechanism of humanities and social sciences education division from the actual situation in our country. So, it will have certain practice significance in guiding the progress of humanities and social sciences education in our country.

60.2 From Division of Knowledge to Educational Division of Labor

60.2.1 The Meaning of Division of Knowledge

Division of labor is diversified. Division of knowledge is closely linked with specialization division of labor that decides the differentiation or division of knowledge, which makes knowledge, classifies according to professional requirements and results in division of knowledge. Zhang argues that division of labor's essence is just the division of knowledge which gives rise to knowledge accumulation and improvement of economic entity and promotes economic growth [1]. We regard knowledge as distribution knowledge, when it's mastered by a collection of economic entities and none of them can fully grasp it. The author thinks that it is the division of knowledge.

60.2.2 Educational Division of Labor

The human society development is a process in which division of labor getting deepened, market getting expanded and production getting roundabout. In this process, the division of knowledge gradually highlights and the educational division of labor also becomes more profound. Young Theorem points out that: "Division will promote the division of labor" [2]. We can further think that Young Theorem also plays a part in the relationship between the education and market division. In short, this is professional division of education. For the professional division of society, the expansion of scale of market brings about roundabout production which makes the division of labor reveals deepening and refining in the labor post. Educational division of labor as the educational institution for laborers meeting the market behavior standard also fits the theory of division of labor in general. So, we think that educational division of labor means the division of educator, educatee, educational institution and educational behavior facing the social division of labor and the market demand with the purpose of division of knowledge.

60.3 Action Mechanism of Educational Division of labor

60.3.1 Form of Educational Division of Labor

Educational division of labor facing the social division of labor and the market demand mainly displays in the following respects: division of higher education, disciplines and specialties, set of subject direction and related courses under disciplines and specialties, the division of the education level (basic education, higher education, vocational education), division of school types (such as comprehensive universities, engineering universities, normal universities, agriculture and forestry universities, medical universities, military universities), etc. They will directly act on the size and structure of whole society knowledge stock. Wang had divided one's knowledge who participated in the division of labor into"knowledge about production technology" and "knowledge about system for coordinating with production" [3]. Based on this, we think that technological knowledge education and social sciences knowledge education are also a kind of differentiation. The recipients of them will appear division followed. According to college students' general employment condition in China, they will look for jobs before graduation (in junior or senior year). Talent market is a signal at this time that reflects graduates' structural characteristics turning into division of labor in society, which actually dependent on knowledge stock they accumulated in university and most of which can not be compared through skill or experience. Their knowledge stock is the not only the unique sigh of differentiation in the talent market, but also the initial knowledge when they entering into the division of labor. We can call it"threshold knowledge" which has been fixed when colleges enter into the talent market and will never change.

The theory of "learning by doing" is just a part of job that engaged in the professional division job, which gives expression to the important meaning of skills in specialization progress produced by division of labor [4]. There are two aspects of foundation for engaging in professional work according to "threshold knowledge": one aspect is the improvement of skills and accumulation of experience, which is increasing function of working hours. Another is probability-distribution function of "threshold knowledge" that comes from colleges "threshold knowledge" stock and innovative thinking from the stock. Both of them will work together to bring improvement of efficiency produced by specialization division. Therefore, the ability needed in the professional division can be expressed as:

$$C = C_0 + C_1(t), \tag{60.1}$$

where C_0 means "threshold knowledge", C_1 means skills acquired from "learning by doing", t means work hours engaged in a professional job. When we only consider market division,

$$\frac{\partial C}{\partial t} = \frac{\partial C_1}{\partial t}.$$

The value of C's change depends only on the specialization work hours devoted to market division.

For the same subject, C_0 is decided by age of education and its change depends on age of education and time of "learning by doing".

60.3.2 Self Promoting Mechanism of Educational Division of Labor

As shown in the diagram below, the efficiency of professional division of labor in part comes from skills and experience accumulation through "learning by doing" and technology division that based on proficiency accumulated over a long period. The other part comes from the improvement of people's way of thinking gained by education and the original basic knowledge about new industry. The latter comes from the division of knowledge and is the result of knowledge accumulation differences in the process of education. Division of "threshold knowledge" roots in educational division of labor. The thinner the education division becomes, the bigger the improvement of knowledge stock's size and structure is. And people's specialization level in the initial state will be higher. So, the degree of division of labor in society will be strengthened, and the market performance will be improved.

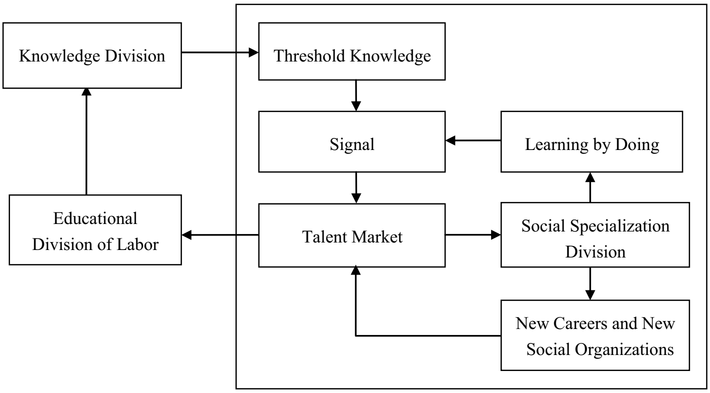


Fig. 60.1 Self promoting mechanism of educational division of labor

The differences of knowledge in society professional division assume that people access into different fields of society professional division according to the signal provided by talent market. In different fields of division, each person with ability will have a wide range of trade and improve their efficiency relying on the knowledge and skills acquired during the education period. The division of labor in society will have further development and create new jobs, career and social organization until this division rejects the improvement of efficiency.

The difference between knowledge stock from humanities and social science education and that from technology education brings the difference of division nature. People who have the knowledge stock of science and technology education mainly make the technical post deep and thin through division in production. Then, people who have the knowledge stock of humanities and social science education principally make the management deep and thin. Management here in a broad sense includes not only enterprise production management but also any function post that assigns the resources of human and things. The appearance of this new job and social organization will also reflect in talent market demand information that transfers the signals to educational industries and workers and makes further adjustments to educational division of it.

Educational division of labor makes the original the theory of division of labor in society deepening which expends from the interaction between product/service market and talent market to “the product/service market-talent market and educational division of labor”. At the same time, knowledge stock changes from exogenous variable to endogenous variable, which then reflects the division fact between market and education. The suppliers of existing knowledge stock make disciplines and specialties education divided constantly brought by educational division of labor. Existing knowledge stock links the educational division chain with the market division chain. Here we relax the assumption that knowledge stock is invariable in original market division model. We think the knowledge stock is different when the educational division of labor changed. Social structure constantly happened following the change of economic structure. It is the change of social modal and the growth of new jobs that reflects the influence of educational division of labor which is getting serious. That is to say, the needs for scale and structure of “threshold knowledge” needs are changing continuously. The change of “threshold knowledge” decides whether the social division of labor needs can be satisfied and meet real needs. Therefore, it is necessary to endogen the education behavior into social division model. The inside part in the right of the chart is not only a common circulation when “threshold knowledge” is exogenous but also the situation described by existing theory. It will form a new social division frame diagram, if we add the educational influence on the social division chain. At this time, the progress of the society and economic development not only relies mainly on the growth of human capital scale but also embodied in its structure’s changes.

Consider education’s effect in the frame of economic development and social progress that expand the viewing angle from market division to social division. Both taking the change education brought to labor’s knowledge stock and improvement market brought to labor’s professional skills into account, they will be two important driving forces promoting the social division. Then, market division and educational division of labor will be two subsystems of social division. The social division’s development roots in that if the two subsystems interact in a virtuous circle. Young Theorem can be further expressed as follow: educational division of labor and social specialization division strengthen each other in the education and market's division processes, if it is expanded from market division to social division.

60.4 Action Mechanisms of Humanities and Social Sciences Education Division

60.4.1 Self Promoting Mechanism of Humanities and Social Sciences Education Division

As it is shown in Fig. 60.1 that the right portion of the diagram represents partly the mechanism of economic growth in the traditional division of labor, while the whole diagram indicates that the overall social division of labor brings economic development and social progress after adding the education. Education could promote economic development and social progress. The development of scientific and technical knowledge and humanities and social science knowledge are the specific form of the division of education. In addition, it performs the division between technical posts and managed posts in the market, so humanities and social science education realizes the self- promotion in the division of education.

Firstly, from the perspective of economic development, one of the marks that measure a country's economic development is the reasonableness of its industrial structure whose an important symbol is the increased proportion of the third industry [5]. The demand for technology is dominant in the second industry and the effect of the education division performs the strong demand for scientific and technical knowledge, but the demand for humanities and social sciences knowledge is not so obvious. Therefore, the development of the discipline or professional construction is both slower than others in humanities and social sciences education, but the demand for the knowledge about service, system and management becomes more and more stronger with the continuous development of the third industry in recent years, such as the transition from industry into service, and from the industrial economy into the knowledge economy and information economy, so the effect of division in Humanities and Social Sciences has become increasingly evident [6].

Secondly, from the perspective of society progress, one of the marks that measure a country's progress is the degree of social civilization and the diversification of social organization. After the "5.12" Wenchuan Earthquake, non-governmental organization (NGO) and non-profit organization (NPO) play an important role in the process of the earthquake relief, the harmonious society and "Love Bank" both reflect the social civilization and progress, because they are not simply the pursuit for material interests. With the various types of intermediary organizations, NGO and NPO's appeared, the social structure develops from the nation to the civil society and the social organization network expands quickly, which contribute to increasing more systems to manage the social organizations and coordinate the relationship among these organizations. The increased demand for systems does not mean necessarily that systems have changed over, so enhancing the supplying capacity of systems is extremely urgent. Therefore, the change and division of the social organizations perform the change of a system, in the meanwhile, which also enhances the requirement of the system in supplying capacity, and makes the social network increase the demand for knowledge about humanities and social sciences. As a result, the division in humanities and social science education is more obvious.

In recent years, our country pays more attention to the discipline construction in the higher school and they enhance the demand for the professional construction and the discipline development urgently. The central government also issued a special document – The views about developing further the philosophy and social sciences.

Finally, from the view of our division in humanities and social science education, many comprehensive universities vigorously run the humanities and social sciences discipline, at the same time, many engineering universities optimize its discipline structure by developing humanities and social sciences disciplines in order to strengthen the artistic culture and optimize the academic atmosphere, such as start the College Chinese to strengthen the cultural quality education, launch psychological education teaching and counseling to promote the students' psychological health, and so on. By February, 2006, there are 406 doctor stations about humanities and social sciences disciplines and 201 key disciplines in our universities which make the professional categories more complete. The new and crossed disciplines emerge, which promotes the development of comprehensive research and complex talent [7]. Over the past decade, our country has built 151 key research bases about humanities and social sciences [9].

60.4.2 Actions of Humanities and Social Sciences Education Division

Humanities and social sciences education is differentiated from the general education and promotes itself, and gets the following three developments.

(1) Knowledge content innovation

Humanities and social science education produces new knowledge and create new thoughts with scientific researches. Universities also strengthen the theoretical study of humanities and social sciences and provide the society with the scientific decision-making service, to participate in the great practice of reform and opening-up policy in China and socialist modernized construction, to serve for the local economic construction and social development positively, and to strive to improve the ability that researches and solves the major theoretical and real problems. For example, from 1992 to 2000, humanities and social science education has gained many major and valuable theoretical results that has proposed a series of creative proposals that contribute to exploring the law about the development of socialism with Chinese characteristics and promoting the establishment and development of the socialist market economy in the reform about the enterprise share holding system, the sustainable development of the national economy, and the international investment, and so on. The researchers has provided 38344 kinds of researches and advisory reports in the decision-making service for the party, the government and enterprises, such as the research about Asia-Pacific Economic Cooperation (APEC), the drafted document about China's accession to the WTO, the objection to the separatism and the guard for the national sovereignty. Among them, many significant results have achieved high economic and social benefits [8]. In the period of " Eleventh Five-Year", the high school has provided more than 20000 consulted reports and policy suggestions to the Central, the State Council and local governments, which has more than 1000 reports and suggestions having been instructed or adopted by the central comrades and the departments beyond provincial level [9].

(2) Knowledge structure innovation

Neil·L Rudenstine, the past president of Harvard University ever spoke that the University must is facing new challenges that we must consider what education should be provided, it emphasizes on impart of humanity, to provide the best education that can not be measured by money. Such kind of education can not only give us strong professional skills, but also enable us to be good at observing, thinking, exploring, and shaping sound personality. Especially make researchers learn to appreciate the art, help the people engage in artistic creation get to comprehend science, and make everyone's life more rich and colorful by the mutual penetration of the different disciplines. The humanities and social science education is not only to cultivate the corresponding talents who have the "threshold of knowledge" about humanities and social sciences to ensure the supply of knowledge to meet the needs of the talent market, but also must make the thoughts, the values and the codes of conduct influence students' thoughts and conducts by the optimization function of the humanities and social science education to make them have the right world outlook, values and outlook on life, and make them have the spiritual enrichment, the sound personality and the wide view, and properly deal with the relationship with the outside world, and effectively adapt to the social development to complete the socialization. Therefore, philosophy has become the popular profession that was selected by the undergraduates in America in recent years [10].

(3) Knowledge organization innovation

Humanities and social sciences education actively adapt for the community's constitution and structure and acclimatize itself to the market's needs through responding with social division of labor, which make its own division deepen.

In the modern society, new education organization forms are constantly producing when social division is deepening. For example, technology information makes the computer became effective tool of humanities and social science research and education. For another instance, both the booming development of television and radio broadcasting university education and e-learning institute are aid in the modern information transmission methods. The appearance of the liberal education in e-learning is certainly the result of infiltration and interaction between natural science education and the humanities and social science education. At this time, natural and social scientists are also connected to each other. It is hard to imagine that a natural scientist with no humanistic edification or ideology influence. Also, a social scientist that does not have any natural scientific knowledge of social is not existed.

On the other hand, increasing division and integration of labor also initiate the constant change of the educational division of labor. Because of the continuous inoculation and influence of new ideas, new concepts and new scientific culture, new career and position appear regularly. All those factors greatly contributed to the change of Humanities and Social Sciences Education Division: ① When the differentiation of the discipline kinds become more and more meticulous, only colleagues of this discipline can really understand one's research depth in a local field. ② The integration among disciplines gets more and more obvious, and the achievements of cross discipline, traverse discipline and the edge discipline are remarkable.

60.5 Conclusion

We have analyzed that the relation between social division of labor and education division of labor and humanities and social change and progress's paths and methods promoted by humanities and social science knowledge and education development. Educational division of labor makes the social organization structure different further and provides more carriers of the humanities and social science knowledge. It is the gradually increasing talents engaged in nontechnical progress of social division that improves the knowledge stock and structure of system supply. This article comes up with and completes the definition of educational division of labor. It argues that educational division of labor facing the social division of labor and the market demand mainly displays in the following respects: division of higher education, disciplines and specialties, set of subject direction and related courses under disciplines and specialties, the division of the education level (basic education, higher education, vocational education), division of school types (such as comprehensive universities, engineering universities, normal universities, agriculture and forestry universities, medical universities, military universities), etc. Furthermore, it reveals the self promoting mechanism of educational division of labor through Fig. 60.1 and analyses the action mechanism of humanities and social sciences education division considering economy development, society progress and our county's practical condition. Finally, it comes to a conclusion that humanities and social sciences education division has effects in the follow three aspects: knowledge content innovation, knowledge structure innovation and knowledge organization innovation. Limited to the subjective and objective conditions, this paper just puts forward a simple analysis method in studying humanities and social sciences education at the view of educational division of labor. It needs more efforts to have a further understanding of this problem. The further research can include development direction of humanities and social science education division mechanism and the relationship among the three actions of it.

Acknowledgements This article receives the subsidization of the fund project of the Humanities and Social Science of the Education Ministry, the number of the project is 10YJC880125.

References

1. Zhang YX (2005) Enterprise theory based on the distribution knowledge. Jilin University (In Chinese)
2. Young AA (1996) Increasing return and economic progress. Comparison of Economic and Social Systems 1:52–57 (In Chinese)
3. Wang DD (1995) Knowledge society and intellectual. Reading 1:82–88 (In Chinese)
4. Young A (1991) Learning by doing and dynamic effects of international trade. Quarterly Jounal of Economics 106:369–405
5. Loasby BJ (1999) Knowledge, institutions and evolution in economics. Psychology Press, London
6. Hayek FA (1937) Economics and Knowledge. Economica 4:33–54
7. Zhu ZG (2006) Philosophie and Social Sciences in Universities Make remarkable achievement. Guangming Daily, February 15th
8. Ministry of Education of the People's Republic of China (2008) Sight-seeing of universities' achievements in philosophy and social science during the tenth five-Year plan [EB/OL]. http://www.moe.gov.cn/edoas/website18/77/info20877.htm,2008-12-02
9. Guangming Daily (2008) Sight-seeing of universities' achievements in philosophy and social science during the eleventh five-Year plan, Guangming Daily, Feruary 2nd
10. Guo YJ (2008) Why did philosophy became popular major. Science Times, April 29th

Chapter 61
Study on Sports Intervention Strategies for Post-Disaster Psychological Recovery of Adolescents

Ying He and Ming Xu

Abstract The article is aimed at bringing some new thoughts on the sports intervention strategies for post-disaster psychological recovery of adolescents. Main symptoms of post-disaster psychological trauma of adolescents, and the theoretical basis for adolescent psychological recovery are discussed in this article by means of documentation, logical analysis and system analysis, etc., with the focus on the theoretical mechanism and involvement strategy. It provides the conclusion that the psychological recovery of adolescents is a long-term systematic engineering and how to make use of sports means for effective psychological intervention is a long way to go.

Keywords Major disaster · Psychological trauma · Adolescent · Psychological recovery · Sports intervention · Strategy

61.1 Introduction

Disaster refers to the natural and social events that cause damages to any natural ecological environment, and material and spiritual civilization construction of human beings, in particular, the lives and properties of people, such as earthquake, volcanic eruption, wind damage, fire, flood, drought, air accident, marine peril, hail and ice disasters, debris flow, epidemic disease and war, etc [1]. Home rebuilding after the disaster is a major problem to be seriously dealt with, while the post-disaster physical and psychological recovery of people shall be given top priority. According to the WTO, 20%-40% of people are of psychologically slightly maladjustment

---

Y. He (✉)
Sports Department, Chengdu Sport University, Chengdu 610041, P. R. China
e-mail: Heying7439@yahoo.com.cn

M. Xu
PE Department, Chengdu University, Chengdu 610106, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_61,

after the disaster and 30%-50% are of moderately or even severely maladjustment, while 20% will suffer severe psychological illness within a year thereafter. According to the psychological definition, there are three criteria to judge the psychological traumatic event: life-threatening, unpredictable and unstoppable. Psychological crisis is a metal disorder that caused by experiencing or witnessing extreme and irresistible traumatic event in person, which then leads to the inserted trauma-related thoughts and memories, lasting evasion from the trauma-related stimulus and increasing alertness of individuals. Psychological crisis is often found in adolescents of areas that worst hit by the disaster. Take the "5.12" Wenchuan Earthquake for example, the destructive earthquake destroyed everything, homes and schools, and changed things a lot in life and learning environment, and also brought adjustment disorder, the symptom of being unable to adapt to the environmental changes, to the adolescents; loss of family, friends and schoolmates, the adolescents felt abnormally high or low, i.e., maniacal or depressed disturbance of emotion, and namely, the mood disorder; experiencing or witnessing the extreme and irresistible earthquake in person caused mental disorder and triggered a series of symptoms of stress reaction neurosis (namely the neurosis) to them, including phobia, anxiety disorder, obsessive-compulsive disorder, hysteria, hypochondriasis and neurasthenia, etc.

When the traumatic event takes place, 70% people will recover themselves by their own ways. But as many as 30% people will suffer different symptoms consecutively in the days and even dozens of years following the disaster [2]. As for the adolescents in the critical period of physical growth and psychological development, but in lack of psychological endurance and social experience, the psychological trauma caused by the disaster may exert serious impact on them and lasting for a whole life. Besides, they have views different from the adult on the disaster, which are characterized by the fear in disaster that is possible in the future, loss of interest in learning at school, regressive behavior, sleep disorder and fear in night, etc. So this means that after the earthquake, we are also in face of psychological trauma rescue, a contact battle to fight for the souls. The adolescents who have been seriously injured and crippled, and have lost schoolmates and families should be of primary importance in this fight of intervention with psychological trauma [3].

It is an urgent and long-term subject to care about the physical and psychological rehabilitation of adolescents, probe the intervention strategy, and seek for scientific and effective way of improving the psychological health level of the adolescents.

61.2 Main Theories of Psychological Recovery

There are many theories on psychological recovery, and conventional neurobiology and psychological theories stress the major task of enhancing the individual sense of security and stability in post-disaster psychological recovery of adolescents so that they can express the painful experience of loss and trauma, while connecting, integrating and repairing the self, interpersonal relationship and social function of the patient and finally accomplish the goal of reconstruction the traumatic memories [4, 5].

Posttraumatic Growth (PTG) emphasizes that the influence of the trauma on people need to be understood from the angle of "conversion", which views the trauma as a chance that the individual may learn how to overcome the difficulties, improve personal strength and overcome themselves. Post-disaster psychological recovery of adolescents may also be a positive psychological construction from the angle of personal growth, which becomes the post-traumatic "prosperity" [6].

The theory of ecological psychology believes that the task of post-disaster psychological recovery lies in the recovery of support to different systems such as microsystem, intermediate system, outer system, macrosystem and epochal system, etc. and to re-balance these systems [7].

The theories of sociology and social work emphasize on trusting the adolescents of disaster area, understanding their needs, finding out the advantages from themselves and the environment, establishing the social support system for the adolescents affected by the disaster so as to bring into full play and realize the self-value and self-empowerment of the adolescents [8].

The article explores by the methods and means of sports the sports intervention strategy in the post-disaster psychological recovery of adolescents from the aspect of sports, so that it may provide some reference for the healthy psychological development of the adolescents after the serious disasters.

61.3 Theoretical Mechanism for Sports Intervention in Adolescent Psychological Recovery

61.3.1 Biological Mechanism

In the consequence of serious disaster, the adolescents are in a mood of fear, sadness and helplessness, etc., which makes them in a depressed and painful state. Physical exercises enhance the neurotransmission of norepinephrine, s-tryptamine and dopamine that may improve the mood; meanwhile, physical exercises stimulate the brain to produce excitatory substance like morphine, to inhibit the low mood and make people feel ease and delighted [9]. Physical exercises also increase the strength of cardiovascular, the healthy status of which matters much for peoples of mental state, so physical exercises are helpful in improving the mental state of post-disaster adolescents.

61.3.2 Psychological Mechanism

(1) Increasing the sense of self-efficacy

Adolescents who have gone through the serious disaster often feel worthless and incapable in the society, etc. Through physical exercises, however, they may achieve success in a sport after their unremitting efforts, so the exercises are effective in letting them feel the joy of success and be confident about themselves.

(2) Diverting attention

Post-disaster adolescents usually focus on a certain circumstance or period of time of that disaster, which may make them accumulate a psychic energy that is troubling and difficult to be released. Physical exercises divert the unpleasant recognition, emotion and behavior of a person. Physical exercises put the adolescents in anxious and stressed states (such as sweating, increasing breath rate and fatigue, etc.), but there is no subjective miserable emotions, so the existence of these physical symptoms improve psychological functions.

(3) Cultivating good quality

Physical exercises could be antagonistic and competitive, the competitiveness and hardship in sport competitions require the participants to bear a certain physical and psychological load, which is good to harden the adolescents; meanwhile, sport competitions always end up in either success or failure, so the adolescents are trained to withstand the result of being a loser.

61.3.3 Social Mechanism

Physical exercises are mostly in groups and collectives, so there are many chances for the participants to be connecting and coordinating and having antagonist activities with each other, which forms a multidirectional interpersonal communication and interaction. The participation in physical exercises meets the needs of adolescents in social communication and enriching personal life-style, and is beneficial not only to increasing the mutual trust and communication of adolescents, but also to eliminating the mental stress and sense of loneliness that the disaster has brought to them.

61.4 Sports Intervention Strategy for Adolescent Psychological Recovery

The post-disaster psychological recovery of adolescents is a system engineering which is divided into the following three stages: “emotion stabilization, active reaction and recovery from psychological trauma”, “psychological adjustment, active adaption and elimination of psychological shadow” and “development and improvement, active recovery and optimization of psychological structure and function”. Full cooperation of the society, schools and households is required for the work of each stage. As an important element in promoting the healthy growth of adolescent students and developing their capacity in cognition, emotion and social interaction, sport exercises and activities help regulate mood effectively, e.g., to divert attentions, abreact affections, change interests, relieve tense nerves and stabilize emotions. Therefore, it is of far-reaching significance to provide a scientific and reasonable sports intervention strategy for the post-disaster psychological recovery of adolescents.

61.4.1 Sports Intervention and Guarantee Strategy

(1) Change of concepts of the government

The government shall change their concepts during the post-disaster recovery, emphasizing both the recovery of material conditions and that of physical and mental health, particularly, adolescents, a social vulnerable group, from mental maladjustment need to be protected and helped by governments at all levels.

(2) Transformation of organization system and operation mechanism

Since the post-disaster recovery would go through a long period of time, changes in the organizational form and operation mechanism of social relief will take place during the role change of the government. Macroscopically, the national administrative department of physical education and the local governments shall carry out regulation and control, while at the micro level, the local department of physical education and all sports organizations shall regulate the operation of sports activities through public-spirited means and government intervention to promote diversified development, so as to guarantee the effective implementation and boosting of psychological intervention strategy.

(3) Establishment of a sports intervention system for post-disaster psychological maladjustment by the State

The State shall establish a support system for implementation of sports intervention strategy at the place where is hit by severe disaster, including the support system for the department of physical education, that for sports organizations and that for individuals. Those systems shall be subject to the law and moral standards and included into the whole social security system to serve as a helpful and indispensable supplement for the sports development of China.

61.4.2 Sports Intervention Involvement Strategy

Former researchers mainly classify the sports activities according to the nature and logical principles of physical education. From the effect of sports activities on the psychology, such activities may be classified as communicative, competitive, psychologically-healthy, ecological and service-oriented activities. Since different sports activities may regulate and be good for different psychological maladjustments, the adolescents shall take part in sports activities selectively according to their specific post-disaster psychological maladjustment.

(1) Exercise prescription for social communication

Communicative sports activities are helpful for both body building and interpersonal communication, typically including *T* dance sports, sports games and ball games that require no direct physical contact, such as table tennis, badminton, tennis and volleyball. Group sport events may provide chances for participants, directly or indirectly, to make more friends and get everyone involved in the group through the sports activities.

As for specific operation, the stadium which can contain a great number of people shall be preferred, with relaxing and cheerful background music played. During the activity, exercise intensity and amount shall be properly adjusted. The communicative sports activities may effectively divert the adolescents' attentions from the memory of the disaster, put them at ease and in a stable mood. Such sports activities will particularly work out for the recovery of the psychological maladjustments such as depression, self-closing and autism.

(2) Exercise prescription for affection abreaction (competitive sports activities)

The competitive sports activities are those that involve physical and mental competition, typically represented by free combat, boxing, taekwondo and ball games that require direct competition, such as basketball, football and American football. Participants who take part in these sports activities may through struggling and fighting relieve themselves from their psychological maladjustments they endure for a long time and get mental satisfaction to some extent, achieve a sense of achievement and feel more confident. By taking part in the competitive sports activities, the adolescents suffer from such anxiety symptoms as continuous tension and worries as well as suppressed psychological maladjustment after the disaster may abreact and divert the negative affections effectively, get rid of the great psychological burden, balance the mood and change the spiritual complexion.

As for specific operation, the competitor shall be a psychologically healthy person (A psychological regulators would be better) or a sport item (such as a sandbag).

(3) Exercise prescription for psychological health

Psychologically-healthy sports activities are characterized by a small amount of excise and relatively high concentration, mainly including such individual events as jogging, walking backward, yoga, qigong and taiga as well as chess and card activities like Go, Chinese chess, etc. Since attentions of the participants are required to be focused on the sporting events during the practice, the participants will be effectively dragged from the memories of the disaster and feel a sense of psychological peace.

As for specific operation, it would be better to have psychological regulators to accompany the adolescents who suffer from panic and phonic disorders during sports activities (chattering what the same time of doing exercise). It would be helpful for them to relax. The panic and phonic disorders will be gradually reduced and even removed through regulation of psychologically-healthy sports activities, in combination with other methods for mental healing.

(4) Ecological exercise prescription

The purpose of ecological sports activities is to get the participants close to the nature, drawing nature spirits from the natural environment, arousing the enthusiasms for life and cultivating relatively strong adaptability and viability. Such sports activities may greatly divert the patients' attentions from the memory of the disaster and will be helpful for the ease of the sense of vulnerability and helplessness. The main exercises include outing, camping, climbing, swimming, hiking, bicycle riding and other activities which will get the participants close to the nature.

(5) Service-oriented exercise prescription

It is intended to help the adolescents to effectively abreact and divert their affections, get rid of the great psychological burden and balance the mood through their participation in the sports activities in which socialized labor division and cooperation will be required, individuality will be shown and the ability of communication and cooperation as well as the sense of care and responsibility will be cultivated. Main exercises include community sports activities, club sports activities, group activities, etc.

61.5 Attentions for Sports Intervention for Adolescent Psychological Recovery

Owning to the fact that sudden accidents have frequently occurred in the recent years, there are a lot of references in which focus is put on the study of crisis intervention from psychological perspective, but few on sports behaviors. Therefore, to improve these subjects, the following problems shall be solved.

61.5.1 Deepening the Understanding of Sports Intervention Functions for Adolescent Psychological Recovery

Having been influenced by prejudices of a great many of people, neither the theory nor the operation of sports intervention for adolescent psychological recovery have drawn much attention of the society, schools and households. Consequently, there are fewer inputs such as human, material and financial resources therein.

61.5.2 Emphasis on the Cultivation of Physical Education Professionals

Currently, most middle schools don't have enough physical education teachers engaged in "mental education" or in primary "mental health", and there is a lack of standardized management for consulting and supervision. More attention, therefore, shall be paid to the enhancement of cultivation of physical education professionals.

61.5.3 Differentiating Each Case and Advancing Step by Step

Appropriate sporting events shall be selected from the sports activities of the same category according to the sports interests and physical conditions of the patients suffering from psychological maladjustment after the disaster. Only being involved in appropriate and interested sports activities can these patients devote themselves and be persistent. Also, only in such way can the regulation and control of sports activities exert an obvious influence.

61.5.4 Effects of Sports Intervention for Adolescent Psychological Recovery

The effects of sports intervention essentially depend on the severity of psychological trauma of the victim. And such external factors as economic aspects, public opinions, charity initiatives, personnel knowledge and accomplishment and diseases will exert an influence on the effects of sports intervention. Some technical problems, such as the method and design of sports intervention, need further exploration. Schools shall pay attention to the creation of files for the psychological health of the students and get psychological experts to carry out psychological consultation for those with poor performance during psychological recovery. Moreover, schools shall pay special attention to the students with serious psychological problems as well as find out and solve their problems in a timely manner. Physical training shall be considered as a significant means for psychological recovery.

61.6 Conclusion

In short, post-disaster psychological recovery of adolescents is a long-term systematic engineering and how to make use of sports means for effective psychological intervention is a long way to go.

References

1. Ouyang XH, Lei H, Tu SS et al (2009) Sports intervention strategy for post-disaster psychological recovery of adolescents & empirical research — Taking some students of boarding

schools suffered from Wenchuan Earthquake as examples. Chinese Journal of Special Education 6:91–96 (In Chinese)

2. Liu G (2008) Symptoms of psychological crisis of mentally wounded children after an earthquake & their treatment. Journal of Sun Yat-sen University — Medical Sciences 6:649–653 (In Chinese)
3. Liu B (2011) Review of study on adolescent psychological recovery after Wenchuan Earthquake. Youth Exploration 2:81–85 (In Chinese)
4. Zhao D (2009) Therapy model & theory for psychological trauma. Journal of South China Normal University (Social Science Edition) 3:125–129 (In Chinese)
5. Zhao G (2009) Intervention for psychological crisis during a disaster — From the perspective of psychiatry. Advances in Psychological Science 3:11–16 (In Chinese)
6. Zhang Q (2011) Post-traumatic growth: A new perspective from psychological trauma from 5.12 Earthquake. Advances in Psychological Science 3:623–630 (In Chinese)
7. Zeng N (2009) Mid-term study report on the subtopic of post-disaster psychological recovery of teachers & students. Education Science Forum 9:59–68 (In Chinese)
8. Guan L (2008) Social work intervention for adolescents in Wenchuan earthquake-stricken area in strength perspective. Journal of Sichuan Administration College 4:357–360 (In Chinese)
9. Tian Y (2011) Advanced physiology of sport and exercise. China Higher Education Press, Beijing (In Chinese)

Chapter 62
A Study on Transportation Infrastructure and Upgrading of Industrial Structure in China

Chen Dong and Liuliu Kong

Abstract The construction of transportation infrastructure influences upgrading of industrial structure by changing flow of production factors. Whether China's high development of transportation infrastructure is beneficial to the upgrading of industrial structure is still a question. By utilizing the data of 1978 $\sim$ 2009 in models of VAR and VEC, the study shows that China's development of transportation infrastructure has a long-term function to improve upgrading of industrial structure. The result of impulse response function (IRF) shows that the tertiary industry begins to response to the transportation infrastructure after 4 to 6 periods. The reason is explained.

Keywords Transportation infrastructure · Upgrading of industrial structure · VEC · IRF

62.1 Introduction

It is known that construction of transportation infrastructure has been made great progress in China since its economics reforming. At the same time, the industrial structure has changed significantly. We want to know whether China's high development of transportation infrastructure is beneficial to the upgrading of industrial structure.

Industrial upgrading theory originated from [2], he first put forward the "Petty-Clark Theorem", which indicates the trend of industry structure from primary industry to tertiary industry during economic development. The scholars outside China studied the influence of transportation infrastructure on economic development earlier. Krugman [9] put forward the Core-Periphery Model which showed that transportation cost has significant influence on industrial aggregation and shifting. When

---

C. Dong · L. Kong (✉)
University of Shanghai for Science and Technology, Shanghai 200093, P. R. China
e-mail: kongliuliu@yahoo.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_62,

the transportation cost falls to the bottom, industry distribution is determined by immovable factors. As the condition of transportation infrastructure improved, the impact of transportation cost declines. Winston [15] offered a different perspective on paying for and investing in the transportation infrastructure. If road and airport systems are priced and invested in efficiently, then the long-run requisite increases in investment are quite modest, the systems would be roughly self-financing in places where some congestion is optimal, and the federal budget deficit is reduced. Harmatuck [6] summarized that the elasticity of aggregate output with respect to infrastructure spending is in the 0.3 to 0.6 range. He concluded in his paper that an increase in highway stocks is associated with modest reductions in manufacturing costs [7]. The cost reductions primarily come about from reduced labor and capital inputs. Shirley and Winston [13] found highway infrastructure investments generate benefits by lowering firms' inventories. Cohen [4] put emphasis on the importance of "broader" economic effects of transportation infrastructure. "Broader" refers to impacts beyond the geographic boundaries within which the infrastructure investments are undertaken and the result indicates this kind of effects is significant. Cochrane et al [3] also found "broader" effects of transportations infrastructure in New Zealand that public infrastructure, especially that related to transportation, may have a positive impact not only in the region where it is located but also on neighboring regions due to the network characteristic of some infrastructure, in which any piece is subordinate to the entire network. Dien [5] studied Vietnam's transportation infrastructure investment and policy and argued that the modern economies are dependent upon transportation in transport people and goods to and from other economies. Access to other economies enables trade and facilitates the specialization of labor and capital, leading to greater productivity and higher wages. Without such access, the improvement of productivity would not occur, and lower average productivity and lower wages happened as results. Jedwab and Moradi [8] found a strong effect of railroad connectivity on cocoa production due to reduced transportation costs when they study the impact of transportation infrastructure on agriculture and development in colonial Ghana. Banerjee et al [1] estimated the effect of access to transportation networks on regional economic outcomes in China over a twenty-period of rapid income growth and concluded that proximity to transportation networks have a moderate positive causal effect on per capita GDP levels across sectors, but no effect on per capita GDP growth. Yu et al [16] used panel data of 28 provinces over the period 1978-2008 to do empirical test showed that there is significant spatial variation in the productivity effects of transport infrastructure in China.

China's scholars also researched the impact of transportation infrastructure on economic development. Liu [11] investigated the effect of highway and marine's fixed capital stock on regional growth, and found that the effect is positive, but the spatial spillover effect is related to different economic characteristics of regions. Liu and Hu [10] used panel data of 28 China's provinces from 1987 $\sim$ 2007 to test on the impacts of transport infrastructure on economic growth. They found that transport infrastructure has a significant positive impact on China's economic growth and that condition of geography and transport infrastructure plays important role in regional disparities. Wei [14] employs spatial econometrics to examine the influence of infrastructure on economic growth and found the development of transportation infrastructure has shortened the spatial distance among regions and lowered the transaction costs. Ren [12] claimed that industrial location is determined by the cost of transport and element. The condition of transportation infrastructure can change the concentrative power and disperse power of industrial center. Transport condition and element cost influence the liquidity of elements and ultimately affect the spatial distribution of economic activity. Zhang and He [17] studied the relationship between transition of industrial structure and element resetting and the result showed that they closely link with each other.

From the summary above, it is obvious that more relative literatures outside China appeared early in 1990s and more domestic literatures or literatures outside China studied China's topic of transportation infrastructure appear in recent years. The reason is that developed countries like USA have completed the transportation infrastructure construction early and the construction of transportation infrastructure in China is doing in recent years. Most of these literatures focused on the linkage between the transportation infrastructure and economic growth, as well as the spillover effect. This paper tries to empirically examine the internal relationship between transportation infrastructure and the upgrading of industrial structure in China.

62.2 Empirical Analysis and Interpretation

62.2.1 Data and Variable Description

The development of an industry can be reflected well by the variation of the ratio of its output in GDP. We take the output ratio of tertiary industry to secondary industry and, i.e., IND as the variable to measure industrial structure. IND = (the output of the tertiary industry)/(the output of the secondary industry).

The variable used to reflect the condition of transportation infrastructure is total distance of highways, railways, civil aviation routes and navigable inland waterways. And we take logarithm of it, i.e., LTR, so that the influence of relative change of transportation infrastructure exerted on industrial structure can be measured.

The data of time series from 1978 to 2009 are drawn from "China Statistical Yearbook". The statistical descriptions are shown in Table 62.1. Fig. 62.1 shows the changes of IND and LTR in the statistical intervals.

Table 62.1 Statistical description of IND and LTR

Variable	Sample Size	Mean	Standard Error	Min	Max
IND	32	0.723197	0.1450065	0.4480067	0.939095
LTR	32	5.469232	0.5515391	4.784655	6.463826

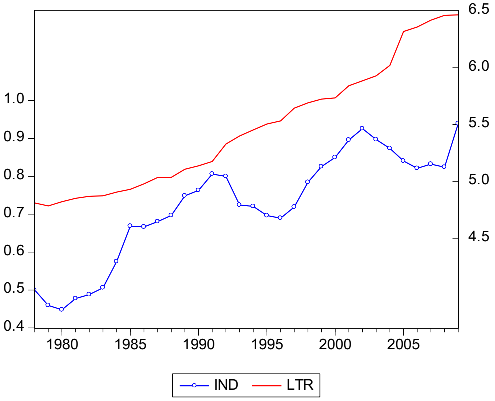


Fig. 62.1 IND and LTR (1978 ∼ 2009)

62.2.2 Model

In this paper, a vector autoregressive (VAR) model which was introduced by Sims in 1980 is used to measure the effects of transportation infrastructure on the upgrading of industrial structure. VAR mode is often used to predict the time series of interconnected systems and analyze the effects of random disturbance on dynamic variable system. All the variables in a VAR are treated symmetrically; each variable has an equation explaining its evolution based on its own lags and the lags of all the other variables in the model. As a result, expert knowledge and structured model can be avoided. A VAR model can be put in the following mathematical form:

$$y_t = \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + H x_t + \varepsilon_t,\ t = 1, 2, \cdots, T, \qquad (62.1)$$

where y_t is a k dimensional column vector of endogenous variables; x_t is a d dimensional column vector of exogenous variables; p is the lag order; t is a the sample number. $k \times k$ dimensional matrix, $\Phi_1, \cdots, \Phi_p$ and $k \times d$ matrix H are coefficient matrixes to be estimated. ε_t is the k dimensional disturbances column vector, and they can be correlated at the same period, but they can not be correlated with their own lagged values and can not be correlated with variables on the right hand side of the equations.

A VAR model demands each time series is stationary. Otherwise, the nonstationary time series should be differenced first, than the stationary differenced time series is used in VAR model. Engle and Granger put forward Vector Error Correction (VEC) model by combining the co-integration theory and the error correction model (ECM). For the series which have co-integration relationship, VEC model cab be built as follows:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t,\ t = 1,2,\cdots,T. \tag{62.2}$$

Every error term in the model is stationary. The model can also be written in Equation (62.3).

$$\Delta y_t = \alpha \mathrm{ecm}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t,\ t = 1,2,\cdots,T. \tag{62.3}$$

In the model, $\mathrm{ecm}_{t-1} = \beta' y_{t-1}$ is error correction term, reflecting the long-term equilibrium relationship between variables. VEC model used in this study is as follows:

$$\begin{aligned}\begin{pmatrix} \Delta \mathrm{IND}_t \\ \Delta \mathrm{LTR}_t \end{pmatrix} &= \alpha \mathrm{ecm}_{t-1} + \Gamma_1 \begin{pmatrix} \Delta \mathrm{IND}_{t-1} & \Delta \mathrm{LTR}_{t-1} \\ \Delta \mathrm{LTR}_{t-1} & \Delta \mathrm{IND}_{t-1} \end{pmatrix} \\ &+ \Gamma_2 \begin{pmatrix} \Delta \mathrm{IND}_{t-2} & \Delta \mathrm{LTR}_{t-2} \\ \Delta \mathrm{LTR}_{t-2} & \Delta \mathrm{IND}_{t-2} \end{pmatrix} + \varepsilon_t. \end{aligned} \tag{62.4}$$

In the following, ADF test would be used to test the stationarity of all the time series, and a co-integration test is done. The Result shows that IND and LTR have cointegration relationship. Granger Causality Test is done for the first-order differences of ΔIND and ΔLTR, and a VEC model is built. After that the impulse response function is used to analyze the interaction between time series.

62.2.3 ADF Test

It is known that majority of the macro-economic time series are not stationary. As stationary is essential for VAR model, an ADF Test is done and result listed in Table 62.2.

Table 62.2 Result of ADF test for IND and LTR

Variable	ADF values	1% Critical Value	5% Critical Value	10% Critical Value	c	Trend	Prob	Stationarility
IND	−2.948	−4.297	−3.568	−3.218	0.16	0.004	0.1628	No
LTR	−2.272	−4.285	−3.563	−3.215	0.912	0.013	0.4361	No
ΔIND	−2.821	−2.644	−1.952	−1.61	None	None	0.0064	Yes
ΔLTR	−2.975	−2.644	−1.952	−1.61	None	None	0.0043	Yes

The test results show that IND and LTR in all significant level having unit root are non-stationary time series. The first-order differences of ΔIND and ΔLTR in the 1% significance level reject the null hypothesis, so the IND and LTR are integrated of first-order time series meet the prerequisite for co-integration testing.

62.2.4 Co-integration Test

Although some time series are non-stationary, if co-integration exists between them, their linear combination will be stationary series. Under this situation, a VEC model will be the better than VAR model. A Johansen co-integration test for IND and LTR is done and the test results are shown in Table 62.2.4.

Table 62.3 Johansen Co-integration test

Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	5% Critical Value	Prob
None	0.356205	15.70429	15.49471	0.0465
At most 1	0.096204	2.933406	3.841466	0.0868

It can be seen from the test results at the 5% significance level, IND and LTR have co-integration relationship, co-integration rank is 1. In the following analysis, a VEC model will be built.

62.2.5 Granger Causality Test

Granger causality is a statistical concept of causality that is based on prediction. According to Granger causality, if a time series B is "Granger-causes" (or "G-causes") of a time series A, then past values of B should contain information that helps predict A above and beyond the information contained in past values of A alone. Since Granger test requires variable sequence stable, the test for ΔIND and ΔLTR is done and the test results are shown in Table 62.4.

Table 62.4 Result of Granger causality test

Null Hypothesis	Lags	P-value	Conclusion
ΔLTR is not the Granger cause of ΔIND	2	0.148	accept
ΔIND is not the Granger cause of ΔLTR	2	0.449	accept
ΔLTR is not the Granger cause ofΔIND	3	0.115	accept
ΔIND is not the Granger cause of ΔLTR	3	0.090	reject *
ΔLTR is not the Granger cause of ΔIND	4	0.012	reject **
ΔIND is not the Granger cause of ΔLTR	4	0.181	accept
ΔLTR is not the Granger cause of ΔIND	5	0.002	reject ***
ΔIND is not the Granger cause of ΔLTR	5	0.337	accept
ΔLTR is not the Granger cause of ΔIND	6	0	reject ***
ΔIND is not the Granger cause of ΔLTR	6	0.265	accept

Note: The significance levels of 1%, 5% and 10% are noted by ***, **, *.

The test results show that the null hypothesis that ΔLTR is not Granger cause of ΔIND in lag of 4 at the 5% significance level is rejected, which means ΔLTR is Granger cause of ΔIND. The test results show that the null hypothesis that ΔLTR is not Granger cause of ΔIND in lag of 5 and 6 at the 1% significance level is rejected, which means ΔLTR is Granger cause of ΔIND. The test results show that the null hypothesis that ΔIND is not Granger cause of ΔLTR in lag of 3 at the 10% significance level is rejected, which means ΔIND is Granger cause of ΔLTR.

From the test results, the following conclusion can be drawn that in the long-term (4, 5 and 6 years) the transportation infrastructure construction significantly affects upgrading of industrial structure.

62.2.6 VEC Model and IRF

The co-integration test shows that long-term equilibrium exists between the upgrading of industrial structure and transportation infrastructure. In the short term they often deviate from the equilibrium path due to various disturbances. A VEC model of rank 1 and lag 2 including intercept (no trend) is built as following:

$$\begin{aligned}\begin{pmatrix}\Delta\mathrm{IND}_t\\ \Delta\mathrm{LTR}_t\end{pmatrix} = {} & \begin{pmatrix}-0.2269877\\ 0.4202626\end{pmatrix}\mathrm{ecm}_{t-1}\\ & +\begin{pmatrix}0.3099969 & -0.1700162\\ -0.1295398 & -0.4135197\end{pmatrix}\begin{pmatrix}\Delta\mathrm{IND}_{t-1} & \Delta\mathrm{LTR}_{t-1}\\ \Delta\mathrm{LTR}_{t-1} & \Delta\mathrm{IND}_{t-1}\end{pmatrix}\\ & +\begin{pmatrix}0.1574046 & -0.0114942\\ -0.1566595 & -0.6425027\end{pmatrix}\begin{pmatrix}\Delta\mathrm{IND}_{t-2} & \Delta\mathrm{LTR}_{t-2}\\ \Delta\mathrm{LTR}_{t-2} & \Delta\mathrm{IND}_{t-2}\end{pmatrix}\\ & +\begin{pmatrix}0.021692\\ 0.085407\end{pmatrix}, \end{aligned} \tag{62.5}$$

$$\mathrm{ecm}_t = 0.214845 + \mathrm{IND}_t + (-0.185485)\mathrm{LTR}_t. \tag{62.6}$$

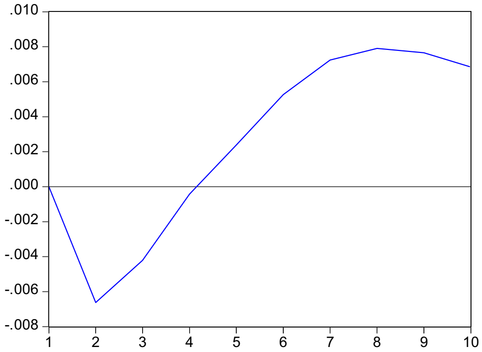
In the model, Equation (62.6) is the error-modification term, reflecting the level of industrial structure and transport infrastructure deviate away from long-run equilibrium. Significance levels of two equations are shown in Table 62.5.

Table 62.5 Result of Granger causality test

D	Equation	Standard Error	R-sq	F-stat	Log likelihood
1	ΔIND	0.028513	0.363933	2.631940	59.25891
2	ΔLTR	0.063035	0.318558	2.150396	47.75554

Significant tests show that the significant overall VEC model is stationary. The results of impulse response function (IRF) analysis are shown in Fig. 62.2.

Fig. 62.2 Impulse response of IND to LTR



From Fig. 62.2, it can be seen that in the long run the pulling effect of LTR to IND is obvious and to reach the highest point on the 6th. It can be interpreted as that the secondary industry firstly responses to the construction of transportation infrastructure and that also can explain why the impulse response IND to LTR in the first three years is negative. After three or four years of the upgrading secondary industry, the pulling effect for the tertiary industry would follow up.

62.3 Conclusion

Based on data of China from 1978 to 2008, a systematic study of relationship between transportation infrastructure and upgrading of industrial structure is made in this paper. The test result shows that in the long-term (4, 5 and 6 years) the transportation infrastructure construction significantly affects upgrading of industrial structure positively and in short-term (2 and 3 years) the effect is negative. We interpreted the phenomenon as that the secondary industry firstly responses to the construction of transportation infrastructure that explains why IND's impulse response to LTR in the first three years is negative. After three or four years of upgrading secondary industry, the pulling effect for the tertiary industry would follow up and about at sixth year the pulling effect reaches its peak. The test result also shows that in short-term (3 years) industrial structure weakly affects transportation infrastructure. We think that in some areas industrial policy can lead to improvement of transportation infrastructure. We think the future research about this topic we should do is to use regional data, such as data of eastern, central and western regions of China, to measure the relationships between transportation infrastructure and upgrading of industrial structure in these regions.

Acknowledgements The research is supported by the key Building Subject of Shanghai Board of Education — "The Operation and Control of Economics System" (J50504).

References

1. Banerjee A, Duflo E, Qian N (2012) On the road: Access to transportation infrastructure and economic growth in China. National Bureau of Economic Research
2. Clark C (1940) The conditions of economic progress. Macmillan, London
3. Cochrane W, Grimes A, McCann P et al (2010) The spatial impact of local infrastructural investment in New Zealand. Motu working paper 10-12:4–38
4. Cohen J (2010) The broader effects of transportation infrastructure: Spatial econometrics and productivity approaches. Transportation Research Part E 46:317–326
5. Dien V (2011) Transportation infrastructure investment and economic integration: A case of Vietnam economy. Kyoto University, Kyoto
6. Harmatuck D (1996) The influence of transportation infrastructure on economic development. Logistics and Transportation Review 32:63–76
7. Holleyman C (1996) Industry studies of the relationship between highway infrastructure investment and productivity. Logistics and Transportation Review 32:93–117
8. Jedwab R, Moradi A (2011) Transportation infrastructure and development in Ghana. Paris School of Economics. Working paper 24:1–47
9. Krugman P (1991) Increasing returns and economic geography. Journal of Political Economy 99:483–499
10. Liu S, Hu A (2010) Transport infrastructure and economic growth: Perspective from China's regional disparities. China Industrial Economics 4:14–23 (In Chinese)
11. Liu Y (2010) Transport infrastructure investment, regional economic growth and the spatial spillover effects-based on highway and marine's panel data analysis. China Industrial Economics 12:37–46 (In Chinese)
12. Ren X (2010) Transportation infrastructure, factor mobility and manufacturing location. Master's thesis, Chongqing University (In Chinese)
13. Shirley C, Winston C (2004) Firm inventory behavior and the returns from highway infrastructure investments. Journal of Urban Economics 55:398–415
14. Wei X (2010) Infrastructure, spatial spillover and regional economic growth. Economic Review 4:82–89 (In Chinese)
15. Winston C (1991) Efficient transportation infrastructure policy. The Journal of Economic Perspectives 5:113–127
16. Yu N, Jong M, Storm S et al (2012) The growth impact of transport infrastructure investment: A regional analysis for China (1978-2008). Policy and Society 31:25–38
17. Zhang Y, He Y (2010) Industrial structure change, factor reallocation and China's economic growth. Economic Survey 3:27–31 (In Chinese)

Chapter 63
Research on Chain Integration and Development Strategy of Modern Service Industry

Guoqin Song, Honglei Deng, Shenghua Zheng and Junjie Zhang

Abstract The development of modern service industry is of highly realistic and historical significance for promoting sound and rapid national economy, accelerating social progress in an all-round manner, and realizing the national strategy of building an innovation-oriented country and harmonious society. This paper, against the backdrop of high-speed development of modern service industry, incorporates the concept of integration of industry chain. Based on related research at home and abroad, this paper applies chain integration theory and service industry development theory comprehensively to further clarify the connotation, modes and influencing factors of the chain integration of modern service industry, and to build up a preliminary framework concerning the integration. This paper also puts forward a set of strategic plans with pertinence and operability, with an aim to offer some guide to the upgrading and structural optimization of modern service industry in China.

Keywords Modern service industry · Integration of industry chain · Development strategy

63.1 Introduction

Global industrial structure has shown the change from “industrial-based economy” to “service economy”. The overall size of the global service industry has reached $28 trillion. The world has entered into the service economy era. The research on the law of global development shows that service industry is changing from that of

---

G. Song
Zhijiang College, Zhejiang University of Technology, Hangzhou 310024, P. R. China

H. Deng · S. Zheng · J. Zhang (✉)
School of Business Administration, Zhejiang University of Technology, Hangzhou 310023, P. R. China
e-mail: neigo123@126.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_63,

labor-intensive to a knowledge-intensive one. Modern service industry with knowledge and advanced technology gradually occupies the dominant position in service industry. It is becoming the leading and pillar industry of economic development. The development of modern service industry is of great real significance and far-reaching historical importance for promoting national economy soundly and rapidly, for accelerating social progress in an all-round manner, and for realizing national strategy of building innovation-oriented country and harmonious society.

Along with the high speed development of modern service industry, the amount of research on the service industry development, especially on development of modern service industry is on the increase rapidly. At present, most research on modern service industry at home and abroad concentrates on the characteristics and connotations of modern service industry, its background and development phases, its relationship with the economic growth, and the phenomenon and cluster effects of modern service industry development, etc [3]. Xu [12] introduced the division and specialization evolution theory of newly-emerging classical economics to modern service industry theory research field, further improving the construction of the theoretical framework of modern service industry.

Industry chain is a relationship connecting the varied links on the upstream and downstream of the industrial chain around specific demand or production of specific products. Those links are interdependent and serve as foundation for each other. Industrial chain integration is a process of accelerating integration of the links between upstream and downstream. Its purpose is to make enterprises in different value chains link more closely together and form coordinating advantage and scale advantage to reduce cost, optimize the allocation of resources and eventually boost the overall competitiveness of industry. In view of the effectiveness of industrial chain integration, it has been applied to all sectors of national economy, involving almost all industries. Research at home and abroad on theory of industrial chain focused mainly on its categorization, formation mechanism, strategy, optimization and integration and so on [10]. Relevant research on industry chain integration mainly focused on its causes, characteristics, main body, mode and ways, functions and policies, etc.

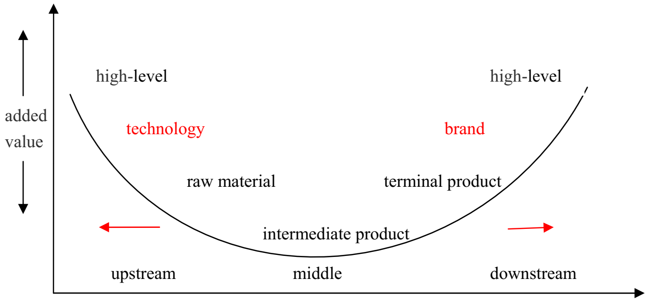


Fig. 63.1 Effective path to integration of industry chain based on knowledge

These researches provide a good reference to the exploration of this paper, but research on precise chain integration of modern service industry remains as a vacuum. With the rapid development of modern service industry, how to apply the theory of integration of industry chain to the development of modern service industry becomes an efficient way to break through the bottlenecks of modern service industry development. It is a policy issue that both the government and academia must face together. Given this and based on relevant study results on industry chain integration at home and abroad, together with the characteristics of modern service industry development, the paper's first part defines mode, connotation and impact factors of chain integration of modern service industry and builds up its theoretical framework from the perspective of the industry chain integration. And on that basis the second part puts forward a set of strategic plans with pertinence and operability.

The innovation of this paper lies in clarifying the connotation of chain integration of modern service industry, in putting forward modes of chain integration of modern service industry, in analyzing the influencing factors of chain integration of modern service industry, and in gradually building up a theoretical framework of chain integration of modern service industry. It is hoped that the result of this research can be of enlightenment to the upgrading and structural optimization of modern service industry in China.

63.2 Connotation and Mode of Chain Integration of Modern Service Industry

63.2.1 Connotation of Industry Chain Integration

63.2.1.1 Industry Chain

Industry chain is a kind of technical and economic relationship among different sectors of industry, and an objective relationship formed according to a certain logic relationship and space distribution relationship [14]. Industry chain is a flow of materials that begins with suppliers, through producers or intermediaries, and ends with terminal consumers [1]. Rui and Li [7] believe that market demands of products relies on successful value creation, and the prerequisite of that is integration of a series of knowledge about customer need, product production and service providing. With the rise of knowledge management in each field, there is also more and more research discussing the industrial chain from the visual angle of knowledge [13]. The essence of industrial chain is functional networks based on knowledge division and coordination. Through division and sharing of knowledge, incremental rewards are created, so is the value for customers [5].

63.2.1.2 Integration of Industry Chain based on Knowledge

The advent of knowledge economy makes knowledge division and cooperation the central problem of industry evolution, thus the new integration theory of industrial chain emerges based on knowledge–based view. The purpose of integration of industrial chain is to improve the capacity of creating customer value to obtain competitive advantage. Knowledge sharing alone is not enough, because what is important is to realize the ultimate purpose of making knowledge, decentralized in different links of industry chain, help create customer value through knowledge integration [2]. Integration of industry chain based on knowledge is an effective way to promote development of knowledge intensive industry to both ends of "smiling curve" (Fig. 63.1).

63.2.1.3 Chain Integration of Modern Service Industry

Modern service industry, as an integrative industry, shows netted conjunction structure with modularity. Scholars, such as Rui et al [8] find that efficient modules survive competitions among all modules so that the capacity of creating customer value of the whole industry chain is enhanced. Modular division structure reduces the cost of operating the modules. Customer demands can be met with relative low-cost through combining modules. The core of the chain integration of modern service industry is knowledge integration (Fig. 63.2). Knowledge externality is internalized through integration so as to improve the capacity of creating customer value to obtain competitive advantage. In addition, through knowledge integration, the level of internal organization and systematization and the degree of external coordination and harmonization are heightened, the internal and external hierarchy is increased and improved, and progress is made in the optimization and upgrading of the industrial structure.

Fig. 63.2 Knowledge flow of chain integration of modern service industry

63.2.2 Mode of Industry Chain Integration

63.2.2.1 Knowledge Alliance

Knowledge alliance is alliance among enterprises, or among enterprise and other business organs to create new knowledge or acquire knowledge, the purpose of which is to acquire sustainable competitive advantage. This kind of alliance stresses on learning from one's partners with complementary knowledge capacity so as to achieve one's own strategic object of improving enterprise capability. The concrete manners include joint venture, mutual shareholding investment, functional agreement, etc [4].

63.2.2.2 Strategic Alliance

Strategic alliance refers to the fact that upstream or downstream enterprises, on the premise of not negating independent operating, link with alliance partners along industry chain in respective advantage domain. The purpose is to promote continuing improvement of economic benefit and improvement of core competitiveness of the whole industry chain, especially of the core enterprises. It is a new type of competition and cooperation mode and one of the most effective ways to integrate modern service industry chain. Strategic alliances mainly include virtual alliance, joint industry alliance and integrated strategic alliance.

63.2.2.3 Network Organization

Network organization mode under the harmonization of core enterprise is defined as one that each module maker designs and manufactures different modules which are finally integrated into final product by core enterprise. At present what international financial industry mainly uses is this mode. With one or some bank groups at the core, many other financial firms operate around it by themselves [9].

63.2.2.4 Industrial Cluster

Industrial cluster is another kind of industry chain integration method to enhance enterprise competitiveness. Core enterprise integrates medium-small-sized enterprises in the clusters, internalizes them with market mechanism, and reconfigures production factors across space and ownership, forming a "small giant" as the main characteristics of the industrial chain, so as to reduce operating cost of core enterprise. Industrial cluster is an organization formed based on close division and cooperation of longitudinal enterprises and relatively complete industry chain on crosswise [6].

63.2.2.5 Equity Merger and Acquisition

Mergers and acquisitions is the main way of modern chain integration of service industry. It is also an effective way to reduce cost or to reconfigure resources and to improve competitive advantage of enterprises. The equity M&A can avoid divergence among enterprises in industry chain for interest competition, and form long-term win-win cooperation relations. It is convenient for determining the size and importance of value creation in each link and identifying the key link of the whole value chain. According to their types, the equity M&A can be divided into horizontal M&A, vertical M&A and mixed M&A.

63.3 Influencing Factor of Chain Integration of Modern Service Industry

63.3.1 System Environment Factor

63.3.1.1 Execution of the Contract

Knowledge innovation in modular industry chain is achieved dispersedly. Although the innovation of each module is independent, the cooperation among enterprises can only be finished through knowledge integration. Execution of the contract among enterprises is involved inevitably. The execution of the contract is not only to ensure fulfilling promises, but also is related to rights division and interest distribution.

63.3.1.2 Protection of Intellectual Property

The demand for protecting intellectual property rights increases with enhanced density of industry knowledge innovation activities. Conversely, poor property protection will suppress the development of knowledge intensive industry. Because the chain integration of modern service industry is based on knowledge, there is a stronger need for protecting intellectual property rights is stronger than other industrial chains.

63.3.1.3 Industry Access Regulation

In the process of its extension, modern service industry chain has to face not only the policy barriers for industry control but also the region access barriers for local protection. Therefore, the government needs to perfect regulation of industry access and ease industry access during the process of industry chain integration.

63.3.2 Internal Factors of Industrial Chain

63.3.2.1 Individualized Characteristics of Nodal Enterprises

The sum of core competitiveness of different nodes enterprises forms core competence of the industry chain. Because the position of industrial chain nodal enterprises is dynamic in the process of integration, enterprises have to readjust the proper upstream and downstream nodes. Nodal enterprises constantly strengthen their own positions in the industrial chain, which continuously optimizes the integration of industrial chain.

63.3.2.2 Knowledge Sharing among Enterprises

Because the integration of industry chain is based on knowledge sharing, knowledge flowing and sharing among enterprises become one of the important factors affecting integration performance. In the process of industrial chain integration, knowledge flowing and sharing first depends on transformation of knowledge among organizations. There are four main knowledge conversion modes: socialization (tacit knowledge gathering together through experience sharing), externalization (transformation from tacit to explicit knowledge for sharing), modularization (combining isolated explicit knowledge components into knowledge system) and internalization (transformation from absorbed explicit knowledge to personalized tacit knowledge) [1]. Through continuous communication and knowledge exchange among enterprises, the industrial chain knowledge level can be constantly improved so as to enhance the core competitiveness of the whole industry chain.

63.3.3 External Factors of Industrial Chain

63.3.3.1 Relevant Government Policy

System is the basis for the development and evolution of enterprises cluster, and government policy plays an extremely important role in guiding the industrial chain integration. The property protection and regulation of industry access in the process of knowledge integration of industry chain rely on mandatory implementation by the government. In addition, reforms of financing system, legal protection of enterprise growth, and market access standard and government management of enterprises are all closely related to government policies.

63.3.3.2 Supporting Services

Whether conducting M&D of enterprises in the same industry or realizing related multi-faceted development, industrial chain integration inevitably involves merger and reorganization of enterprises which requires a lot of fund. So it is necessary for the capital market to provide support. Securities market, banks and other financial institutions can play a huge role in this aspect. In addition, intermediary service (such as accounting firms, consulting enterprises), business service, talent service, local culture, and many other related services have great influence on integration of industry chain [11].

63.4 Strategy to Promote Chain Integration of Modern Service Industry

63.4.1 Integrating Cognitive Environment and Reaching Social Extensive Consensus

Differences between modern service industry and traditional service industry cause public's lacking of recognition to development of modern service industry chain, so cognitive education is necessary for promoting integration of modern service industry chain. It is necessary to enhance public understanding of the character, status and guild regulation of modern service industry in the whole society and define the role of government, enterprises, industrial associations, financial institutions and the public in development of modern service industry. It is also needed to let the public and integration participators fully realize the importance of innovation, and actively encourage and participate in innovation, so as to increase support to the integration of modern service industry chain. It is important to let stakeholders fully aware of both the opportunities and challenges in the industry chain integration and look for their own development opportunities.

In addition, it is also necessary to strengthen the risk-awareness education of industry chain integration, so as to increase consciousness and ability to predict and prevent risk of integration. There must be a lot of risks in the implementation process because of unpredictability, complexity and difficulty in the integration of new industries. Therefore, through risk cognitive education, it is needed to let participants recognize the coming risk and actively take corresponding measures, so as to avoid and reduce the risk of integration to utilize the integration effects to maximum.

63.4.2 Integrating External Environment and Optimizing External Driving Mechanism

(1) Restructuring Regulation Structure

Modern service industry is an industry system interlaced and fused by service industry, manufacturing industry, tourism industry and so on. It is a comprehensive industry with strong industrial linkage. Therefore, it is necessary to establish a comprehensive regulation structure with broad participation, which can effectively avoid goal conflict among branches of industrial regulation organizations and avoid regulation vacuum. It is also needed to establish coordination mechanism among government departments, to gradually break traditional regulation system of industrial division and to avoid repeating construction and resource waste.

(2) Establishing Industry Organization

With the deepening of market economy, it is necessary to actively support the growing of industry organization of modern service industry, the purpose being not only to make these industry organizations play a role in “service, self-discipline, coordination and supervision”, but also to be an important driving force for industrial chain integration. Industry organizations together with government should set up a public service platform for modern service industry. They can provide all-around service including information, technology, capital and talent. They can formulate industry rules and unify industry standards. They can coordinate the investment and financing activities of the industry and guide capital flow. They can formulate industry standards and guide investment and financing activities of the industry. They can establish evaluation system and propel the efficient operation of industrial chain integration.

(3) Establishing Expert Panel

An Expert panel should be set up, which consists of senior officials in related governmental departments, experts from businesses and academia, to study development of modern service industry, chain integration, regulatory organization integration, corresponding policies of modern service industry, industry plans and corresponding policies of its branches.

63.4.2.1 Integrating System Environment and Constructing Security System

(1) Drawing Development Blueprints

Due to the lack of integrity planning, each branch industry tends to make its own industry plan, which results in huge overlap and repeated resource allocation, thus seriously restricting chain integration and overall development of modern service industry. Therefore, it is necessary to take the integration of industry chain as a primary task for the promotion of modern service development, and to put it on the agenda of the government. It is called on to redefine, clarify, classify and integrate the overlapping parts of the existing plans, to realize synergy and uniformity to a maximum extent.

(2) Easing Industry Barriers

It is essential to formulate relevant local rules and regulations to promote the integration of modern service industry chain and set up few industry entry barriers as far as possible, to remove relevant regulations which block the development of industry chain integration, to break profit pattern of departmental segmentation and to cancel administrative monopoly measures. Through the integration of management departments, resource flow and restructuring among departments ought to be promoted, so as to promote the integration of the industry chain. It is necessary to ease up market admittance further, and make use of the exemplary roles of excellent enterprises to bring more diversified investment to promote effective integration of the industry chain.

(3) Launching Corresponding Policy

The government should formulate positive financial and taxation policies and reward policies to promote the integration of modern service industry, and provide support for enterprises at home and abroad which participate in investment in M&A or joint-stock form with duty-free policy. The government should also grant them preferential policies in expropriation, loans, applying for special fund of modern service industry development, electricity utilization, water use, power capacity expansion, etc. Related special fund should also be established.

(4) Establishing Security System

The government should perfect the social security system as soon as possible to solve the domestic troubles and make industrial chain integration run smoothly. First it is necessary to accelerate reforms of social insurance system and further improve insurance system of pension, unemployment, work-related injury and maternity. Second, it is needed to improve social relief and social welfare system, perfect urban minimum livelihood guarantee system and moderately readjust social security standards. Third, it is necessary to raise insurance rate, increase tax types and establish multi-level and multi-faceted social insurance system.

63.4.2.2 Integrating Financing Environment and Constructing Financial System

It is necessary to integrate financing environment of modern service industry. Through converting the use of loans, making use of the capital market, guiding private investment, speeding up the introduction of foreign capital and strengthening the small and medium-sized enterprise financing network, financial system which can support modern service industry development and industrial chain integration should be built up. First, it is necessary to encourage and support commercial banks, adjust usage of all kinds of loans, and actively support all kinds of M&A activities. Second, it is needed to make full use of stock market and bond market to provide sufficient funds for industrial chain integration. Third, it is also necessary to give full play to trust institutions and effectively connect currency market, capital market and industry market through trust services. The fourth is to strengthen property right market to make it an effective channel to modern service industry chain integration. The Fifth is to develop and perfect risk investment system of modern service industry.

In addition, it is important to encourage all kinds of economic entities to invest in modern service industry in multi-channel and polymorphous forms and actively explore effective way and form of introducing foreign capital. It is also necessary to establish special fund and introduce foreign advanced fund and management mode, through effective management and capital operation, to guide and support the integration of modern service industry chain.

63.4.3 Integrating the Internal Environment and Strengthening Internal Driven Mechanism

63.4.3.1 Integrating Industry Structure and Forming a Reasonable Industry Structure

It is necessary to actively advance integrating process among service industry and other industries, between branches of modern service industry, optimize structure of modern service industry through integration, and forming reasonable industry structure which can support industrial chain integration. The integration, structure optimization and upgrading of the whole modern service industry and its branch industries should be speeded up through industrial integration. In each branch industry, harmonious development system of industry chain should be built up and priority should be given to industries with high added value and powerful motive force.

63.4.3.2 Integrating Product Structure and Forming a Firm Micro-foundation

It is necessary to give strong support to enterprises engaged in independent and innovative R&D of products. And it is needed to encourage cooperation and joint research among enterprises in different links of industry chain to integrate product structure. It is important to develop actively the “high, fine, special and new” products and promote service products to refinement, differentiation, high-level and high added value direction. It is also necessary to strengthen the integration and correlation of products and services by introducing and self innovation to further promote the integration of modern service industry chain.

63.4.3.3 Integrating Industry Organizational Structure and Forming Core Competitive Edge

Industry organizational structure should be integrated in order to realize the mechanism with enterprises as main body in the chain integration of modern service industry. It is feasible to support the integration of modern service industry chain through implementing strategies of both collectivization based on superiority brand and enterprises clusters (such as the cultivation of leading enterprise group, the construction of mid -small service enterprises cluster, etc), the integration of marketing resources, the integration of talent resources (such as creation of talent double pass mechanism, establishment of advanced training school and corresponding specialty in universities, etc) and the integration of information resources.

63.5 Conclusions

With development of economic globalization, modern service industry becomes a dominant industry for global economic development. Promoting the integration of industry chain is not only an effective way for industry upgrading and structural optimization, it is also the foundation of space development of modern service industry.

This paper, against the backdrop of high-speed development of modern service industry, incorporates the concept of integration of industry chain. Based on correlated research at home and abroad, the chain integration theory and service industry development theory are comprehensively applied to the building up of the theoretical framework of modern service industry chain integration mainly from three aspects, namely, connotation, mode and its influencing factors. And the paper then puts forward a set of strategic plans with pertinence and operability. The construction of theoretical framework not only improves the theory of chain integration of modern service industry, but also provides the theoretical guidance for upgrading and structural optimization of modern service industry in China. Meanwhile, relative strategic plans offered by this paper can also be used as guides to Chinese modern service industry development.

This paper also has some limitations. First this paper constructs the theoretical framework of modern service industry chain integration with inductive method. It is a summary of the existing research on industry chain integration and service industry development. The result can cover the current research achievements. But the theory of industry chain integration and service industry development is an ever developing one, and with the deepening of the research in the future, the width and depth of the theory will be expanded. And just as the modern service industry chain integration theory will be enriched and perfected, so we will continue to expand our research in future study. Second, this paper uses qualitative method constructing modern service industry chain integration theory frame and putting forward relevant policy suggestions, while the quantitative method are not adopted. Therefore, future research needs further discussion in quantitative aspects.

Acknowledgements This research is “research on development space and innovation path of modern service industry of Zhejiang Province under the background of industry transformation and upgrading” — 2011 scientific and technological project of Zhejiang Province (NO. 2011C35002).

References

1. He Y (2009) Rearch on influencing factor of Integration of leisure industry chain. PhD thesis, Zhejiang University of Technology (In Chinese)
2. Jin S (2006) Research on structure and integration on creative industry chain, taking cosplay industry of China as the case. PhD thesis, Beijing Jiaotong University (In Chinese)
3. Li Z (2007) Review of modern service industry research. Commercial Times 15:12–15 (In Chinese)
4. Liu M (2006) Research on integration theory of industry chain based on knowledge share. PhD thesis, Fudan University (In Chinese)
5. Liu M, Weng J (2007) Division of industry chain and knowledge integration. Science of Science and Management of Science & Technology 7:92–96 (In Chinese)
6. Pu Q, Gu Z, Sun C (2006) Research on mode of integration of industry chain based on enterprise core competency. Enterprise Economy 2:59–61
7. Rui M, Li X (2009) Structure and operation of network of industrial chain. Truth & Wisdom Press, Shanghai
8. Rui M, Liu M, Ren J (2006) Integration of industry chain. Master’s thesis, Fudan University Press (In Chinese)
9. Teng F (2007) Research on mechanism of network industry chain of CBD cluster in Beijing. PhD thesis, Capital University of Economics and Business (In Chinese)
10. Wang Y, Li G (2005) Present situation of industrial chain. Industrial Technology & Economy 10:59–63 (In Chinese)
11. Wu Q (2004) Rearch on influencing factor of the growth of enterprise clusters. PhD thesis, Zhejiang University (In Chinese)
12. Xu X (2010) First exploration of theoretical analysis framework of modern service industry. Productivity Research 1:24–26 (In Chinese)
13. Zao Q, Jiang Z (2008) Connotation and characteristic analysis of industrial chain. Business research 11:133–136 (In Chinese)
14. Zheng D, Zhang Z, Yu J (2011) Disscussion on industrial chain integration theory. Science & Technology Progress and Policy 1:64–68 (In Chinese)

Chapter 64
Lean and Green: A Business Model Framework

Susana Duarte and V. Cruz-Machado

Abstract Going lean and green is a trend that identifies new business opportunities for organizational improvement and for competitiveness. Besides, there are quality awards to assist organizations to improve their performance among them the Shingo Prize, the Malcom Baldrige National Quality Award, the European Foundation for Quality Management. The aim of this study is to develop a conceptual framework for lean and green business organizations. To attain the paper objective in a first stage a comparison between quality awards is developed to provide a comprehensive understanding of each framework and to explore how they assist to modeling a lean and green organization. After defining lean and green management approaches, it seeks to cross-reference between the awards frameworks and lean and green culture; a number of assessment guidelines and criteria were designed to connect and integrate lean and green principles and tools. It is proposed seven different criteria and respective criterion score to assess a lean-green business organization.

Keywords Lean · Green · SP · EFQM · MBNQA · Business models

64.1 Introduction

With the extremely competitive business environment, the globalization and the weight on customer orientation, many organizations realized the importance to be both lean and green. The lean and green defined as new business models strategies implementations can be seen as new opportunities for business environment improvement. Lean and green strategies are often seen as compatible initiatives because of their joint focus on waste reduction, efficient use of resources and focus on

---

S. Duarte (✉) · V. Cruz-Machado
UNIDEMI, Departamento de Engenharia Mecânica e Industrial, Faculdade de Ciências e Tecnologia (FCT), Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
e-mail: scd@campus.fct.unl.pt

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_64,

satisfying customer needs [7, 19]. Some authors have the idea that lean and green are synergetic approaches [1, 3]. However there is a little understanding of the basic mechanisms through which a new business model can be implemented.

Various business models have been embodied in awards, such as Shingo Prize (SP), Malcom Baldrige National Quality Award (MBNQA) and European Foundation for Quality Management (EFQM) excellence model [11, 18, 19]. The models change in structure and scope and are based on different principles, but the goals is to try to reach a high performance organization. There is an attempt by researchers to compare and contrasts the awards, but only between the MBNQA and the EFQM [6, 18]. In addition, there is no evidence on literature relative of the awards contributions in a lean-green organizational environment.

Hence this paper aims to focus on the development of a new framework for providing direction and guidance to an organization in achieving a lean-green business environment. The awards mentioned some "near common" characteristics in their frameworks namely leadership, people, strategic planning, stakeholders, processes, resources and results and can be defined as key criteria for lean and green.

This paper is organized as follows: Sect. 64.2 presents a characterization of the quality awards under study with a comparison between them; in Sect. 64.3 a definition of a lean-green business model is developed, presenting a conceptual framework for assess the lean-green organization. Finally, some concluding remarks are drawn.

64.2 Business Models

64.2.1 Quality Awards

Professional Institutions developed models, in the sense of awarding a prize to the best practices developed by the organizations. The models are recognized worldwide, providing guidelines and may be used as self-assessment models [6].

The SP model establishes in 1988 and is a multi-level program recognizing tactical, integrative, and strategic application of standard lean principles [14]. The goal is to assess and certificate the organization through a cultural transformation on lean thinking [19]. The framework is defined by two elements: the house and the diamond. The house details the principles of operational excellence and the power of balancing effort into four dimensions: the cultural enablers, the continuous process improvement, the enterprise alignment and the results. The diamond represents the transformation process for embedding the principles into the organizational culture [14].

Other award under study is the Malcolm Baldrige National Quality Award (MBNQA). This model was established in 1987 in the USA. The objective is to help the organizations to improve their competitiveness [12]. The framework consists in seven categories that are interconnected; it starts at the top with the organizational profile, the environment, the relationships and strategic situation that are the influences and the challenges that faces; at the bottom is the measurement, analysis and knowledge management and in at the center there are 6 categories, namely leadership, strategic planning and customer focus that are all integrated and flow into workforce focus, operations focus and results [12].

Another award which is considered a counterpart of the MBNQA in Western Europe is the European Foundation for Quality Management (EFQM) excellence model and was founded in 1991. It recognizes industry leaders with an undisputable track record of success in turning strategy into action and continuously improving their organization's performance [8]. The framework consists in nine categories, five of these are enablers and four are results. The enablers cover what an organization does and how it does, while the results refer to what an organization achieves, caused by the enablers. Finally, the enablers are improved by the feedback given by the results [8].

Some research has been conducted in this area. Kumar [11] made a qualitative comparison between Deming Prize and MBNQA which tried to understand the differences and similarities between them. Talwar [18] made a comparative study of framework, criteria and criterion score of twenty excellence models/national quality awards identifying their common features, contradictions and suggestions. Politis and Siskos [13] proposed a methodology that consists of an integrated framework of evaluation criteria based on international self-assessment models. Dror [6] made in his work a comparison of organizational performance management frameworks between MBNQA, EFQM and Balanced Scorecard.

Table 64.1 Linkages between assessment criteria of quality awards

SP [14]	MBNQA [12]	EFQM [8]
• Cultural enablers (150) (15%)	• Leadership (120) • Workforce Focus (85) (20.5%)	• Leadership(100) • People (100) • People results (100) (30%)
• Enterprise alignment (200) (20%)	• Strategic Planning (85) (8.5%)	• Strategy (100) (10%)
	• Customer Focus (85) (8.5%)	• Customer results (150) • Society results (100) (25%)
• Continuous improvement (400) (40%)	• Measurement, Analysis and Knowledge Management (90) • Operations Focus (85) (17.5%)	• Partnerships and Resources (100) • Processes, Products and Services (100) (20%)
• Results (250) (25%)	• Results (450) (45%)	• Key results (150) (15%)
Points: 1000	Points: 1000	Points: 1000

64.2.2 Comparison between Awards

There have been many attempts to compare the various quality awards looking for common and missing elements [6, 11, 18, 20].

The awards define their objectives on the basis of TQM principles [6]; all emphasize the customer satisfaction, employee satisfaction and community satisfaction [11] and indicate a continuous improvement culture. These awards can be implemented in all kind of organizations and in all kind of sectors.

In addition, each consists of a non-prescriptive assessment framework; they provide guidelines and may be used as self-assessment models. The procedure includes the development of a report describing what an organization achieves with regard to a predefined set of criteria [13].

The assessment criteria and the score differ from model to model [11], but all have a total score of 1000 points. The scoring method makes possible to evaluate criteria [6]. The SP model is categorized by four criteria groups (cultural enablers, continuous process improvement, enterprise alignment and results). In the EFQM model, the criteria comprise two groups (enabler and results), while the criteria of the MBNQA model consists of three groups (leadership triad, results triad and measurement, analysis and knowledge management).

However “near common” characteristics is mentioned by the models. The models MBNQA and EFQM mentioned the criteria “leadership”; in the SP model “leadership” is imbued in its four criteria. The human side is mentioned with different descriptions: “individual” for SP, “workforce” for MBNQA and “people” for EFQM. Others characteristics are mentioned in all the three models namely strategy, stakeholders, process, resources and results.

In a tentative to compare and contrasts the three assessment criteria of quality awards, the linkage between the three models have been developed as shown in Table 64.1. The analysis as illustrate that:

- The human side of the criteria has more importance in EFQM (30% of the total number of points) and MBNQA (20.5%) awards;
- SP (20%) awards are more concerned with strategy and policy issues;
- The concerns with the customer (and external stakeholders) is more evident in EFQM (25%) award;
- The concerns with internal operations (product and process development) is more evident from SP (40%) award;
- The models have different scores for results SP (25%), MNBQA (40%) and EFQM (15% or 35% if other external results are considered).

The awards may contribute to model a lean and green organization; they mentioned a set of “near common” characteristics in their frameworks namely “Leadership”, “People”, “Strategic planning”, “Stakeholders”, “Processes”, “Resources” and “Results” and these can be considered the key criteria for a lean and green implementation. These analyses provide some inspirations to model a lean-green business environment.

Table 64.2 Elements for a lean-green organization

Awards Criteria	Lean-green Elements
Leadership	• Management commitment to lean and green thinking • Vision and mission • Resource allocation for lean and green projects • Management communication • Identifying investment opportunities • Ethical conduct • Corporate social responsibility • Flat organizational structure • Legal requirements and govern norms • Management long term employment • Team management for decision making • Value stream mapping
People	• Employee training and coaching • Employee commitment and motivation • Multi-skilled employees • Safety improvement programs • Employee empowerment • Employee participation • Rewards and recognition • Cross functional teams • Employee suggestion schemes • Communication between employees • Multi functional training • Job rotation or flexible job responsibilities • Lean-green kaizen event • Employee initiatives lean-green
Strategic Planning	• Clear lean and green strategy • Establish lean and green policies, plans, objectives and processes • Strategy shared by all levels of the organization • Strategy deployment • Strategy with focus on the customer/stakeholders
Stakeholders	• Creating value for customers/stakeholders • Proactive and long-term relationship • Level of involvement of the key stakeholders • Manage partnerships • Information sharing • Share environment risks • Supplier training and development • Supplier selection according to lean and green criteria • Supplier evaluation • Takt time
Resources	• Capacity optimization • Alternative sources of energy • Spaghetti chart • TPM • New equipment technologies • A3 report
Processes	• Add value for the customer/stakeholder • Waste reduction (lean waste and green waste) • Lean and green design, manage and improve processes • Work environment/housekeeping (5S+Safety) • Standardization and work instruction • Multidisciplinary approach to design • Promote continuous improvement (in all the supply chain) • 3R‘s
Results	• Monitor and measure all aspects of value • Define lean and green measures • Measures up-to-date • Economical results • Environmental results • Operational results • Social results • Data analysis

64.3 The Lean-green Business Model

64.3.1 The Lean-green Management Model

The lean-green business model can be seen as a new management approach. The compatibility with lean and green approaches may develop a hybrid business environment. The lean culture involves continuous improvement and improves quality and productivity by reducing cost, time and waste in all operations; the green culture aims to reduce environmental impacts while eliminate environmental waste in organizations. The both concepts require changed attitude and establishment of organizational cultures supporting the philosophy underlying each concept [10]. Thus, lean and green concepts can be implemented in all organizational areas [2, 5], with the application of various specific principles and tools [10]. A cross-reference between quality awards contribution and specific principles and tools (i.e., elements) selected on literature review [4, 9, 17, 21] were developed. Table 64.2 presents the topics elements for a lean-green transformation. The criteria leadership, people, strategic planning, stakeholders, processes, resources and results are identified in the quality awards and were selected as lean and green new criteria for assess the lean-green organization and to understand the organization dynamics.

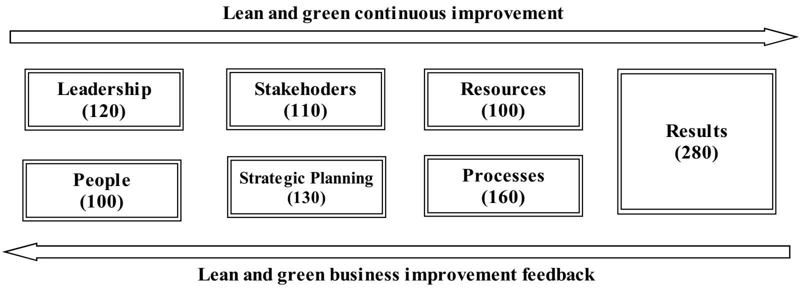


Fig. 64.1 Framework for assess the lean-green organization

64.3.2 Framework for Assessment Lean-green Model

The conceptual framework is proposed to model a lean-green business environment. Using the information collected in the literature review, it is possible to find some relationships between lean-green criteria. To the authors [2, 15, 16] the leader set the organizational direction, shares the values of vision and allows an environment for involvement of everyone, enabling the use of employee's skills and knowledge for the benefit of organization. The leadership category and people category have an important role. According to [10], lean and green need employee involvement in order to be successful. Thus, Puvanasvaran et al [15] mentioned that the participative leadership and the employee empowerment are issues that prevail in a lean-green approach. The strategic planning refers to a strategy focus on customer and others stakeholders since they can place constraints on the organization's business [12] and consequently their relationship must be planned and managed [8], leading to a long-term relationship. The lean and green promote involvement of stakeholders in order to achieve business success [10]. The Process is important to a lean-green approach since they focus on improving process by reduction waste and optimize the resources [15]. Thus process and resources criteria are closed and they carry out the work in a lean-green organization.

In addition, it is proposed a scoring based on a 1000 points score, similar to the adopted by the awards under study. With the data from the awards scoring (Table 64.1) it is possible to propose a criteria score for lean-green approach. The score for each lean-green model criterion was calculated based on the percentage values obtained in Table 64.1. It was added the values of each criteria group, getting a final score for each criterion proposed. Lean-green criterion score $=$ $[\text{Score (SP)} + \text{Score (MBNQA)} + \text{Score (EFQM)}]/3$. For example the line in Table 64.1 that consists in Enterprise alignment (20%) from SP; Strategic Planning (8.5%) from MBNQA and Strategy (10%) from EFQM (2010) gives a total of 130 in 1000 points. Thus the Strategic Planning criterion score is 130 points. Fig. 64.1 presents the framework with the criteria and respective scores to model a lean-green organization. All criteria point to results. The model is based on continuous improvement and also indicates the importance of the results feedback.

64.4 Conclusion

This study suggests that quality awards can be a good starting point for modeling a lean and green business. This study helps to understand that there are connections between quality awards and lean and green approaches at different levels. A conceptual framework was proposed to model a lean and green business environment. This framework helps the managers to self-assess their business in terms of a lean-green approach. The lean and green elements were proposed for each criterion with a corresponding scoring. The list of elements can be used to guide in future improvements. However, not all lean and green elements were defined. Future research requires more operational indications to obtain a specific lean-green organization approach. In addition, this study can be developed in a more qualitative approach using an exploratory case study methodology to understand if the framework and respective elements are important to the business needs. A multiple case study approach could provide a deep understanding of the research topic.

Acknowledgements Authors would like to acknowledge Fundação para a Ciência e Tecnologia for its support (project MIT-Pt/EDAM-IASC/0033/2008). Susana Duarte was supported by a PhD fellowship from Fundação para a Ciência e Tecnologia (SFRH/BD/60969/2009).

References

1. AME — Association for Manufacturing Excellence (2008) Green manufacturing: Case studies in lean and sustainability. Productivity Press, New York
2. Bergmiller G, McCright P (2009) Parallel models for lean and green operations. In: Proceedings of the 2009 Industrial Engineering Research Conference. http://zworc.com/site/publications_assets/parallelModels.pdf; (accessed on 19-10-2009)
3. Carvalho H, Azevedo S, Duarte S et al (2011) Green and lean paradigms influence on sustainable business development of manufacturing supply chains. International Journal of Green Computing 2:45–62
4. Chiarini A (2011) Integrating lean thinking into ISO 9001: A first guideline. The International Journal of Lean Six Sigma 2:96–117
5. Cruz-Machado V, Leitner U (2010) Lean tools and lean transformation process in health care. International Journal of Management Science and Engineering Management 5:383–392
6. Dror S (2008) The balanced scorecard versus quality award models as strategic frameworks. Total Quality Management & Business Excellence 19:583–593
7. Duarte S, Carvalho H, Cruz-Machado V (2010) Exploring relationships between supply chain performance measures. In: Proceedings of the Fourth International Conference on Management Science and Engineering Management 91–95
8. EFQM — European Foundation for Quality Management (2011) Introducing the EFQM Excellence model. EFQM
9. Gurumurthy A, Kodali R (2009) Application of benchmarking for assessing the lean manufacturing implementation. Benchmarking: An International Journal 16:274–308
10. Johansson G, Winroth M (2009) Lean vs. Green manufacturing: Similarities and differences. In: Proceedings of the 16th International Annual EurOMA Conference, Implementation Realizing Operations Management Knowledge, Göteborg, Sweden
11. Kumar MR (2007) Comparison between DP and MBNQA: Convergence and divergence over time. The TQM Magazine 19:245–258
12. MBNQA — Malcom Baldrige National Quality Award (2011) 2011-2012 Criteria for Performance Excellence. Baldrige Performance Excellence Program
13. Politis Y, Siskos Y (2010) Self-assessment for measuring business excellence: The MUSABE method. Total Quality Management & Business Excellence 21:1063–1083
14. Prize SS (2010) The shingo prize model & application guidelines. The Shingo Prize for Operational Excellence. Jon M. Hustsman School of Business, Utah State University
15. Puvanasvaran A, Kerk R, Muhamad M (2011) Principles and business improvement initiatives of lean relates to environmental management system. In: Proceedings of the IEEE International Technology Management Conference 439–444
16. Ryder (2010) White Paper series: Lean guiding principles for the supply chain, Principle 1: People Involvement. Ryder supply chain solutions, United States. http://www.dcvelocity.com/whitepapers/presenters/ryder/ (accessed on 02-04-2011)
17. Sharma M, Kodali R (2008) Development of a framework for manufacturing excellence. Measuring Business Excellence 12:50–66
18. Talwar B (2011) Comparative study of framework, criteria and criterion weightage of excellence models. Measuring Business Excellence 15:49–65
19. Torielli R, Abrahams R, Smillie R et al (2011) Using lean methodologies for economically and environmentally sustainable foundries. China Foundry 8:74–88

20. Wongrassamee S, Gardiner P, Simmons J (2003) Performance measurement tools: the balanced scorecard and the EFQM excellence model. Measuring Business Excellence 7:14–29
21. Zhu Q, Sarkis J, Lai K (2008) Confirmation of a measurement model for green supply chain management practices implementation. International Journal of Production Economics 111:261–273

Chapter 65
A Study on Meta-synthesis Mode of the Systems Engineering of Governance of Large Enterprise Group

Sheng Ma and Rui Wang

Abstract This paper defines the concept and connotations of large enterprise group, then describes and analyzes the main content and the framework model of the governance of large enterprise groups. Finally, with the ideas, theories and tools of systems engineering, meta-synthesis mode of the systems engineering of corporate governance of large enterprise group is discussed.

Keywords Large enterprise group · Corporate governance · Systems engineering · Meta-synthesis

65.1 Introduction

Enterprise group is a form of economic organization when the single enterprise, after its continuous development and growth, has established a number of wholly-owned, holding or equity participation in subsidiaries or associated companies. Enterprise group, as a multi-enterprise conglomerate, appeared before the Second World War, when the West called it "Concern" in contrast with the single large enterprise nature of the "Trust" [11]. In Japan, the 1950s saw the dissolution, restructuring and reconstruction of zaibatsu, resulting in the formation of the economic conglomerate "the Keiretsu" with financial enterprises as the core economy, and established itself as "Enterprise Group" in the Western industry. That concept at that time refers to the former enterprises of zaibatsu, when the post-war U.S. occupation forced the dissolution of the Japanese zaibatsu, adapted to the Japanese policy of the corporate serialization and industrial restructuring, re-organized in a new form. In addition, the

S. Ma (✉)
School of Economy and Management, Chengdu University, Chengdu 610106, P. R. China
e-mail: mahongyi76@163.com

R. Wang
School of Accounting Administration, Southwest Finacial Universtiy, Chengdu 611130, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_65,

South Korean consortium known as the "Chaebol", and the family business as the main members of the industry group in India and other Southeast Asian countries, are instances of the enterprise groups [8–10]. However, the academic community so far has not yet reached an agreement on the precise definition and the specific connotations of "enterprise group".

Based on the analyses of the researches, the enterprise group is defined as: enterprise group, as an independent legal entity in the marketplace, is an intermediate organization formed with property or strategic contracts, in order to overcome market failures and organizational failures in the long-term transactions and realize more efficient trading. This concept has three implications: firstly, enterprise group is a collection of enterprises formed by several companies through organic economical connection; secondly, enterprise groups is a relatively stable form of organization based on the long-term trading relationship of member enterprises and the common normative framework of the group; thirdly, enterprise group is an intermediate organization between the enterprises and the market and this intermediate organization has achieved the organic connection between enterprises and markets [12–15].

In fact, the existing literature, indicates that both in theoretical circles and among practitioners there is not a clear definition of large enterprise groups and there is a tendency to identify enterprise groups with large enterprise groups. In this regard, the connotation of large enterprise groups are defined as follow:

1. Large enterprise group is an economic union consisting of many enterprises and institutions through a variety of ways of investment and production business collaboration, with a parent and subsidiary companies as the main body. It refers to those enterprise groups that are the larger part of national economy and have more influence. Large enterprise groups do not have corporate capacity.
2. The parent company of the large enterprise groups has registered capital of more than RMB 50 million yuan, and has at least five subsidiaries.
3. The parent company of large-scale enterprise group and its subsidiaries, have a sum total of registered capital of more than RMB 100 million yuan.
4. The member units of the enterprise group have corporate capacity.
5. The large enterprise groups in this paper refer to those large enterprise groups that are included in the scope of the National Bureau of Statistics. To be more specific, they are: the central enterprise groups, national pilot enterprise groups approved by the State Council, enterprise groups approved by the State Council departments in charge, enterprise groups approved by the provincial, autonomous regions and municipal governments and other types of enterprise groups whose operating income (the main business income and other operating income) and total assets are more than RMB 500 million yuan.
6. The statistical coverage of the operating income and total assets of large enterprise groups include: the parent company of the enterprise groups; the wholly owned subsidiary (units), absolute and relative owned subsidiary (units) in China and overseas, with the exception of shares and collaborative enterprises (units). Except a few large enterprise groups that have not established a consolidated statements system, the financial data of large enterprise groups, are consolidated report data.

For simplicity, in the following analysis, “enterprise group” or the “group” in the paper all refer to “large enterprise groups (LEG)” if not stated otherwise.

65.2 Corporate Governance of LEG

The corporate governance of large enterprise group refers to a series of institutional arrangements that connect and regulate the rights, responsibility, and benefit relationship of the Group owner, decision-making bodies, operators, employees and other parties of interest concerned [4].

Large enterprise group is an intermediate form of organization, whose members include both the parent-subsidiary form of the hierarchical nature and affiliates of the horizontal nature. Member companies have the independence of legal sense, and there is asymmetry of information between them, therefore, between the parent and subsidiary companies there is the “agency problem” based on equity; and between the affiliated companies, there are the problems of “trust” and “cooperation” due to their respective unique resources. Meanwhile, the self-interested behavior of the parent company in the group tends to harm the interests of small shareholders and other stakeholder, so the game of interests also exists between the parent company and these stakeholders. Solution to these problems depends on the cultivation of the governance mechanisms of the parent company as the main group, that is, a series of institutional arrangements on quasi-rents bargains to coordinate the relationship between enterprises of the group to achieve the consistency in goal orientations of the member companies and synergy in collaborative behavior in order to effectively realize the system function of the enterprise group. This series of institutional arrangements are the problems that the corporate governance of large enterprise group is to solve.

65.3 Systems Engineering of Corporate Governance of LEG

According to the preceding analysis, the large enterprise group itself is a complex giant system and its governance system is a complex giant system, these two complex giant system superimposed together constitute a special complex giant system. Obviously, governance of such a complex giant system is a complex system engineering. its system engineering properties are mainly reflected in two aspects: First is its engineering properties, i.e., the complexity and the huge scale of the governance systems determine its engineering properties of governance, in other words, governance of large enterprise groups is a project, rather than just a job or task; Second is its system features, i.e., the engineering problems of governance of large enterprise groups is more suitably analyzed and studied systematically from the perspective of system theory. Otherwise, any missing link in the analysis and contents are likely to produce flawed analysis and research findings [6, 7].

Though the governance systems engineering of large enterprise groups is very complex, its essence remain the same. From the macroscopic perspective, the main body of this governance systems engineering mainly includes three aspects: First, there is the system engineering of internal governance, including the anti-structures engineering of governance structure, design engineering of governance mechanism and governance model design engineering. Second, there is system engineering of external governance, including governance engineering of the capital market, governance engineering of the manager market and governance engineering of product market. Third, there is the system engineering of guarantee, including systems engineering of legal protection, systems engineering of policy and the systems engineering of organizational guarantee.

65.4 Meta-synthesis Modes of Governance Systems Engineering of LEG

Governance of large enterprise groups is a complex system engineering, and we are trying to use the comprehensive integrated qualitative and quantitative methods to analyze it. Here, the focus of analyses is on the structural features of the governance system, dimensions of the meta-synthesis and modes of meta-synthesis [1–3, 5].

65.4.1 The Structure and Characteristics of the Governance System of LEG

As an open complex giant system, the governance system of large enterprise groups has its unique frame structure, space-time structure, operation structure and holistic features.

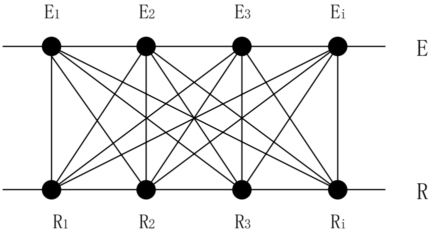
(1) Frame Structure

Above analysis of the structure of governance system of large enterprise groups indicates that S (the structure of the governance systems of large enterprise groups) is composed by set E (the elements of the system) and the set R (the relationship between these elements). In this complex giant system, each element E_i and its corresponding R_i relationship constitutes a subsystem For example, $S_1 = \{E_1, R_1\}$ constitute the subsystem of internal governance of large enterprise groups; $S_2 = \{E_2, R_2\}$ constitute the subsystem of external governance of large enterprise groups, and $S_3 = \{E_3, R_3\}$ constitute the subsystem of governance guarantee of large enterprise groups. From the perspective of system theory, the numerous sub-systems influence each other and promote each other, thus constituting a complex giant system of governance of large enterprise groups. This can be shown in Fig. 65.1.

(2) Time-Space Structure

The space-time structure of the system refers to the association of system elements in time and their arrangement in space. In the case of the governance systems

Fig. 65.1 Frame structure of governance system of LEG



of large enterprise groups, its spatial and temporal structure are shown in the following aspects: Firstly, the governance of large enterprise groups is a long, even a permanent system engineering; secondly, the governance actions and measures (such as the formation of the group, the development of group's charter, the establishment of offices, the confirmation of the group's internal governance structure, the construction of various governance mechanisms, the rectification of the external governance environment, governance guarantee, etc.), can not be achieved simultaneously, but in a chronological order; Thirdly, there is a clear structure of spatial arrangement between the governance body of the group. for instance, the governance bodies of the parent companies, subsidiaries, and affiliated companies are generally in different geographical space; Fourthly, within each subsystem of the governance system of large enterprise groups, its governance actions (such as the establishment of governance structure, the design of governance mechanisms, etc.) have different importance and priority. In other words, the governance actions of each subsystem display a chronological order and arrangement in space. Specifically, the spatial and temporal structure of the governance systems of large enterprise groups is shown in Fig. 65.2.

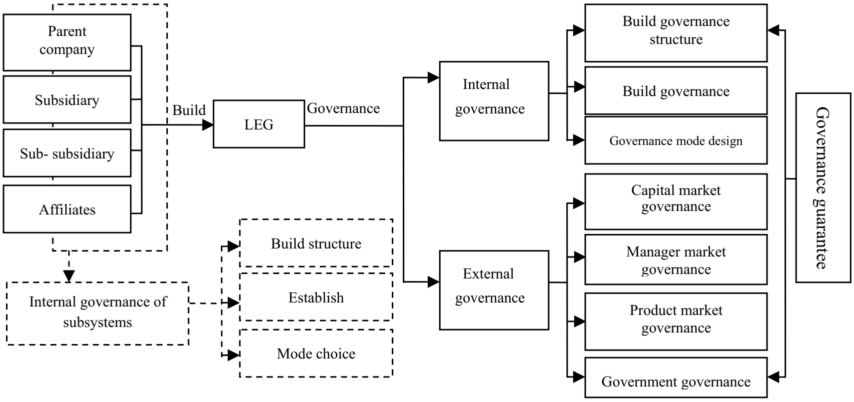


Fig. 65.2 The warehouse layout of company A and the order-picking locations

(3) Operation Structure

Operation structure of the system refers to the interdependence and ways of connection between constituent elements of the system during operation. In the governance systems of large enterprise groups, parent companies, subsidiaries and affiliates, all as independent corporate entities, operate independently in their own governance boundary (legal boundary). Meanwhile, they operate under the framework of the entire enterprise group in accordance with the laws of general corporate governance through capital bond or other contract (agreement). With the enterprise group as a whole, the elements of its governance system and components will influence and interact with each other, which constitute the subsystem of the internal governance, the subsystem of external governance and the subsystem of governance guarantee of the enterprise groups. Of course, the subsystems of internal governance, external governance and governance guarantee are not isolated or static. Rather, they will interrelate and influence each other, so as to constitute the complex giant system of the governance system of the whole enterprise group, thus resulting in the emergent properties of the governance system of the group. In addition, the governance subsystems of the parent companies, subsidiaries, affiliates not only operate according to general corporate governance laws of their own, but also maintained a complicated relationship with the governance system of the whole enterprise group. Fig. 65.3 describes the operation structure of the governance system of large enterprise groups.

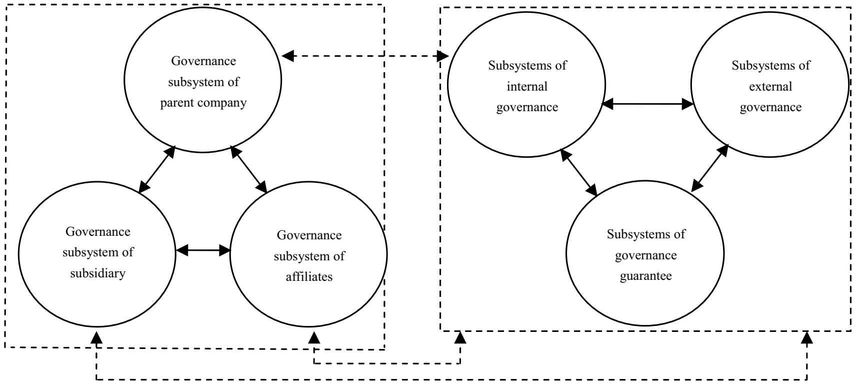


Fig. 65.3 Operation structure of governance system of LEG

(4) The Holistic Features

The governance systems of large enterprise groups is an open complex giant system, and during the operation processes there are exchanges of material, information, and energy between the constituent elements, between the various subsystems, as well as between the whole group governance system and the external environment. The exchanges of material, information, and energy make such elements of the system as its structures and functions keep changing dynamically, which make the complex giant system of the group's governance display the holistic features of openness, complexity, high-dimensionalness, massiveness and holistic emergence in addition to the aforementioned system characteristics of integrity, correlation, purposefulness, structuredness and environmental adaptability

- Openness

The openness of the system refers to the interrelation and the exchanges of material, energy or information between the system and the external environment. For the governance systems of large enterprise groups, governance actions such as establishment of governance structure, the construction of governance mechanisms and design of governance model in the internal governance system need to gather relevant information from external environment. Governance contents such as governance of its capital market the governance of manager market and governance of products market in the external governance system also requires the group and its external environment continue to exchange matter, energy, and information. At the same time, the subsystems of legal protection, policy guarantee and organizational guarantee in the governance guarantee system are connected with the external system. These characteristic are the effective realizations of the openness in the governance systems of large enterprise groups.

- Complexity

Governance system of large enterprise groups is composed of a number of subsystems and constituent elements. These subsystems and constituent elements are large in numbers and various in types, and the relationship between them is extremely complex, with multiple levels and structures, In addition to the previously discussed the system of internal governance, the system of external governance, system of governance guarantee, the governance system of parent company, governance system of subsidiary and governance system of affiliated companies, there are the legal system, policy system, environmental system, personnel system, financial system, marketing systems and strategic systems, etc.. Within the governance system of large enterprise groups, such a large number of subsystems and elements interact and influence each other, showing a complex nonlinear relationship. For example, during the bankruptcy liquidation of a large enterprise group in China –Guangdong International Trust and Investment Corporation-even management of the corporation had no idea of how many subsidiaries does it have, where are these subsidiaries located and who are their legal representatives.

- High-dimensionalness

Governance system of large enterprise groups is mainly composed of three major subsystems: the system of internal governance, the system of external governance and governance guarantee system. Each subsystem contains a number of respective subsystems. For example, the system of internal governance includes the governance structure subsystem, the governance mechanism subsystem and the governance model subsystem; the external governance system includes a subsystem of capital markets, manager market subsystem and products market subsystem. Governance guarantee system includes legal protection subsystem, policy guarantee subsystem and organizational guarantee subsystem. In addition, the governance systems of large enterprise groups include customer management subsystem, stakeholder management subsystem, network management subsystem, and cultural governance subsystem and learning management subsystem. These subsystems can be further broken down, forming a huge, multi-layered, multi-dimensional system structure. It can be concluded that the governance system of large enterprise group is an open complex giant system involving human, natural world and society and that this open complex giant system has a high number of dimensions.

- Uncertainty

The uncertainty of the system is relative to the certainty of the system. Certainty means that there is no uncertainty in the system and that the real-time input and real-time status of the system can clearly and uniquely determine the real-time status and real-time output of the system of the next moment, such as Newton's agenda. Uncertainty means that there are uncertainties in the system and that real-time input and real-time status of the system can not be clearly and uniquely determine the real-time status and real-time output of the system of the next moment, such as the weather forecast [16]. Clearly, the governance system of large enterprise groups has great uncertainty. For example, in the continuing operations of the enterprise group, new subsidiaries or other collaborative enterprises will join it, and some former subsidiary or cooperative enterprises will sever the group; as another example, the shareholders, board of directors, managers and other governance structures of the group companies, subsidiaries and affiliated companies are in dynamic changes, so there is great uncertainty; yet another example, there is also great uncertainty in the legal system, policy, systems, organizational system, and external economic environment systems of the group's governance guarantee system, and in the elements of these systems

- Emergent properties

As mentioned earlier, the emergence of the system means that the system has a transition from low level to high-level, and on the basis of microscopic evolution the macro system will have radical mutations in performance and institutions. The Emergent properties of system include the system whole emergence and emergence between system's hierarchies The system whole emergence means that when the various parts of the system form a whole, there will emerge some characteristics (such as the nature, functions, etc.) that the whole have while the various parts do not have. Emergence between system's hierarchies means that when several components on the low-level form a higher level, some new properties, functions and elements will emerge. For large enterprise groups, the group's parent companies, subsidiaries, and affiliated companies form together organically through capital, contracts and other ties, and they influence and interact with each other with mutual coordination This would make the whole group have the cohesion, core competitiveness and even monopoly that any member of the group previously did not have and thus the overall functions of the group as a whole is greater than the sum of functions of each individual member, resulting in the whole emergence. Similarly, there are emergent properties between the various hierarchies within the large enterprise groups (such as between the various subsidiaries, between the affiliated companies, or even between the same departments across different subsidiaries within the group) Emergent properties are the results of the nonlinear interaction between the governance bodies of the governance systems of large enterprise groups. It is one of the most important characteristics of the governance systems of large enterprise groups, and also is one of our main concerns.

In summary, the governance systems of large enterprise groups is a complex giant system with openness, complexity, high-dimensionalness, uncertainty and emergent properties, whose frame structure, space-time structure and operation structures also display strong systematicity. To analyze and study this complex giant system, a single qualitative or quantitative method is inadequate for a scientific and comprehensive inspection and inquiry of it. We need new scientific approaches to it.

The meta-synthesis method, which is a Dialectical unity of reductionism and holism and combination of micro-studies and macro studies, is just the new approach to the scientific study of governance of large enterprise groups from a new perspective.

65.4.2 Meta-Synthesis Modes of Governance Engineering of LEG

In the previous paragraphs, we have made progressively elaborate explanation of large enterprise groups, the governance of large enterprise groups, the governance systems of large enterprise groups and the systems engineering of governance of large enterprise groups, and have analyzed their structural characteristics and the meta-synthesis dimensions. On this basis, we can design the meta-synthesis modes of governance engineering of large enterprise groups, as shown in Fig. 65.4.

In Fig. 65.4, under the guidance of the ideas and methods of system theory, we first integrated the ideas, theories, methods and techniques of meta-synthesis. On this basis, we design the hall for workshop of meta-synthetic engineering system (HWME system) of man-machine combination and from qualitative to quantitative, which is composed of knowledge systems, expert systems and machine system. Through the HWME system, the governance objective system, governance structure, governance mechanisms and governance modes in the complex giant system of the governance system of large enterprise groups are subject to a series of analysis diagnosis, testing, simulation and repeated researches after qualitative meta-synthesis, combination of qualitative and quantitative meta-synthesis and quantitative meta-synthesis. Quantitative conclusions are put into practices to optimize and transform the entire governance system. The optimization and transformation will be feedbacked to the complex giant system of governance of large enterprise group through elements and channels of the system in the forms of the new objectives and new information. After the governance system has digested and processed such information, it will, by means of new technology, make new hypothesis, test and revise it, and make successive approximation of optimal governance results. In the complex giant system of governance of large enterprise groups, implementation of all governance work, complementation of governance tasks and the achievement of governance objectives in all the governance chains (ranging from the establishment of governance objectives system, qualitative meta-synthesis, combination of qualitative and quantitative meta-synthesis, quantitative meta-synthesis and optimization

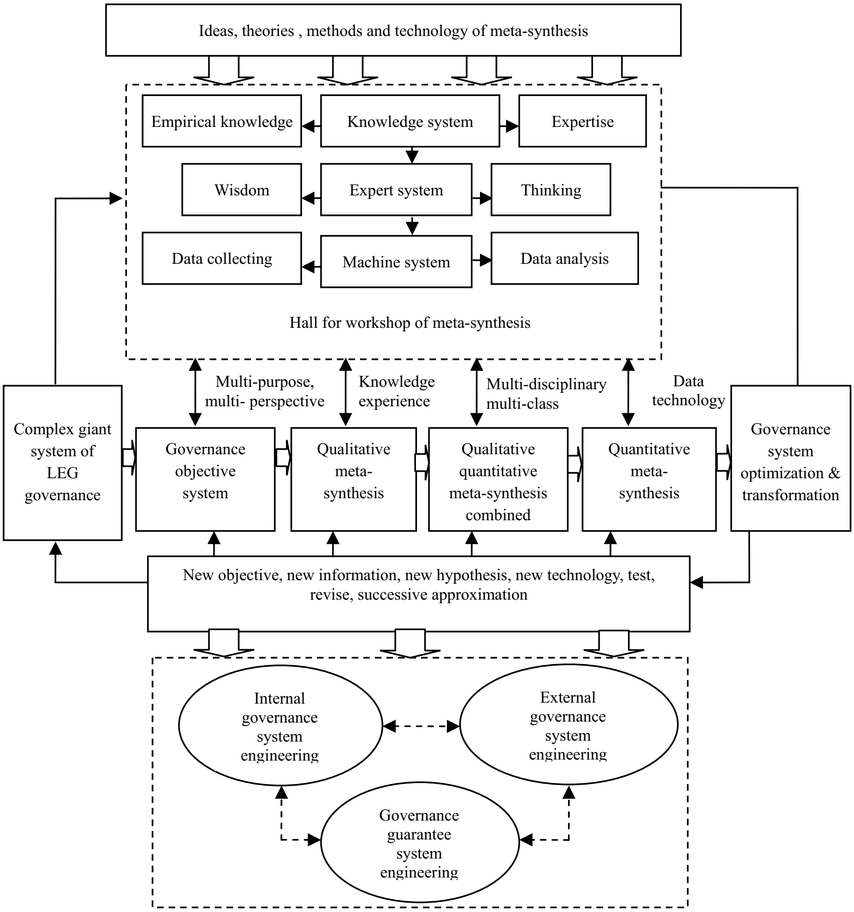


Fig. 65.4 Dimension of meta-synthesis of governance engineering of LEG

and transformation of the governance system) are realized by three main projects, namely: systems engineering of internal governance, systems engineering of external governance and systems engineering of governance guarantee.

65.5 Conclusion

In conclusion, the paper mainly includes three parts. Part One describes and analyzes the concept and characteristics of enterprise group, and then, on this basis, defines the definition and connotations of large enterprise groups. Part Two describes and analyzes the contents of governance of large enterprises group. Part Three analyzes the meta-synthesis of systems engineering of governance of large enterprise groups from the perspective of systems engineering.

References

1. Xu JP, Cui J (2011) Non-governmental organizations (NGOs) mode of meta-synthesis in linkage of post-disaster aid. Disaster Science 26:138–144
2. Xu JP, Du WJ (2010) Mode of meta-synthesis in systems engineering of post-disaster NGO assistance — A Case Study of Wenchuan 8.0 earthquake. Disaster Science 25:102–110
3. Xu JP, Lu Y (2008) Mode of meta-synthesis in earthquake reconstruction systems engineering. Systems Engineering Theory and Practice 16:2–16
4. Xu JP (2002) Extensions of the topsis for multiple attribute group decision making problems based on interval members. Progress in System Science and Systems Engineering. Science Press
5. Xu JP, Hao CJ (2008) Mode of meta-synthesis in systems engineering of Wenchuan Post-Disaster counterparts aided Reconstruction. Systems Engineering Theory and Practice 13:2–13
6. Yu B (2009) System engineering theory. China University of Science and Technology Press (In Chinese)
7. Li BS, Yu XH (2008) Management systems engineering. China Renmin University Press (In Chinese)
8. Li W (2005) Science of corporate governance. Higher Education Press (In Chinese)
9. Xi YM, Zhao ZY (2006) Corporate governance. Higher Education Press (In Chinese)
10. Liu YG (2008) Corporate governance of state-owned enterprises. China University of Science and Technology Press (In Chinese)
11. Sun LC (2009) Management and control of enterprise group. Economic Science Press (In Chinese)
12. Ma S (2009) Optimization analysis of corporate governance of large state-owned enterprise groups. Economic Tribune 11:63–65
13. Ma S (2009) Analysis of the systems engineering characteristics of governance in large state-owned enterprise groups. China Economic and Trade Tribune 12:65–66 (In Chinese)
14. Xi YM (2002) Governance of enterprise group. China Machine Press (In Chinese)
15. Xie ML (2007) Governance of enterprise Group from the perspective of coordination and cooperation. Economic Science Press (In Chinese)
16. Yan GL (2008) Systems engineering. China Machinery Press (In Chinese)

Chapter 66
Discussion on the Application of Knowledge Management in Enterprise Management

Liang Zhao, Xiang Huang and Jinghui Hao

Abstract The benign development of the economy depends heavily on the knowledge in the practice platform of application and innovation. Along with the knowledge management in the field of business management, internal and external environment has also undergone a significant change, so as to promote the concept of enterprise management innovation.

Keywords Enterprise management · Knowledge management · Economic development · Application

66.1 Introduction

Knowledge management has become an important factor in the enterprise management. Given that more and more attention is paid to the pivotal role of knowledge in the management, enterprises should promote the knowledge management, and utilize explicit and tacit knowledge capital in a rational and simultaneous manner by virtue of modern information resources and sharpen their emergency capabilities so as to improve their comprehensive competitiveness [1].

66.2 Content of Knowledge Management

The main contents of knowledge management consist of the following six aspects: first, the knowledge in the knowledge management, including knowledge from books and employees' direct and indirect experience; second, basic parts of knowledge management, such as techniques of network management and various channels

---

L. Zhao (✉) · X. Huang · J. Hao
Business Administration City University Of Macao, Macao 000853, P. R. China
e-mail: huhuhuzl@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_66, © Springer-Verlag London 2013

of exchanges and contact among the personnel; third, the role of knowledge management in the actual operation process of enterprises, whose purpose is to ensure the share and application of the latest knowledge (concepts) in enterprises and facilitate the efficient formation of the knowledge flow which flows smoothly and pushes the practice based on knowledge resources of enterprises so that every employee can have access to the latest knowledge related to goals of enterprise management and make due contribution to enterprises; fourth, learning and retrieval of knowledge, which means to apply all kinds of software and create the atmosphere of continuous study within a team; fifth, spread of knowledge, including the share of knowledge through a variety of network platforms; sixth, share and evaluation of knowledge, such as shaping a relaxing corporate culture, promoting the application of knowledge, and establishing a positive evaluation system which can facilitate the benefits brought by knowledge and promote the study [2].

66.3 Conditions for the Application of Knowledge Management in Enterprises

Enterprises should not only make clear the goals of knowledge management, but also achieve the rational and organic combination of knowledge management and corporate strategies. Only in this way can the sound application of knowledge capital be ensured in enterprise.

1. Traditionally, the core of enterprise management is focused on corporate material resources with the management of corporate soft resources (knowledge resources) ignored to a large extent. It's impossible for enterprises to win in the fierce market competition if they have no clear idea about the concept that knowledge capital is indeed the most important resource.
2. It's necessary to create a working and learning environment filled with humanistic spirit and beneficial to the share of knowledge actively and initiatively. Knowledge management embraces both the maximum application of existing knowledge resources and the improvement of internal and external environment to realize the easier transmission of knowledge (awareness). The cultural atmosphere of sharing knowledge should be created because knowledge emerges in the process of active communication and interaction among team members. It's a must to let all employees in the organization agree the behavior of knowledge contribution and share should be encouraged and rewarded and they should unite with personnel inside and outside the organization into an ambitious team promoting the development and innovation of knowledge. The development of the organization environment is based on benign competition of strength instead of mutual damage of interests.
3. Knowledge innovation is the basis of corporate survival and development. Innovation is the core of knowledge development Innovative spirit and capacity is a crucial link of corporate culture. Enterprises should actively give full play to

employees' initiative and innovation, encourage them to make innovation and achievements continuously and foster the awareness of sharing innovative fruits with team members which can stimulate employees' strong aspiration for knowledge innovation.

4. A new organizational regime suited to the development should be established. An organization with benign operation is a necessary guarantee for knowledge management. It's necessary to make innovation of regime actively and initiatively, establish a system suited to knowledge transmission, put the strategies of knowledge management into practice in the structure of the organization and an information system based on knowledge management.

66.4 Elements of Knowledge Management Innovation

66.4.1 Strategic Innovation

Strategy is the basis of awareness for the corporate development. Development is impossible without clear and definite strategies. Strategic innovation constantly based on changes of the market can keep enterprises successful enduringly. Meanwhile, it's necessary to set up an inclusive production and marketing regime based on international exchanges and cooperation [3].

66.4.2 Conceptual Innovation

Virtual official mode is advocated. Due to the increasing progress of information technology, the network will serve as a platform for working and learning in the future. Adopting this mode, employees will be more willing to share and apply their individual ideas resulting from the practice.

66.4.3 Regime Innovation

An enterprise with continuous learning or a really excellent enterprise is bound to have a mature and constantly updated learning regime.

66.4.4 System Innovation

A flat organizational system is necessary to coexist with a pyramid one. A flat organizational system is quite compact and flexible established through reducing institutions, which can decrease the cost for the management and coordination of the organization. Employees with various knowledge, capabilities and backgrounds of practice are scattered in a corporate organization with complicated structure, which can improve the efficiency of organization management.

66.5 Innovations and Application of Knowledge Management in Enterprises

Corporate competition mainly refers to the competition of talent and knowledge, which really drive the development of enterprises. Those enterprises with rich intellectual resources will win the competition. Knowledge is the key and basic element of the production of enterprises, which has replaced the labor force and material resources and become the main part of the value of corporate products. To take Tongrentang for example, the following discusses the unique innovation and application of talent management based on knowledge management [4].

66.5.1 Establish a Talent Introduction Mechanism Featuring Active Absorption and Timely Entrustment with Important Positions

(1) Campus recruitment

Choose talents best suited to corresponding positions and foster them with a clear target. For grassroots positions, we tend to adopt the type of campus recruitment. With strong plasticity, the graduating students generally have strong capabilities for learning. So once they are allowed into the enterprise, they will find it easier to recognize corporate value and show more loyalty to the enterprise. Employees' loyalty is expected by enterprises.

Tongrentang adopts two successful types of campus recruitment, one of which is the unique propaganda lecture. It's an important channel for graduates to know Tongrentang. Through the exquisite design of links such as introduction of corporate backgrounds, planning of career, participation in the interactional games, Students can feel the profound culture with a history of 340 years in the relaxing atmosphere and thus position themselves properly. The other successful type of campus recruitment is to establish "Tongren Club". As the unique club of Tongrentang, it organizes students to visit the enterprise. Students can have the chance to become a member of Tongren Club and receive the training for free after passing the preliminary selection. The learning of professional etiquette, outward development and other courses can ensure students' positive attitude towards profession, which has become a "cushion" between universities and enterprises. Thus, both enterprises and applicants can benefit a lot.

(2) Consulting recruitment

Choose talents that enterprises need most and entrust them with important positions. Consulting recruitment is targeted at those positions of low or high end management and techniques, with a variety of professional talents engaged in such fields as IT operation and maintenance, network monitoring and quality management.

(3) Establish a rational salary incentive mechanism prioritizing the performance and reflecting different values of talents

Sales bonus is directly related to sales performance. More pay is for more work and the salary is based on the work load. Every sales person is encouraged to improve the capabilities for higher income through learning. Thus, the individual value of all employees is displayed, which is also a process of the application of knowledge resources.

66.5.2 Establish a Talent Cultivation Mechanism Featuring a Clear Purpose and Comprehensive Incentive

In terms of learning, employees are classified into four levels, namely, ordinary employee, department head, project manager, senior managing officer. Different levels correspond to different positions with corresponding learning content stipulated. In terms of courses, they range from the simple to the professional with various needs considered comprehensively including technology development, products manufacturing, freight logistics, marketing planning and practice, and rear service support and management. The new mode featuring different levels, positions and training content makes the training more targeted and motivates trainees' interest for learning and desire for maturing which are beneficial for rapid improvement of their capabilities and are the reflection of the concept for building a learning organization.

66.5.3 Establish a Cadre Reserve Mechanism Focusing on Practical Skills and Long-term Needs

Candidates for reserve store manager usually work in the forefront of sales stores for over two or three years. They are the cream of all employees and excellent in the achievements of learning and capabilities for management and implementation with the spirit of hard work and contribution. After taking several tests for internal competitive positions, those with passing scores are allowed into the store manager reserve plan. Reserve store managers will continue the learning and practice in different positions, constantly widen their horizons and improve their management skills. A reserve store manager needs serve as duty manager to assist the store manager and improve their professional capabilities in at least two or three stores of different kinds. During the learning process, their management concept will come into being gradually, and begin to be armed with comprehensive capabilities for independent management of a store. On the whole, as the social and economic pattern changes, people have fully realized that knowledge capital is the kernel production force and plays a pivotal role in the value added process of product and labor service value. From this perspective, knowledge management is bound to be integrated into the enterprise management.

References

1. Zhao L (2011) Countermeasures and implications of the management of America-Soviet Crisis under the Cuba missile crisis. Intelligence 22:44 (In Chinese)
2. Fang J (2005) Classification of knowledge and learning of corporate knowledge. Technical Economy and Management Studies 1:56 (In Chinese)
3. Na Y (2006) Studies on knowledge shift model of demand projects and strategies. Tianjin University (In Chinese)
4. Wang G, Hu P (2006) On knowledge creation of enterprises. Chongqing University Journal (Social Science) 20:78–80 (In Chinese)

Chapter 67
The Credit Competition between Local and Foreign Bank with Limited Fund

Xudong Chen and Yong Zeng

Abstract Assuming foreign bank with limited fund and local bank with unlimited fund, this paper constructs the credit competition between two banks, the result shows that: when the fund of foreign bank is relatively enough, two banks compete for low-risk customers, all low-risk customers can get loans; When the fund of foreign bank is not enough, two banks monopolize their own familiar low-risk customers, parts of the low-risk customers can't get loans, credit rationing appears. Moreover, the profit of foreign bank is not strictly monotonic with its fund, that is to say, when foreign bank has less fund, the profit of foreign bank may stay the same.

Keywords Limited fund · Credit competition · Credit rationing

67.1 Introduction

Since China joined the WTO on December 11, 2001, China's banking reform has speeded up significantly. The introduction of foreign strategic investors was thought to be inevitable for China's banking reform and the path of reform that was encouraged and supported by the regulatory authorities [16], then foreign banks started to enter China one after another. The law of The People's Republic of the regulations on the administration of foreign Banks and The People's Republic of China foreign bank regulations implementing rules that were issued at the end of 2006 encouraged foreign banks to be foreign legal person banks, and foreign banks enjoyed the same national treatment with local banks. By the end of 2010, 185 banks from 45 countries and regions had set up 216 representative offices in China, the banks from 14 countries and regions had established 37 foreign legal person banks, the total assets of foreign banks in China reached up to 1.74 trillion, Table 67.1 describes the total

X. Chen (✉) · Y. Zeng
School of Management and Economics, University of Electronic Science and Technology of China,
Chengdu 610054, P. R. China
e-mail: chenxudong198401@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_67, © Springer-Verlag London 2013

assets of foreign banks, the number of institutions and the foreign banks' market share, it can be clearly seen that the total assets of the foreign banks in China and the number of institutions rose steadily from 2004 to 2010, but foreign banks' market share fluctuated. For foreign banks' market share, it can be clearly seen that the foreign capital bank's market share rose steadily from 2004 to 2007, but the number declined from 2007 to 2010, although the 2010 market share rebounds a bit, the number of 2010 only stayed the same as the number of 2004.

Table 67.1 The data of foreign banks in China (2004-2010) units: percentage, house, billion

Year	2004	2005	2006	2007	2008	2009	2010
Foreign banks' market share	1.84	1.91	2.11	2.38	2.16	1.71	1.85
the number of institutions	188	207	224	274	311	338	360
Total assets	5823	7155	9279	12525	13448	13492	17423

When foreign banks entered China in 2001, it was widely circulated that "wolf is coming" [12]. People thought that the perfect governance mechanism and high level risk management of foreign banks would affect the survival of local banks. But now even if foreign banks become foreign capital legal person banks and enjoy the exactly same national treatment with local banks, there is another voice that "foreign banks behave badly in China" [6]. The bad performance of foreign banks makes us think whether foreign banks are as competitive as we expected. As is known to all, at the present stage of China, because of the big gap of interests of saving and loan, the main business of banks in China is credit business. Although foreign banks enjoy exactly the same national treatment with local banks in law, compared with local banks, foreign banks have two weakness: first, the local banks are more familiar with the customers in the markets than foreign banks; second, the number of foreign banks' branches is much less than the number of the local banks' branches, which will restrict the foreign banks' ability to collect deposits, leading to the limited fund of the foreign banks. According to the report published by China Banking Association in 2010, at the end of 2010, there are as many as 194.9 thousand national banks' branches in China, where the Agriculture Bank of China has as many as 23486 branches, while HSBC bank (China) who has the most branches in China among of all foreign banks in China, owns only 111 branches.

The classical credit theories of [7–9, 13] show the importance of the asymmetric information for bank credit competition. Further more, Classical bank credit competition model of [2–4] and the subsequential researches of [5, 10, 11] show that collateral can help banks distinguish different risk borrowers. nevertheless there are few research about foreign banks' branches, Xu [15] considers the credit competition between foreign bank and local bank based on the view of branches, obtained the conclusion: the foreign bank's profits are influenced by the amount of the local banks' branches which have existed and the total number of customers in the market. In summary there are rare researches about credit competition of bank with limited fund, this paper hopes to make some contribution in this respect.

Based on the above analysis, assuming foreign banks with limited fund and local bank with unlimited fund, this paper considers the credit competition between local bank and foreign bank based on the perspective of collateral. First of all, when foreign bank has relatively enough fund, this paper established the two banks' credit competition model, and concludes that both banks compete for low risk customers in the market, and all low risk customers can get loans, at this time the foreign capital bank's fund constraints doesn't work; Second, when foreign bank fund is not enough, two banks' credit competition is constructed, and the conclusion shows that both banks tend to exploit their more familiar customers, even if both banks still have surplus fund, they don't want to offer more loans, there will be some customers who can't get loans, then the credit rationing[1] emerges. Moreover, the profit of foreign bank is not strictly monotonic with its fund, that is to say, when the fund foreign bank is less, the profit of foreign bank may stay the same.

The rest of the paper is organized as follows: Sect. 67.2 establishes the basic credit competition model and analyzes how the restrictions of the foreign bank's fund influences bank credit competition; Sect. 67.3 analyzes the equilibrium and provides the results, draws the conclusion that "foreign bank behave badly" is not a good thing.

67.2 The Basic Model of the Credit Competition

Based on the bank credit competition model of [5], there are two banks in the credit market, Chinese local bank I has existed for a long time in the market and foreign bank E just entered China, the financing cost of local bank I and foreign bank E were respectively ρ^I and ρ^E, assuming that all enterprises (borrowers) uniformly distribute in one line of unit length, each enterprise needs to borrow 1 Yuan from the bank, there are two types of risk enterprise: high risk enterprise and low risk enterprise, and the proportion for high risk and low risk is $v:(1-v)$. The low risk enterprise can borrow \$1 and invest in a project that yields revenue X with probability $1-\theta_L$ and and zero with probability θ_L. For high risk enterprise, they can borrow \$1 and invest in a project that yields revenue X with probability $1-\theta_H$, and zero with probability θ_H, where $0<\theta_L<\theta_H<1$. We assume that low risk enterprise is creditworthy, and high risk enterprise is uncreditworthy, namely $(1-\theta_H)X-\rho^j<0$, $(1-\theta_H)X-\rho^j>0$, $j=I,E$. Local bank I and foreign bank E are located at both endpoints of the line, bank I has 1 unit money, which represents that bank I can offer all enterprises loan, bank E has money k, where $0<k<1$, which represents that bank E can provide loans to the enterprises that are apart from bank E at most k. No matter bank I or bank E has asymmetry information with enterprises, that is to say, before bank offers loans to enterprises, all enterprises know their own risk type but

---

[1] Credit rationing refers that the demand of credit market loan is greater than supply, parts of the customer can't get a loan, for more details see [14].

the bank do not know the risk type of enterprise. For simplicity all enterprises who want to borrow money form the bank have enough collateral, the reservation utility of enterprises is 0.

when enterprises borrow money from the bank, the bank offers a loan contract (R,C) to the enterprise, namely enterprise needs to pay interest rate R to the bank and provides an amount of collateral C, when enterprise' investment succeed, they will pay the bank interest rate R, then the bank will return the collateral to the enterprise, when the enterprise' investment fails, the enterprise is not able to repay the loan, the bank will confiscate the collateral according to loan contract and sell the collateral in the market. We assume disparity in collateral valuation between borrower and lender by defining the lender's valuation of collateral as βC, where $0 \leq \beta < 1$. When the bank j provides loans contract (R,C) to the borrowers, its profit is $\pi^j(R,C) = (1-\theta)R + \beta\theta C - \rho^j$, the revenue for enterprise is $u(R,C) = (1-\theta)(X-R) - \theta C$, so the loan contract (R,C) will generate a surplus for $(1-\theta)X - \rho - (1-\beta)\theta C$, the surplus is the total profit of investment, where part of the surplus will be allocated to the bank, the other part of the surplus will be allocated to the enterprise. It can be easily seen that the use of collateral will lead the social welfare loss $(1-\beta)\theta C$. that is, if the enterprise's revenue stay the samethe profit that the bank gains when the bank demands the enterprise to provide collateral is less $(1-\beta)\theta C$ than that the bank gains when it does not demand the enterprise to provide collateral, this is the price that the bank demands enterprise to offer collateral. When the bank j offer the contract (R_m^j, C_m^j) to the enterprise m, the bank's profit is $\pi_m^j(R_m^j, C_m^j) = \pi^j(R_m^j, C_m^j, \theta_m)$, where $j = I, E$ and $m = H, L$. When the bank j provide loan contract $\{(R_H^j, C_H^j), (R_L^j, C_L^j)\}$ for all enterprise, the profit of bank j is $\pi^j = v\pi_H^j(R_H^j, C_H^j + (1-v)\pi_L^j(R_L^j, C_L^j)$, the revenue of enterprise is $u_m^j(R_m^j, C_m^j) = u^j(R_m^j, C_m^j, \theta_m^j)$, we note $u^j(R_m^j, C_m^j)$ as u_m^j for simplicity.

when enterprise lend money from the bank, they need to pay the bank interest rate R and provide collateral C, in addition they need to pay for the transaction cost $w_1 x$, x is the distance from enterprise to the bank I, w_1 is the transaction cost of per length. For example the distance from an enterprise to the bank I is $(1-x)$, the distance from an enterprise to the bank E is $1-x$, the transaction costs of the enterprise loaning to the bank I and bank E respectively are $w_1 x$, $w_E(1-x)$. Due to exist in the market for long time, local bank I has much information about the human environment, together with wide good customer resources, and has established a relatively stable and favorable cooperation relations, so local bank is more familiar with local enterprise, and foreign bank is not familiar with local enterprise, namely compared with local bank, foreign bank has information disadvantage. According the view of [1], the different transaction costs of two banks reflect the extent of information asymmetry of two banks, the more familiar with the market the transaction cost is smaller. When local bank offers a loan contract for (R_m^I, C_m^I) to low risk enterprise m, the profit of the low risk enterprise is $u_m^I - w_1 x$, because the reservation utility of enterprise is 0, so only when $u_m^I - w_1 x \geq 0$ meets enterprise will borrow money from bank I, meanwhile bank E the offers a loan contract (R_m^E, E_m^E) to enterprise m, the profit of enterprise is $u_m^E - w_E(1-x)$, only when participation constraint condition of the enterprise $u_m^E - w_E(1-x) \geq 0$ meets, enterprise m will apply loans to the foreign bank E.

Next we first quote two conclusions of [5]:

Conclusion 1: In the case that the revenue of two risk types' customers applying loans to the bank j meets $\frac{u_H^j}{1-\theta_H} \leq \frac{u_L^j}{1-\theta_L}$, when the proportion of high risk enterprise in the market satisfies $v > v_1$, where

$$v_1 = \frac{(1-\beta)\theta_L(1-\theta_L)}{\theta_H - \beta\theta_L - (1-\beta)\theta_L^2},$$

the bank provides the following loan contract $\{(R_H^j, C_H^j), (R_L^j, C_L^j)\}$ to the enterprises. The high risk enterprises choose to higher rate and lower collateral, while low risk enterprises choose to lower rate and higher collateral, where

$$R_L^j = X - \frac{\theta_H u_L^j}{\theta_H - \theta_L} + \frac{\theta_L u_H^j}{\theta_H - \theta_L},$$
$$C_L^j = \frac{(1-\theta_H)u_L^j - (1-\theta_L)u_H^j}{\theta_H - \theta_L},$$
$$R_H^j = X - \frac{u_H^j}{1-\theta_H}, C_H^j = 0.$$

Conclusion 2: when the bank j provides loan contract (R_L^j, C_L^j) to make the revenue of the low risk enterprise u_L^j, the profit of the bank j is $\pi_L^j = (1-v)[(1-\theta_L)X - (1+M)u_L^j - \rho^j]$, where $M = \frac{(1-\beta)\theta_L(1-\theta_H)}{\theta_H - \theta_L}$. Bank j only offers loan contract

$$\left(X - \frac{\theta_H}{\theta_H - \theta_L} u_L^j, \frac{1-\theta_H}{\theta_H - \theta_L} u_L^j\right),$$

only low risk enterprises choose to apply loans from bank, high risk enterprises do not apply loan from the bank.

Conclusion 1 shows that when the proportion of high risk enterprise reaches up to a certain degree, the bank will demand all its customers to provide collateral, only low risk enterprises will apply loans to the bank, high risk enterprises will give up loan. The use of collateral can help the bank distinguish different level risk enterprise, namely the enterprises who apply loan to the bank are low risk enterprise. In this case the bank would rather endure the social loss by demanding the customer to provide collateral than endure the loss caused by asymmetry information. Conclusion 2 indicates that there is a one-to-one relationship between the optimal loan contract (R, C) offered by the bank and the revenue u_L^j, namely for each loan contract (R, C) offered by the bank, there exists only a corresponding revenue U_L^j, meanwhile for each revenue U_L^j obtained by the enterprise, there exists only a optimal loan contract (R, C). Bank will choose its decision variables R, C when it offers a loan to the enterprise, based on the above analysis bank can choose U_L^j as its decision variable. The following research of this paper U_L^j is regarded as the decision variable of the bank.

According to the above two conclusions, we study the bank credit competition between foreign bank E with limited fund and local bank with unlimited fund.

67.2.1 Bank Credit Competition Model When Bank E has Relatively Enough Fund

Intuitively, the profits of the bank are influenced by two factors: market share and profit of per customer. Interest rate and collateral are higher, the less customers apply to loan, then the bank gets the less market share, although higher profit of per customer bank customers, due to the less market share, the profit of bank may be less. So the bank will choose a proper interest rate and collateral to make the profit maximization. First we consider the situation that foreign bank E does not have enough fund, the conclusions are drawn as follows:

Proposition 67.1. *When*

$$\frac{w_I}{w_I+w_E}+\frac{\rho^I-\rho^E}{3(w_I+w_E)(1+M)}+\frac{w_E-w_I}{3(w_I+w_E)}\leq k<1,$$

both banks compete for low risk, all the low enterprise can get a loan, foreign capital bank capital constraints doesn't work.

The indifference condition of the low risk enterprises lending money to either bank are obtained as follows:

$$u_L^I-w_Ix=u_L^E-w_E(1-x), \tag{67.1}$$

so

$$x=\frac{w_E+u_L^I-u_L^E}{w_I+w_E}. \tag{67.2}$$

The constraint condition of bank E' fund is:

$$1-x\leq k. \tag{67.3}$$

The intuitive mean of foreign bank' fund constraint is that the foreign bank can only offer loans to the enterprises who are away from the bank at most distance k.

The low risk enterprises located in the left of indifference point apply loans to the bank I, The low risk enterprise located in the right of indifference point apply loan to the foreign bank E, u_L^j, u_E^j are decision variables of both banks.

The profits of bank I and bank E are respectively:

$$\pi^I = \lambda(1-v)\left[(1-\theta_L)X-(1+M)u_L^I-\rho^I\right]\frac{w_E+u_L^I-u_L^E}{w_I+w_E}, \tag{67.4}$$

$$\pi^E = \lambda(1-v)\left[(1-\theta_L)X-(1+M)u_L^E-\rho^E\right]\frac{w_I+u_L^E-u_L^I}{w_I+w_E}. \tag{67.5}$$

The both banks maximize their own profit by choosing proper decision variable u_L^j, u_E^j:

$$\frac{\partial\pi^I}{\partial u_L^I}=\frac{\partial\pi^E}{\partial u_L^E}=0. \tag{67.6}$$

The market share of bank I is

$$x=\frac{w_E}{w_I+w_E}+\frac{\rho^E-\rho^I}{3(w_I+w_E)(1+M)}+\frac{w_I-w_E}{3(w_I+w_E)}. \tag{67.7}$$

At this time, the fund constraint of foreign bank doesn't work, the both banks compete for all low risk enterprises, all low risk enterprises can get loan. Through the above analysis we can see, though foreign bank's fund is limited, as long as the fund of foreign bank exceeds a critical point, the credit competition between foreign bank with limited fund and local bank with unlimited fund are same as the credit competition between the both banks with unlimited fund. In other words, if the fund of foreign bank reaches a critical point, the constraint fund of foreign bank does not influence the bank credit competition.

67.2.2 Bank Credit Competition Model When Bank *E* Doesn't Have Enough Fund

When

$$k<\frac{w_I}{w_I+w_E}+\frac{\rho^I-\rho^E}{3(w_I+w_E)(1+M)}+\frac{w_E-w_I}{3(w_I+w_E)},$$

insufficient fund will influence the foreign bank credit plan, due to the deficiency of the foreign bank insufficient fund foreign bank E prefer to obtain more profit from per customers rather than compete with bank I to get more market share. At this time bank I knows foreign bank's lack of funds, so bank I won't compete for market share like 2.1. In this case, the logic of competition is listed as follow: first foreign bank E knows their own fund is limited, so bank E will exploit its familiar client as far as possible. even if the fund of foreign bank E is limited (due to the limited fund, bank E can only offer loan to the enterprises which is away from bank E at most k) to the part of the enterprise within the loan, bank E may offer loan to the enterprise with a part of its money. For local bank I, it knows bank E can only offer loan to the part of enterprises which are away from bank E at most k, that is to say, the rest of enterprises must apply loan to bank I if they want to lend money. So bank I will exploit these enterprise as far as possible.

Proposition 67.2. *(1) When*

$$\frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E} \geq k \geq 1-\frac{(1-\theta_L)X-\rho^I}{2(1+M)w_I},$$

low risk enterprises can get loans, the revenue of enterprises provided by both banks is $u_L^j = (1-k)w_1$, $u_L^j = kw_E$, *profits of both banks are*

$$\begin{aligned}\pi^I &= \lambda(1-v)[(1-\theta_L)X-(1+M)(1-k)w_I-\rho^I](1-k),\\ \pi^E &= \lambda(1-v)[(1-\theta_L)X-(1+M)kw_E-\rho^E]k.\end{aligned}$$

(2) When

$$k < \min\left(1-\frac{(1-\theta_L)X-\rho^I}{2(1+M)w_I}, \frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E}\right),$$

part of the low risk enterprises can't get a loan, the revenue of enterprises provided by both banks is $u_L^I = \frac{(1-\theta_L)X-\rho^I}{2(1+M)}$, $u_L^E = kw_E$, *the profits of both banks are*

$$\begin{aligned}\pi^I &= \frac{\lambda(1-v)[(1-\theta_L)X-\rho^I]^2}{2(1+M)w_I},\\ \pi^E &= \lambda(1-v)[(1-\theta_L)X-(1+M)kw_E-\rho^E]k.\end{aligned}$$

(3) When

$$k > \frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E} \text{ and } \frac{(1-\theta_L)X-\rho^I}{2(1+M)w_I} \geq 1-\frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E},$$

the revenue of enterprises provided by both banks are:

$$u_L^I = \left(1-\frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E}\right)w_I,\ u_L^E = \frac{(1-\theta_L)X-\rho^E}{2(1+M)}.$$

All low risk enterprise can obtain loans. Profits of both banks are:

$$\begin{aligned}\pi^I &= \lambda(1-v)A\left(1-\frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E}\right),\\ A &= \left[(1-\theta_L)X-(1+M)\left(1-\frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E}\right)w_I-\rho^I\right],\\ \pi^E &= \frac{\lambda(1-v)[(1-\theta_L)X-\rho^E]^2}{2(1+M)w_E}.\end{aligned}$$

(4) When

$$k > \frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E} \text{ and } \frac{(1-\theta_L)X-\rho^I}{2(1+M)w_I} < 1-\frac{(1-\theta_L)X-\rho^E}{2(1+M)w_E},$$

parts of low risk enterprise can't get a loan, revenues of enterprises are:

$$u_L^I = \frac{(1-\theta_L)X-\rho^I}{2(1+M)},\ u_L^E = \frac{(1-\theta_L)X-\rho^E}{2(1+M)},$$

all low risk enterprise can obtain loans, profits of both banks are:

$$\pi^I = \frac{\lambda(1-v)[(1-\theta_L)X-\rho^I]^2}{2(1+M)w_I},$$
$$\pi^E = \frac{\lambda(1-v)[(1-\theta_L)X-\rho^E]^2}{2(1+M)w_E}.$$

For the enterprises who apply loan to the foreign bank E, if bank E can provide revenue u_L^E to the enterprises, the distance between the enterprises and bank E is x, then profit of the enterprises is $u_L^E - w_E x$. So only when $u_L^E - w_E x \geq 0$ the enterprise will apply a loan to bank E, so the biggest distance that enterprise will apply a loan to bank E is $x = u_L^E / w_E$, if the distance between foreign bank E and the enterprise is more than u_L^E / w_E, the enterprise will not lend money from the foreign bank E.

Bank E's profit function can be expressed as:

$$\pi^E = \lambda(1-v)\left[(1-\theta_L)X-(1+M)u_L^E-\rho^E\right]\left(\min\left(\frac{u_L^E}{w_E},k\right)\right), \qquad (67.8)$$

u_L^E / w^E represents only so many enterprises who want to apply loan to the foreign bank E, k represents that bank E's fund is limited.

We can maximize the foreign bank's profit (67.8) by basic convex program.

67.3 Result Analysis

Through the analysis of the second section we can find that, when bank E has relatively enough money, namely

$$\frac{w_I}{w_I+w_E}+\frac{\rho^I-\rho^E}{3(w_I+w_E)(1+M)}+\frac{w_E-w_I}{3(w_I+w_E)} \leq k < 1,$$

both banks compete for low risk enterprises, all low risk enterprises can get loans, the profit of all the low risk enterprise is positive. Though bank E has less money than bank I, as long as the fund of foreign bank exceeds a critical point, the credit competition between foreign bank with limited fund and local bank with unlimited fund are the same as the credit competition between both banks with unlimited fund, that is to say, in this case the lack of fund does not bring foreign bank negative effect.

When

$$k < \frac{w_I}{w_I + w_E} + \frac{\rho^I - \rho^E}{3(w_I + w_E)(1+M)} + \frac{w_E - w_I}{3(w_I + w_E)},$$

foreign bank's fund constraint works, foreign bank is more willing to exploit more familiar customer, Proposition 67.2 (1), (3) shows that though all low risk enterprise can obtain loans, they must provide more collateral and pay higher interest rates to get loans, at this time both banks do not compete heavily as before, both banks look like two monopolistic banks, they try to exploit their own familiar customers as much as possible. Proposition 67.2 (2), (4) indicates that parts of low risk of enterprise can't get loans from any bank, even if both banks have surplus fund, no bank want to offer loan to those enterprise who does not get loans, then credit rationing appears.

We analysis how the foreign bank' fund affects the foreign bank' profit: when

$$k \le \frac{(1-\theta_L)X - \rho^E}{2(1+M)w_E}, \frac{\partial \pi^E}{\partial k} > 0,$$

namely the fund of foreign bank is less, the profit is the smaller, in this case the foreign bank will lend all its money to the borrower. for short, the fund is less, the profit of foreign bank is less, so the profit function is monotonic function with its fund; When

$$\frac{(1-\theta_L)X - \rho^E}{2(1+M)w_E} < k < \frac{w_I}{w_I + w_E} + \frac{\rho^I - \rho^E}{3(w_I + w_E)(1+M)} + \frac{w_E - w_I}{3(w_I + w_E)},$$

foreign bank' profit stay unchanged, at this time both banks exploit their own familiar customers, both banks do not use all their money, the lack degree of foreign bank fund would not affect the profit, when

$$k \ge \frac{w_I}{w_I + w_E} + \frac{\rho^I - \rho^E}{3(w_I + w_E)(1+M)} + \frac{w_E - w_I}{3(w_I + w_E)},$$

although both banks compete for all low risk customers, both banks have surplus fund, so the amount of the foreign bank' money will not affect foreign bank's profit.

From the above analysis, we can see, the foreign bank's profit is not strictly monotonic function with its fund all the time, in other words, even if in some case foreign bank has less money, its profit may stay the same.

For all the low risk enterprises in the market, foreign bank's limited money leads negative effect to the enterprises, actually foreign bank's limited fund leads to weaker competition between two banks, and the enterprises will pay higher interest rates and provide more collateral to get loans, some low risk of enterprise even can't get a loan. In real world, vast number of small and medium-sized enterprises in our country has faced this dilemma. So we can say that the biggest victims caused by foreign bank's limited fund is not foreign bank, but all the enterprise in the market, the most severely affected of which are those who are not familiar with either bank.

67.4 Conclusions

Foreign bank's performance in China is not as good as we expected, the shortage of fund leaded by the shortage of branches in China is the main cause of the foreign bank's bad performance, based on this reason this paper constructs the bank credit competition between foreign bank with limited fund and local bank with unlimited fund, the conclusion shows that the shortage of fund leads foreign bank unwilling to compete with local bank, both banks are more willing to exploit their familiar customers, and even if both banks have spare money they are still not willing to offer loans to some customer, then the credit rationing emerges. Based on this view, the shortage of foreign bank's fund will lead to the monopoly of the bank and credit rationing phenomenon, which will lead social welfare loss. In real world, the largest number enterprises in the Chinese market are small and medium enterprises who make major contribution to Chinese economic growth, Either local bank or foreign bank is not familiar with them, these enterprises must pay higher price to get the loan, and sometimes even they are willing to pay for the higher rate banks are not willing to offer loan to them. When we recall the time that foreign banks are introduced into China in 2001, we all had such an ideal goal: foreign banks can make a contribution to the small and medium enterprise financing, so "foreign bank perform badly in China" is not necessarily a good thing.

As is known to us all, the reason why foreign bank's fund is limited is that the number of foreign bank's branches is too small, so analyzing how the number of foreign bank's branches affect the bank competition can be pretty interesting.

References

1. Ariccia G (2001) Asymmetric information and the structure of the banking industry. European Economic Review 45:1957–1980
2. Besanko D, Thakor A (1987a) Collateral and rationing: Sorting equilibria in monopolistic and competitive credit market. International Economic Review 28:671–689
3. Besanko D, Thakor A (1987b) Competitive equilibrium in the credit market under asymmetric information. Journal of Economic Theory 71:291–299
4. Bester H, Screening V (1985) Rationing in credit markets with imperfect information. American Economic Review 75:850–855
5. Chen X, Zeng Y (2011) Foreign entry and steady-state of multiple-stage credit competition in bank industry based on collateral view. In: Proceedings of the Sixth Chinese Management Conference, Chengdu
6. Hu R (2010) Foreign banks' bad performance in China. http://www.eeo.com.cn/finance/banking/2010/04/25/168492.shtml
7. Petersen M, Rajan R (1995a) The benefits of firm-creditor relationships: Evidence from small business data. Journal of Business 68:351–381
8. Petersen M, Rajan R (1995b) The effect of credit market competition on lending relationship. Quarterly Journal of Economics 110:407–443
9. Rajan R (1992) Insiders and outsiders: The choice between informed and arm's-length debt. Journal of Finance 47:1367–1400

10. Sengupta R (2007) Foreign entry and bank competition. Journal of Financial Economics 84:502–528
11. Sengupta R (2009) Lending to uncreditworthy borrowers. Working paper, Federal Reserve Bank of St. Louis
12. Shan Y, Chen L (2001) Eaten by the wolves or dancing with the wolves. China Trade News
13. Sharpe S (1990) Asymmetric information, bank lending, and implicit contracts: A stylized model of customer relationships. Journal of Finance 45:1069–1087
14. Stiglitz J, Weiss A (1981) Credit rationing in markets with imperfect information. American Economic Review 71:393–410
15. Xu Z, Zeng Y (2011) Credit competition between domestic bank and foreign bank based on branch networks. In: Proceedings of the Eighth Chinese Finance Conference, Jinan
16. Zhu Y, Zeng Y, Li P et al (2008) Introducing the overseas strategic investors into chinese banks: backgrounds, disputes and reviews. Management World 1:22–37

Part VII
Manufacturing

Chapter 68
Determinants of Rice Export from Pakistan

Iqbal Javed and Abdul Ghafoor

Abstract Rice is the world's third largest crop, behind maize and wheat. Pakistan stands at number twelve in rice producing countries and number five in rice exporting countries. Although there exists a lot of potential for rice exports from Pakistan but many factors hamper its expansion. The objective of present study was to conduct export margin analysis and quantify the impact of major factors influencing rice export from Pakistan to United Kingdom for two varieties of rice super basmati and PK-386 (coarse rice). Primary data were collected through a survey of 40 rice exporters selected purposively from the list obtained from Rice Exporters Association of Pakistan. The information collected from these exporters was thus analyzed using descriptive statistics and double log form of regression analysis. According to results, net export margin of super basmati was Rs. 25688.72/ton and percent export margin was 36.12 percent whereas in case of PK-386, net export margin was Rs. 18182.03/ton and percent margin was 40.19 percent. The estimated regression model for super basmati showed that education, sale price of super basmati and total marketing cost were significant while age, purchase price and freight charges were non-significant variables. Coefficient of determination was 0.77 and also F value was significant. The results for PK-386 showed that education, total marketing cost and freight charges were significant variables, whereas age, purchase price of and sale price were non-significant variables. Coefficient of determination for this model was 0.74. The findings suggested that proper management should be adopted in rice export policy by extending domestic production base, targeting high priced markets and awareness about importance of these variables for boosting rice exports from Pakistan.

I. Javed
Institute of Agricultural and Resource Economics, Faculty of Social Sciences, University of Agriculture, Faisalabad 38000, Pakistan

A. Ghafoor (✉)
Institute of Business Management Sciences, Faculty of Social Sciences, University of Agriculture, Faisalabad 38000, Pakistan
e-mail: ghafooruaf@hotmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_68, © Springer-Verlag London 2013

Keywords Rice · Basmati · Export · Regression

68.1 Introduction

Rice is an important cereal crop in world. There are 119 rice producing countries among which China has the leading share in total world production of rice. Pakistan's share of world rice production is 1.30 percent and it stands at number twelve in rice producing countries. In Pakistan among different crops, rice has predominant position. It is the second major cereal crop after rice and feeds a considerable portion of our population [5].

Pakistan grows good quality rice to meet both domestic demand and for export. For the year 2008-09, area sown for rice was estimated at 2963 thousand hectares, 17.8 percent higher than last year, with a production of 6952 thousand tons, and 24.9 percent higher than last year. The size of the crop was estimated at 6952 thousand tons 24.9 percent higher than last year. Higher production of rice crop is primarily based on over achievements of area targets in Punjab and Sindh. In Punjab, area surpassed the target by 12.1 percent and as a result production overshot the target by 14.7 percent. Sindh production surpassed the target by 22.2 percent solely on accounts of area, which surpassed the target by 23.2 percent [5]. In case of rice, domestic prices have been rising in tandem with international price as sizeable quantities of rice is being exported. Pakistan produces more than local demand thereby leaving a significant quantity of rice available for exports each year. Since there are no export restrictions in place right now, the domestic consumer has to pay the same price as the international consumer does for Pakistani rice [7].

Inappropriate storage capacity forces the producer to bring their produce to the market which creates glut in the market and price goes down. A delayed payment to the producer by the commission agents or other buyers of the produce is another problem [9]. Although export of rice is increasing from Pakistan yet facing many challenges due to absence of long term policy. The Rice Exporters Association of Pakistan (REAP), a recently established private organization, emphasized on the need that government should announce long-term policy so that Pakistani exporters can survive in the tough competition particularly with India, which is facilitating its exporters by giving them heavy subsidy [6]. There are many factors which affect the rice export from Pakistan. These include international prices, quality of rice, storage facilities, marketing costs, exporter's experiences, Government regulations and international standards. In this background, the study in hand was undertaken to examine the overall performance of rice export from Pakistan. In addition an effort was made to quantify major factors affecting export of rice from Pakistan.

68.2 Methodology

Universe for the present study was the rice exporters from the rice producing areas of Pakistan including Hafizabad, Gujranwala and Shekhupura. A list of total rice exporters of these three districts was obtained from Rice Exporters Association of Pakistan. The exports of rice were selected on the specific criteria, i.e., exporters, who were exporting rice to UK (high value market), were selected. The study was conducted for two types of rice viz. super basmati and PK-386. Sampling is the use of a subset of the population to represent the whole population [8]. An adequate and scientifically sound sample was essential if a limited investigation had to yield valid results. Thus forty rice exporters were selected in consultation with experts from Rice Exporters Association of Pakistan using random sampling technique. A Pre-tested questionnaire was used to collect the data from selected exporters through personal interviews. Personal interview methods are widely used in marketing statistics [3]. Data were collected from 1 April to 1 August, 2010. To analyze the result of present study, following techniques were used:

Average was calculated by using following formula:

$$AM = \sum X/N. \tag{68.1}$$

Percentage was calculated using following formula:

$$P = F/N * 100. \tag{68.2}$$

For calculating the margins in export supply chains:

$$MM = Ps/Sp * 100, \tag{68.3}$$

where Ps stands for Price spread and Sp for Sale price.

In order to estimate effect of major factors on export of rice from Pakistan, the relationship between dependent and independent variable is given as:

$$Y = f(X_i), \tag{68.4}$$

where, Y represents export quantity (tons); X_i representes vector of quantitative variables $i = 6$.

In more specific form, Equation (68.4) can be written as:

$$Y_i = \beta o X_i^{\beta_i} e^{\mu}. \tag{68.5}$$

Equation (68.5) can be further explained as:

$$Y = \beta o X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} e^{\mu}. \tag{68.6}$$

By taking natural log on both sides, Equation (68.6) can be written as:

$$\ln Y = \beta 0 + \beta 1 \ln X_1 + \beta 2 \ln X_2 + \beta 3 \ln X_3 + \beta 4 \ln X_4 + \beta 5 \ln X_5 + \beta 6 \ln X_6 + \mu, \quad (68.7)$$

where

X_1 : education of the exporters measured in schooling years;
X_2 : age of the exporters measured in years;
X_3 : purchase of rice (Rs/ton);
X_4 : sale of rice (Rs/ton);
X_5 : total marketing cost (Rs/ton);
X_6 : freight charges to UK (Rs/ton).

Statistical Package for Social Scientists (SPSS) was used for data analysis.

68.3 Results and Discussion

The collected data were analyzed to draw inferences about export performance of rice from Pakistan. In this context, in first step margins in export of rice from Pakistan to UK market were estimated. Marketing margin or price spread is a commonly used measure of the performance of a marketing system [1] Average purchase price for United Kingdom market for super basmati rice was Rs. 55035.71 per ton. Average marketing cost for United Kingdom market was Rs. 5441.426 per ton. According to findings of this study average sale price was calculated as Rs. 86165.86 per ton. As far as the gross export margin for this market was concerned, it was found Rs. 31130.15 per ton and percent export margin was 36.2 % whereas net export margin was Rs. 25688.72 per ton which accounts for 29.8 percent of sale price (Table 68.1).

Table 68.1 Export margin analysis of basmati rice (Super Basmati)

Activity	Average charges (Rs. / Ton)
Purchase Price of Super Basmati	55035.71
Processing Charges	1040
Packaging Charges	2464.46
Transportation Charges	1212.19
Custom Clearance Charges	75.88
Clearing Agent Charges	556.59
Other Marketing Charges	92.29
Total marketing cost	5441.42
Sale Price of Super Basmati	86165.86
Gross Export Margin	31130.15
Percent Export Margin	36.12
Net Export Margin	25688.72

Pakistani exporters also export the non basmati rice (PK-386) to the United Kingdom. Average purchase prices for United Kingdom market for non basmati rice (PK-386) were Rs. 35222 per ton. Average marketing cost for United Kingdom market was Rs. 5486 per ton. According to findings of this study average sale prices were calculated as Rs 58889.84 per ton. As far as the gross export margin for this market was concerned, it was found Rs. 23668.07 per ton and percent export margin was 40.2 % whereas net export margin was Rs. 18182 per ton which accounts for 31percent of sale prices (Table 68.2).

Table 68.2 Export margin analysis of non basmati (PK-386)

Activity	Average charges (Rs. / Ton)
Purchase Price of Non Basmati	35221.77
Processing Charges	1032.258
Packaging Charges	2487.61
Transportation Charges	1203.47
Custom clearance charges	79.9548
Clearing agent charges	586.40
Other marketing charges	96.35
Total marketing cost	5486.043
Sale price of non basmati	58889.84
Gross Export Margin	23668.07
Percent Export Margin	40.19041
Net Export Margin	18182.03

The relationship between dependent variable that is quantity of super basmati and independent variables (Education of Exporter, Age of Rice Exporter, Purchase Price of super basmati, export price of super basmati, Marketing costs, and Freight charges for United Kingdom) was estimated by employing the double log form of regression model, because scattered plot between variables suggest4ed such a relationship. A commonly used measure of the goodness of fit of a regression model is R^2 called coefficient of determination. If all the observations fall on the regression line R^2 is 1. If no linear relationship between $Y\&X$ R^2 is 0 [4]. The co-efficient of determination gives us information about proportion of variation in dependent variable, explained by the independent variables [2]. Collinearity (or multicollinearity) is the undesirable situation where the correlations among the independent variables are strong. Tolerance is a statistic used to determine how much the independent variables are linearly related to one another (multicollinear). VIF or the Variance Inflation Factor is the reciprocal of the tolerance. As the VIF increases, so does the variance of the regression coefficient, making it an unstable estimate. Large VIF values are indicator of multicollinearity. If the value of VIF is greater than 10 then there exists problem of multicollinearity. In our analysis, all values of VIF were less than 10 which showed no multicollinearity existed in the data set (Table 68.3).

The value of R^2 in our analysis was 0.77 which stated that all independent variables jointly explained 77 percent change in dependent variable i.e. export of super basmati to united kingdom. This value also explained that rest of 23% change in dependent variable was caused by some other variables, effect of which could not be explained by given model. Adjusted R^2 means adjusted for degree of freedom. It

Table 68.3 Collinearity statistics of variables

Variables	Tolerance	Variance Inflation factor (VIF)
Age of exporters (Years)	.275	3.642
Education (Years of Schooling)	.310	3.223
Purchase price of super basmati (Rs./ton)	.751	1.331
Sale price of Super Basmati (Rs./ton)	.168	5.961
Total Marketing cost (Rs./ton)	.931	1.075
Freight charges for Dubai (Rs./ton)	.861	1.162

is used for cross sectional data. The value of adjusted R^2 in our analysis was 0.72 which is significant. The value of adjusted R^2 means that all independent variables explained 72% variation in the dependent variable, keeping all other factors constant. F-ratio implies that all independent variables are significant or non-significant factors for causing variation in the dependent variable. The F-value in our analysis 16.14 ($p < 0.05$) which was highly significant explained the overall appropriateness of model.

The coefficient of education 1.47 ($p < 0.10$) showed positive sign and was significant. The coefficient of variable explained that for every one percent increase in education (Years of Schooling) there might be an increase of 1.47 percent in export quantity of super basmati to United Kingdom market, keeping all other factors constant. The coefficient of age of exporter is 0.130 ($p > 0.05$) that is insignificant. The coefficient of variable explained that for every one percent increase in age there might be an increase of 0.130 percent in export quantity of super basmati to the United Kingdom Market, keeping all other factors constant. The coefficient of purchase price -0.419 ($p > 0.05$) showed negative sign and was significant. The coefficient of variable explained that for every one percent increase in purchase price there might be a decrease of -0.419 percent in export quantity of super basmati to United Kingdom, keeping all other factors constant. The coefficient of sale price of super basmati is 0.287 having a positive sign that is significant at 10% level of confidence. The coefficient of total marketing cost -0.343 ($p < 0.05$) showed negative sign and was significant. The coefficient of variable explained that for every one percent increase in marketing cost there might be a decrease of 0.343 percent in export quantity of super basmati to United Kingdom Market, keeping all other factors constant. The coefficient of freight charges to United Kingdom is 0-.055 that for every one percent increase in freight charges there is 0.055 percent decrease in export quantity of super basmati to United Kingdom, keeping all other factors constant (Table 68.4).

Export model for Non Basmati (PK-386)

In our analysis, again all values of VIF are less than 10 which showed no multicollinearity existed in the data set (Table 68.5).

The value of R^2 was 0.74 which stated that all independent variables explained 74 percent change in dependent variable i.e. export of non basmati to United Kingdom. This value also explained that rest of 26 % change in dependent variable was caused

Table 68.4 Export model of super basmati for United Kingdom

Variables	Coefficient	Standard Error	T-Value	Significance (P-value)
(Constant)	14.567	4.832	3.015	.005***
Education of exporters (schooling years)	1.478	.807	1.831	.078**
Age of exporters (Years)	.130	.205	.635	$.530^{NS}$
Purchase price of super basmati (Rs./Ton)	−.419	.358	−1.169	$.252^{NS}$
Sale price of super basmati (Rs./Ton)	.287	.148	1.933	.063**
Total marketing cost (Rs./Ton)	−.343	.150	−2.293	.030*
Freight charges (Rs./Ton)	−.055	.076	−.728	$.472^{NS}$
R^2	.77			
Adjusted R^2	.72			
F- Value	16.140			

Table 68.5 Collinearity statistics of variables

Variables	Tolerance	Variance Inflation factor (VIF)
Age of exporters (Years)	.345	2.901
Education of rice exporters (years of Schooling)	.404	2.473
Purchase price of non basmati (Rs./Ton)	.590	1.694
Sale price of non basmati (Rs./Ton)	.719	1.390
Total Marketing cost (Rs./Ton)	.326	3.070
Freight charges for Dubai (Rs./Ton)	.290	3.445

by some other variables, effect of which could not be explained by given model. The value of adjusted R^2 in our analysis was 0.68 explaining that all independent variables explained 68% variation in the dependent variable, keeping all other factors constant. The F-value in our analysis 11.87 $(p < 0.05)$ which was highly significant explained the overall appropriateness of model.

The coefficient of education 0.87 $(p < 0.05)$ showed positive sign and was significant. The coefficient of variable explained that for every one percent increase in education (Years of Schooling) there might be an increase of 0.87 percent in export quantity of non basmati to United Kingdom market, keeping all other factors constant. The coefficient of age of exporter is 0.178 $(p > 0.05)$ that is insignificant. The coefficient of variable explained that for every one percent increase in age there might be an increase of 0.178 percent in export quantity of non basmati (PK-386) to the United Kingdom, keeping all other factors constant. Domestic purchase prices affect the amount of export of that commodity. The coefficient of purchase price of non basmati is $-0.08(p > 0.05)$ showed negative sign and was insignificant. The coefficient of variable explained that for every one percent increase in purchase price there might be a decrease of -0.08 percent in export quantity of non basmati to United Kingdom, keeping all other factors constant (Table 68.6).

The coefficient of export price of super basmati is 0.192 $(p > 0.05)$ showed positive sign that is insignificant. The coefficient of total marketing cost -0.136 $(p < 0.10)$ showed negative sign and was significant. The coefficient of variable ex-

Table 68.6 Summary statistics of data used for export model of non basmati

Variables	Coefficient	Standard Error	T-Value	Significance (P-value)
(Constant)	18.056	4.970	3.633	.001***
Education of exporters (schooling years)	.878	.393	2.234	.035*
Age of exporters (Years)	−.178	.127	−1.400	$.174^{NS}$
Purchase price of non basmati (PK-386) (Rs./Ton)	−.081	.384	−.212	$.834^{NS}$
Sale price of non basmati (Rs./Ton)	.192	.115	1.677	$.107^{NS}$
Total marketing cost (Rs./Ton)	−.136	.078	−1.741	.094**
Freight charges (Rs./Ton)	−.298	.093	−3.215	.004***
R^2	.74			
Adjusted R^2	.68			
F- Value	11.87			

plained that for every one percent increase in marketing cost there might be a decrease of 0.136 percent in export quantity of non basmati to United Kingdom Market, keeping all other factors constant.

68.4 Suggestions

The study was conducted to examine rice export process and its determinants from Pakistan. So keeping in view findings of study, following suggestions are proposed for improving export of rice from Pakistan.

1. The study was conducted to examine rice export process and its determinants from Pakistan. So keeping in view findings of study, following suggestions are proposed for improving export of rice from Pakistan.
2. In United Kingdom the export price of rice is higher as compared to other markets but at the same time competition is stiff. Pakistani exporters should compete and export rice to the United Kingdom. But it is somewhat tough job to export to the United Kingdom because high quality standards are required for exporting to this market as compared to other markets. There is need that government and rice exporters both should try to comply with requirements of this high value market.
3. Export margin analysis revealed that net margin was high in export of super basmati rice. So there is need to increase production of super basmati at the same time managing and improving its export process.
4. Empirical findings showed that export of rice decreased with increase in domestic price.

So there is need to control the domestic prices for increasing export because competition is high and in other competitive countries the domestic prices are low. At the same time cost of production has increased in Pakistan overtime due to inflation and the growers of rice are not getting their due margin. If this situation exists the farmers will leave growing rice, and if the prices increase, the export will be affected badly. So in this critical situation there is need of involvement of government to protect both sides. So the government should give attention to this matter and take suitable action by making long term policies.

References

1. Abbott JC, Makeham JP (1990) Agricultural economics and marketing in the tropics. Intermediate Tropical Agricultural Series, 2nd edn, Longman Group Ltd.
2. Abolagba EO, Onyekwere NC, Agbonkpolor BN et al (2010) Determinants of agricultural exports. Journal of Human Ecology 3:181–184
3. Cooper DR, Schindler PS, Sun J (2009) Business research methods. Statistics and Probability Series. McGraw-Hill/Irwin, New York
4. Chaudhry SM, Kamal S (1996) Introduction to statistical theory part II. Al-Hajaz Printing Press, Lahore
5. Government of Pakistan (2010) Economic survey of Pakistan (2009-2010). Economic Advisor's Wing, Finance Division, Islamabad Pakistan
6. Government of Punjab (2006) Rice marketing. Marketing and Economics Department Lahore, Report Produced Under the Project of Agriculture Marketing Information Service Publication No. 03/2006
7. Muslim Commercial Bank (2008) Economic report. Slippery Exchange, Simmering Inflation, No. 59
8. Malhotra NK (2008) Marketing research: An applied orientation, 5th edn. Prentice Hall, India
9. Nosheen M, Iqbal J (2008) Acreage response of major crops in Pakistan (1970-1971 to 2006-2007). ARPN Journal of Agricultural and Biological Science 3:5–6

Chapter 69
Analysis of Production Capacity and Sampling of Primary and Contingent Products

Tingting Qu, Yujie Zhong and Zhineng Hu

Abstract This paper establishes a model group of diffusion process of primary and contingent products, and explores the impact of free samples on diffusion process considering repeat purchase, multiple-unit purchase and various pricing strategies under supply restrictions. The paper shows that a proper production capacity to meet the market can be determined by balancing the production capacity and cost. When the production capacity is big enough, there is no need to set up the preparatory period to produce products. When the production capacity is too small to meet the demand, there is no need to sampling; only when the production capacity reaches a certain extent, the sampling level keeps in a stable level.

Keywords Primary product · Contingent product · Product sampling · Production capacity · Price strategy

69.1 Introduction

The literature of the new product diffusion mainly focus on the marketing analysis of a new product. Actually, the diffusion of the new product is linked with other products. Peterson and Mahajan developed four types of multi-product growth models for independent products, complementary products, contingent products and substitute products [2]. Considering that contingent product must be used with its corresponding primary product, contingent product diffusion model implies that buyers who have purchased a given product may become the potential purchasers of its related product, and the success of a product is directly contingent upon the success of its related product [2].

Jain et al established a Bass model in the presence of supply restrictions, capturing the dynamics of supply restrictions and to allow management to evaluate the

---

T. Qu · Y. Zhong · Z. Hu (✉)
Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, P. R. China
e-mail: huzn@scu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_69,

impact of such supply restrictions, and the usefulness of the proposed model is illustrated by an application examining the diffusion of new telephones in Israel [3]. Kurawarwala and Matsuo provided [5] an integrated framework for forecasting and inventory management of short life-cycle products, and validate the model by using disguised demand data from a PC manufacture, but they do not consider the supply restrictions. Kumar and Swaminathan [6] presented a modified Bass model to find production and sales plans that maximize profit during the lifetime of the product in a firm with a fixed production capacity, and prove that the optimal sales plan is indeed of the "build-up" type. Ho et al [7] generalized the Bass model by allowing for a supply constraint, and show that delaying a product launch to build up an initial inventory may be optimal and can be used as a substitute for capacity.

Jain et al [4] showed an approach for determining optimal product sampling for a new product. In the practical marketing, there are several common cases for product sampling: (1) Sampling for experience. For example, a firm usually gives a small bottle/bag of perfume to a customer for experience. (2) Sampling for multiple-unit purchase. For example, the firm would also like to give a free one if multi-units purchased at a time, such as the sale of toothpaste. (3) Sampling for bundling sale. For example, the firm would like to sell a bag of toothpaste and toothbrush, which price is slightly lower than the price of independent sale of toothpaste and toothbrush. For these cases, this paper only considers the first two cases.

Based on the review above, this paper focuses on the analysis of primary and contingent products incorporating production, inventory, and marketing strategies in the presence of supply restrictions. The paper is organized as follows: Sect. 69.2 states the problem and assumptions, then formulates a theoretical model group in the presence of supply restrictions; Sect. 69.3 conducts a numerical simulation computation for the model group, and analyzes the impact of supply restrictions for primary and contingent products under various market variables; Sect. 69.4 draws the main conclusions, the managerial implications of findings, limitations, and directions for future work.

69.2 Modeling

This section develops the diffusion equations of primary and contingent products, and presents a model group to determine the production capacity and the sampling level of the product under various marketing strategies in the presence of supply restrictions.

69.2.1 Problem Statement

In the diffusion process, the consumers are divided into four types: adopters, waiters, losers and demanders. The capacity of the firms is always limited, and there may be shortage and backlog in the product diffusion process. Therefore, the firm may need to delay a product launch to build up an inventory. This type of action can be stated in more detail with the help of a few critical time points:

1. t_p is the number of preparatory periods before the new product launches the market.
2. t_l is the period that the firm launches the product to the market.
3. t^* is the period of emerging the current production and inventory can meet the demand.

The diffusion process involves hypotheses below:

1. The diffusion of contingent products is affected by the diffusion of primary product, but not vice versa.
2. The geographic boundaries of the social system do not change over the diffusion process.
3. Nature of a product doesn't change over time.
4. The diffusion process is ternary: unknown, the potential adopters of a product either adopt or do not adopt the product.
5. Consumers get only one sample once time.
6. The production costs of primary and contingent products change with the production, and not considering the delivery time.
7. The firm produces the primary and contingent products at the same time.

The notations of the problem are shown below, in which product i $(i = 1,2)$ is indicated as primary product and contingent product respectively:

t : period (1 to T);
a_i : coefficient of external influence of ith product;
$\overline{N}_i$: number of ith product's potential adopters;
b_i : coefficient of internal influence of ith product;
$N_i(t)$: cumulative number of adopters of ith product through diffusion by time t;
$n_i(t)$: number of adopters of ith product through diffusion by time t;
$D_i(t)$: cumulative number of purchasers of ith product through diffusion by time t;
$d_i(t)$: number of purchasers of ith product through diffusion by time t;
$N_{fi}(t)$: cumulative number of adopters of ith product through sampling by time t;
$n_{fi}(t)$: number of adopters of ith product through sampling by time t;
$W_i(t)$: number of waiters of ith product through diffusion by time t;
$w_i(t)$: variation number of waiters of ith product through diffusion by time t;
$L_i(t)$: cumulative number of losers of ith product through sampling by time t;
$l_i(t)$: number of losers of ith product through sampling by time t;
$S_i(t)$: cumulative sales volume of ith product in period t;
$s_i(t)$: sales volume of ith product in period t;
$R_{pi}(t)$: number of potential repeat purchasers of ith product in period t;
$I_i(t)$: inventory volume of ith product in period t;
t_i^* : production point on demand of ith product;
r_i^* : production volume of ith product before reach production point on demand;
r_{pi} : the repeat purchase rate of ith product;
i_r, l_i : the discount rate and the loss rate of ith product;

$R_i(t)$, $r_i(t)$	: cumulative and noncumulative production volume of *i*th product in period t;
ω_i	: number of multiple-unit adoptions of *i*th product;
$p_i(t)$, $c_i(t)$	: price and production cost of *i*th product in period t;
c_{wi}, c_{hi}, c_{fi}	: wait, hold and sampling cost of per unit of *i*th product;
τ_i	: the service life of *i*th product;
$\gamma_{ni}(t)$	: the ratio of new adopters in the market who get; the free sample but never adopted *i*th product before;
$\gamma_b(t)$	: the ratio of product *i*th potential adopters in the total market.

69.2.2 Model Development

Peterson and Mahajan [2] presented a basic diffusion model of primary and contingent products, which can be extended below when considering the entry time of contingent product:

$$\begin{cases} n_1(t+1) = \begin{cases} a_1[\overline{N}_1 - N_1(t)], & t < t_{11} \\ [a_1 + b_1 N_1(t)][\overline{N}_1 - N_1(t)], & t \geq t_{11} \end{cases} \\ n_2(t+1) = \begin{cases} [a_2 + \sigma N_1(t+1)][N_1(t+1) - N_2(t)], & t < t_{l2} \\ [a_2 + b_2 N_2(t) + \sigma N_1(t+1)][N_1(t+1) - N_2(t)], & t \geq t_{l2}, \end{cases} \end{cases} \tag{69.1}$$

where $n_i(t+1) = N_i(t+1) - N_i(t)$; t_{l1} is the launch period of *i*th product, $N_i 0 = 0 (i = 1,2)$. σ is the coefficient of positive influence of primary product on contingent product. Only the users of primary product can become the potential consumers of contingent product; therefore, $\overline{N}_2$ is replaced by $N_1(t)$.

Jain et al [4] pointed out that word-of-mouth plays a major role in influencing the product adoption, and hence trial among innovators, early adopters, and other key influencing agents is critical to the success of the product. The goal of product sampling for the firm is not only to initialize the diffusion process, but also to improve brand loyalty. When considering the impact of samples, diffusion Equation (69.1) is replaced by:

$$\begin{cases} n_1(t+1) = \begin{cases} [a_1 + b_1 N_{f1}(t)][\overline{N}_1 - (N_1(t) + N_{f1}(t))], & t < t_{11} \\ [a_1 + b_1 (N_1(t) + N_{f1}(t))][\overline{N}_1 - (N_1(t) + N_{f1}(t))], & t \geq t_{11} \end{cases} \\ n_2(t+1) = \begin{cases} [a_2 + b_2 N_{f2}(t) + \sigma(N_1(t+1) + N_{f1}(t+1))] \\ [(N_1(t+1) + N_{f1}(t+1)) - (N_2(t) + N_{f2}(t))], & t < t_{l2} \\ [a_2 + b_2(N_2(t) + N_{f2}(t)) + \sigma(N_1(t+1) + N_{f1}(t+1))] \\ [(N_1(t+1) + N_{f1}(t+1)) - (N_2(t) + N_{f2}(t))], & t \geq t_{l2}, \end{cases} \end{cases} \tag{69.2}$$

where $\gamma_{bi}\gamma_{ni}(t+1)n_{fi}(t+1) = N_{fi}(t+1) - N_{fi}(t)$, $\gamma_{ni}(t+1) = 1 - (N_i(t) + N_{fi}(t))/\overline{N}_i$, $\gamma_{ni}(0) = 1$, $N_{fi}(0) = \gamma_{bi} n_{fi}(0)$. Especially, $\gamma_{ni}(t) = 1$ means all of the people got the free samples are those who have not purchased *i*th product ($i = 1,2$) yet.

Hence, over diffusion process, the adopters of new product can be divided into two parts: the purchasers and the people who get the free sample; obviously,

$$\begin{cases} N_1(T)+N_{f1}(T)\le \overline{N}_1 \\ N_2(T)+N_{f2}(T)\le N_1(T)+N_{f1}(T). \end{cases} \tag{69.3}$$

Generally, the impact of price introduction under Bass model framework has resulted in two types of normative pricing strategies:

1. skimming pricing strategy, which uses a higher price initially to "skim" the market when the market is still developing;
2. penetration pricing strategy, in contrast, which uses a lower price initially to capture a larger market share.

Parker [9] proposed diffusion models, for which either the coefficient of external influence alone is influenced by price or the coefficient of internal influence alone is influenced by the same. Jain and Rao [11] showed that price affects the diffusion rate (via the coefficients of external and internal influence). While Horsky gave support to the assertion that price affects the market potential [12].

Following the ideas given by Maier [13] and Mesak [8], the price response function $g(p(t))$, through a change becomes $g_i(p_i(t))=\left(\frac{p_i(t)}{p_i(0)}\right)^{-\eta_i}$, where $g_i>0$, $g_i'<0$, $g_i''-\frac{2g_i'^2}{g_i}<0$, $i=1,2$. $g_i(p_i(t))$ represents the relative price of ith product, $p_i(0)$ is the benchmark price.

Studies derived from skimming pricing strategy assume that price affects the market potential, then Equation (69.2) is changed as follows:

$$\begin{cases} n_1(t+1)= \\ \begin{cases} [a_1+b_1N_{f1}(t)][\overline{N}_1-(N_1(t)+N_{f1}(t))], & t<t_{11} \\ [a_1+b_1(N_1(t)+N_{f1}(t))][\overline{N}_1 g_1(p_1(t))-(N_1(t)+N_{f1}(t))], & t\ge t_{11} \end{cases} \\ n_2(t+1)= \\ \begin{cases} [a_2+b_2N_{f2}(t)+\sigma(N_1(t+1)+N_{f1}(t+1))] \\ [(N_1(t+1)+N_{f1}(t+1))-(N_2(t)+N_{f2}(t))], & t<t_{l2} \\ [a_2+b_2(N_2(t)+N_{f2}(t))+\sigma(N_1(t+1)+N_{f1}(t+1))] \\ [(N_1(t+1)+N_{f1}(t+1))g_2(p_2(t))-(N_2(t)+N_{f2}(t))], & t\ge t_{l2}. \end{cases} \end{cases} \tag{69.4}$$

The penetration pricing strategy produces a multiplicative effect on the rate of diffusion; then Equation (69.2) is changed as follow:

$$\begin{cases} n_1(t+1)= \\ \begin{cases} [a_1+b_1N_{f1}(t)][\overline{N}_1-(N_1(t)+N_{f1}(t))], & t<t_{11} \\ [a_1+b_1(N_1(t)+N_{f1}(t))][\overline{N}_1-(N_1(t)+N_{f1}(t))]g_1(p_1(t)), & t\ge t_{11} \end{cases} \\ n_2(t+1)= \\ \begin{cases} [a_2+b_2N_{f2}(t)+\sigma(N_1(t+1)+N_{f1}(t+1))] \\ [(N_1(t+1)+N_{f1}(t+1))-(N_2(t)+N_{f2}(t))], & t<t_{l2} \\ [a_2+b_2(N_2(t)+N_{f2}(t))+\sigma(N_1(t+1)+N_{f1}(t+1))] \\ [(N_1(t+1)+N_{f1}(t+1))-(N_2(t)+N_{f2}(t))]g_2(p_2(t)), & t\ge t_{l2}. \end{cases} \end{cases} \tag{69.5}$$

Under supply restriction, three groups of the potential consumers include adopters who have purchased the product, waiters who are willing to wait to purchase the product, and the losers who are not willing to wait. Therefore,

$$N_i(t) + N_{fi}(t) = D_i(t) + L_i(t) + W_i(t). \tag{69.6}$$

The consumers of purchasing ith product in period $t+1$ is

$$d_i(t+1) = D_i(t+1) - D_i(t). \tag{69.7}$$

The variation of waiting consumers of ith product in period $t+1$ is

$$w_i(t+1) = \gamma_{bi}\gamma_{ni}(t+1)n_{fi}(t+1) + n_i(t+1) - d_i(t+1) - l_i(t+1). \tag{69.8}$$

The losers of waiting consumers of ith product in period $t+1$ is

$$l_i(t+1) = L_i(t+1) - L_i(t) = l_i W_i(t). \tag{69.9}$$

In equations above, $N_i(0) = D_i(0) = L_i(0) = 0$, $W_i(0) = n_{fi}(0)$, and t_{li} is the period of ith product being launched the market; when $t < t_{li}$, $d_i(t) = 0$.

Nondurable products, which have a service life τ_i, usually are repurchased by consumers on demand. Buying M units and getting one free is quite useful and necessary to encourage consumers to make multiple-unit adoption decision for firms, therefore, the service life of product i is indicated as $\tau_{mi}(=\omega_i\tau_i)$, where $\omega_i \in [1, +\infty)$, the adoption units by one consumer at a time, is introduced to represent the average value of quantities according to the statistical significance [14]: when $\omega_i \geq 2$, the multiple-unit ownership includes the free sample; however, when $\omega_i = 1$, it only represents the individual adoption. So the potential repeat purchaser is

$$R_{pi}(t) = \begin{cases} D_i(t-\tau_{mi}) - r_{pi}\sum\limits_{j=1}^{\tau_{mi}-1} R_{pi}(t-j), & \tau_{mi} > 1, t > \tau_{mi} \\ D_i(t-\tau_{mi}), & \tau_{mi} = 1, t > \tau_{mi} \\ 0, & t \leq \tau_m. \end{cases} \tag{69.10}$$

The repeat purchasers include three groups, and the variation volume of waiters of repeat purchasers of product i in period t is

$$w_{ri}(t+1) = W_{ri}(t+1) - W_{ri}(t) = r_{pi}R_{pi}(t+1) - d_{ri}(t+1) - l_{ri}(t+1). \tag{69.11}$$

The losers volume of repeat purchasers of product i in period t is

$$l_{ri}(t+1) = l_i W_{ri}(t), \tag{69.12}$$

where $W_{ri}(t) = d_{ri}(t) = l_{ri}(t) = w_{ri}(t) = 0$ (when $t \leq \tau_{mi}$).

Because of supply restriction, the firm's production capacity is limited by the largest production capacity; then the volume of production, sales and inventory are changed when considering the shortage cost, waiting cost and inventory cost.

Considering the repeat purchase, the adopters of product i in period t is:

$$s_i(t) = d(t) + d_{ri}(t). \tag{69.13}$$

In individual purchase case, $s_i(t)$ is the sales volume of product i in period t. In multiple-unit purchase case, the sales volume of product i is $(\omega_i - 1)s_i(t)$.

The inventory volume of product i in period t is:

$$I_i(t+1) = I_i(t) + r_i(t+1) - \omega_i s_i(t+1) - \gamma_{fi}(t)n_{fi}(t+1), \qquad t \geq t_{pi}, \tag{69.14}$$

where $I(t_{pi}) = r(t_{pi}) - \gamma_{fi}(t)n_{fi}(t_{pi})$ $(t_{pi} \geq 0)$, $I_i(t_{pi}) = r_i(t_{pi})$ $(t_{pi} < 0)$, t_{pi} is the preparatory period of product i; $\gamma_{fi}(t)\,(= \frac{c_{fi}}{c_i(t)/r_i(t)})$ is the sampling proportion of product i.

The production volume of product i in period t is:

$$r_i(t) = \begin{cases} r_i^*, & t_{pi} \leq t < t_i^* \\ \max(\omega_i s_i(t) + \gamma_{fi}(t)n_{fi}(t) - I_i(t-1), 0), & t \geq t_i^*, \end{cases} \tag{69.15}$$

where $\omega_i s_i(t) + \gamma_{fi}(t)n_{fi}(t) \leq r_i^*$ $(t \geq t_i^*)$.

The production cost of product i in period t is:

$$c_i(t) = \alpha_i(r_i(t))^{\beta_i}, \quad \alpha_i > 0,\ \beta_i \geq 1. \tag{69.16}$$

69.2.3 Objective Function

In the presence of supply restrictions, the firm should balance the benefits and the losses for getting the maximum profits, and the sampling levels. So in individual adoption case, net present value (NPV) is:

$$\begin{aligned}\pi_i = {} & \sum_{t=0}^{T} \frac{1}{(1+i_r)^t}[p_i(t)s_i(t) - c_{wi}W_i(t) - c_{wri}W_{ri}(t) - (h_i + c_{fi})n_{fi}(t)] \\ & - \sum_{t=t_{pi}}^{T} \frac{1}{(1+i_r)^t}[c_{hi}I_i(t) + c_i(r_i(t))],\end{aligned} \tag{69.17}$$

where c_i is the cost of ith product; h_i is the unit cost of handling the sampling of ith product (which includes labor and the material cost of wrapping, portaging and transportation except the production cost); but it does not include the production cost c_{fi} $(\leq c)$.

Similarly, the net present value (NPV) in multiple-unit adoption case is:

$$\begin{aligned}\pi_i = {} & \sum_{t=0}^{T} \frac{1}{(1+i_r)^t}[p_i(t)(\omega_i - 1)s_i(t) - c_{wi}W_i(t) - c_{wri}W_{ri}(t) \\ & -(h_i + c_{fi})n_{fi}(t)] - \sum_{t=t_{pi}}^{T} \frac{1}{(1+i_r)^t}[c_{hi}I_i(t) + c_i(r_i(t))].\end{aligned} \tag{69.18}$$

69.2.4 Model Group

Taking all above factors into consideration, a model group given below can be established to provide an analytical framework for incorporating explicitly the effects of marketing mix variables on the new product diffusion.

$$\begin{cases} \max \quad \pi = \pi_1 + \pi_2 \\ \text{s.t. Equation } (69.2) \sim (69.18), \end{cases} \tag{69.19}$$

where r_i^*, t_{pi}, t_{li}, t_i^*, $n_{fi}(t)$, $d_i(t)$, $d_{ri}(t)$ are the decision variables.

69.3 Numerical Analysis and Results

The model group (69.19) is a nonlinear optimization problem. The production capacity of the firms is generally limited, so keeping no inventory or production on demand throughout the life cycle of the product is impossible. This section analyzes the diffusion of primary and contingent products in the presence of supply restrictions, incorporating the production, inventory, sales and marketing strategies.

69.3.1 Parameter Settings

For durable-type innovation, Jain et al [4] showed that the coefficient of external influence is 0.02, the coefficient of internal influence is 0.35, and the market potential is 54 million, which actually depict the diffusion process of first purchase behavior of consumables in model (69.19). Other parameter values are conveniently selected for illustration purposes, which vary over a reasonable range in our analysis. Therefore, the priority is to give some parameters as follows:

1. The coefficient of external influence: $a_1 = 0.03$, $a_2 = 0.02$; maximal potential of primary product: $\overline{N}_1 = 54$ million; the coefficient of internal influence: $b_i = 0.35$.
2. The unit cost of the sample of each product is $h_1 = 1$ and $h_2 = 0.6$; while the unit production cost of the sample of each product is $c_{f1} = 1$ and $c_{f2} = 0.5$.
3. Discount rate $i_r = 0.1$, and the elastic coefficient of price response function $\eta_1 = \eta_2 = 3.8385$. The basic prices of new products are assumed as $p_1 = 10$, and $p_2 = 4$. Then in the case of skimming pricing strategy, the price decreases with time; while in the case of penetration pricing strategy, the price increases with time.
4. The contingent product is lagged two periods behind primary product in the market. The repeat purchase rate $r_{p1} = 0.1$ and $r_{p2} = 0.12$; the delayed time of repeat purchase $\tau_1 = 3$ and $\tau_2 = 2$. The positive effect, of which primary product makes on contingent product, is $\sigma = 0.0005$.

5. The relative parameters of production cost are $\alpha_1 = 2.5$, $\alpha_2 = 2$, $\beta_1 = 0.99$, and $\beta_2 = 0.99$.

69.3.2 Impact of Supply Restrictions

Ho et al [7] pointed that delaying a product launch to build up an initial inventory may be optimal and can be used as a substitute for capacity.

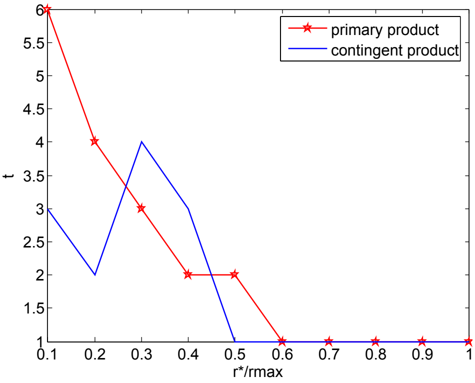


Fig. 69.1 The preparatory period of two products in the presence of supply restrictions

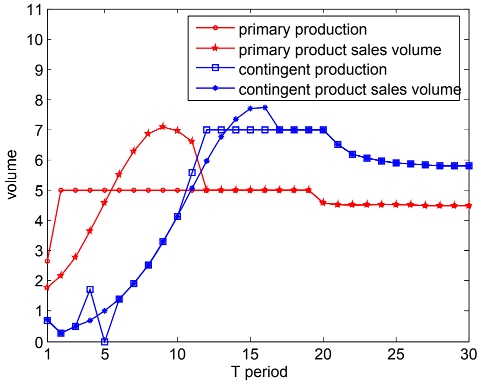
The preparatory period of production can reduce the loss, which is generated due to the shortage. Without considering the marketing strategies, a simple trend based on the NPV can be shown in Fig. 69.1.

In generally, the preparatory period of primary and contingent products become short with the production capacity increasing (Fig. 69.1). When the production capacity of primary product is 1 or 2, the number of potential adopters of contingent product is small. There is no need to have a great initial inventory, so the preparatory period of contingent product is shorter. With the increase of primary production capacity, the potential adopters of contingent product expand greatly. At that time, the preparatory period of contingent product is needed to extend longer. When the production capacity of primary and contingent product reach 6 and 5 respectively, the demand of consumers can be satisfied enough, which results in being no preparatory period.

The production of the firm has an impact on the sales volume in the presence of supply restrictions. The firm should control the production capacity for obtaining the largest NPV and satisfying the demands. Fig. 69.2 shows the production capacity of primary and contingent products, and compares the production and sales volume between them under the presence of supply restrictions.

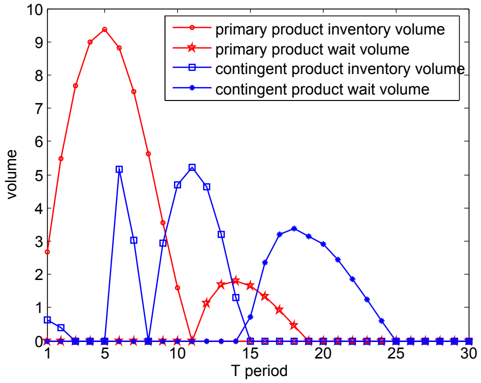
In the presence of supply restrictions, the firm predicts the production of primary product in period 1. After having a basic understanding of the market, the

Fig. 69.2 The production and sales of two products in the presence of supply restrictions



firm produces at a fixed capacity 5, then on demand (Fig. 69.2). From period 1 to 5, the production of primary product is larger than the sales volume, so the inventory gradually increases to the maximum. From period 6 to 11, the sales volume of primary product is larger than the production, so the inventory gradually decreases to 0. Between period 12 and 19, the waiters and losers emerging for the demand of primary product are larger than its production. The firm produces primary product on demand after the period 19.

Fig. 69.3 The inventory and waiting of two products in the presence of supply restrictions



For the adopters of primary product is the potential consumers of contingent product, the situation is complex about the production and sales volume of contingent product (Fig. 69.2). Due to the diffusion of primary product, the sales volume can be predicted approximately. Therefore, the production curve of contingent product is almost coincident with the sales curve before period 10. The production increases until to the period 11, then keeps constant at the capacity 0.7 from period 11 to 20. Between period 5 and period 15, the inventory of contingent product increases to the largest, then decreases to 0 (Fig. 69.3). From period 15 to period 25, the waiters and losers emerging for the demand of contingent product are larger than its production. The contingent product is produced on demand after period 25.

The sales volume of contingent product increases with that of primary product before period 10, but after period 11, the former is larger than the latter because the life cycle of the contingent product is shorter than primary product, and the repeat purchase rate is larger than that of primary product. Similarly, the trend of two products' production curves is similar to the trend of sales curves.

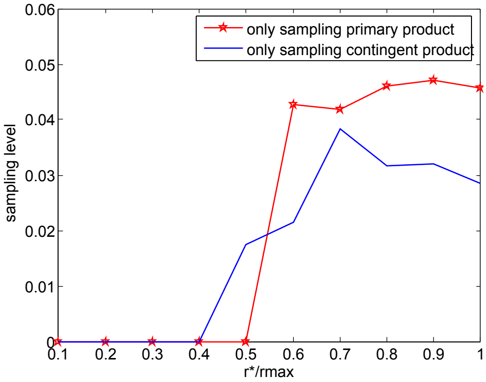


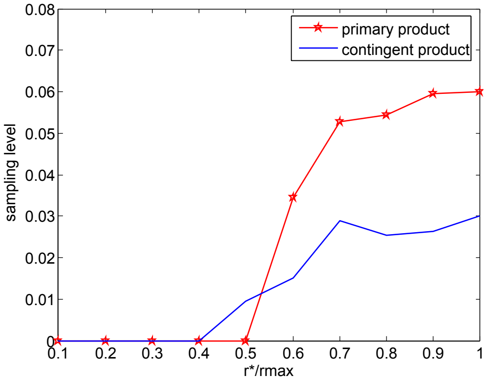
Fig. 69.4 Impact of production capacity on only sampling primary or contingent product

69.3.3 Impact of Supply Restrictions on Sampling

To simplify the statements, the time decision points and production capacities of primary and contingent products are the same. There are three sampling strategies: only sampling primary product, only sampling contingent product and sampling both products. Fig. 69.4 shows that the impact of the production capacities of two products on the sampling and compares the sampling level and the NPV of three sampling strategies in the presence of supply restrictions.

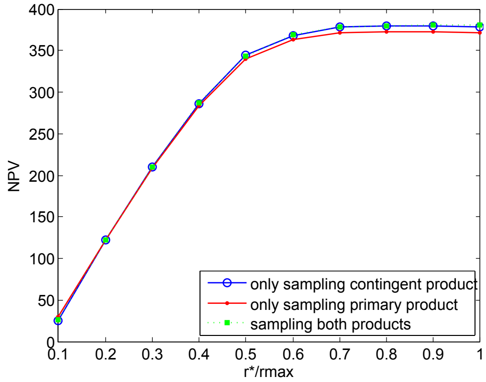
The sampling level of only sampling primary product is always 0 before its production capacity reaches 0.5 of maximum capacity, then it increases to a certain level with the production increasing (Fig. 69.4). The reason why the trend changes like this is the production can't meet the demand before the production capacity reaches 0.5, there is no need to sampling primary product. For only sampling contingent product, the sampling level is 0 before its production capacity reaches 0.4, then increases to the largest when capacity is 0.7, but followed by another decline (Fig. 69.4). When the production capacity is less than the demand, there is no need to sampling contingent product. When the production capacity is larger than 0.7, the production can satisfy the demand and the consumers won't increase with the sampling increasing.

Fig. 69.5 Impact of production capacity on sampling both products



With increasing the production capacities of two products, their sampling levels increase from zero to the relatively stable levels (Fig. 69.5). Similarly, when the production capacity is too small to satisfy the demand first, the sampling is unnecessary. With increasing the production capacity, the sampling levels of two products should increase to attract more consumers to adopt the products; but when the production capacities of two products reach a certain extent, the consumers won't increase too much, so there is no need to increase the sampling levels of two product. Comparing three sampling strategies, the sampling level of contingent product is less than that of primary product mainly because the value of primary product is larger than that of contingent product, and the attractiveness of sampling former is bigger than sampling latter.

Fig. 69.6 Impact of production capacity on the NPV of three sampling strategies



With increasing the production capacity, the NPV under three sampling strategies increase from zero to a stable extent (Fig. 69.6). When the production capacities increase to 5, the firm's ability of meeting the market increases rapidly, so the NPV also increases rapidly. When increasing the production capacity continually, the cost of inputs is almost the same with the profit bringing by the increase of the production capacity. Therefore, the change of NPV is small. Compared the NPV under three sampling strategies, sampling both products is better than the other two sampling strategies. And sampling contingent product is better than only sampling primary product.

69.3.4 Impact of Supply Restrictions on Sampling under Price Strategies

Although price strategies — including unchanged price strategy (U), penetration price strategy (P), and skimming price strategy (S) — have various price strategy combinations, Table 69.1 shows only the same prices for primary and contingent products. Sampling both products is the best sampling strategy, so here only consider the case of sampling both products.

Table 69.1 Impact of price strategies on sampling under supply restrictions

Pricing Strategies	Primary Product		Contingent Product		NPV
	SL	PC	SL	PC	
(U, U)	0.033	0.625	0.023	0.875	357.877
(P, P)	0.026	0.75	0.018	0.875	380.238
(S, S)	0.039	0.625	0.034	0.75	369.846

* SL: Sampling Level; PC: Production Capacity.

Comparing the sampling level of primary and contingent products, the sampling level and NPV of primary product is larger than contingent product, so the attractiveness of sampling primary product is bigger than sampling contingent product. Comparing the NPV of three price strategies, penetration price strategy is better than the other two price strategies, and the skimming price strategy is better than unchanged price strategy.

The sampling levels of two products under penetration price strategy is less than unchanged price strategy, but skimming price strategy is larger than unchanged price strategy (Table 69.1). Penetration price strategy can attract the consumers to buy the products, so the sampling level is no need to bigger than unchanged price strategy. Due to the high price of skimming price strategy, it can compensate the attractiveness of consumers by increasing the sampling level.

Let the unchanged price strategy be basic standard. Comparing the production capacities of primary product, the production capacity is bigger under penetration price strategy. In order to meet the demand generated by lower price, the firm should expand its production capacity. The production capacity of contingent product under skimming price strategy is less than under unchanged price strategy, for higher price may bring less sales. Naturally, decreasing the production capacity can not only meet the demand but also decrease the cost.

69.4 Concluding Remarks

In the numerous products diffusion literature, there are few researches about contingent products under supply restrictions. This paper established a model group of primary and contingent products with the limited production capacity of the firm, which combined the marketing strategies and consumers' purchase behavior characteristics. Some conclusions can be drawn below through the numerical simulation for the sampling and production capacity: (1) Preparatory period is not needed when the production capacity is large enough. (2) For primary product, the firm may trial production at the beginning if the production capacity is limited, then according to a fix capacity after grasped the market and finally production with the demand level. However, for contingent product, the diffusion trend is based on the primary product. (3) Under different production capacity, both sampling two products is optimal. (4) The best strategies is penetration price strategy.

The limited is not considering the impact of replenishing time of inventory and assuming that primary product and contingent product are produced by a company at the same time point, which will be considered and improved in the near future.

Acknowledgements This research is supported by National Natural Science Foundation of China (Grant No. 70971091).

References

1. Bass M (1969) A new product growth model for consumer durables. Management Science 15:215–227
2. Peterson A, Mahajan V (1978) Multi-product growth models. In: Shedth J (ed.) Research in Marketing. JAI Press, Greenwitch
3. Jain D, Mahajan V, Muller E (1991) Innovation diffusion in the presence of supply restrictions. Marketing Science 83–90
4. Jain D, Mahajan V, Muller E (1995) An approach for determining optimal product sampling for the diffusion of a new product. Journal of Production Innovation Management 12:124–135
5. Kurawarwala A, Matsuo H (1996) Forecasting and inventory management of short life-cycle products. Operations Research 1:131–150
6. Kumar S, Swaminathan J (2003) Diffusion of innovations under supply constraints. Operations Research 11:866-879
7. Ho H, Savin S, Terwiesch C (2002) Managing demand and sales dynamics in new peoduct diffusion under supply constraint. Managing Science 2:187–206
8. Mesak I (1996) Incorporating price, advertising and distribution in diffusion models of innovation: Some theoretical and empirical results. Computers Oprations Research 23:1007–1023
9. Parker P (1992) Price elasticity dynamics over the adoption life cycle. Journal of Marketing Research 24:358–367

10. Meade N, Islam T (2010) Using copulas to model repeat purchase behaviour-an exploratory analysis via a case study. Europran Journal of Poerational Research 200:1007–1023
11. Jain D, Rao R (1990) Effect of price on the demand for durables: Modeling, estimation and findings. Journal of Business and Economic Statistics 8:163–170
12. Horsky D (1990) A diffusion model incorporating product benefits, price, income, and information. Marketing Science 9:342–365
13. Maier F (1998) New product diffusion models in innovation management — A system dynamics perspective. System Dynamics Review 14:285–308
14. Steffens P (2003) A model of multiple-unit ownership as a diffusion process. Technological Forecasting and Social Change 70:901–917

Chapter 70

A Study on Early Warning Mechanism of Enterprise Credit Risk Management based on Bayesian Mode

Qingfeng Bu and Haitao Sun

Abstract The haze of economic crisis has not dropped off, and the enterprises still are faced with a big challenge due to the fierce market competition. In order not to miss any chance, enterprises usually operate by using credit pattern at each payment, which brings hidden dangers for the occurrence of bad and doubtful debts. To limit such risks, it is needed to establish an early warning system. From the perspectives of both organizational guarantee of risk management and forecasting techniques, the discussion on early earning mechanism has been made by the author using Bayesian Model in the hope of helping the enterprises to predict and reduce the risks of credit transactions through this mechanism.

Keywords Risk management · Forecasting · Early warning mechanism

70.1 Introduction

With the more fierce market competition, the enterprises have to conduct transactions by using credit pattern in order to increase their market shares. Although the growth in sales can bring paper profit, the precipitation of a large amount of receivables may change the cash inflow that supports the normal operation of companies and cause some bad and doubtful debts. Thus, the companies are affected in production, even faced with a huge hidden risk for their survival. The author observes that most of the enterprises have not set up a complete early warning mechanism against transaction risks. In the transaction process it is very hard to give a precise early warning to the risks and some necessary precautions, especially for the suppliers who are anxious to sell goods out, even neglect the risk existence. In the transaction of ordinary goods credit sale and deferred payment, the major risk for sellers is

---

Q. Bu (✉) · H. Sun
Shanghai Medical Instrumentation College, University of Shanghai for Science & Technology, Shanghai 200093, P. R. China
e-mail: LOOOOOGLE@163.COM

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_70,

failure in collecting payment in full and on time. Thus, it leads to higher financial cost and bad debts, shorter working capital, even serious labor disputes and survival crisis for sellers.

This type transaction without consideration of its result is mainly because the management of the enterprises is lack of risk awareness of transaction based on not being cheated if no cheating others. Nevertheless, the major reason is that the enterprises have not setup a complete early warning mechanism to limit and monitor the transaction, with which a number of risk factors from the other party such as financial status, repayment ability, management, credit status, and transaction purpose can be scientifically controlled and accessed. To some extent, the risk likelihood calculation gives certain early warning, and provides with decision basis to the top management. Nowadays, the China's economy is left in an excess-supply state, which brings bigger goods transaction risk constantly troubling the enterprises. The paper aims to present an efficient and effective early warning mechanism against in-kind transaction risk in order to avoid occurring risks from origin.

70.2 The Principal Theories for Early Warning Mechanism of Enterprise Credit Risk Management

70.2.1 Definition

Risk is the potential that a chosen action or activity (including the choice of inaction) will lead to a loss (an undesirable outcome). The notion implies that a choice having an influence on the outcome exists (or existed). Potential losses themselves may also be called "risks" [1]. The transaction risk mentioned in the paper means that failure in taking back all the receivables, or just taking back part of it, and nothing coming back result in a economic loss to company. Credit sale, namely sell on credit, means a sales transaction by which the buyer is allowed to take immediate possession of the purchased goods and pay for them at a later date [2]. Credit sale is transaction action without any guarantee and mortgage. Accounts receivable are profit for the companies that sell goods on credit, provide with labor service to their users. This economic income is predictable, caused by the corporate marketing policies, which inevitably lead to accounts receivable, meanwhile bring about more operation risks for companies [3].

70.2.2 The Principal Theories for Early Warning Mechanism of Risk Management

Based on risk predication techniques, an early warning mechanism of risk management is the organizational system of information management that is stipulated in the form of system, which consists of management and executives of early warning again risks. Furthermore, the execution is composed of technique group, survey group and credit assessment group. The organization system, and information feedback is shown in Fig. 70.1, where the solid arrow stands for organization structure, and the dotted arrow for information feedback.

Therefore, organizational system and technique one are the two wheels of risk warning, which are dependent on each other, and none of them can be dispensed with. Technique system is not a tool reliable without guarantee of organization system; on the contrary, lack of operation tool, organization system can be a show without technique support.

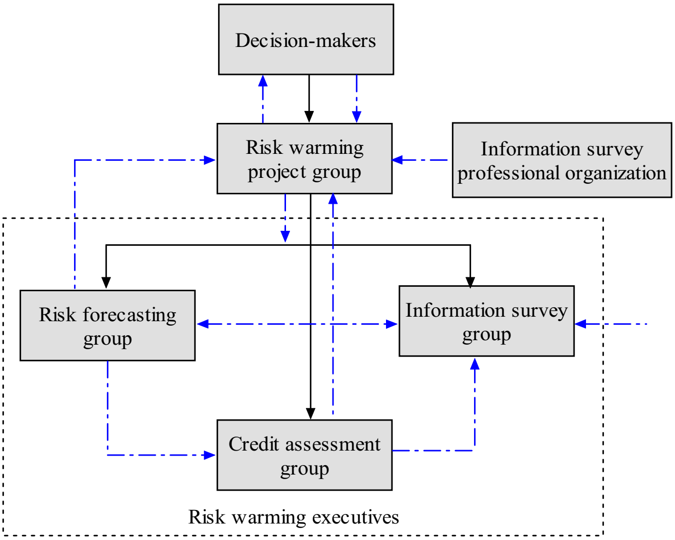


Fig. 70.1 Risk warning management system & information feedback

70.3 Designing Organizational System of Early Warning Mechanism of Enterprise Credit Risk

70.3.1 Designing Principal

The organization implementing goal-directed designing principle focuses on a specific objective, for example, a specific product and service. Therefore, organization system is designed from the angle of objectives [4]. The goal-directed organization needs all sorts of experts to work together. For instance, the risk warning-directed organization needs forecasting experts and survey professionals to work together. Generalists and professional are responsible for management of the goal-directed organization, which benefits for cultivating top management personnel, highlighting the objectives and achievements. Relatively, the handling procedure and method are less important. Therefore, the organization system seems to be less strict, but with strong adaptation and creation.

70.3.2 Designing Risk Warning Structure

Based on the designing principal of goal-directed organization, the author makes some adjustment to suit early warning mechanism of enterprise risk management. To prolong its time restriction to have long-term and procedure may benefit sustainability and efficiency of risk management. Organization structure can be seen in Fig. 70.2.

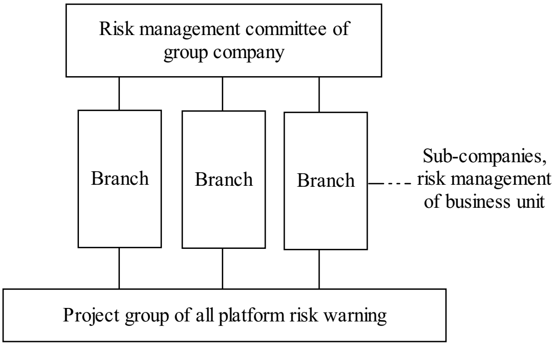


Fig. 70.2 Group company risk management structure

Here risk warning projects include risk warning technique group and making survey group, which can be detailed in Fig. 70.3, where Fig. 70.1 stands for project supervisor; 2 for technique group leader; 3 for the group leader of making survey; 4, 5 and 6 for technique operators; 7 and 8 for survey makers.

Forecasting and survey making should be in focus. To increase the reliability and accuracy of warning and to reduce the errors due to personal experience judgment, the number of operators in technique group should be no less than 3 people with commercial experience and specialty background. They operate independently to ensure the subject likelihood of risk factors and the rationality of weight determination.

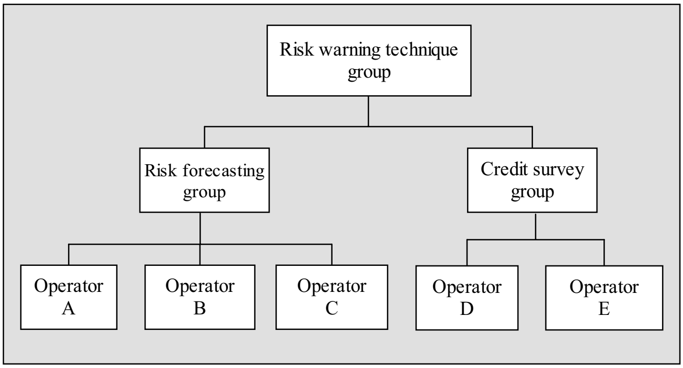


Fig. 70.3 Risk warning project group structure

70.4 Technique Modeling of Enterprise Credit Risk Forecasting

70.4.1 Modeling Theory — Bayesian Game Modeling

Defining Bayesian game strategically includes action set of the involved A_i and their type T_i, their belief P_i and their support function U_i. Where G is for game, so $G \doteq \{A_1,\cdots,A_n;\ T_1,\cdots,T_n;\ P_1,\cdots,P_n;\ U_1,\cdots,U_n\}$. To complete Bayesian game statement, the technique is needed here. Supposing the achieved probability distribution of the initial natural reason $p(t_1,\cdots,t_n)$ introduces types, once t_i is presented to the involved I, he (or she) can use Bayesian Law to calculate belief probability.

$$pi(t-i/ti) = \frac{pi(t-i,ti)}{p(ti)} = \frac{pi(t-i,ti)}{\sum pi(t-i,ti)},\ t-i \in T-i.$$

Naturally, if the type of the involved are isolated, so $p_i(t-i)$ is not dependent on t, while belief is from probability distribution $p(t_1,\cdots,t_n)$ in advance [5].

The probability common expression of Bayesian formula: Bayesian theorem is very useful in probability computing and risk decision making, and has achieved a lot of voluble achievements. According to Bayesian formula, the probability common expression can be expressed as follows:

Let natural state θ have k sorts, denote by $\theta_1,\theta_2,\cdots,\theta_k$ separately; $P(\theta_i)$ indicates natural state θ_i prior probability occurred; x indicates the survey result. $P(x|\theta_i)$ indicates the probability that the survey results happen to be x on condition θ_i, which is condition probability. Therefore:

Joint probability:

$$P(x\theta_i) = P(\theta_i)P(x|\theta_i).$$

Marginal probability:

$$P(X) = \sum_{i=1}^{k} P(\theta_i)P(x|\theta_i).$$

70.4.2 Designing Risk Forecasting Modeling

70.4.2.1 Identify Risk Indicators

Risk indicator refers to all kinds of risk indicators in commodity transaction. It is an information object or information target of the partners, on which suppliers make surveys to facilitate the credit sales. Risk indicators (r) are divided into firm indicators (F) and soft indicators (S).

Firm indicators (F) mean the major financial risk indictors, of which data source come from financial statement such as balance sheet and income statement. Soft indicators compass a wide range, which, basically, can be chosen according to the situation of enterprises themselves. For instance, business range, purchasing purpose, response of suppliers, wok state of staff, vehicles, real estate, etc. belong to risk factors (r), which performance status are the early warning indicators of transaction risks (R).

70.4.2.2 Risk Forecasting Formula

According to Bayesian formula, the total probability calculation formula is as follows:

$$P(R) = \sum_{i=1}^{n} P(r_i) \cdot P(R/r_i). \tag{70.1}$$

Corollary:

$$\begin{aligned} \because \text{Original formula} = \ & P(r_1) \cdot P(R/r_1) + P(r_2) \cdot P(R/r_2) + \cdots \\ & + P(n_k) \cdot P(R/n_k) + \cdots + P(r_n) \cdot P(R/r_n). \end{aligned} \tag{70.2}$$

Suppose: the 1^{st} risk factor is a firm indicator, namely, financial indicator F, then,

$$P(r_1) \cdot P(R/r_1) = P(F) \cdot P(R/F).$$

Suppose other risk indicators $(r_2 \cdots, r_n)$ are soft ones $(S_1 \cdots, S_{n-1})$, then,

$$\begin{aligned} P(r_2) \cdot P(R/r_2) &= P(S_1) \cdot P(R/S_1) \\ P(r_n) \cdot P(R/r_n) &= P(S_{n-1}) \cdot P(R/S_{n-1}) \end{aligned}$$

$$\begin{aligned} \therefore \text{Original formula} = \ & P(F) \cdot P(R/F) + P(S_1) \cdot P(R/S_1) + \cdots \\ & + P(S_{n-1}) \cdot P(R/S_{n-1}). \end{aligned} \tag{70.3}$$

Due to infinity of soft indicators, one more soft one does not affect its result, therefore, Equation (70.3) can be written as

$$P(F)\cdot P(R/F)+P(S_1)\cdot P(R/S_1)+\cdots+P(S_{n-1})\cdot P(R/S_{n-1})+P(S_n)\cdot P(R/S_n)$$
$$\therefore P(R)=P(F)\cdot P(R/F)+\sum_{i=1}^{n}P(S_i)\cdot P(R/S_i).$$

Posterior probability formula:

$$P(r_k/R)=\frac{P(r_k)\cdot P(R/r_k)}{\sum_{i=1}^{n}P(R/r_i)},$$

where,

$P(R/r_i)$ = Risk factor weight.
$P(R/F)$ = financial indicator weight.
$P(R/S_i)$ = soft indicators weight
$P(r_i)$ = subjective probability of risk factors.
$P(F)$ = subjective probability of financial indicator.
$P(S_i)$ = subjective probability of soft indicators.

And,

$$0\le P(r_i)\le 1,\ 0\le P(F)\le 1,\ 0\le P(S_i)\le 1. \tag{70.4}$$

70.4.2.3 Determining Risk Factor Probability and Their Proportion

(1) Determining $P(F)$

To determine firm indicator of risk factors, F fraction model by Chinese scholar Shouhua Zhou is adopted here. Then,

$$F=-0.1774+1.1091X_1+0.1074X_2+1.9271X_3+0.0302X_4+0.4961X_5,$$

where,

X_1 = (closing current assets - closing current debt)/closing total assets;
X_2 = closing retained earnings/closing total assets;
X_3 = (net profit + depreciation)/average total liabilities;
X_4 = closing shareholders/market value;
X_5 = (net profit + depreciation +interest)/average total liabilities.

To choose the five independent variables is on the basis of financial theory in the model, which critical point is 0.00274. If the F fraction calculated is below 0.0274, it means the financial crisis will occur in the near future. If above that, the enterprise may go on with their stable operation.

Through the calculation result of buyer's F fraction model, it can be judged what status financial risk factor is in, by which judging its objective probability of transaction risk occurred.

- When $F < 0.0274$, it means the financial crisis will occur in the near future. Hence, it may bring transaction risk to suppliers. Reference Interval of subjective probability of risk occurrence should be $(0.4, 1]$.
- When $F > 0.0274$, it means the financial status sounds good, without risk. Reference Interval of subjective probability of risk occurrence should be $(0, 0.6]$.

(2) Determining $P(S_i)$

The performance state of soft indicators can be classified into 3 grades as x_1, x_2 and x_3, of which x_1 is excellent grade for active and beneficial performance; x_2 is average grade, ambiguous performance, x_3 is bad grade for passive and disadvantageous performance. According to some survey and experience, reference Interval of function value of subjective probability of soft risks should be $f(x_1) \in [0, 0.5)$, $f(x_2) \in (0.3, 0.6)$, $f(x_3) \in (0.6, 1]$.

(3) Determining $P(R/F)$ and $P(R/S_i)$

Although determining weight is of a little subjectivity, we may adopt expert routing approach to try to move the bias away due to the prejudice of the people involved.

70.5 Summary

It is very effective to stop risk occurrence by using early warning mechanism and scientific risk forecasting techniques. The organizational system of risk warning management and forecasting model, along with analysis method and frame of risk warning management may be a reference for enterprises to setup early warning mechanism in credit transaction, meanwhile providing with organization and technique support to the top management making decision.

References

1. Zhang G, Ma L (2005) Introduction to forecasting and decision making. Capital University of Economics and Business Press, Beijing
2. Jin B (2006) On account receivable management. Academic Journal of Lioaning Economic Vocational College 4:81-82
3. Xu Y (2004) Cause analysis and measures of Zheng Baiwen's failure in credit sales. Academic Journal of Jilin University 4:51-55
4. Rui M (2005) Management: A modern Perspective. 2nd edn, Shanghai People's Press, Shanghai

5. Christian M, Daniel S (2005) Game theory and economics. Economics and Management Press, Beijing

Chapter 71
Analysis on Supply Chain Risk Factors based on Structural Equation Model

Xin Liu

Abstract This paper focuses on the analysis of supply-risk-factors identification and corresponding structural equation modeling in internal supply chain, and finish the model specification, model estimation and model evaluation employed multivariable regression analysis and path analysis as well as confirmatory factor analysis. The analysis shows that the main factors of the supply chain risk are technical quality, merchandise inventory, business information, trade factors, and price-cost factors.

Keywords Supply chains · Risk analysis · Identification · Affecting factors · Structural equation modeling

71.1 Introduction

In this network information age, competition in the market is more intense than ever before, and this trend will continue making the forms of competition alone between enterprises in the past that no longer existed. By the principle of collaborative commerce, cooperative competition, win-win and even all-win and the competition of supply chain of customers, suppliers, R&D centers, manufacturers, distributors and service provider partners, the commercial operation mode has taken over instead. Moreover, the competitiveness of supply chain network depends considerably on the ability to control various risks in supply chain management process. As one of the most important sources of risk, the supply risk, how to identify the risk of the supplier to improve the competitiveness of the supply chain, plays a notably role for the modern enterprise.

This paper discusses the key factors affecting supply risk identification in internal supply chain, proposes the supply risk identification model based on structural equa-

---

X. Liu (✉)
Business School, Sichuan University, Chengdu 610064, P. R. China
e-mail: liuxin67@sina.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_71, © Springer-Verlag London 2013

tion modeling, which provides a risk analysis of supply chain from technical factor and quality factor as well as cost factor, and derives the key affecting factors detailed in the analytic demonstration. Using questionnaire method for different trades conducted in different types of enterprises, the main factors of supply risk identification are quantitatively analyzed in this paper. The results show that the model of supply risk identification is the appropriate theoretical and practical bases which can be beneficial to identify supply risk for the downstream enterprises in the supply chain.

71.2 Supply Risk Identification Factors and Preliminary Model

The factors affecting the supply risk include both internal supply chain factors and external environmental factors [1–6]. According to the investigation of the literature [7–16], this section analyzes supply-risk-affecting factors from the supplier itself and the internal cooperation of supply chain, and groups the influence factors into six areas in which every category of factors are decomposed into several sub-factors based on different situations.

71.2.1 The Supply-risk-identification Factor Analysis

(1) Technical factors

The technical level of the supply determines product quality and its capacity. Ma et al [10], Peng [11] pointed out that the maturation of the technology, the use of new technology, IT technology and software system failures and supply chain management are significantly related. Therefore, the sub-factors of "technology" are set below: supplier capacity, supplier ability to develop new products, suppliers' ability to rapidly change capacity, advance of supplier production facilities, and dedicated equipment for the investment of supplier.

(2) Quality factors

The Quality is a significant factor for the survival and development of the company, and is undoubtedly a crucial factor for the formation of dynamic supply chain which also could achieve its desired goal. The quality factor is vital to the survival of supply chain network. Poor-quality product is lack of market competitiveness and would be out of the market sooner or later. And also, product quality provided by the supplier is the key to the final product quality. Kraljic [8], Lee and Billington [9], Zsidisi [12] pointed out that the procurement of raw materials/parts quality, whether can be compliant with business requirements, affect the production and product quality seriously; the suppliers' product quality has a direct impact on the downstream product quality. The quality factor is essential for the supplier, and is mandatory. If the supplier does not guarantee their product quality, they would soon be eliminated. Therefore, the sub-factors of "quality" are set below: quality level of product of the supplier, stability of the product of the supplier, consistency between the product quality of supplier and the enterprises' goal, ISO certification status.

(3) Cost factors

The cost factors mainly refer to the raw materials from the suppliers, the cost of primary products or the consumer goods components. The price of the supplier's product determines the price of the consumer goods and the input-output ratio of the whole supply chain, and has a certain degree of influence on the profit margins of producers and distributors. Zsidisin [12], Hallikas et al [13] proved that inventory managed by supplier, long-term supply contracts and increment of supplier price are positively related to the total cost of the supply chain, and have a significant impact on the performance of supply chain operations. The purchase price of the raw materials and the parts to a great extent decide the product cost, so as to determine the product competition ability and ability of resisting the market price fluctuation. The supplier price and its cost is also one source of supply risks. Consequently, the sub-factors of "cost" are set below: rationality of the price procedure, rationality of the price, supplier's ability of reducing costs.

(4) Inventory factors

Inventory for reducing the risk affects not only the availability of products, but also the cost of products. Only by coordinating inventory between the supplier and the downstream enterprises, it can reduce the risk of the whole supply chain. The sub-factors of "inventory" are set below: ability of the supplier inventory management, matching between supplier inventory strategies and downstream enterprises, supplier stock levels.

(5) Trading factors

When the supplier cooperates with the downstream enterprises, it inevitably involves the order inventory and delivery. when the amounts, types and specifications of procurement of the raw materials/parts temporarily are changed to meet customer's demand and remained the same with the order, Lee and Billington [9], Zsidisin [12] indicated that supplier delivery directly affect the supply chain's ability to respond to customer's demand whether the delivery can be completed within the established date. Therefore, the sub-factors of "trading" are set below: order receipt (response), orders to meet (stock), order lead time, supplier delivery accuracy, supplier delivery timeliness, supplier delivery quality (logistics loss).

(6) Information factors

The information factors (such as real-time communications and sharing information, automation and intelligent information processing, the entire supply chain demand chain reaction in information and other information to the customer) are the core competitiveness of supply chain factors. The good information level of supplier is the necessary condition for the market sensitivity, inventory reduction, cost savings, speed of response, partnerships to maintain and so on. A huge supply chain — maintaining flexibility and winning in a market environment where the speed becomes a key competitive factor to the advantages and the compatibility of the information system — should be taking into account when selecting the suppliers. Then the sub-factors of "information" are set below: advance of supply information system, communication of supply information system and the enterprise, accuracy of supply information delivery, timeliness of supply information, sharing level of supply information.

71.2.2 Supply Risk Identification Model

To further research the various relationships between risk factors and supplier risk, a supplier risk identification model is established (Fig. 71.1), where “technology”, “cost”, “inventory”, “trade”, “information” are variables, “quality” is the intermediate variable, and “supply risk” is the dependent variable.

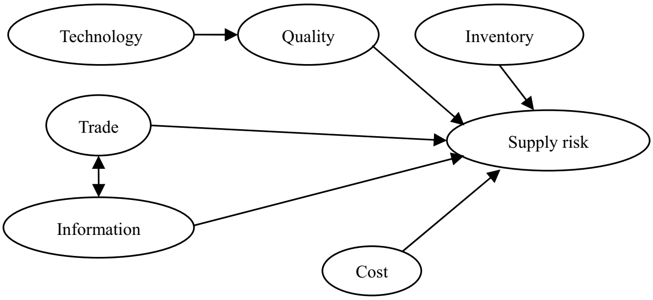


Fig. 71.1 Primary model of supply risk identification

71.3 Structural Equation Modeling of Supply Risk Identification

Using questionnaire method for different trades conducted in different types of enterprises, the main factors of supply risk identification are quantitatively analyzed.

71.3.1 Research Methods and Processes

Using the AMOS statistical analysis method, this section verifies the relationship among “technology”, “quality”, “costs” and “inventory”, “trade”, “information” and “supply risk”, which involves three steps below:

Step 1. Questionnaire design. The final two-part questionnaire is designed on the basis of affecting factors of supply, and with discussions with experts as well as seeking professional advices and amending with the preliminary research method. The first part, including 8 sorts of description factors of supply risk, has a total of 32 secondary indicators. The questionnaire uses a typical five-level Likert to measure from low to high. And the second part is the enterprise's basic information.

Step 2. Respondents' selection and implementation of questionnaire. Respondents are relevant staff in the different trades. 300 questionnaires are handed out and 155 valid questionnaires are collected.

Step 3. Input and statistical analysis of the questionnaire data. The AMOS software is used for structural equation modeling analysis of the collected data to study relationships between risk affecting factors and supply risk.

71.3.2 Modeling of Structural Equation

The modeling method of structural equation [17–19], utilized with multivariable regression analysis, path analysis and confirmatory factor analysis method, is a statistical data analysis tool. The structural equation model (SEM) is depicted with path diagram using software AMOS 6.0 to finish the model specification, model estimation and model evaluation.

(1) Model specification

As shown in Fig. 71.2, the road path is used to build the SEM model of supply risk identification, which notations indicate below: x_1, capacity; x_2, capability of development a new product; x_3, the ability to rapidly change capacity; x_4, advance of supplier production facilities; x_5, dedicated equipment for the investment of supplier; x_6, rationality of the price procedure; x_7, the rationality of price; x_8, supplier's ability of reducing costs; x_9, the ability of manage inventory; x_{10}, matching between supplier inventory strategies and downstream enterprises; x_{11}, supplier stock levels; x_{12}, order receipt (response); x_{13}, orders to meet (stock); x_{14}, order lead time; x_{15}, supplier delivery accuracy; x_{16}, supplier delivery timeliness; x_{17}, supplier delivery quality (logistics loss); x_{18}, advance of supply information system; x_{19}, communication of supply information system and the enterprise; x_{20}, accuracy of supply information delivery; x_{21}, timeliness of supply information; x_{22}, sharing level of information; y_1, quality level of product; y_2, stability of the product; y_3, consistency between the product quality of supplier and the enterprises' goal; y_4, ISO certification status; y_5, contract distribution implementation when cooperate with the suppliers; y_6, information or technical disclosure risk situation when cooperate with the suppliers; y_7, production problems when cooperate with the suppliers. γ_i is the coefficient of η and ξ_i, that is, as the dependent variable η the degree of directly affect to the effect variable ξ_i; β is the coefficient of η_2 and η_1, that is, as the dependent variable η_2 the degree of directly affect to the effect variable η_1; both λ_{ij} and λ_{ij}^{y} are regression coefficient and represent the degree of directly affect of observed variable to the structural variables.

(2) Model estimation

By AMOS analysis [20, 21], the regression coefficient between variables in structural equation models is passed in the test of significance. According to the calculated weight, the key factor of supply risk identification is quality, sequentially followed by the inventory, the information, trading factors, and finally price-cost

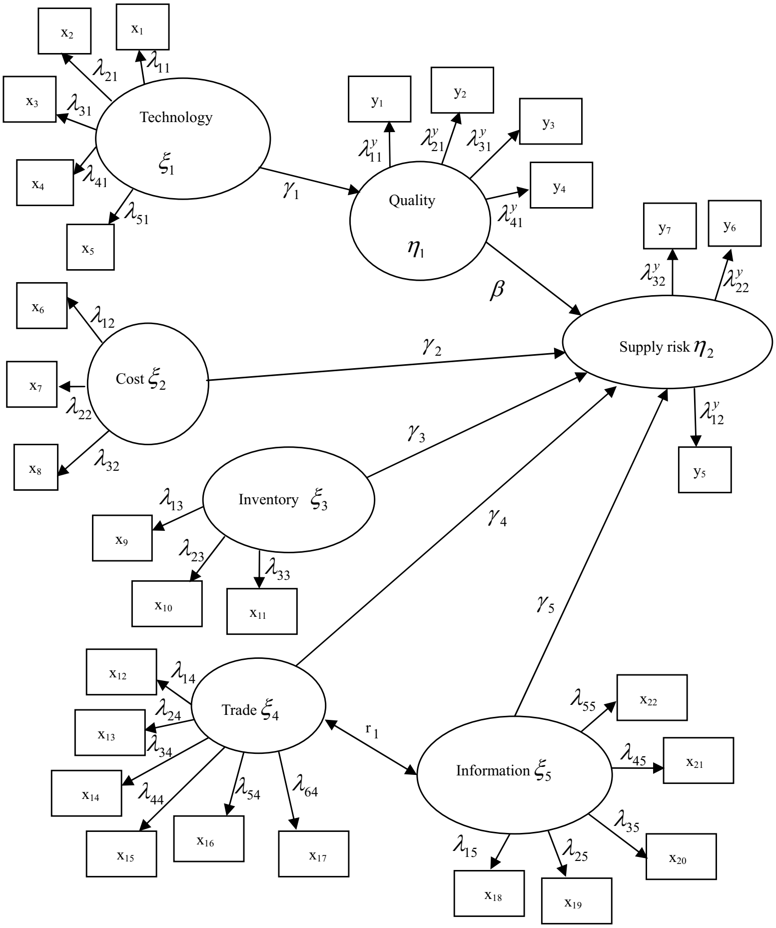


Fig. 71.2 Road map of supplier risk identification model

factors. The influence of technological factors on supply risk identification is not directly, but indirectly through quality factors.

(3) Model evaluation

From Table 71.1, the statistical indicators of the degree of the model fits the data show that the model fitted with a good performance.

Table 71.1 Model fitting index

Main index	CMINDF	GFI	AGFI	TLI	CFI	RMSEA
Value	1.364	0.907	0.857	0.902	0.915	0.043

71.3.3 Model Results

The risk identification model (as shown in Fig. 71.3) shows the following conclusions:

1. Technical factors have a significant positive impact on quality factors: For technical factors, increasing the risk level of 1 unit would increase unit of quality factors of risk levels by 0.68. Quality factors also have a significant positive impact on supply risk identification: For quality factor, increasing the risk of 1 unit would then increase supply risk of 0.52. Indirect effects of technical factors can be also calculated, namely the increase of 1 unit would result in supply risk increased by 0.35 $(0.68 * 0.52)$ units.
2. Trade factors also have a significant positive impact on the supply risk identification: For trade factor, increasing the risk of 1 unit would result in the increase of the suppliers' risk of 0.30. Information factors have a significant positive impact on supply risk identification: For the information factors, increasing risk factor of 1 unit would result in the suppliers' risk of 0.33. And there is a strong correlation, which coefficient is 0.63, between trade and information factors.
3. Cost factors also have a significant positive impact on the supply risk identification: For cost factor, the increase of the risk of 1 unit would increase the suppliers' risk of 0.20.
4. Inventory factors also have a significant positive impact on the supply risk identification: For inventory factor, the increase of the risk of 1 unit would increase the suppliers' risk of 0.33.

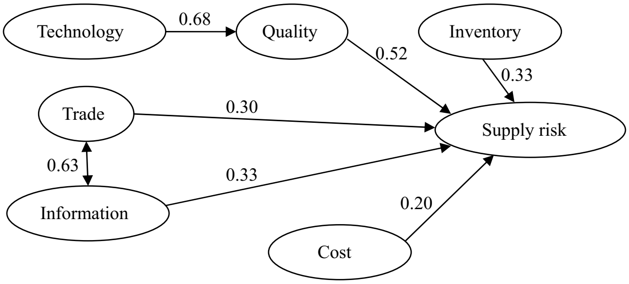


Fig. 71.3 Model of supply risk identification

71.4 Conclusions

With the literature and practical research, the structural equation modeling method is used to establish the supply risk identification, and obtain the key factors affecting the supply risk. The results show that the supply risk identification model has a useful theoretical and practical basis, and has a certain role in guiding downstream enterprises of supply chain to identify the supply risk.

For a better view of supply risk identification, there are some topics for future research in the area, such as an analysis of factors affecting and controlling the supply risk from the internal supply chain, and the subsequent work will be integrated into more affecting factors include external environment, manpower cost and so on.

References

1. March J, Shapira Z (1987) Managerial perspectives on risk and risk taking. Management Science 33:1404–1418
2. Zsidisin GA (1999) A grounded definition of supply risk. Journal of Purchasing & Supply Management 21:217–224
3. Hernandg LR (2000) Integrated risk management in the internet age. Risk Management 47:537–543
4. Mentzer JT, DeWitt W, Keebler JS et al (2001) Defining supply chain management. Journal of Business Logistics 22:1–25
5. Johnson ME (2001) Learning from toys: Lessons in managing supply chain risk from the toy industry. California Management Review 43:106–125
6. Zsidisin GA (2003) Managerial perception of supply risk. Journal of Supply Chain 39:14–25
7. Harland C, Brenchley R, Walker H (2002) Risk in supply networks. Journal of Purchasing & Supply Management 9:51–62
8. Kraljic P (1983) Purchasing must become supply management. Harvard Business Review 61:407–4l3
9. Lee HL, Billington C (1992) Managing supply chain inventory: Pitfalls and opportunities. Sloan Management Review 15:65–73
10. Ma S (2002) How to deal with risk: The risk prevention mechanism of supply chain enterprise. http://www.chianbyte.net (In Chinese)
11. Peng D (2002) The risk of supply chain and its distributing model. Inner Mongolia Science & Technology and Economy 21:52–53 (In Chinese)
12. Zsidisin GA, Ellram LM, Carter JR et al (2004) An analysis of supply risk assessment techniques. International Journal of Physical Distribution & Logistics Management 34:397–413
13. Hallikas J, Karvonen I, Pulkkinen U et al (2004) Risk management processes in supplier networks. International Journal of Production Economics 90:47–58
14. Chopra S, Meindl P (2004) Supply chain management: Strategy, planning and operation. 2nd edn, Prentice Hall Inc
15. Tapiero CS (2007) Customers risk and quality control in a collaborative supply chain. European Journal of Operation Research 18:683–694
16. Levary RR (2008) Using the analytic hierarchy process to rank foreign suppliers based on supply risks. Computers & Industial Engineering 55:535–542
17. Chopra S, Sodhi MS (2004) Managing risk to avoid supply-chain breakdown. MIT Sloan Management Review 27:53–61

18. Spekman RE, Davis EW (2004) Risky business: Expanding the discussion on risk and the extended enterprises. International Journal of Physical Distribution & Logistics Management 34:414–433
19. Kleindorfer PR, Saad GH (2005) Managing disruption risks in supply chains. Production and Operations Management Society 14:53–68
20. Zsidisin GA, Ellram LM, Carter JR et al (2004) An analysis of supply risk assessment techniques. International Journal of Physical Distribution & Logistics Management 34:397–413
21. Neiger D, Rotaru K, Churilov L (2009) Supply chain risk identification with value-focused process engineering. Journal Operation Management 27:154–168

Chapter 72
Construction Project Risk Assessment

Yajun Wang

Abstract This paper used Equal Risk Curve math the Fuzzy Matrix method to appraise the quantitative construction project risk in an attempt to reduce the influences of subjective factors in risk estimate and provide a reference of bidding decision-making to contractors.

Keywords Construction project · Risk · Equal risk curve · Fuzzy matrix

72.1 Introduction

Risk usually means any possibilities of economy or financial loss and damage or injury by the activity uncertainty [1]. The risks come over the construction processes to the contractor. It is necessary to total risk analysis for project management and value the risk range and effetely for decision making on the scientifically bid price [2].

72.2 Equal Risk Curve Establish

Equal risk curve includes the risk being probability and risk consequences. The identified risk bracket three level are: low, middle and high. Lower risks bring the micro effect to construction project goal; otherwise, higher risks bring the adverse effect. But middle risks should change the project implement. P_f and P_s present risk occur and no risk probability. As the result $P_s = 1 - P_f$. C_f and C_s present un-utility value and success value through the project implement result [3].

Y. Wang (✉)
School of Economic and Management, Liaoning Shihua University, Fushun 113001, P. R. China
e-mail: wyjgy888@sohu.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_72, © Springer-Verlag London 2013

With the Utility Theory: $C_f + C_s = 1,\ 0 < C_s < 1,\ 0 < C_f < 1$. So project risk coefficient is:

$$R = 1 - P_s C_S = 1 - (1 - P_f)(1 - C_f) = P_f + C_f - P_f C_f. \tag{72.1}$$

There is $P_f = (P_{f1} + P_{f2} + \cdots + P_{fi} + \cdots + P_{fn})/n$, n is number of risk, P_{fi} is the risk i occur probability.

$C_f = (C_{f1} + C_{f2} + \cdots + C_{fi} + \cdots + C_{fm})/m$, m is number of risk result, C_{fi} is un-utility value and success value of risk I implement in the project.

It is obvious that $0 < R < 1$. R increase with risk bigger, whereas smaller. When draw equal risk curve, R putted a value between 0 and 1 firstly, for example 0.1. Secondly, P_f and C_f putted various combination between 0 and 1. Drawing those combinations on the horizontal axis C_f and vertical axis P_f. Get a curve line with dots. Repeat the steps to create another curve line (Fig. 72.1) duplicate. Weighing the risk compare with risk coefficient.

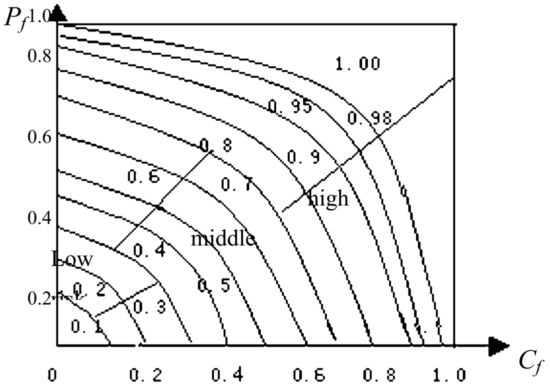


Fig. 72.1 Equal risk curve

In the construction project actually management, risk coefficient R should calculate based on Equation (72.1) to measure the construct project risk and provide scientific basis.

72.3 Risk Coefficient Calculations

Risk valuation objective was to be going construct project. It is necessary evaluate project's risks objectively consider subjective factors. For assessment equitably contractor must research the local situation and employer behavior past. To assume the develop new market investigation statistics shown in Table 72.1.

To making the project risk analysis correctly for trend after get local or owner research. Now calculate with mathematical model: select several finished project

Table 72.1 Main risks statistics of local situation in a particular market

Delay period (month)	Probability (%)	Fully funded	Probability (%)	Design & construct	Probability (%)	Results
2	20	70%	15	Light delay	50	0.1
2 ∼ 6	4	60%	12	General delay	20	0.3
6 ∼ 12	3	50%	5	Serious delay	5	0.5
12 ∼ 18	2	30%	3	Serious delay; re-design partial	3	0.7
More than 24	1	20%	2	Serious delay; re-design total	2	0.9

Note: survey contents as well as more detailed, some date Quantitative value or probably qualitative.

sample to build mathematical model, through gray correlation and weighting distance calculate got detail of project. The procedure are: (1) select sample; (2) transfer sample to weight number; (3) work out gray correlation and weighting distance; (4) find the project's position [4–7].

It is assume that project cost 24 million, time limit for a project is 12 months, and advance fee is 400 million. Do the research of project investor's behaviors records below (as shown in Table 72.2).

Table 72.2 Main risks statistics of developer's behavior past in a particular market

Sample	Payments (month)	Funded	Design & construct	Cost (million)	Duration (month)	Advance fee (thousands)
1	Delay two month	70%	General delay	40	22	720
2	Delay two month	70%	light delay	35	20	680
3	Half a year	70%	General delay	20	12	450
4	?	?	?	24	12	400

72.3.1 Standardization Matrices [8]

Calculate payment situation firstly: build matrix below

$$D = \begin{vmatrix} 2 & 40 & 22 & 720 \\ 2 & 35 & 20 & 680 \\ 6 & 20 & 12 & 450 \end{vmatrix}.$$

Standardization: $a_{ij} = a_{ij}/\text{Max}(a_{ij})$ was

$$D = \begin{vmatrix} 0.33 & 1.00 & 1.00 & 1.00 \\ 0.33 & 0.88 & 0.91 & 0.94 \\ 1.00 & 0.50 & 0.55 & 0.63 \end{vmatrix},$$

$$\text{Project}: |y \ \ 0.60 \ \ 0.50 \ \ 0.56|.$$

72.3.2 Relation Grade Calculates

Calculate differentials matrix: $\Delta R = |a_{i1} - a_{ij}|$,

$$\Delta R = \begin{vmatrix} 0.00 & 0.67 & 0.67 & 0.67 \\ 0.00 & 0.55 & 0.58 & 0.61 \\ 0.55 & 0.50 & 0.45 & 0.37 \end{vmatrix}.$$

Calculate relation grade coefficient: $R = |r_{ij}|, r_{ij} = (\min\Delta + k\max\Delta)/(\Delta r_{ij} + k\max\Delta)$

MinΔ and maxΔ express min or max element in the matrix ΔR. k value between 0.1 and 1 was 0.5

Like that: relation grade is:

$$R = \begin{vmatrix} 1.00 & 0.33 & 0.33 & 0.33 \\ 1.00 & 0.38 & 0.37 & 0.35 \\ 0.00 & 0.40 & 0.43 & 0.48 \end{vmatrix}.$$

Calculate relation range (average value) $RR = |(r_{1j} + r_{2j} + r_{3j})/3|$, get:

$$RR = |1.00 \ \ 0.37 \ \ 0.38 \ \ 0.39|.$$

Normalization: $W_j = rr_j + 1/|rr_j + 1|$ get:

$$W_j = |0.32 \ \ 0.33 \ \ 0.35|.$$

72.3.3 Calculate Fuzzy Matrices

Calculate fuzzy distance $d(A, A_{ij+1})$, A is assume construct project.

As same as get:

$$d(\underline{A}, A_{1j+1}) = \begin{array}{l} |1.00 - 0.66| = 0.40 \\ |1.00 - 0.55| = 0.45 \\ |1.00 - 0.56| = 0.44. \end{array}$$

72.3.4 Calculate Weight

$$d(\underline{A}, A_{2j+1}) = \begin{cases} 0.28 \\ 0.36 \\ 0.38, \end{cases} \quad d(\underline{A}, A_{3j+1}) = \begin{cases} 0.10 \\ 0.00 \\ 0.07. \end{cases}$$

Based on the above work,

$$\text{Sample 1} : 0.32 \times 0.40 + 0.33 \times 0.45 + 0.35 \times 0.44 = 0.4305,$$
$$\text{Sample 2} : 0.32 \times 0.28 + 0.33 \times 0.36 + 0.35 \times 0.38 = 0.3711,$$
$$\text{Sample 3} : 0.32 \times 0.10 + 0.33 \times 0.00 + 0.35 \times 0.07 = 0.0565.$$

So the weight is:

$$\text{Sample 1} : 1/0.4305 \div (1/0.4305 + 1/0.3711 + 1/0.0565) = 0.102,$$
$$\text{Sample 2} : 1/0.3711 \div (1/0.4305 + 1/0.3711 + 1/0.0565) = 0.119,$$
$$\text{Sample 3} : 1/0.0565 \div (1/0.4305 + 1/0.3711 + 1/0.0565) = 0.779.$$

72.3.5 Risk Coefficient

Including antecedent weight, this project payment situation is:

$$2 \times 0.102 + 2 \times 0.119 + 6 \times 0.779 = 5.1 \text{ (month)}.$$

By the same rule to calculate funded rate is 70% with general delay. Table 72.1 show us the every situation occur probability and incidence. Equation (72.1) should help calculate risk coefficient is:

$$\begin{aligned} P_f &= (P_{f1} + P_{f2} + \cdots + P_{fi} + \cdots + P_{fn})/n = (0.04 + 0.15 + 0.2)/3 = 0.13, \\ C_f &= (C_{f1} + C_{f2} + \cdots + C_{fi} + \cdots + C_{fm})/m = (0.3 + 0.1 + 0.3)/3 = 0.23, \\ R &= P_f + C_f - P_f C_f = 0.13 + 0.23 - 0.23 \times 0.13 = 0^{i}.33. \end{aligned}$$

Fig. 72.1 should show us which the middle level risk project is.

72.4 Conclusion

Use above methods analysis the risks of construct project, which preclude subjective estimate affecters effectively and enhance objectivity. This method apply base on the local project market understanding and familiar with developer's behavior. In calculating, analysis actually with more samples and research.

References

1. Li Q (1999) Construction contract management. China Architecture & Building Press, Beijing (In Chinese)
2. Cong P (2000) Construction project management. China Architecture & Building Press, Beijing (In Chinese)
3. Lu Y, Lu J (2001) Project risk management. Tsinghua University press, Beijing (In Chinese)
4. Bian C (2002) Risks of construction project and its avoiding measures. Construction Enterprises Management 162:15–16 (In Chinese)
5. Gu J (2001) Claims on overseas project management. Construction Economy 224:21–23 (In Chinese)
6. Li J (2002) Projects contracts model and risk management. Construction Economy 232:44–46 (In Chinese)
7. Li J (2002) On the operation of state-owned construction enterprises. Construction Economy 232:12–16 (In Chinese)
8. Operations Research Group (1990) Operations research. Tsinghua University Press, Beijing (In Chinese)

Chapter 73

The Risk Assessment of Marketing Management System on the Basis of Multi-level Fuzzy Comprehensive Evaluation

Qingfeng Bu and Fan Zhang

Abstract The risks of marketing management system exist everywhere but many enterprises have one-sided understanding on them. Bad loans result from sale risks but lagging sales is related to the risks of product planning or a shady promotion program. Rapid staff turnover does not help either. STP marketing strategy planning, marketing mix planning and competitive factors will bring marketing risks.It is essential to identify these risks and evaluate their effects.

Keywords Marketing management system · Individual research output · Evaluation index system · Bibliometric indices

73.1 Introduction

A lot of research work has been done from the perspective of risk sales, commodity trades, credit by experts and scholars. The author holds that a source factor, marketing planning which may bring about marketing risk is ignored. For instance, the product is not what the market wants owing to deviation of marketing research In the early stage or lagged idea of planner. This kind of risk from product planning does happen on our side and cause irreparable damage to the enterprise Based on the marketing planning, this paper from the perspective of enterprise itself analyzes risks caused by STP marketing strategy planning, marketing combination strategy, competition factors and environmental factors. The paper also evaluates the severity of some risks and proposes multi-level fuzzy comprehensive evaluation model of risk assessment to help decision makers of enterprise marketing planning to analyze and evaluate the risks to which the company is exposed from a new perspective and make corresponding measures to minimize the occurrence of risks.

Q. Bu (✉) · F. Zhang
Shanghai Medical Instrumentation College, University of Shanghai for Science and Technology, Shanghai 200093, P. R. China
e-mail: LOOOOOGLE@163.COM

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_73,

73.2 Identification Risk of Marketing Management System

Risks of Marketing Management System refer to the opportunities or possibilities of suffering losses or receiving extra yields. Obviously, this definition is a broader one which contains all risks caused by marketing factors. Risks of marketing management system studied by this paper mainly refer to fluctuation of enterprise marketing management system and failure of marketing campaigns caused by nondeterminacy and failing of marketing planning [1]. In view of the category of research of marketing management system in this paper, risks identification of marketing management system can be identified from the following three aspects: risks of STP marketing strategy, risks of marketing combination strategy, competition risk.

73.2.1 Risks of STP Marketing Strategy

Risks of STP Marketing strategy refer to those caused by accidents in enterprise's marketing activity which may arise from uncertainty of market segmentation, target market selection, positioning. These risks often make enterprise confused and lost in marketing activity which may achieve twice the result with half the effort. Then sales staff are replaced frequently, which still can not bring a promising market. Likewise, some marketing managers find that half of the money even more than half of the money on advertising are wasted but they don't know what is really going wrong. The fact is that there is something wrong with the source of such products Consumers have no idea about the product, have not the least idea of the function of the product, let alone purchase it. Those risks mainly result from unreasonable market segmentation, improper target market selection, hazy market positioning. These risks will lead to inconsistency of enterprise's subjective request to product and they even will cause chaos of subjective request to product, price, promotion and channels. So these risks are ones which will result in overall failure.

73.2.2 Risks of Marketing Mix

Risks of marketing mix refer to those caused by accidents in enterprise 's marketing activity which may arise from unreasonable program of product or product mix, price, channel and promotion. These risks mainly result from failure of product or product mix to fulfill market needs, poor price strategy of high- quality, low price or low quality, high price, chaotic channel setting and channels management, rampant selling beyond agreed areas and betrayed order and implementation of boring even disgusting promotion plans.

73.2.3 Risks of Competition

Risks of competition mainly refer to those caused by adverse impact on enterprise's marketing activity made by other stakeholders. They pose threats to enterprise's marketing activity in different aspects. These threats include the competition between enterprises in the industry, potential entrant, forward integration in the face of suppliers who are getting stronger, the enhancements of customer's capability to recognize products and bargain and substitutes.

73.3 Building of Marketing Management System Risk Assessment Model and Empirical Analysis

73.3.1 Index Constitution of Risk Characteristics of Marketing Management System

From the above identification of marketing management system risks, risks of marketing management system can be identified from three aspects: X_1, X_2, X_3. 12 evaluation index $X_1 \sim X_{12}$ are constructed, namely market segmentation, target market selection, market positioning, product strategy, price strategy, channel strategy, promotion strategy, competition in the field, potential entrant, suppliers, substitutes customers waiting substitute [2].

Empirical research is conducted on the risk assessment of marketing management system of energy drinks of a company in the market. The evaluation matrixes of single factor and weight vector are derived through expert evaluating and normalization method. As shown in Table 73.1.

73.3.2 Multi-level Fuzzy Comprehensive Evaluation

As shown above, we determine the fuzzy evaluation index set $X(x_1, x_2, \cdots, x_{12})$, judgment set $V(v_1, v_2, v_3, v_4)$, then determine a fuzzy relation R from X to V [3],

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{14} \\ r_{21} & r_{22} & \cdots & r_{24} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{n4} \end{bmatrix}, \quad (0 \le r_{ij} \le 1). \tag{73.1}$$

And then, we determine weight vector $A = (a_1, a_2, \cdots, a_{12})$ of judgment factor by AHP method, and attain its mathematical model B of fuzzy comprehensive evaluation,

$$B = A * R = (a_1, a_2, \cdots, a_{12}) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{14} \\ r_{21} & r_{22} & \cdots & r_{24} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{n4} \end{bmatrix}. \tag{73.2}$$

We put the corresponding digit into the equation, and acquire

$$\begin{aligned} B = \; & (0.09, 0.12, 0.29, 0.12, 0.04, 0.06, 0.08, 0.06, 0.04, 0.03, 0.05, 0.02) \\ & \times \begin{bmatrix} 0.6 & 0.3 & 0.2 & 0 \\ 0.5 & 0.3 & 0.2 & 0 \\ 0.9 & 0.1 & 0.0 & 0 \\ 0.6 & 0.3 & 0.1 & 0 \\ 0.4 & 0.3 & 0.2 & 0.1 \\ 0.6 & 0.2 & 0.1 & 0.1 \\ 0.6 & 0.2 & 0.1 & 0.1 \\ 0.1 & 0.3 & 0.4 & 0.2 \\ 0.1 & 0.2 & 0.3 & 0.4 \\ 0.1 & 0.3 & 0.2 & 0.4 \\ 0 & 0.2 & 0.4 & 0.4 \\ 0.1 & 0.4 & 0.3 & 0.2 \end{bmatrix}. \end{aligned}$$

We get the solution by using Mathematical tool software Mathematica.

$$B = (0.562, 0.221, 0.144, 0.082). \tag{73.3}$$

The result of the risk assessment of marketing management system of energy drinks of a company in the market:

$$V(v_1, v_2, v_3, v_4) = V(0.562, 0.221, 0.144, 0.082), \tag{73.4}$$

$$\max(0.562, 0.221, 0.144, 0.082) = 0.562. \tag{73.5}$$

We can confirm that risks of the product's marketing system belong to v_1 class. That is, risks of STP Marketing strategy and Marketing Mix are smaller and the product has a competitive edge in the market.

73.4 Conclusion

Risks of STP Marketing strategy and risks of marketing mix are Essential risk in enterprise's marketing while Risks of competition are operating risks. The accumulative effect of these three kind of risks will pose a larger threat to the marketing management system. they are systematic factors that should not be neglected in the success of marketing task. multi-level fuzzy comprehensive evaluation is an explo-

Table 73.1 The evaluation matrixes of single factor and weight vector

					Evaluation Rank V			
Impact factors	Index system	Observation sample	Evaluation index	Weight vector A	Very good & no threat v_1	Good & less threat v_2	Average & medium threat v_3	Bad & great threat v_4
STP Stratigy	X_1 0.5	Market Segmentation	X_1	a_1 0.9	0.6	0.3	0.2	0
		Market Targeting	X_2	a_2 0.12	0.5	0.3	0.2	0
		Market Positioning	X_3	a_3 0.29	0.9	0.1	0.0	0
Markting mix	X_2 0.3	Product Strategy	X_4	a_4 0.12	0.6	0.3	0.1	0
		Price Strategy	X_5	a_5 0.04	0.4	0.3	0.2	0.1
		Channel Strategy	X_6	a_6 0.06	0.6	0.2	0.1	0.1
		Promotion Strategy	X_7	a_7 0.08	0.6	0.2	0.1	0.1
Competition	X_3 0.2	Competition in Industry	X_8	a_8 0.12	0.1	0.3	0.4	0.2
		Potential Entrant	X_9	a_9 0.04	0.1	0.2	0.3	0.4
		Supplier	X_{10}	a_{10} 0.03	0.1	0.3	0.2	0.4
		Succedaneum	X_{11}	a_{11} 0.05	0	0.2	0.4	0.4
		Customer	X_{12}	a_{12} 0.02	0.1	0.4	0.3	0.2

ration to evaluate risks of marketing management system and it also provide a new prospective for the evaluation of risks of marketing management system.

References

1. Liu H, Ge S (2010) Features and application research of forecasting model. China High Technology Enterprises 16:108–109
2. Zhang L, Zhou Z (2004) Marketing risk early-warning model based on BP net corporation. Management Review 16:21–28
3. Qian Z (2007) Index weight determine methodology of marketing risk early-warning. Commercial Economy Studies 6:21–22

Chapter 74
An Earthquake Emergency Materials Dispatching Method based on WSPT Rule

Fumin Deng, Yijuan He, Yingkang Shi, Cui Yang and Jin Wen

Abstract In order to ensure the emergency resources arrived in the disaster area in time and reduce the rescue losses by resources dispatching, when quantity of available vehicles is limited in, a single point to a single point emergency problem is considered to solve the priority scheduling problem about kinds of materials in same place. After classifying the emergency materials, analytic hierarchy process (AHP) approach is employed to get weight of materials, then the dispatch order for materials is calculated based on weighted shortest processing time first (WSPT) rule and results is given by LEKIN, furthermore it supplies a reference method for earthquake emergency material dispatching.

Keywords AHP · Earthquake · Emergency · Material · Scheduling · WSPT

74.1 Introduction

China is one of the countries which suffered natural disasters frequently. These disasters usually cause huge economic losses and casualties. When a disaster happened, it is important to ensure emergency materials arrived in time. Under the circumstances of the current emergency management belongs to dispersive management in our country, it can't manage well and command uniformly when disasters appeared. Therefore, further study on emergency supply management is quite necessary.

At present research on emergency material dispatching can be classified in two main categories: vehicles scheduling and establish emergency supplies models. Özdmar [1] studied on the vehicle routing problem when supply is in limited quan-

---

F. Deng (✉) · Y. He
Business School, Sichuan University, Chengdu 610065, P. R. China
e-mail: dengfum@sina.com

Y. Shi · C. Yang · J. Wen
West China Hospital, Sichuan University, Chengdu 610041, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_74,

tities, commodity demand can be forecasted and vehicles don't have to return to depots at current time as well as on future dates. Jae [2] put forward a vehicle scheduling model with the objective of maximizing the wounded survival rate base on the uncertain transport routes. In the domestic, He and Liu [3] used the fuzzy multi-objective programming method to solve a multi-objectives combinatorial model problem. Zhang et al [4] discussed an option about vehicles' transport routes on emergency rescue, and used the traveling salesman theory to establish utility functions for decision-making. Gong et al [5] developed techniques of dispatching optimization and dynamical routing in order to reduce response time and avoid further deterioration.

In establishing the emergency supplies models, Fiedrich et al [6] focused on building a model for multi-disaster-place transportation and allocating resource under the limit of time and resource. Lin and Li [7] established a model to minimize the time and number of depots, and maximize the safety based on the limited of transportation. Song et al [8] introduced a gray programming model with multi-objectives including the earliest emergency start-time, the fewest relief participant areas and the highest preference degree of requirement constraints. Chang and Chen [9] put forward a dynamic continuous consumption emergency scheduling model, with the goal of the model includes minimizing earliest emergency start time and the least disaster relief participated places, then GA is used to solve the model. Gan et al [10] established a non-linear mixed integer programming model, and minimized the total time from relief points to different resource requirement points.

From the literature review, the domestic and foreign researchers mainly focused on emergency vehicle routing selection and optimization. In this research, the characteristics of emergency supplies is given, then the scheduling optimization problem of several materials is analyzed on basis of the limited vehicles, finally weighted shortest processing time first (WSPT) provide the order about the materials.

74.2 The Classification of Earthquake Emergency Supplies

With the reference of "The Emergency Security Material Classification and Product Catalogue", the National Development and Reform Commission divided the emergency materials into 13 classes. Including: protective articles, life assistances, life supporting, rescue carrier, temporary lodging, pollution cleaning, power fuel, engineering equipments, engineering materials, equipment tools, lighting equipments, communication broadcast and transportation means.

As the truth that emergency materials have different characteristics in different period after the earthquake, it can be classified in three stages, that is post-earthquake relief, post-earthquake setting and post-earthquake reconstruction.

The 72 hours after earthquake is the best period for life rescuing, materials in this period are pressing and numerous. It is essential to meet the need of materials, thus materials are classified: medical supplies, foods, mechanical equipments, warming goods and others [11].

1. **Medical Supplies:** Because the injured in earthquake are mostly bone fracture, medical supplies demanded after earthquake are mainly ventilator, monitor instrument, one-time protective clothing, masks, stretcher, all kinds of disinfectants, etc [12].
2. **Foods:** Foods should be needed to meet the feeding and clothing problem of victims after the earthquake, therefore the major foods are cookies, bread, chocolate, water and instant noodles.
3. **Mechanical Equipments:** The priority respond after earthquake is to rescue life, during this time mechanical equipments were required, which contains life detection instrument, manual hydraulic pump, rescue tools, heavy-duty hydraulic dilator, hydraulic-pincers.
4. **Warming Goods:** after the earthquake, a large numbers of quilts, tents, etc. are needed for civilians to keep warm.
5. **Others:** Besides, fuel, lighting, communication tools, etc are also important supplies needed.

74.3 Factors that Affect the Scheduling of Earthquake Emergency Materials

Earthquake with sudden, large-scale casualties, serious destructive, etc. characteristics, which makes the demanded materials after earthquake be large quantities requirements, short delivery cycle, etc. Then the scheduling of emergency materials should be given shorter transport time and less delay [13].

74.3.1 Characteristics of Emergency Materials after Earthquake

The characteristics of earthquake determine the following features about emergency materials:

1. The requirements of materials are huge in number, urgent in time and varied in categories. Plenty of relief materials should be needed in a short time after earthquake, and the survivors will be surged soon, which leads to a great increased materials' requirements in number and category.
2. The uncertainty of materials' requirement. Since earthquake have serious destructiveness for the infrastructure, roads destroyed seriously and communication almost interrupted, the demanded information can not be passed on, thus causing the information incompletely and increasing the difficulty of scheduling.
3. Weak economy of the materials transportation. The scheduling of emergency material in earthquake has lower transportation cost than the traditional. It arranges time in the first place, and takes rescue as the first goal other than transportation cost.

4. Serious damage for the transportation infrastructure. A strong damage could be caused by earthquake, especially for transportation infrastructure, and it makes the transportation difficult and supplies delayed, then the difficulty of materials scheduling will be increased.

74.3.2 Factors that Affect the Scheduling of Emergency Materials [14]

(1) Geographical Factors

Earthquake tend to make great impact on physical environment and damage transportation infrastructure seriously. For an excellent scheduling, a clear information about disaster area itself and surrounding is needed. The information can help us develop an exact transportation program and guarantee the least scheduling delay rating.

(2) Demand Information Factors

Because of the great damage for communication facilities caused by earthquake, the information about the disaster and material requirements is not precise. Then the more precise information, the more accurate scheduling.

(3) Resource Factors

Owing to the collapsed houses and destroyed infrastructure, the local resources are scarce after the earthquake. That requires scheduling with limited resources should be the optimal allocation. This is also the significance of scheduling—optimizing and using with the resources limited.

(4) Time Factors

Whether the emergency can arrive in time is related to saving lives after the earthquake, so the scheduling during this time emphasis timeliness, it requires transportation time as shorter as possible.

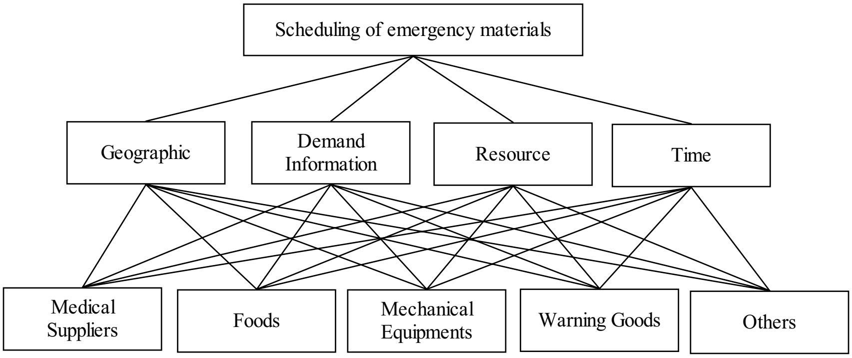


Fig. 74.1 The level model of scheduling about emergency materials

74.4 The Calculation of Materials' Weight

Analytic Hierarchy Process (AHP) is an effective approach, which aims to determine their weights through dividing complex problem into levels and analyzing each factors [15, 16]. According to the last section, the factors about scheduling have been concluded, then AHP is used to definite their weights. The level model is showed in Fig. 74.1 [17–20].

Step 1. Building the judgment matrix.

Table 74.1 Index judgment matrix A1

	Geographic	Demand information	Resource	Time
Geographic	1	2	1/2	1/3
Demand information	1/2	1	1/3	1/7
Resource	2	3	1	1/5
Time	3	7	5	1

Index Judgment Matrix (geographic):

$$B1 = \begin{bmatrix} 1 & 5 & 1 & 7 & 7 \\ 1/5 & 1 & 1/5 & 2 & 2 \\ 1 & 5 & 1 & 5 & 7 \\ 1/7 & 1/2 & 1/5 & 1 & 1 \\ 1/7 & 1/2 & 1/7 & 1 & 1 \end{bmatrix}. \tag{74.1}$$

Index Judgment Matrix (demand information):

$$B2 = \begin{bmatrix} 1 & 3 & 2 & 5 & 7 \\ 1/3 & 1 & 1/3 & 1/3 & 2 \\ 1/2 & 3 & 1 & 3 & 7 \\ 1/5 & 3 & 1/3 & 1 & 3 \\ 1/7 & 1/2 & 1/7 & 1/3 & 1 \end{bmatrix}. \tag{74.2}$$

Index Judgment Matrix (resource):

$$B3 = \begin{bmatrix} 1 & 7 & 1 & 7 & 7 \\ 1/7 & 1 & 1/7 & 1/3 & 3 \\ 1 & 7 & 1 & 7 & 7 \\ 1/7 & 3 & 1/7 & 1 & 2 \\ 1/7 & 1/3 & 1/7 & 1/2 & 1 \end{bmatrix}. \tag{74.3}$$

Index Judgment Matrix (time):

$$B4=\begin{bmatrix} 1 & 7 & 2 & 7 & 9 \\ 1/7 & 1 & 1/5 & 1/3 & 3 \\ 1/2 & 5 & 1 & 5 & 7 \\ 1/7 & 3 & 1/5 & 1 & 3 \\ 1/9 & 1/3 & 1/7 & 1/3 & 1 \end{bmatrix}. \tag{74.4}$$

Step 2. Calculating the single ranking weight and inspecting its consistency.

According to the consistency rate $CR = \frac{CI}{RI} < 0.1$, then the consistency of the judgment matrix is acceptable ($CI = \frac{\lambda - n}{n-1}$, the details of RI is shown in Table 74.2).

Table 74.2 Average random consistency index RI

Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59

Rule hierarchy 1: From Table 74.1 and Table 74.2, we can calculate the weighting vector ω_1, maximum eigenvalue λ_1 and consistency index CR_1 of matrix A_1. $\omega_{A1} = (0.145, 0.072, 0.201, 0.582)$, $\lambda_{A1} = 4.139$, $CR_{A1} = 0.052 < 0.1$ through the consistency check.

Rule hierarchy 2: From Matrix (74.1) $\sim$ Matrix (74.4), we can calculate the weighting vector ω_k, maximum eigenvalue
lambda$_k$ and consistency index CR_k in Table 74.4. The CR_k of Table 74.3 have passed the consistency check by calculating.

Table 74.3 The structure table of rule hierarchy 2

k	B_1	B_2	B_3	B_4
ω_k	0.408 0.096 0.383 0.059 0.055	0.427 0.094 0.288 0.144 0.047	0.399 0.069 0.399 0.089 0.043	0.485 0.070 0.304 0.104 0.037
λ_k	5.044	5.253	5.360	5.288
CR_k	0.0098	0.0566	0.0802	0.0642

Step 3. Calculating the general ranking weight and inspecting its consistency.

Table 74.4 displays the hierarchy general ranking weight of factors.

Hence, considering the factors about geographical, demand information, resource, time, within the scheduling of emergency materials, the weights of medical supplies, foods, mechanical equipments, warming goods and others are $\{0.4524, 0.0753, 0.3334, 0.0973, 0.0415\}$.

Table 74.4 The hierarchy general ranking weight

	Medical Supplies	Foods	Mechanical Equipments	Warming Goods	Others
Total Weights	0.4524	0.0753	0.3334	0.0973	0.0415

74.5 The Using of Scheduling Rules

74.5.1 Conspectus of WSPT Rule

Using the identified types of material weight to analyze the goods dispatched with the rules. According to the four factors of weight ω_{A1} analyzed by AHP, the time factor of weight is calculated to 0.582, that is transport the material to the destination in the shortest time [21, 22].

On base of the feature upward, the total transportation time is set as the scheduling goal and with all kinds of material weights to accomplish the scheduling by rule WSPT. In WSPT, the first goal is total weighted completion time ($\sum \omega_j C_j$). According to this rule, there are j tasks set $T = (T_1, T_2, \cdots, T_j)$ [23], the goal of scheduling is: $min \sum_{T_j \in T} \omega_j P_j$, then job is set as the descending order of ω_j / P_j in this rule [24].

Among of them, ω_j is the jobs' weight, it represents unit time cost or the additional value of job j; P_j is the jobs' completion time; is the jobs' processing time.

In the emergency supplies scheduling: processing time — the delivery time;
jobs' weight — the weight under the influence of emergency scheduling.

74.5.2 The Results of Scheduling by WSPT

Selecting one from the medical supplies, foods, mechanical equipments, warming goods and others as A, B, C, D, E, assuming it will transport to the same place (due to the dissimilar features, the different materials have different announcements, so when delivering to the same place, the spending time is different), Table 74.5 shows the details about each job.

Table 74.5 Material basic information

Materials	A	B	C	D	E
P_j	6	4	9	5	4
ω_j	0.4524	0.0753	0.3334	0.0973	0.0415

The results by LEKIN shows in Fig. 74.2. It shows the scheduling order is: A, C, B, D, E, that is medical supplies, mechanical equipments, foods, warming goods

Fig. 74.2 The results of scheduling by WSPT

and others. From that, we can conclude in emergency dispatching, medical supplies is scheduling and delivering firstly, mechanical equipments is in second place, then the following is foods, warming goods and others. The result also accord with the aim of rescue in 72 hours after earthquake, after the earthquake, medical supplies and mechanical equipments is needed to relieve the injured.

74.6 Conclusion

In emergency rescue the research of the scheduling problem could provide scientific basis for supplies scheduling in emergency condition. In this article, first the AHP is used to found the hierarchical model, then every kind of material weight is calculated, finally WSPT is applied to get an optimization scheme with single point and more resource. This scheme solves the problem of classifying amounts of resource and precedence scheduling in actual scheduling, and supplies the scientific basis for making emergency scheduling scheme. For developing further emergency management, more factors of scheduling should be considered, such as: the loss taken by material delay, emergency vehicles loading, road block and so on; and a further research can be started through the aspect of single point to multipoint or multipoint to multipoint.

Acknowledgements This research is funded by the National Nature Science Foundation of China (71131006; 71020107027; 71192197) and the Foxconn Technology Group's Talent Selection Research Program (11F81210101).

References

1. Özdamar L, Ekinci E, Küçükyazici B (2004) Emergency logistics planning in natural disasters. Annals of Operations Research 129:217–245
2. Jae Y (2003) Stochastic scheduling problems for minimizing tardyjobs with application to emergency vehicle dispatching on unreliable road networks. University of New York, New York
3. He JM, Liu CL (2001) Fuzzy programming problem for vehicle dispatch under time restriction. Control and Decision 16:318–321

4. Zhang Y, Guo XF, Wang XF (2006) Route choice for transporting exigency succor materials. Journal of Safety and Environment 6:51–53
5. Gong BW, Yang ZS, Lin CY (2009) Dispatching optimization and routing guidance for emergency vehicles in disaster. In: Proceedings of IEEE International Conference on Automation and Logistics 1121–1126
6. Fiedrich F, Gehbauer F, Rickers U (2000) Optimized resource allocation for emergency response after earthquake disasters. Safety Science 30:41–57
7. Lin X, Li HJ (2010) Scheduling model and it's solution for earthquake relief supplies under transport capacity. Journal of Disaster Prevention and Mitigation Engineering 30:58–63
8. Song XY, Liu CH, Chang CG (2010) Gray programming model for emergency material dispatch. Application Research of Computers 27:1259–1262
9. Chang CG, Chen DW (2010) Study on multi-destination emergency scheduling model under dynamic continuous consumption. Logistics Systems and Intelligent Management 3:1532–1535
10. Gan Y, Qiao YH, Li RC et al (2009) Research of emergency resource scheduling model under potential disaster situations. International Symposium on Emergency Management 480–483
11. Guo JF, Zhou G (2011) Research on emergency material demand forecast method under large-scale earthquakes. Value Engineering 22:27–29
12. Li X (2009) Experience of guaranteeing medical supplies in the state of emergency. Chinese Medical Equipment Journal 30:114–115
13. Li D, Liu GL, Gao YJ (2009) Uncertainty optimization model for emergency resource scheduling. Knowledge Acquisition and Modeling, 30:55–58
14. Tang WQ, Zhang M, Zhang Y (2009) Process model for materials dispatching in large-scale emergencies. China Safety Science Journal 19:33–37
15. Zhu W, Hu AH (2005) Emergency logistics selecting scheme with AHP. Logistics Technology 3:45–47
16. Zhang YL (2011) Research on the reserve mode of emergency materials based on AHP. Journal of Catastrophology 26:120–125
17. Zhou L, Liu N (2010) A multi-periods emergency materials scheduling model based on rough set. In: Proceedings of the International Symposium on Emergency Management 223–226
18. Ou ZW, Wang HY, Jiang DL et al (2004) Emergency logistics. Journal of Chongqing University 27:164–167
19. Qian J (2009) A study on nature of emergency materials and inventory-management for emergency materials. Logistics Science and Technology 7:15–18
20. Jia XL, Wang L, Liu KZ (2009) Research on emergency materials inventory control in the unexpected events. Logistics Technology 28:36–200
21. Zhang R (2009) An achievability modle of emergency material dispatching. In: Proceedings of Eighth Wuhan International Conference on E-business 2886–2897
22. Chai XR, Wang RJ (2010) Research of emergent materials dispatching algorithm based on multi-depot and multi-materials. Computer Engineering and Applications 46:224–226
23. Liang XD, Liu ZS, Yang Y et al (2011) Weighting collaborative task sequencing based on dependency logic breakdown. System Engineering 29:98–102
24. Pinedo M (2007) Scheduling: Theory, algorithms and systems. 2nd Edn, Tsinghua University Press, Beijing 27–32

Chapter 75
Optimization based on PERT Corporate Procurement Process — Using M Company as Example

Hanwen Zhan, Li Li, Guosheng Chen and Xiaojun Zhao

Abstract This paper firstly introduces the enterprise procurement process which may have problems, then the PERT is presented as an analysis tool. A digital products company (M company) is chosen as a research sample, and the procurement of business work flow optimization can be obtained through case study and quantitative analysis, the optimization method can be extended to undertake relevant analysis.

Keywords PERT · Purchasing · Process optimization · The procurement cycle · Key route

75.1 Introduction

Process refers to the day-to-day operational rules. Purchasing work is always regarded as an important part of the enterprise's business, and the rationality and the optimization of the purchasing process will directly affect the company's profits and competitiveness [1].

Even after the procurement process is designed, daily operation needs to be constantly optimized and improved [2]. The authors find that although the procurement flow operation in many enterprises has been affirmed by customers of enterprises in process design, in operation efficiency and in its management, but there are still some problems in the procurement of goods order cycle and in the safe inventory through the theoretical literature review and practice of enterprise survey results [3].

H. Zhan · L. Li
Central South University Of Forestry and Technology, Changsha 410004, P. R. China

G. Chen(✉)
Central South University Of Forestry and Technology, Changsha 410004, P. R. China
Hunan Institute of Tourism Planning and Design Research Institute, Hengyang 421008, P. R. China
e-mail: chenguosheng04@163.com

X. Zhao
Hunan Institute of Tourism Planning and Design Research Institute, Hengyang 421008, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_75,

To solve these problems properly, this article will use the purchasing management of modern enterprise theory and the practice achievement of enterprise for optimizing procurement process in supply chain, for changing and establishing a new model of purchasing management, which has good synergistic effect with the others link in supply chain operation [4].

To achieve the research goal, the article plans to combine quantitative analysis method with case analysis method for discussing the procurement of business work flow optimization method with PERT as analysis tool, with M company as a research sample [5].

75.2 About M Company and Its Current Procurement Process

M company was founded in 1993, the company's main business is digital products; it has established 17 platforms in the country, and has set branches and offices in many countries and regions [7]. Company M's purchases is greatly large, but the procurement process module has seriously affected the operation and effectiveness of the company's supply chain, which has become one of the outstanding problems of the company management and development [8]. For example, its procurement process for optimizing the transformation will greatly reduce the costs to win more space, and then the company received more profits in sales [6]. M company's procurement process in this stage can be present as Fig. 75.1.

75.3 Analysis of the M Company Procurement Process

A complete order cycle consists of order processing cycle, purchasing circle, production cycle and delivery cycle.

At present, the main reasons of M company's long ordering cycle can be simply summarized as follows:

(1) It takes too long to deal with the purchase order

The orders from customers must be delivered by means of Excel and e-mail in the company, which takes a lot of time.

Orders coordinate staff for dealing with the need when purchasing quantity input and finishing check repeat, resulting that the order processing time is too long, and greatly reduce the order processing efficiency.

(2) M company and supplier fail to share information

At present, M company still hasn't joined in the alliance of suppliers' production plan. Before receiving the purchase order, supplier fails to understand the company's stock situation and order plan timely, which may cause that the supplier's production plan, to a certain extent, fail to match the purchasing plan. However, purchasing stuff often find that the existing suppliers of inventory quantity and quality can't meet the needs of production. Therefore, M company will look for alternative suppliers or

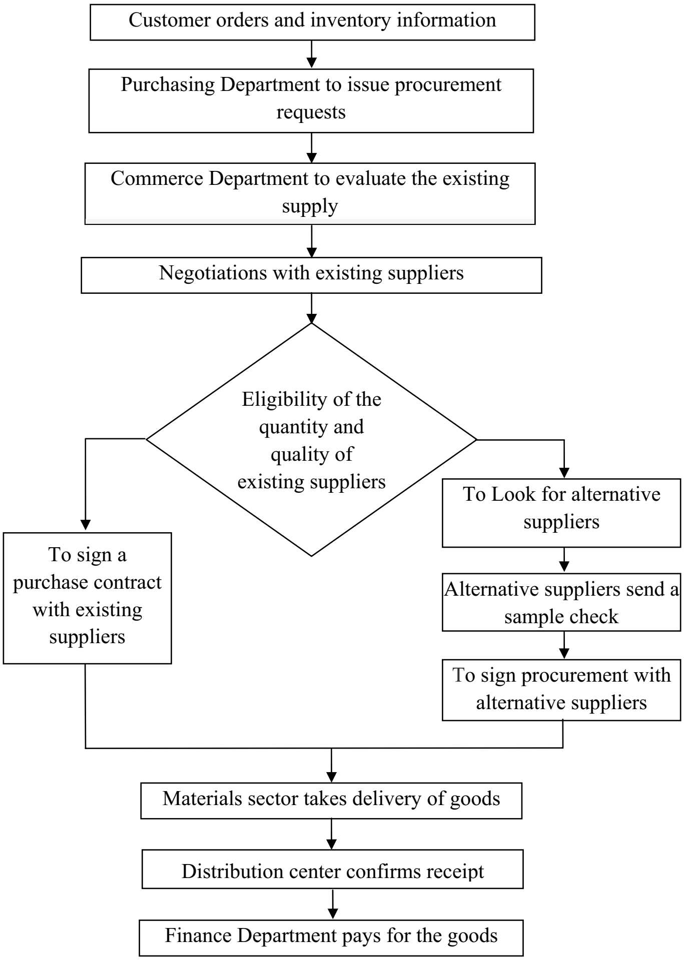


Fig. 75.1 M company procurement flow chart

adjust the suppliers temporary t production plan, which will delay the goods delivery time, causing purchasing lead time growth.

(3) Purchasing management system lacks of planning

At present M's purchase department works relatively independent. The design of purchasing process lacks scientificness. M is neither familiar with the ending storage sales nor certain about the demands of customers, which often collects the quantity of orders when receiving customers' orders and can not foresee the demand of products, so only when the company make orders do the suppliers start to produce, which makes the course of ordering too long.

(4) The difficulties to share and lag of material purchasing and warehousing information

Purchasing department cannot know the latest situation of the inventory which is often quarantined by purchasing stuff in warehouse. While there may be some changes after finishing checking the materials. In case of the shortage of materials, purchasing stuff often purchases more in quantity, leading to the inefficiency of inventory and taking up a lot of money as well.

(5) Material purchasing method

At present M's purchasing department is still using the traditional method of material purchasing that the main energy is in the comparison of price, bidding and bargaining between one or more suppliers, taking the lowest price as the first selection standards when selecting suppliers.

It takes so little consideration into the stability of supple, safety, market and the demands of clients that the phenomena like changing suppliers frequently, taking the inferior-quality product as good one and unstability of supple appears and that make it difficult to get affordable purchasing benefits.

75.4 PERT Introduction

PERT (Project Evaluation and Review Technique) is using Network analysis plan to project and analysis to the evaluation of technology. It can coordinate each procedure, reasonable arrangement of human, material, time, funds on the whole plan and make plan complete quickly. PERT is widely used in the modern planning and analysis aspect which are important methods of the modern project management.

PERT network is a similar process arrows chart. It describes the project that contains the sequence of all kinds of activities, mark every activity time or related costs. For PERT network, project managers must consider to do what kind of work that can determine the dependent relationships between time, and identify potential problem of the link. With the help of PERT we can also compare different action plan in progress and cost effect easily.

Constructing PERT figure, there are three concepts need to be identify: event, activities and key route.

1. Events present the end of the main activities;
2. Activities present the process of between an event to another;
3. Critical Path the longest of spending in the sequence of events and activities in PERT network.

Developing a PERT network requires managers to complete all the necessary key activities of the project, then make the order of between them according to the dependence of activities, and estimate the every activity accomplish time. The work can be reduced to five steps:

1. Be sure every project must be meaningful activities to complete, finishing every activity produces events or results;

2. Determine the sequence of activities;
3. The activity process that from start to finish graphics has made clear out the relationship of every activity and other activities. We use circle present events, an arrow line shows the activity, the results get a picture arrow lines flow chart, we call it a PERT network;
4. Estimation and calculation of the completion time of each activity;
5. By estimating a network diagram include the estimation of activities, managers can develop every activities' start end and dates of the entire project schedule. There no slack time in the key route, any delay of key route will delay the entire project deadline directly.

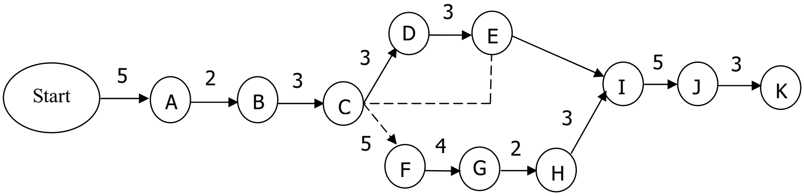


Fig. 75.2 The PERT chart of M company's original procurement flow working

75.5 The Optimize Mode of M Company's Procurement Flow Working

According to the idea and model of PERT chart, the PERT chart's details of M company's original procurement flow working are as followings Fig. 75.2:

The PERT network's details of M company's original procurement flow working are as following Table 75.1

Accordingly, the shortest time of M company's original procurement flow working is: $5+2+3+3+2+3+5+3=26$ days, the longest time (namely key route) is: $5+2+3+3+2+5+4+2+3+5+3=37$ days.

The reformed procurement flow working chart of M company is as Fig. 75.3.

The PERT chart's details of M company's reformed procurement flow working are as followings Fig. 75.4.

The PERT network's details of M company's reformed procurement flow working are as followings Table 75.2.

Accordingly, the shortest time of M company's reformed procurement flow working is: $3+1+3+1+2+3+5+3=24$ days, the longest time (namely key route) is: $3+1+3+2+2+3+5+3=25$ days.

Table 75.1 The PERT network of M company's original procurement flow working

Events	Descriptions	Expected time(days)	Precede events
A	Analysis of customer order and inventory information	5	D
B	Purchase department sending out procurement request	2	A
C	Commerce department assessing existing supplier	3	B
D	Negotiating purchasing quality with existing suppliers	3	C
E	Signing purchasing contract with existing suppliers	2	D
F	Seeking alternative suppliers	5	C, E
G	Alternative suppliers sending sample for testing	4	F
H	Signing purchasing contract with alternative suppliers	2	G
I	Material department picking up the goods	3	E, H
J	Distribution center confirming receipt	5	I
K	Financial department paying the money	3	J

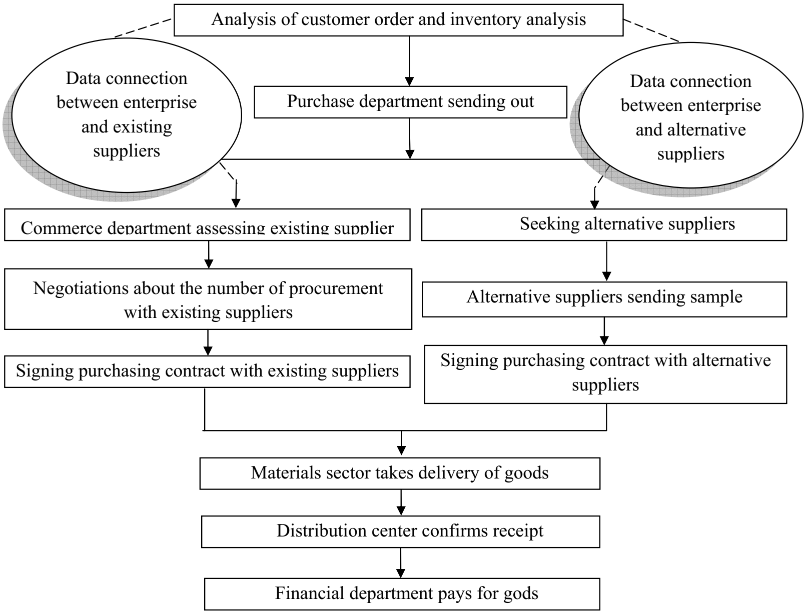


Fig. 75.3 The reformed procurement flow working chart of M company

The datum in the Table 75.1 show that: the reformed procurement flow working of M company not only optimized the procurement flow working, but also shorten the procurement period.

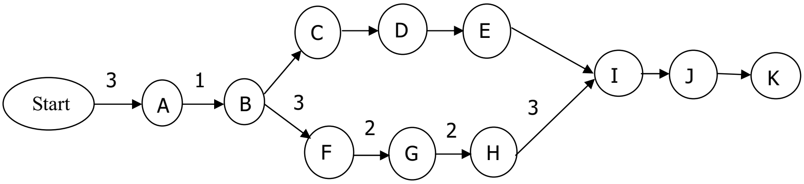


Fig. 75.4 The PERT chart of M company's reformed procurement flow working

Table 75.2 The PERT network of M company's reformed procurement flow working

Events	Descriptions	Expected time(days)	Precede events
A	Analysis of customer order and inventory information	3	–
B	Purchase department sending out procurement request	1	A
C	Commerce department assessing existing supplier	3	B
D	Negotiating purchasing quality with existing suppliers	1	C
E	Signing purchasing contract with existing suppliers	2	D
F	Seeking alternative suppliers	3	B
G	Alternative suppliers sending sample for testing	2	F
H	Signing purchasing contract with alternative suppliers	2	G
I	Material department picking up the goods	3	EH
J	Distribution center confirming receipt	5	I
K	Financial department paying the money	3	J

75.6 Endnotes

Enterprise purchase management not only affects the quality of the purchase cost, the quality of the procurement and supply timeliness directly, but also brings tremendous influence on the corporate image of enterprise and the factor of user's satisfaction, as well as decides the comprehensive competitiveness of enterprise.

This article is in connection with the M company in the purchasing process problems, it constructs the M's original and optimization purchasing work flow's PERT network diagram, calculates for its route time, and optimizes the Pattern of the M's procurement work flows.

Although this study belongs to an individual case research, and it fails to upgrade to the level of theoretical summary, but according to the theory of the PERT tools characteristics, the purchasing process optimization models constructed in this paper should be in other types of enterprise with high portability, which is also the future direction and focus.

References

1. Mehra S, Inman RA (2004) Purchasing management and business competitiveness in the coming decade. Production Planning & Control 15:710–718
2. Leenders MR, Fearon HE, Flynn AE et al (2002) Purchasing and supply management. McGraw-Hill
3. Byun DH (2000) The AHP approach for selecting an automobile purchase model. Information & Management 38:289–297
4. De Boer L, Labro E, Morlacchi P (2001) A review of methods supporting supp1ier selection. European Journal of Purchasing and Supply Managetnent 7:75–89
5. Xue XF (2007) Enterprise purchase management system design and implementation. Computer Knowledge and Technology (Academic Exchanges) 8:37–39
6. Zhang JX (2003) Material purchasing management system development and application. Construction Technology 12:23–24
7. wang F (2008) Project purchasing the standardization of the management mode. Petroleum Chemical Industry the Administrative Cadre Institute 9:76–77
8. Zheng ZX (2009) Concerning enterprise purchase management innovation practice. Logistics Engineering and Management 11:51–54

Chapter 76
The Mode of Super-cluster Learning to Manufacturing Enterprises based on the Case Study about “DEC” and “Galanz”

Yunfei Shao, Wei Li and Shoujun Yin

Abstract This paper puts forward the theory that it exists a dynamic matching relationship between the super cluster learning mode and cluster enterprise growth path. Through the analyses of the similarities and differences of the super cluster learning during the transformative growing of two local enterprises, the “DEC” and the “Glanz”, it further shows theoretical framework of the cluster learning mode. The paper also demonstrates the similarities and differences of the use of super cluster learning mode in different enterprises, and shows the promotional effect that the cluster learning mode bring to the transformation of a enterprise.

Keywords Super cluster learning · Cluster learning · Enterprise transformation

76.1 Introduction

Since China’s reform and opening up, on one hand, the rapid development of industrial cluster plays a decisive role in the national economy. However, on the other hand, the industrial cluster of China still has greater gap with foreign successful industrial clusters [1]. The professional division of labor and cooperation competition makes the cluster enhance the ability of integrating resources [2–4]. Promoting the rapid growth of enterprises clusters has become a critical task for China to the upgrade the industrial clusters and ensure the sustainable development of regional economic. The key factors that affect business transformation cluster in China at this stage are the differences of industrial characteristics and the differences existed in regional innovative resources [5].

The similarities and differences in the using of the super cluster learning by the local enterprises are investigated in this paper. Through exploratory case study, the

---

Y. Shao · W. Li (✉) · S. Yin
School of Management and Economics, University of Electronic Science and Technology of China, Chengdu 610054, P. R. China
e-mail: liwei-20@qq.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_76, © Springer-Verlag London 2013

promotional effect that the cluster learning mode brings to the transformation of an enterprise has been proved and the dynamic matching relation between the super cluster learning mode and the growth of enterprise has been explained too. These researches provide a reference for the development and transformations of the cluster enterprises in our country, and enrich its growth strategies as well.

76.2 Literature Review

A cluster of learning basic point is: to increase knowledge is the result of external [6]. Study abroad will be divided into formal and informal learning networks learning network [7]. The main points of a cluster of two learning modes, one based on the enterprise level of formal learning and informal networks based on individual-level learning [8], second, among individuals within a group learning and learning systems [9].These two categories are essentially based on the cluster members within the network to carry out the standard for classification learning arrangements. Enterprises in the growth process, select the cluster to promote learning because of its local cooperation and knowledge transfer, business creation and growth of clusters become an important driving force.

In recent years, studies have shown that the role cluster learning played in promoting growth of cluster enterprises has been overestimated, however, the importance of the out-cluster-learning is overlooked [10]. Out-cluster-learning is so-called super clusters learning in this paper. Based on the out-cluster-learning, we provide better development mode for enterprises by using the super clusters learning mode [11, 12]. The phenomenon of the relocation of cluster enterprises and even recession of these firms are increasingly emerging around the world [13]. The heterogeneity of enterprises' capabilities required that cluster enterprises must take different learning modes, including the super cluster learning mode, to handle the different specific issues met in the process of development [14]. Wang [15] held the idea that cluster learning has a significant learning effect for the enterprises in the development stage, but its learning effect is not obvious at maturity. Zucchella [16] considered the super cluster learning has features of exploration and openness, and it requires companies to seek, find and use new knowledge in a grater range, stimulate and promote innovation and sustainable growth of the enterprises.

Based on the enterprises life cycle theory, a dynamic matching relation between the super cluster learning mode and cluster enterprise growth path has been studied in our paper. Through the comparative analysis of upgrade strategy and main problems that the "DEC" and the "Glanz" faced during their stages of transformation and upgrade, we get dynamic matching model (see Fig. 76.1) from the combination of the super cluster learning mode and the growth of cluster enterprises by using the inductive reasoning method [17]. The specific relationship between them are listed as follows: in development period, enterprises learned advanced technology from off-site industry then digested and absorbed the technology in time; enterprises use off-site cross-industry learning to achieve business diversification in growth period;

enterprises learned from cross-industry learning from the local integration to obtain a competitive advantage in maturity period. From the theoretical mode, we can see super cluster learning has been permeated with innovative from beginning to end, and it emphasize on how to obtain new resources and how to use it. So this study analyzed the problems in business growth. Super cluster learning mode can solve the bottleneck in the development of enterprises and reap excessive profits.

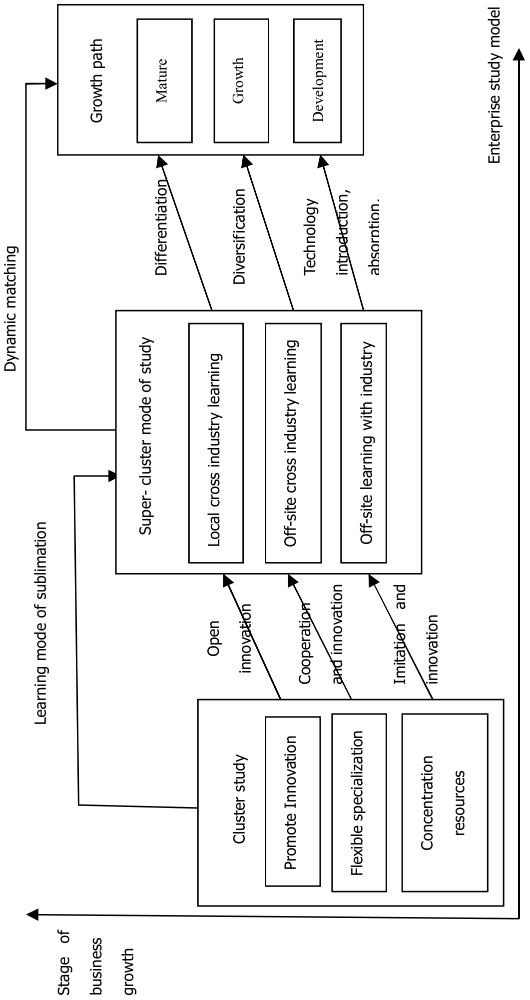


Fig. 76.1 Super cluster learning and business growth path of the dynamic matching model

76.3 Method

This paper's purpose is to develop new theories rather than testing existed theories. So this study has following characteristics: descriptive, inductive and exploratory. Case study is an effective way to build and verify theories, the validation of the theory can be deepened by the combination of the relevant literature research and the experience gained through case studies [18, 19]. Yin [20] pointed out that compared single case for challenge a theory, multiple cases studies are used to build a theory. Based on analyses of two cases studies, these papers validate the theory of super cluster learning. Eisenhardt [19] also pointed out that the multiple case studies can be replicated to support the conclusions of the case; we can find the similarities and differences in different companies by these studies in their upgrade process.

These paper selections of two target case business are Sichuan, Deyang, "DEC" and Guang dong, Shunde, "Glanz". There are three reasons to chose these two companies. First, these companies have a successful learning practice in the using of super cluster learning mode, and an explicitly evolutionary relationship exists between their growth stages and the super cluster learning mode. From "DEC" 40 years' transformation process and "Glanz" 30 years' transformation process, the use of the super-cluster learning mode have brought lots of positive effect to the development of these two enterprises. They two are representatives of the successful use of the super cluster learning mode. They are in line with the requirements of the case sample and construction. Yin has repeatedly stressed that the typical cases and extreme situations are more appropriate to study cases. The developments of these two enterprises in the cases show that it really exists a dynamic matching relationship between the super-cluster learning mode and enterprises growth path. These two cases meet the requirements that "a typical case must make the research process clearly visible", Yin said. Second, the "DEC" and "Glanz" attaches great importance to the training and enhancement of their learning ability, and they make this ability become driving force for their transformation. Their experiences have reference value and universal significance to other manufacturing enterprises. Therefore, these two cases suit the requirements of being typical and universal. Third, thanks for the superiority of geographical, geo-science and other favorable conditions, the author keeps a good contact with the two companies and exchanges information by the formal and informal way, gained comprehensive information about cases. Theoretical significance of this study is listed below: it exist a dynamic matching relationship between super cluster learning mode and business growth path. Different super cluster learning modes are for different enterprises period, enterprises should select different super cluster learning mode in accordance with their different development stage and technical capacity.

76.4 Case Study

76.4.1 *"DEC" Case*

76.4.1.1 "DEC" Process of Growth

"DEC" is located in Deyang City, Sichuan Province; its large-scale power plant equipment manufacturers of China, and one of the Top National Machinery Industry [21]. The enterprises experienced a number of remarkably important changes in its growth process (see Fig. 76.2), its main products include thermal power equipment, wind power equipment, optical equipment, gas turbine and its components. As a leading enterprise of the machinery industry, "DEC" has created a lot of records of the technical innovation in China's equipment manufacturing industry, such as 300,000 kilowatts steam turbine in 1980s, 600,000 kilowatts steam turbine, nuclear power rotor etc in 1990, the world's unique natural gas power test station in 2000, low temperature fan in 2006, the world's first one million kilowatts of supercritical air-cooling unit in 2010.

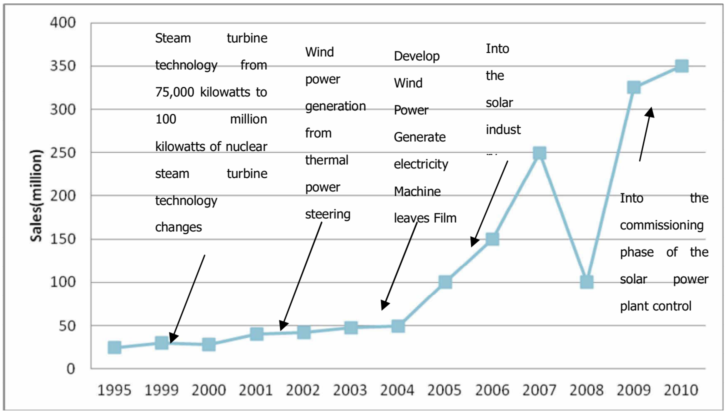


Fig. 76.2 "DEC" process of growth and the important transition event

(1) Transition of nuclear steam turbine technology from 75,000 kilowatts to 100 million kilowatts (1990-2000).

In the early days, "DEC" was support by the Harbin Steam Turbine Plant, the drawing data were primarily from this plant, and its main productions were 50MW and 200MW steam turbine. In the early 1990s, "DEC" introduced 600,000 kilowatts turbine technology from the Hitachi, and based on the introduction, "DEC" opened the market of supercritical 600,000 kilowatts turning turbine, 1 million kilowatts of nuclear power steam turbine and 100 kilowatts of supercritical steam turbine and struggled to get the leading position in the domestic turbine industry.

(2) The transition from thermal power generation to wind power generation (2000-2005).

In 2004, "DEC" found that the development of thermal power equipment market had reached peak and would begin to fall, so it must look for new market opportunities to ensure sustainable development. Based on the current saturated market and getting power generation technology and future trends in the energy industry into consideration, "DEC" recognized the power generation equipment market will increasingly use green energy, wind. Therefore "DEC" decided to enter the wind power generation with its good customer relations and their own technical capacity of complete sets.

(3) Wind power generation simultaneously with the light (2006-present).

In 2006, the "DEC" was developing the wind power industry business, at the same time, its leaders to proposed "multi-electricity-simultaneously strategy" and put forward to the opto-electronics industry. "DEC" entered the solar energy industry by the means of mergers and acquisitions. And it selected Emei Semiconductor Research Institution (ESRI) which has years of experiences in polysilicon production as acquisition targets. Pouring lots of money, "DEC" expanded its production capacity of polysilicon with research techniques of ESRI. And, as a result, "DEC" entered a totally new industry, solar power.

76.4.1.2 "DEC" Transition Phase and Super Cluster Model of Dynamic Matching Learning

In the transition process, "DEC" adopted different super cluster learning mode in accordance with its own characteristics at different times, and it was Off-site industry learning at first, then was from off-site cross-industry learning and was from local cross-industry study at last (see Fig. 76.3). In the development process, "DEC" has always been guided by the technology innovation strategies and taken different super cluster learning modes at different times.

76.4.2 "Glanz" Case

76.4.2.1 "Glanz" Process of Growth

"Glanz" is a global professional home appliance manufacturer, is an outstanding representative of Chinese home appliance business groups. Galanz Group was founded in 1978. Since "Glanz" entered the home appliance industry in 1992, the "Glanz" people committed to promote the construction and development of "Global microwave manufacturing center", "Global air-conditioning manufacturing center," "Global small appliance manufacturing center". Production and sales of its microwave oven, light furnace enjoy the largest share in the global market, "Glanz" entered the camp of the world's front- line air-conditioner brands. The enterprise

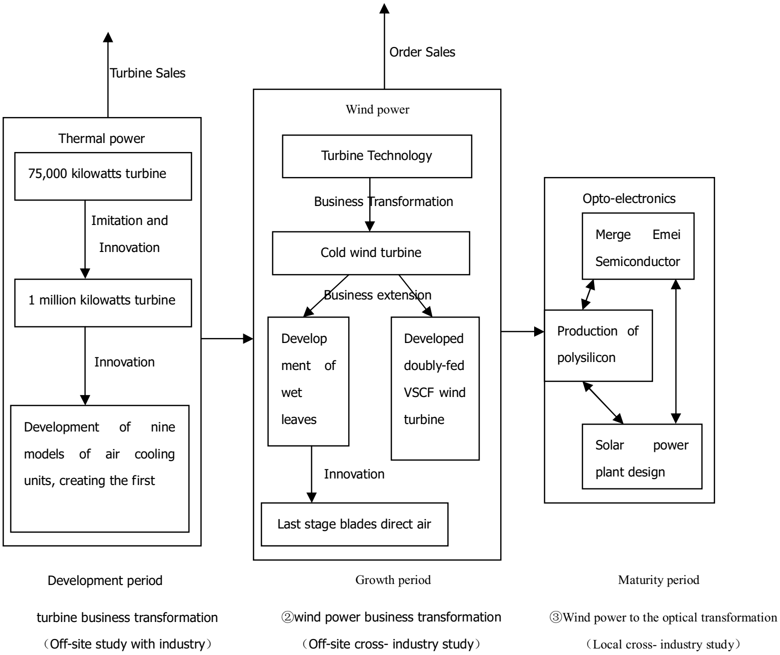


Fig. 76.3 “DEC” super cluster growth path and mode of learning

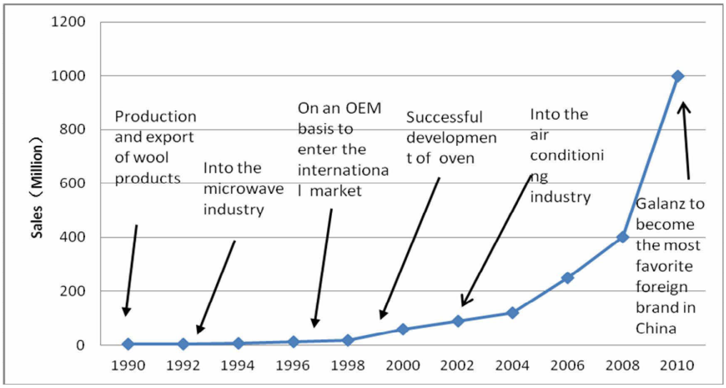


Fig. 76.4 “Glanz” process of growth and the important transition event

had experienced a number of important changes in the growth process (see Fig. 76.4). In 2004, “Galanz” were sold at nearly 200 countries and regions, annual sales reached 13 billion Yuan and exports worth $700 million. “Glanz” has become one of local successful enterprises in China.

(1) From down processing to export a variety of wool (1978-1991)

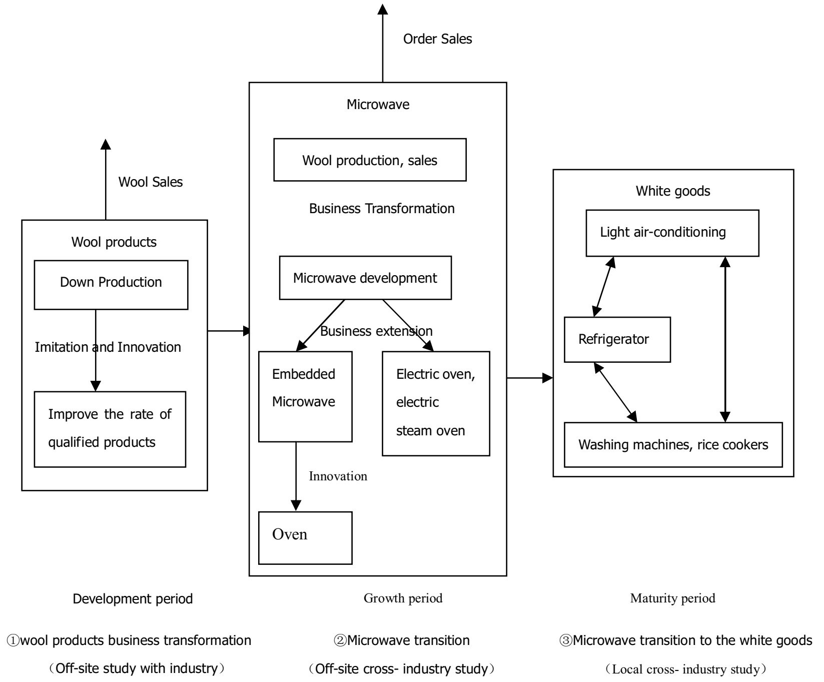


Fig. 76.5 “Glanz” super cluster growth path and mode of learning

“Glanz” was first established for the down processing. In the early 1980s, “Glanz” sent technicians to study advanced technology in Japan, introduced a variety of wool equipment, so that the pass rate of their products has been climbing and rocketed to 90% from the initial rate, 30%. And “Glanz” sent technical specialist to learn expertise in the southern area of China. In 1991, “Glanz” become an enterprise with over 200-million-yuan turnover; its products expand from the initial down processing to the white rabbit yarn exports and dyed yarn exports.

(2) From the wool product exports to the microwave oven industry (1992-2000)

In 1992, “Glanz” realized that down market was saturated; it must look for new market opportunities to ensure sustainable development. Taking the saturation of the current market and the enterprises life cycle theory into account, “Glanz” analyzed the development trend of home appliance industry and recognized that the microwave oven industry would be the focus of the future development. At that time the microwave oven industry was still in the initial stage in China, this industry would have a good development prospect. As a result, “Glanz” decided to get into the microwave industry with their good customer relationships.

(3) From the microwave industry to the white goods industry (2001-present)

In 2001, “Glanz” was in the microwave industry, at this time, its leaders proposed the “white goods industry strategy”. And “Glanz” introduced the production lines equipped with the newest international technology and learned from the white goods

Table 76.1 "DEC" and "Glanz" comparative analysis

Study mode	Comparison project	Case enterprises	
		"DEC"	"Glanz"
Cluster learning	Time	1966-1989	1978-1982
	Core business	Learning the drawing of steam turbine	Cleaning and handling eiderdown
	Problems	Low value-added of products; Lacking personnel and funds; inadequate absorption of existing technology, technology did not translate into success.	Low value-added products; instable of business sources; market competition fierce.
	Life cycle	Start-up	Start-up
	Upgrade strategy	Introduction of technical personnel; learning management experience of enterprise within the cluster; increasing the absorption and digestion of technical.	Expand production, the implementation of economies of scale; actively looking for clients, through the survival of the storm.
Off-site industry learning	Time	1990-2000	1983-1991
	Core business	Production and innovation steam turbine	Exports white rabbit yarn and eiderdown
	Problems	The original technology has been out of the market; digesting new technology needs to a lot of money; production process is not standardized.	Product qualified have low rate; profit space is limited; not have their own brand; lack of technical personnel.
	Life cycle	Development period	Development period
	Upgrade strategy	Introduced to Japan's Hitachi's advanced turbine technology; a large number of recruiting of technical personnel; increasing capital investment; standardized production processes.	Introduced to Japan's Panasonic advanced production lines; increasing the passing rate; expand production lines and achieve economies of scale; establish their own brand.
Off-site cross-industry learning	Time	2000-2005	1992-2000
	Core business	Research and production of wind turbine parts.	Production and manufacture microwave ovens, self-developed electronic oven and light oven.
	Life cycle	Growth period	Growth period
	Upgrade strategy	Use the superiority of thermal power technology, introduced German wind power advanced technology; digesting the introduction of wind power technology.	Introduced to Japan microwave oven production technology, through learning into microwave industry, improve product quality; establish own brand.

Local cross-industry learning	Time	2006 to present	2000 to present
	Core business	Producing gold silicon, constructing solar power station.	Producing air-conditioning, development light air-conditioning.
	Problems	A single core business, not take advantage of the enterprise; rigid corporate culture is not conducive to open innovation.	A single core business, not take full advantage of this technological; rigid human resource is not good for recruiting talents.
	Life cycle	Maturity period	Maturity period
	Upgrade strategy	Through mergers into the solar industry, design and control the production of solar power station, build solar power station.	4 billion to build the world's largest air conditioner manufacturing for research technology; establish companies safeguard mechanism.

industry leader in China, Haier. On the basis of learning from Haier and its technical superiority at microwave technology, "Glanz" developed light-wave air-conditioner and seized the market very soon.

76.4.2.2 The Dynamic Matching between "Glanz" Transition Phase and Super Cluster Learning Mode

At the transition period, "Glanz" adopted different super-cluster learning mode in accordance with their characteristics at different times, and learn from off-site cross-industry learning, then shift to learn from local cross-industry study (see Fig. 76.5). In the development process, "Glanz" has always been guided by the technology innovation strategies and taken different super cluster learning modes at different times.

Based on the enterprises life cycle theory and taking the development and achievements of these two enterprises into account, their development process can be divided into four stages: start-up, development period, growth period, and maturity period. The two companies are in maturity period now. Based on cluster theory and the super cluster theory, they can divide the super cluster learning into three modes: off-site industry learning, off-site cross-industry learning and local cross-industry learning. Off-site industry learning mainly refers to learning advanced technology, paying attention to technology introduction, digestion, absorption, at last, innovation. Off-site cross-industry learning mainly refers to finding new interest growth points, achieving diversified development, entering new industries, learning new technologies and management for enterprises to create new glories. Local cross-industry learning mainly refers that enterprises are in the maturity period, all sectors of the enterprise have tended to run stably, and the enterprise must implement an integrated strategy to enhance the competitive advantages. Here are the comparative analyses of these two enterprises on growth phase, the main business, exiting problem, learning and upgrading strategies (Table 76.1).

Table 76.2 "DEC" and "Glanz" super cluster learning and coordination between the growth paths

Stage	Comparison Project	Case enterprises	
		"DEC"	"Glanz"
A	Super cluster learning of choice	Started in state formally approved in may 1965; period acceptance of the formal infrastructure in November 25, 1974; clusters study is mainly.	Founded in 1978 years ago, the primary service is a town eiderdown product; is cluster learning is mainly.
	Growth rate management	Establish their rules and regulations; introducing technical personnel and based on original drawings for innovation; laid a certain innovation foundation.	Establish their production process system, mainly in eiderdown processing; laid a certain innovation foundation.
	Growth of power management	Mainly for technology transfer and digestion, not so much innovation.	*t* is mainly a simple manual processing; the product pass rate is low, so the product sold not well.
B	Super cluster learning of choice	Technology has been out of the market, so after a rigorous market research decided to introduce Japan's Hitachi's advanced steam turbine technology.	The low rate of qualified products, after rigorous market research, decided to introduce the Japanese advanced processing lines.
	Growth rate management	Standardize work processes, introduced to Japan's advanced technology, and reform the existing technology; research and development out of 100 million kilowatts of nuclear power turbine.	Introduced to Japan's advanced technology, reform the existing technology; improving qualification rate reached 90% products are exported to overseas.
	Growth of power management	The introduction of the implementation of technology-digestion-innovation, mainly use off-site with industry to learn from foreign advanced development model.	The introduction of the implementation of technology-digestion-innovation, mainly use off-site with industry to learn from foreign advanced development model.
C	Super cluster learning of choice	In 2004, analysis the future energy industry trends, find thermal power equipment market will reach its peak and began to fall, power generation market will be transformed into the wind as the representative of the green energy industry, by considering introducing of German advanced wind power technology.	In 1992, the analysis of the future of home appliance industry trends, find eiderdown market will reach saturation, recognizing microwave ovens are good prospects, introduced to Toshiba Corporation of Japan and learned the advanced production line.
	Growth rate management	Further improve the work processes and incentives, it can improve business innovation and reward staff, such as merit pay and bonus.	Establish an innovative corporate culture, reward innovation and enterprise personnel.
	Growth of power management	Through careful analysis of their strengths and weaknesses, to take off-site cross-industry study into the wind power industry, the business successfully from thermal power to the wind power business transformation.	Through careful analysis of their strengths and weaknesses, to take off-site cross-industry study into the microwave industry, from wool to enable enterprises to achieve successful business transformation microwave.

D	Super cluster learning of choice	In 2006, DEC not only development the wind power industry but also put forward "more power simultaneously" strategy; through mergers into the solar industry, choose have many years of experience in polysilicon production Emei Semiconductor Research.	In 2001, in the development of microwave business, proposed the establishment "the world's largest air-conditioning manufacturing center" strategy, decided to enter the air conditioning industry; enterprise learning to Haier; air conditioner sales in 2010 amounted to 200 million units.
	Growth rate management	Within the enterprise to promote open innovation, establish an open innovation platform and improve the incentive mechanism.	In human motivation, the enterprises use equity and bonuses, a multi-level talent to achieve the coordinated development.
	Growth of power management	Recognizes only produce turbine equipment and wind power equipment are not enough, they must be taken simultaneously, a wide development model, take the local-cross industry learning into the optoelectronics industry, building solar power plants.	Recognize only produce microwave ovens is not enough , they should make use of existing strengths; take the local cross-industry learning into the air conditioning industry, the development of light air-conditioning business.

Note: A: Start-up; B: Development period; C: Growth period; D: Maturity period.

76.5 Conclusion and Recommendations

The studies show that the main elements of business growth management include the options for the super cluster approach for different stages, the control of business growth rate and the coordination in growth momentum. The first dimension is the selection of the growth direction. In the business growth process, the selection and change of the direction of business growth is a kind of direct responses of enterprises to the opportunities and threats in the market. Different stages of business ask for different directions of growth management. The second dimension is the control of business growth, which lay the foundation for enterprises to pursuit the profit. The third dimension is the choice of super cluster learning mode.

According to the super-cluster learning mode adopted by the "DEC" and "Glanz" in different stages of transition (see Table 76.2), this paper draws the following conclusions:

1. From Table 76.2, "DEC" and "Glanz" had made successful business transformation at different stages of business growth by using the same super cluster learning mode. It indicated the super cluster learning play an important role at the promotion of firms' transformation growth. For those enterprises which had passed start-up stage and survival stage, it is an important driving force for the enterprises to accomplish the transition from cluster learning to super cluster learning.

2. Drawn from Fig. 76.1, we can see the different super clusters learning modes suit for different periods of enterprises development; they should select different super cluster learning modes in accordance with their different stage of development and technical capacity. In general, for manufacturing enterprises, they choose off-site industry learning in the early development period. They can not only introduce the advanced foreign technology but also digest and absorb the technology. Until the company has a large number of skilled personnel and rich technical experience, they should shift to off-site cross- industry learning. Its main task is taking cooperation with foreign enterprises. They can develop innovative products with independent intellectual property rights to enhance their own ability of innovation. At the mature period, enterprises should choose to the local cross-industry learning and study the advantages of local enterprises, and expand the industrial chain business.

Acknowledgements Fund project: Natural Science Fund projects (71172095).

References

1. Zhu XB, Lin Q (2008) The differences in the evolution of the sources of the competitive advantage of the cluster of small-and medium-sized enterprises. Management of the World 10:75–86, 187
2. Romanelli E, Khessina O (2005) Regional industrial identity: Cluster economic development. Organization Science 16:344–358
3. Wang J, Tong X (2001) On our local significance of the research enterprise cluster. Economic Geography 5:550–553
4. Wang J (2001) Local strategic industries. China's Industrial Economy 3:47–54
5. Wen Y, Tong LA (2006) Chinese manufacturing enterprises of IPR protection strategy-manufacturing enterprises in Jiangsu Province-based survey of empirical analysis of intellectual property protection. Industry Economic Research 1:132–140
6. Capello R (1999) Spatial transfer of knowledge in high technology milieux: Learning versus collective learning processes. Regional Studies 4:353–365
7. Enright MJ (2003) Regional clusters: What we know and what we should know. Innovation Cluster and Interregional Competition. Spring Publications, Berlin
8. Ci R, Li Z, Liu H (2005) Cluster learning and innovation performance: Shengzhou necktie manufacturer based on empirical analysis of clusters. Economic Geography 612–615
9. Cai N, Wu JB (2005) Network-based industrial clusters and collective learning mechanism innovation. Research Management: 22–28
10. Visser E, Boschma R (2004) Learning in districts: novelty and lock-in in a regional context. European Planning Studies 6:793–808
11. Bathelt H, Malmberg A, Maskell P (2004) Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28:31–56
12. Vissere J, Atzema O (2007) Beyond clusters: Fostering innovation through a differentiated and combined network approach. Evolutionary Economic Geography 5:1–24
13. Eriksson R, Lindgren U, Malmberg G (2008) Agglomeration mobility: Effects of localization, urbanization and scale on job changes. Environment and Planning A 10:2419–2434
14. Asheim B, Isaksen A (2002) Regional innovation systems: The integration of local sticky and global ubiquitous knowledge. Journal of Technology Transfer 27:77–86

15. Li P, Wang J (2008) Comparison of technology diffusion in the same industrial clusters at different stages — An Empirical study of aluminum industries in Dali, Guangdong and Linqu, Shandong Province. China Soft Science 5:67–73
16. Zucchella A (2006) Local clusters dynamics: Trajectories of mature industrial districts between decline and multiple embeddedness. Journal of Institutional Economics 2:21–44
17. Wolcott H (1999) Writing up qualitative research. Sage, Newbury Park, CA
18. Yin R (2002) Case study research, design and methods. Sage, Thousand Oaks, CA
19. Eisenhardt K (1989) Building theories from case study research. Academy of Management Review 14:532–550
20. Yin R (2003) Applications of case study research. Sage, Thousand Oaks, CA
21. Qin Y, Yun F, Xin Y (2009) The impact of enterprise's technology capacity on industrial innovation: A case of DE Corporation's industrial innovation. Technology Economics 1:23–26

Chapter 77
Analysis on Classification and Industrial Relevancy of Shenyang Modern Service Industry

Jiaqi Gao, Kai Li and Shumei Wang

Abstract Based on the literature review of domestic and foreign standards of modern service industry classification and the actual situation of Shenyang City, this paper discusses the definition and classification of Shenyang modern service. And then uses Shenyang input-output tables 2007 to calculate sensitivity coefficient and influence coefficient and analyze industrial relevancy of Shenyang modern service. In the future, government should not only develop producer services but also expend the field of modern service in order to expand employment and promote industrial upgrading.

Keywords Modern service industry · Classification · Industrial relevancy

77.1 Introduction

One relevant aspect of the growing importance of the service sectors in modern economies refers to their internationalization patterns. The rapid diffusion of Information and Communication Technologies (ICTs) and the strong technological dynamics that characterizes the provision of new services in many industries of the economy have in recent decades increased the scope for service tradability and internationalization [1–3]. In September 1997, the "modern service industry" was first emerged in the party's fifth major report. Party Congress report clearly stated "speed up the development of modern service industry, improve the proportion of the tertiary industry in the national economy." The development of modern service

---

J. Gao (✉) · S. Wang
International Business School, Shenyang University, Shenyang 110044, P. R. China
e-mail: holiday1005@126.com

K. Li
Business Administration School, Northeastern University, Shenyang 110004, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_77,

industry is not only a strategic move to enhance the quality of the national economy but also an effective means to enhance the competitiveness of other industries.

Shenyang is a city of heavy industry based on equipment manufacturing industry. And with the effective implementation of the strategy of ‘revitalizing the northeast old industrial base’, industry of Shenyang has entered a period of rapid development. The refinement of the internal division of labor in equipment manufacturing promotes the rapid growth of producer services such as logistics, research design, intermediary consulting, legal and financial. As the economic and per capita income in Shenyang gradually increase, the development of modern service industry is stable and dynamic, moreover, has the distinct characteristics of the old industrial base. On the one hand, new technologies, new way of services transform and upgrade traditional service industry to the modern service industry, such as the modern financial industry, modern real estate, modern logistics, modern social services, etc.; on the other hand, the development of information industry and informationization brings modern service industry, such as computing technology software service, mobile communications service, information consulting service, etc.. Therefore, it is important to re-understand the types of the modern service industry for a deep understanding of their economic status and role, but also provide a theoretical basis for guiding the modern service industry in line with modern economic development.

77.2 The Classification of Modern Service Industry in Shenyang

The modern service industry is the inevitable trend of traditional service industry development and change. The significant differences between modern service industry and traditional service industry are ‘high-tech, high-human resources, high labor productivity and value-added’ [4], and derived from that the development trend: the new knowledge and technology, the new business conditions, the new mode of growth, new services and new management concepts as well as ‘low consumption of resources and low environmental costs’. For now, current scientific theory about modern service industry of accurate concept and classification haven’t had common understanding.

77.2.1 Literature Review

Huang defines our country modern service industry defined as two parts in accordance with the service object [5]. First, modern producer services, refers to the application of modern science and technology, to satisfy the production requirements of the various services, such as modern logistics, e-commerce, finance and insurance, information service, technology research and development, enterprise management service, etc.. Second, modern consumer services, refers to the services to meet the needs of individuals, such as tourism, real estate, education, health care, entertainment and community service.

Xu and some others have the view of that the modern service industry is the knowledge-intensive producer services, generated in the stage of the high development of industrialization, developed mainly rely on electronic information technology and modern management idea [6]. Based on the connotation of the modern service industry they described, at the design of statistical standards, to take the most representative three prominent features of the modern service industry ‘productive, modern IT support and high knowledge-intensive’ as the main basis for division of modern service industry and traditional service industry to define the scope of the statistical object.

Zhu indicates, at present in China to develop the modern services mainly includes seven parts: information services; modern logistics; finance; E-commerce services; culture, education, sports, entertainment; knowledge, technology consulting, creative industry; to adapt to the residents living standards improve generated or through the information technology, demand management technology, the modern concept upgraded, high added value services [7].

According to the characteristics of modern services, Zhong yunyan qualitatively divides the modern service industry into three categories [8]. First, with the emerging features of modern service industry, generated by the direct result of informationization and science and technology development, emerging industry, such as computer and software services, information consulting services, convention and exhibition industry, is not exist in the traditional services. Second, with partial characteristics of modern service industry, accompanied the industrialization, using the information technology, derived from the traditional services, such as logistics industry. Because of derived from the traditional services, such industries have a certain relationship with the traditional services, but remain relatively independent. Third, relying on information technology and modern management concepts to transform and upgrade traditional service industries, with partial characteristics of modern service industry, including other services that do not belong to the first two categories. These industries are closely associated with the traditional services. Latter two categories are equipped with partial characteristics of the the modern service industry, in order to facilitate the statistics can be combined into one class.

Although the domestic scholars classify modern service industry according to different criteria, the industries covered by the modern service industry are basically same, that include financial services, business services, logistics, information services, real estate, tourism, education and culture, sports and entertainment industry.

77.2.2 The Classification Method of Shenyang Modern Service Industry

According to international and China's industrial sector classification standard, combined with the reality of Shenyang economy, in accordance with the broad standard of modern services, modern service industry in Shenyang, include roughly 10 major industries.

1. Financial industry, including banking, insurance, securities, trust, venture capital industry, etc.
2. Real estate, including real estate investment and development, property management and real estate brokerage services. Mainly refers to the real estate services.
3. Electronic information services, namely information transmission, computer services and software industry, including fixed-line telecommunications services, mobile telecommunications services, Internet information services, radio and television transmission services, computer systems services, infrastructure and application software services, etc.
4. Tourism.
5. Modern logistics industry, which is refers to the modern circulation services that takes centralized distribution, third-party supply and commercial brokerage services as representation.
6. Business services, including the legal industry, accounting, notary, employment agencies, consulting, advertising, design industry, convention and exhibition industry, market management services, etc..
7. Scientific research and technology services, including natural science and social science research, technology supervision, technology exchange and promotion, etc.
8. Education and training industry, including higher education, vocational education and professional skills training, but does not involve the scope of compulsory education.
9. Health, social security and social welfare industries, including medical services, health services, social welfare industry.
10. Culture, sports and entertainment industries, including film and television industry, publishing, broadcasting, audio-visual industry, performance industry, library industry, museum industry and sports industry.

According to the classification of the basis and standard of Shenyang City, the 10 major industries are divided into three categories: mature service industry, emerging service industry based on the IT and the service industry for improving the scientific and cultural quality. The classification is shown in Table 77.1.

Table 77.1 the classification method of Shenyang modern service industry

Level 1 Classification	Level 2 Classification	Level 3 Classification
Mature service industry	Financial industry	Banking, insurance, securities, trust, venture capital industry, etc.
	Real estate	Real estate investment and development, property management and real estate brokerage services
	Electronic information services	Telecommunications services, internet information services, computer systems services, etc.
	Tourism	Tourism
Emerging service industry based on the IT	Modern logistics industry	Centralized distribution, third-party supply and commercial brokerage services
	Business services	The legal industry, accounting, notary, employment agencies, consulting, etc.
	Scientific research and technology services	Research and Experiment, technology supervision, technology exchange and promotion, etc.
The service industry for improving the scientific and cultural quality	Education and training industry	Higher education, vocational education and professional skills training
	Health, social security and social welfare industries	Medical services, health services, social welfare industry
	Culture, sports and entertainment industries	Film and television industry, publishing, broadcasting performance industry, Library industry, museum industry and sports industry, etc.

77.3 The Correlation between Modern Service Industries in Shenyang City

77.3.1 An Analysis of Influence Coefficient of Modern Service Industry

Industry influence reflects the impact of the final product of a industry changes on the entire national economy total output changes. An industry affects other industries, the ripple effect is called industry influence coefficient. Influential coefficient is the ratio of a particular industry influence and the average industry influence of the other national economy departments, Reflects the relative importance of a particular industry to the national economic development, calculated as follows:

$$F_j = \sum_{i=1}^{n} b_{ij} \bigg/ \left(1/n \sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij}\right),\ j = 1,2,\cdots,n, \tag{77.1}$$

where, F_j is the influence coefficient; b_{ij} is completely consumed coefficient, means the number of the direct and indirect cost of product i when producing unit of product j, $(i = 1,2,\cdots,n)$.

Influence coefficient calculation result is more than 1 or less than 1, indicating the influence of the industry in all sectors is above average or below. The higher the influence coefficient of an industry, the more important it plays the role in promoting economic growth.

According to the data of 2007 Shenyang input-output tables, we calculate the influence coefficient of 9 major industries (tourism data loss) of Shenyang modern service industry, which is shown in Table 77.2.

Table 77.2 Influence coefficient of 9 major industries of Shenyang modern service industry

No.	Industries	$\sum_{i=1}^{n} b_{ij}$	$\sum_{i=1}^{n} \sum_{j=1} nb_{ij}$	F_j
027	Modern logistics industry	1.736414	15.553237	1.3397191
029	Electronic information services	0.941730	15.553237	0.7265857
032	Financial industry	1.414002	15.553237	1.0909642
033	Real estate	0.936832	15.553237	0.7228067
034	Business services	1.138386	15.553237	0.8783144
035	Scientific research and technology services	1.507222	15.553237	1.1628874
039	Education industry	0.731480	15.553237	0.5643687
040	Health, social security and social welfare industries	2.079232	15.553237	1.6042181
041	Culture, sports and entertainment industries	1.218469	15.553237	0.9401019

From Table 77.2, we see that the greater influence industries is concentrated in emerging services based on the IT, moreover, mature service industry and the service industry for improving the scientific and cultural quality's influence smaller.

77.3.2 An Analysis of Sensitivity Coefficient of Modern Service Industry

Industry Sensitivity reflects the induction of an industry subject to various industries in the national economic system changes.

An industry influenced by other industries, the ripple effect is called sensitivity coefficient. The greater the industry Sensitivity coefficient is, related industries require, the greater demand for this industry. That is to say, this industry plays a larger role in restricting economic development.

Sensitivity coefficient is the ratio of a particular industry Sensitivity and the average industry Sensitivity of the other national economy departments, calculated as follows:

$$E_i = \sum_{i=1}^{n} b_{ij} \Bigg/ \left(1/n \sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij} \right), \ i = 1,2,\cdots,n, \tag{77.2}$$

where, E_i is the Sensitivity coefficient; b_{ij} is completely consumed coefficient, means the number of the direct and indirect cost of product i when producing unit of product j, $(i = 1,2,\cdots,n)$.

Sensitivity coefficient calculation result is more than 1 or less than 1, indicating the induction of the industry in all sectors is above average or below. The higher the sensitivity coefficient of an industry, the greater it effects national economic development. That means the industry is essential in the development of the national economy, with the properties of the basic industries and bottlenecks industry, should be given priority in development.

According to the data of 2007 Shenyang input-output tables, we calculate sensitivity coefficient of 9 major industries (tourism data loss) of Shenyang modern service industry.

From Table 77.3, we can see that the sensitivity coefficient of modern logistics industry, financial industry, health, social security and social welfare industries, electronic information services, is greater than 1. These industries should be the key development of modern service industries of Shenyang.

Table 77.3 Influence coefficient of 9 major industries of Shenyang modern service industry

No.	Industries	$\sum_{i=1}^{n} b_{ij}$	$\sum_{i=1}^{n} \sum_{j=1} nb_{ij}$	F_j
027	Modern logistics industry	4.487486	13.658729	3.942522
029	Electronic information services	1.167910	13.658729	1.026078
032	Financial industry	2.897237	13.658729	2.545394
033	Real estate	0.797960	13.658729	0.701055
034	Business services	1.148020	13.658729	1.008603
035	Scientific research and technology services	0.141649	13.658729	0.124447
039	Education industry	0.147782	13.658729	0.129835
040	Health, social security and social welfare industries	1.626331	13.658729	1.428828
041	Culture, sports and entertainment industries	0.249484	13.658729	0.219186

77.3.3 Cross-correlation Analysis

According to the size of the influence coefficient and the sensitivity coefficient, these nine industries can be divided into the following categories (as Fig. 77.1).

By Table 77.3, we conclude that modern logistics industry, financial industry, health, social security and social welfare industries, these three industries, these three sectors is sensitive to changes in other industries, and has a great influence on other industries and a high degree of correlation with other industries. They are the key to the development of modern service industry. Electronic information services, and Business services, the development of these industries restrict the development of other industries. Scientific research and technology services, although this industry has a smaller binding force on the development of other industries, however, if it has developed well, it will play a significant role in promoting the development of other industries. Real estate, education industry, culture, sports and entertainment industries, these industries have a low degree of correlation with other industries, play a small effect on the development of other industries.

77.4 Conclusions

It can be seen from the above analysis, the modern service industry of Shenyang mainly provide supporting service for industrial production. This is consistent with the status that the manufacturing industry continues to be the city's pillar industry. So, the modern service industry development strategy of Shenyang is to focus on developing supporting service of industrial production, while also extending the scope of new modern service industry, expanding employment, and promoting the upgrade of industrial structure.

(1) Develop the suitable industrial production supporting services.

In the world of incentive competition, manufacturing industry is experiencing global resources optimization allocation and strategic reorganization. The huge market potential and cheap labor resource make the Northeast region become one of the

Influence coefficient

Sensitivity coefficient	>1	<1
>1	modern logistics industry Financial industry Health, social security and social welfare industries	Electronic information services Business services
<1	Scientific research and technology services	Real estate Education industry Culture, sports and entertainment industries

Fig. 77.1 Cross-correlation analysis

major areas of large-scale transfer of world manufacturing. Shenyang as the center of the northeastern city has more potential for development.

In the long run, accelerate the development of modern industrial production supporting services, while emphasis on the development of the manufacturing industry can provide strong support for building advanced manufacturing base. That should also take into consideration the interaction development of manufacturing and service industries. When economic develop into an advanced stage, this problem will become very obvious. The more knowledge-intensive manufacturing industries, the higher requirements of interaction development with modern producer services need.

(2) Expand the scope of the new service sector and pay more attention on information services.

Information service industry in China has become the leading industry of national economy, pillar industries and strategic industries. It has become an important industry to promote modern service industries as well as the whole national economy. Developing information services, first of all, is to develop e-commerce, making trade, finance, logistics, tourism, exhibitions, government procumbent, education electronic commercialized. In addition, that should strengthen the enterprise information construction; improve the information level of various industries. Secondly, strengthen the application of information technology and network in the fields of manufacturing, finance, commerce, urban construction. And last, make great efforts to train information technology talents to improve the level of the city's informationization and IT applications.

References

1. Aharoni Y, Nachum L (2000) Globalization of services: Some implications for theory and practice. 1st edn, Routledge, London
2. Miozzo M, Miles I (2002) Internationalization, technology and services. 1st edn, Edward Elgar & Cheltenham, UK
3. Caste F (2010) The internationalization of firms in the service Industries: Channels, determinants and sectoral patterns. Technological Forecasting & Social Change 77:500–513
4. Liu MR (2006) The modern service industry statistic index system and survey research methods. 1st edn, Shanghai Jiaotong University Press, Shanghai
5. Huang FH (2004) Research on Nanjing emerging service industry development under the background of economic globalization. Science & Technology and Economy 1:18–22
6. Xu GX, Chang N (2004) Design on the statistical classification standards of modern service. Statistical Research 12:10–12
7. Zhu QR (2005) Analysis on China modern service industry. Shanghai Business 10:35–38
8. Zhong YY (2009) Research on the definition of modern service industry. Statistical & Decision 6:168–169

Chapter 78
A Research on the Government Guidance to Industry Innovation Management based on the Empirical Analysis of Spaceflight Industry

Xiaoyan Li, Weifeng Fan and Jiangying Guan

Abstract Innovation of science and technology is the impetus of national economic development. The government plays a significant role in supporting to improve the capability of independent innovation. Based fuzzy comprehensive evaluation method, through the empirical analysis to the aerospace engineering group, guiding role of the government to industry science and technology innovation has been analyzed. The corresponding measure of increasing the industries' innovation ability have been put forward.

Keywords Innovation · Innovation management · Government guidance · Evaluation

78.1 Introduction

Technical progress and innovation is the impetus of national economic development. Enterprise of national defense science and technology as the main part of the national strategy industry lead progress of the high and new technology, the high-low of innovation ability concerns directly to the strong-weak of the country core competitiveness, aerospace is the backbone and heart physical strength of national defense industry. Innovative idea, innovative technology, system innovate and innovative environment which are required by industry, government should give play to appropriate intervene effect, proceed to impact of arranging reasonable system, drafting development strategy and project, protecting intellectual property and so on in the process. So the premise how to play the government role is must to understand the autonomous innovate level of aerospace industry which is dominated by government, through the appraise of autonomous innovation ability to the aerospace

---

X. Li (✉) · W. Fan · J. Guan
School of Humanities and Social Sciences Institute, Nanjing University of Science and Technology, Nanjing 210094, P. R. China
e-mail: lixiaoyansw@yahoo.com.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_78,

industry, using the management innovation of science and technology experience and practice for reference, fully attracting all orders of society, all interest subjects participate in with policy leverage as the fulcrum, market regulation as the means, forming the social atmosphere with collaborative innovation, forming innovative behavior with multi-agent and multiple factor assist each other, work in combination and work more closely around the innovative target. In the process of innovation and technology management, discuss the road which promote technology innovation cooperate with innovation of system and mechanism quickly, government play the role of policy guidance and resource integration fully. In the meantime constructing platform and laying down a regulation, to attract all orders of society and interest subjects participate jointly social management to put forward corresponding countermeasures and suggestions, exploring a new way of industry innovation management that is government guide.

78.2 Literature Review

At present, the studies of foreign government science and technology innovation management concentrate on macroscopic and medium beddings. For instance, the studies of innovational policy architectural [5–8] which are created by various countries and the study of region innovational support, innovational platform [9, 10], also the evaluation of innovation ability, overwhelming majority is assessment study on technological innovation capacity.

It focuses on selecting evaluation index in the literature of evaluating the microscopic enterprise innovation ability. Bresson and Amesse [1] used seven indexes to compare the enterprises' technical innovation ability and innovation trend, which are innovative capital input/workers number, innovative capital input/sales revenue, unspecialized innovative capital input/workers number, special innovative capital input/workers number, special innovative capital input/sales number, export sales revenue/sales revenue and enterprise's innovation trend. Barton (1992) considered technology innovation ability consists of innovation management, technology system, consciousness of science and technology of the people who control technology. So he viewed technology innovation ability consists of the skill of techniques and senior mechanic, the ability of technical system, management ability values and other elements. Ransley and Rogers [2] have put forward seven aspects of assess should be considered: technology strategy, projects' select and management, core competence, effectiveness, external consciousness, technology transformation and personnel through research summaries to enterprise optimum R&D practice. Chiesa [3] has build enterprise technological innovation audit model, it has five dimensions: product innovation, product development, process innovation, science obtain, innovative support and procedural protection; Rogers [19] evaluated five core fields for corporate: performance, structure, personnel, process and technology with technology transfer, technology exchange, knowledge management and knowledge innovation. Morrison and Terziovski [4] estimated organizational innovation ability from four sides: innovation input, innovation process, innovation product and innovation strategy based on innovative system integration and network model.

The following selection based on the innovative guidance and evaluation by the government should refer to the above targets" selection. Above studies have revealed innovation especially technology and system innovation mechanism, but those critical research have inevitable defects: Putting too much emphasis on the role of innovation while ignoring other factors effect in economic development, especially the government to the innovative leading role; The background is capitalist market economy, but there is no intensive study on innovative generation and operation mechanism under the condition of economic transition; The economic globalization and integration trend influence on innovation generation and operation mechanism hasn't been further research; Not fully understand the concept of "super science, group management", paying attention to promote collaborative innovation, pursuing the overall effect, making people fully aware of the strategic position of innovation in the economic development and social progress of macroscopic level.

Chinese scholars study innovation of science and technology in the macroscopic are few focusing on functional management such as fiscal policy [11, 12], financial policy [13–15] and so on. It is plenty research of enterprises' independent innovation ability, most of theses researches focus on ability elements and evaluation method choice, the researches of government guide innovation are few for the macroscopic level [16]. To study the assessment of the innovation ability, often focuses on the discussion of indicator setting and index calculation method. In fact, whether use fuzzy mathematics, multilevel grey evaluation or DEA to calculate the indicator numerical, are not the key to technology innovation ability evolution. Evaluating of enterprises' independent innovation ability, the key is to find the factors of affecting enterprise innovation ability level, and take measures to achieve the aim of enhancing enterprises' independent innovation ability. From the above analysis's we can see, these studies still exist certain disadvantages, specific analysis's are as follows:

First of all, the current researches and the countermeasures of the government to the innovation guidance, most of the researches are the innovation of our country enterprise general or area, there are few involves the government to a certain trade guidance. Secondly, in constructing the evaluation index system, no one can put forward the corresponding evaluation index system according to different industry or one trade outstanding the industry characteristics. Even if the authoritative statistics bureau just from Chinese enterprise as a whole put forward the evaluation index system. Thirdly, in the evaluation system of independent innovation ability still lack an own, precise perfect evaluation system. At present the main method is to refer the over method according the technical innovation ability evaluation model, basically having layer analytical method, fuzzy comprehensive evaluation method, data envelopment analysis, artificial neural network evaluation method, etc.

In the foreign researches of technology innovation on the R&D input more research [9, 10], considering national defense, the R&D spending of exploration space and national science and technology level change in the same direction, and often from the angle of input and output evaluate defense competitive power, considering defense technology innovation is not only need the national encourage policy, but also need to increase investment strength in the labor power and financial, give full play to the advantages of system, mechanism, environment, platform and other so on. These research with some reference significance to our government study science and technology management innovation development, but part of the study does not fully comply with the actual condition of our country.

For the evaluation of government guidance to industry independent innovation ability, usually need to set up comprehensive evaluation index system, confirm evaluation standards, quantitative indicators and other decomposition steps. First of all, should be based on aerospace science and technology strategy and military needs, synthesize expert opinion of weapon equipment development strategy, equipment purchaser, production unit and space related units and other fields, analyze the objectives and concrete index of the index system, building the index system which can comprehends describe and reflect all kinds of attributes to contribution degree of evaluation target. Secondly, the space science and technology industry all relevant units to provide data, as the basis of determining the index metrics, including index normalization, quantitative index. If conditions allow, as far as possible using existing description attribute data as the measurement classification standard, such as technology adaptability, can according to the feedback data from the equipment product which are used by forces as a reference standard to confirm the index. Thirdly, many kinds of methods can be used to evaluate the factors, verify the result of evaluation by each other, and compare the various evaluation results with intuitive judgment by decision makers, in order to improve the credibility of the evaluation.

78.3 The Government Analysis of the Space Independent Innovation Driving Force Function Mechanism

Independent innovation driving force of the industry has two kinds, namely the enterprises' internal innovation power and external innovation power. The so-called enterprises' external innovation power are those factors who exist in enterprises' external and have great impact on independent innovation behavior or form "dynamic field". The enterprises' internal innovation power are the factors exist in the enterprise internal and create internal power to the technological innovation activities. Among them, the enterprises' external innovation power include all primary independent innovation dynamic elements who exist in enterprise external, such as the market demand, market competition, technology development and government policy support, etc.; The enterprises' internal innovation power include all primary technology innovation dynamic elements what exist in the enterprises' interior, such as enterprise interests, the enterprise interior incentive mechanism, etc. In the external driving force, only rely on market, science and technology, and other factors could not provide automatic external environment which are benefit for innovation, rely on the support of the government is the most important support of innovation. Almost all countries government is adopting all kinds of support and motivation innovation policies and means [10, 16–18]. In some countries, the government on promoting of technology innovation has a long history. Such as Britain in the early establishes the patent system is meaning for establishing and protecting the new technology, encouraging technology transfer, etc. It is can be say; the independent innovation level depends on the support of the government to innovation activities to a great extent.

According to the elements analysis's of space independent innovation dynamical system, the evolution mechanism path and path selection are formed by the ability of independent innovation, generalize the operation way of space independent innovation dynamic mechanism as follows: in the affecting and influence of natural environment, macro environmental factors, from the demand of the market, the pressure of competition, gravity of science and technology and support force from the government policy behavior, will directly or indirectly translate into space enterprise benefit driving force, and will be the power source of aerospace institutions independent innovate. The government cultivate the spirit of the entrepreneur has reaction and amplifying function to interest driving force, it can directly drive space institutes in different subjects take part in independent innovation, and through the enterprise culture and enterprises' internal incentive mechanism indirectly drive personal subject take part in independent innovation; Innovation country atmosphere and enterprise innovation ability under the government guide and support ultimately ensure the enterprises for independent innovation activities smoothly. And the successful innovation activities adverse effect on technology, market, government and environment, stimulate new innovation demands, so make innovation activities to a spiral up trend. Based on the above analyses, a space institutes under the guidance of the independent innovation industry dynamic mechanism operation way to see figure 1. In figure thick lines represent the main function of the innovation dynamic elements, thin lines represent effect of the external environment factors to the innovation of dynamic factors, the dotted lines represent the reaction of the independent innovation activities to the outside dynamic elements and environment.

78.4 Constructing Space Independent Innovation Ability Evaluation Index System

Analyzing the system inscape of space industry independent innovation ability and the function way of government in industry dynamic mechanism, established evaluation index system by five elements, eighteen indicators (see Fig. 78.2 shows).

78.5 The Government Selection of Evaluation Methods for the Space Independent Innovation Ability Support

Due to the construction of the index system both have qualitative indexes and quantitative indexes, hosing comprehensive method based on fuzzy mathematics, accord-

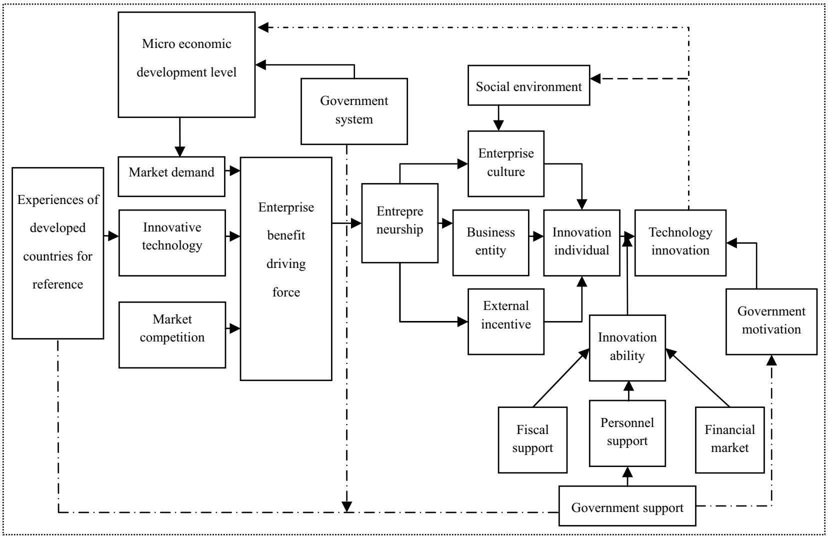


Fig. 78.1 The driving force of the government for the space independent innovation mechanism

ing to membership theory of fuzzy mathematics translate qualitative evaluation into quantitative evaluation, which use fuzzy mathematics to make an overall evaluation farthings or object that are restricted by various factors, make sure the target weights use analytic hierarchy process.

78.5.1 Fuzzy Comprehensive Evaluation Steps

Step 1. Making sure the evaluation objects, factors set and comments set.

According to the actual needs determine evaluation object sets, evaluation factors set and comments set (i.e. decisions set).

The object sets: $O = \{o_1, o_2, \cdots, o_l\}$,
Factor sets: $U = \{u_1, u_2, \cdots, u_m\}$,
Decisions set: $V = \{v_1, v_2, \cdots, v_n\}$.

Step 2. Establishing weight distribution vector A of m evaluation factors.

Each factor in evaluation factors concentration in “evaluation target” has different status and role, namely each evaluation factors in the comprehensive evaluation occupies different proportion, the proportion called weights, to determine the weights have many methods, can use expert consultation method, the analytic hierarchy process or relative important degree level related calculation method, etc.

Step 3. Obtaining fuzzy comprehensive evaluation matrix by the single factor for fuzzy evaluation.

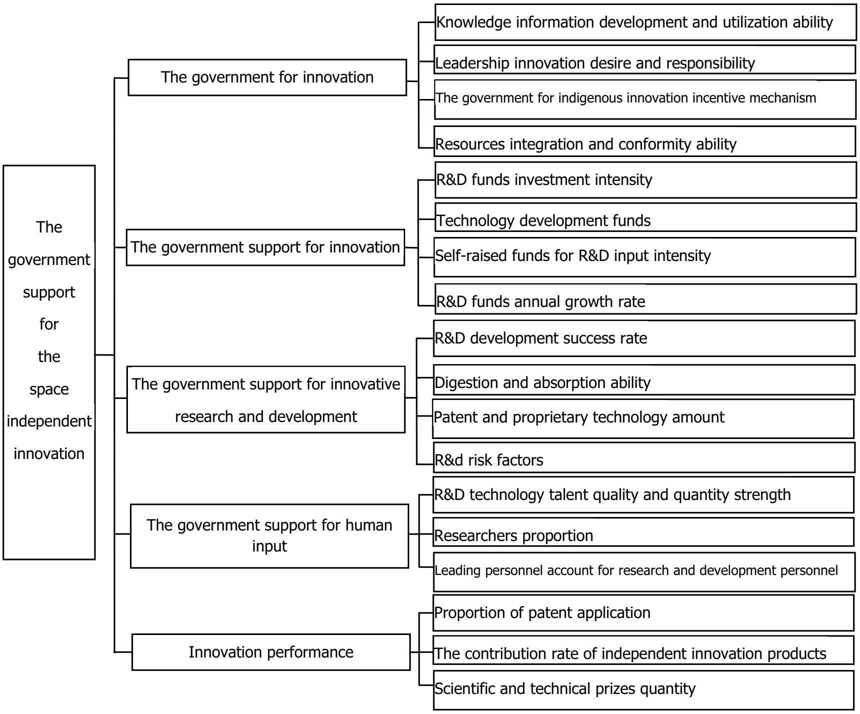


Fig. 78.2 Space independent innovation ability evaluation index system

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_m \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}. \tag{78.1}$$

Each of the evaluation object shall establish a comprehensive evaluation matrix R, $R_i = (r_{i1}, r_{i2}, \cdots, r_{ij})$ is single factor evaluation of the i factor u_i, so r_{ij} means frequency distribution of the i $(1 \le i \le m)$ factor u_i above the j $(1 \le i \le n)$ comment v_j. The general will be normalized to meet $\sum_{i=1}^{n} r_{ij} = 1$.

Step 4. Getting comprehensive evaluation result by compound operation.

$$V = A \cdot R. \tag{78.2}$$

Step 5. Calculating each evaluated object's score.

78.5.2 Membership Determination

(1) Membership sure of quantitative index

In all indexes, one kind is positive index, namely indexes are the bigger the better; another kind is the inverse index, namely the indexes are the smaller the better. To every index u_i $(i = 1, 2, \cdots, m)$ construct respectively membership functions $v_{1i}, v_{2i}, v_{3i}, v_{4i}$ belongs to $v_{1(\text{best})}$, $v_{2(\text{better})}$, $v_{3(\text{general})}$, $v_{4(\text{bad})}$. Suppose c_i is the minimum value of index u_i, d_i is the maximum value.

(2) Membership sure of qualitative index

The performance evaluation system for the qualitative indexes can take quantitative method. First make sure comments set V, then through the questionnaire, in view of the actual situation to give each index score, then statistics, and then is membership determination.

$$v = \left\{ v_{1(\text{best})}, v_{2(\text{better})}, v_{3(\text{general})}, v_{4(\text{bad})} \right\}.$$

78.6 Space Enterprises' Empirical Evaluation of Independent Innovation Ability

In order to get the support of the government for the space industry degrees, the study object is aerospace science and industry innovative enterprise, the purpose is to measure aerospace science and technology industrial enterprises' independent innovation ability. This project sample filter conditions: (1) background; (2) the products; (3) products mating. According to the condition select 10 aerospace listed companies: China's Satellite, Spaceflight Electromechanical, Aerospace Information, SPACECOM, Space Long Peak, Space Electrical, Aerosun, Aerospace Science and Technology, Aerospace Power, Aerospace Electronic, etc. Data collection includes two aspects: one is fuzzy weighted vector data acquisition, select analytic hierarchy process, use experts investigation to score each index, then statistics; On the other hand is fuzzy relation matrix evaluation level data collection. To evaluation matrix of quantitative index, according to the enterprise annual report collect data, according to the membership formula to determine; For qualitative indexes, use the form of questionnaire investigation to obtain.

(1) The analytic hierarchy process confirm indexes weights

Hire five experts to according to the basic judgment and identity index level, combine with the specific independent innovation management of 10 aerospace science and industry enterprises, to evaluate every enterprise, thus provide the basic material for scientific evaluation independent innovation ability of aerospace science and industry enterprise. Take Aerogun as example, according to expert judgment, construct judgment matrix, then use DPS software to calculate the weight of the first and secondary level, use the same method obtain the three level index weight.

(2) The fuzzy relation matrix rank data collection

The quantitative index rating matrix can be confirmed according to the formula of index membership, according to Aerosun annual report data get original data, and then take the original data into the formula, obtain the fuzzy evaluation level for quantitative index; Confirming qualitative indexes membership, through the experts questionnaire ways to get, experts give evaluation for each qualitative indexes, then use statistical methods to consolidate, can get qualitative indexes membership. On the above weight value and fuzzy comprehensive evaluation, such as shown in Table 78.1.

(3) The fuzzy comprehensive evaluation

• Construct fuzzy relation matrix to comprehensive assess. According to the data (as shown in Table 78.1), structure fuzzy relation matrix. Suppose innovation organization and management index fuzzy relation matrix is R_{11}, so:

$$R_{11} = \begin{bmatrix} 0.20 & 0.40 & 0.40 & 0.00 \\ 0.30 & 0.50 & 0.20 & 0.0 \\ 0.25 & 0.45 & 0.20 & 0.10 \\ 0.40 & 0.50 & 0.10 & 0.00 \end{bmatrix},$$

fuzzy transform:

$$\begin{aligned} V_1 &= U_{11} \cdot R_{11} \\ &= \begin{bmatrix} 0.0486 & 0.1301 & 0.1604 & 0.3743 \end{bmatrix} \times \begin{bmatrix} 0.20 & 0.40 & 0.40 & 0.00 \\ 0.30 & 0.50 & 0.20 & 0.00 \\ 0.25 & 0.45 & 0.20 & 0.10 \\ 0.40 & 0.50 & 0.10 & 0.00 \end{bmatrix} \\ &= \begin{bmatrix} 0.2386 & 0.3438 & 0.1150 & 0.0160 \end{bmatrix}, \end{aligned}$$

also available,

$$\begin{aligned} V_2 &= [0.5113 \quad 0.4887 \quad 0.0000 \quad 0.0000], \\ V_3 &= [0.1792 \quad 0.7548 \quad 0.0091 \quad 0.0030], \\ V_4 &= [0.1706 \quad 0.8294 \quad 0.0000 \quad 0.0000], \\ V_5 &= [0.2872 \quad 0.7128 \quad 0.0000 \quad 0.0000], \end{aligned}$$

use comprehensive evaluation result of above seven aspects $V_1, V_2, V_3, V_4, V_5, V_6$ to constitute higher level of fuzzy relation matrix,

$$V' = \begin{bmatrix} 0.2386 & 0.3438 & 0.1150 & 0.0160 \\ 0.5113 & 0.4887 & 0.0000 & 0.0000 \\ 0.1792 & 0.7548 & 0.0091 & 0.0030 \\ 0.1706 & 0.8294 & 0.0000 & 0.0000 \\ 0.2872 & 0.7128 & 0.0000 & 0.0000 \end{bmatrix}.$$

Similarly make fuzzy relation matrix and the corresponding index weight to fuzzy comprehensive,

Table 78.1 Index weight and fuzzy evaluation level

Target Layer	Rule Layer	Weight	Scheme Layer	weight	Comments Level			
					Best	Better	Ordinary	Bad
The government support for the space independent innovation	The government for innovation organization and management	0.1273	I	0.1301	0.20	0.40	0.40	0.00
			II	0.0486	0.30	0.50	0.20	0.00
			III	0.0817	0.25	0.45	0.20	0.10
			IV	0.2048	0.40	0.50	0.10	0.00
	The government support for innovation investment	0.1526	V	0.4673	0.78	0.22	0.00	0.00
			VI	0.0909	0.18	0.82	0.00	0.00
			VII	0.3264	0.23	0.77	0.00	0.00
			VIII	0.1154	0.48	0.52	0.00	0.00
	The government support for innovative research and development	0.3719	IX	0.2159	0.21	0.79	0.00	0.00
			X	0.3936	0.25	0.75	0.00	0.00
			XI	0.1528	0.00	0.81	0.19	0.00
			XII	0.1692	0.12	0.88	0.00	0.00
	The government support for human input	0.1683	XIII	0.2779	0.24	0.76	0.00	0.00
			XIV	0.4424	0.15	0.85	0.00	0.00
			XV	0.2161	0.1	0.90	0.00	0.00
	Innovation performance	0.1297	XVI	0.4736	0.23	0.77	0.00	0.00
			XVII	0.1392	0.14	0.86	0.00	0.00
			XVIII	0.3872	0.41	0.59	0.00	0.00

I: Knowledge information development and utilization ability; II: Leadership innovation desire and responsibility; III: The government for indigenous innovation incentive mechanism; IV: Resources integration and conformity ability; V: R&D funds investment intensity; VI: Technology development funds; VII: Self-raised funds for R&D input intensity; VIII: R&D funds annual growth rate; IX: Patent and proprietary technology amount; X: Development success rate; XI: The technical level advanced degree; XII: The independent innovation products rate; XIII: R&D technology talent quality; XIV: Researchers proportion; XV: Leading personnel for research share of development personnel; XVI: Application for patent proportion; XVII: The contribution of the independent innovation products; XVIII: Scientific and technical prize number.

$$V = U \cdot V' = (0.2410 \quad 0.6311 \quad 0.0180 \quad 0.0032).$$

Fuzzy evaluation V translate into total score. give V a weight $W = (W_1, W_2, W_3, W_4)$, here $W_1 = 100, W_2 = 80, W_3 = 60, \quad W_4 = 40$, which can be concluded the enterprise comprehensive score:

$$V = \sum_{i=1}^{4} V_i \cdot W_j = 0.2410 \cdot 100 + 0.6311 \cdot 80 + 0.0180 \cdot 60 + 0.032 \cdot 40 = 75.796.$$

Similarly, get the other space enterprise comprehensive score, such as Table 78.2 shows:

Table 78.2 Space enterprise sample composite scores and order

EN	CS	SEC	AI	S	SLP	SE	A	AST	SP	AE
Synthesis score	68.405	65.402	68.790	80.917	69.526	70.466	75.796	74.857	70.327	80.406
Ranking	9	10	8	1	7	5	3	4	6	2

EN: Enterprise Name; CS: China Satellite; SEC: Spaceflight Electromechanical; AI: Aerospace Information; S: SPACECOM; SLP: Space Long Peak; SE: Space Electrical; A: Aerosun; AST: Aerospace Science and Technology; SP: Space Power; AE: Aerospace Electron.

(4) The analysis of the ratings

From Table 78.1, we can know the hired industry experts' basic judgment and identification of the indexes. By using analytic hierarchy process, we can see that the government's support to innovation occupied 0.3719, which is more important than the other four secondary indexes. The score of innovation performance is 0.0501, fully proves that innovation lies in the process, so taking control of the process rightly brings good results (performance). In the government organization and management of innovation, resources integration and conformity ability are particularly important, followed by the knowledge information development and utilization ability, besides, independent innovation incentive mechanism is also very important; In the government to innovation investment support index, R&D inputting is the most important index, accounting for almost half of the other indexes, the funds from the government to the R&D project is most important, secondly is self-raised funds for R&D inputting intensity, it shows that the enterprise should not only rely on the government financial support, but also rely on their own money to support innovation; in the government's support to the innovative research and development, the highest scoring is the develop success rate, followed by patent and proprietary technology, shows that research and development funds must have results, and the number of patents represents the enterprise's innovation achievements; In the government support on the innovative talents, the proportion of researchers takes the most, this suggests that researchers have became capital resources of enterprise innovation, and provides guidance for the national defense personnel training; Innovation performance is the measure results for industry system, but also the measure of industrial innovation achievements under the government support, pay more attention to the protection of intellectual property rights, from the viewpoint of development to support innovation industry development, and the government's affirm to enterprise innovation results.

Through fuzzy comprehensive evaluation method with qualitative and quantitative indexes we get Table 78.2, and we can get such information: electronic communications are commonly at the top and aerospace communication, aerospace electronic innovation evaluation respectively takes the first and the second place, this is inseparable from that the government has been always advocating to rely on scientific and technological innovation to promote industrial upgrading, establish large multi-professional chief research institute, national key laboratory, important electronic equipment research center and production base; The last one is spaceflight electromechanical, investigate the deep-seated reason is that the auto business makes its main business, but the main business income drop to less than 35%, new energy and new materials may form the new profit growth point in the future; the comprehensive score of Chinese satellite innovation ability is low too, the reason is that the satellite's space application and space industrialization is low, the ground system independent research ability and the application efficiency are also low, the industry chain is not perfect yet, at present the ground equipment localization rate is less than 30%, the overall ability is weak and still has not built a long-term, continuous, stable air-ground comprehensive satellite technology and application system.

78.7 Conclusions

(1) The government should increase the investment in the resources of innovative research development

Resource allocation and financial input are the basis and guarantees for the smooth operation of scientific and technological innovation. The government should further optimize the allocation of resources in aerospace science and industry development strategy and professional construction plans, and guarantee that the resource allocation of talents, finance, and material meet the needs of the three main businesses and the core professional innovation and development; ensure the funding in the innovation field, especially the investment of self-financing, make sure that the input of self-innovation accounts the income ratio more than 3%. Increase the early efforts to technological development, focus on the development of the strategic and key industry which can support and stimulate the improvement of aerospace science and industry core competence, especially improve the constructions of new basic conditions and innovation platform.

- Support the basic research, the applied basic research, and the frontier technology research. Strengthen the development of emerging technology and vulnerable technology; improve the layout of the aerospace science and industry technology. Aim at the forefront of world science and technology development, speed up the implementation of the State Key Program for Basic Research (or the major infrastructure projects of national security) for the demand of national strategy, in the fields of aerospace defense, information technology and equipment manufacturing. Make use of aerospace science and innovation to deploy a number of major cutting-edge technology research projects in the main fields which are related to the country's future and strategic security, and lay a solid foundation for the development of the aerospace science and industry.
- Accelerating the construction of the technological innovation. We will strive to promote the construction of experimental platform for main research center and

the engineer center of our country, the important laboratory of the national defense, and the industrial art center. Further improve the sharing network of the aerospace technology and art material to achieve a real open service.

The government should guide properly in increasing the research and development funds and investment: firstly, the government should lead the input of the aerospace companies according to the investment, by the means of the budget of state-owned enterprises to increase the technology development and research expenditure proportion in the finance expenditure. Secondly, encouraging the enterprise itself to raise the innovation funds, through the loan from bank, buying shares of the companies voluntarily, and the actively absorption of the domestic and overseas investment, to develop the high technological venture company. Thirdly, by the combination of asset capital and finance capital and the industrialized technology innovation promote the development of company. Fourthly, lead the strategic reorganization of the advanced industries in the excellent resources to bring the outside investment, construct the new concept company. broaden the application areas of aerospace technology.

(2) Guide enterprises to establish independent innovation organization and management mechanism

First of all, the government copes with the independent innovation of the industry to make the general layout and promotes a new environment for independent innovation, and builds a good platform in which talents, projects and resources can settle down by innovating institution, perfecting system, and improving mechanism. Secondly, the government guides enterprises to handle the relationship between the introduction of advanced technology and the independent innovation properly, and choose the different innovation mode according to their actual conditions. Such as borrow people, wisdom and resources from othersTake research cooperation as the cutting point, combine the technical demand of the enterprise and the innovation research of the college and the scientific institution together. Take the international science and technology cooperation mode of a “dumbbell” which has two heads as breakthrough point, make efforts to promote the tight butt between foreign high-end innovation resources and industry innovation demand, complete the introduction, digestion, absorption and re-innovation of the international advanced technology more efficiently, promoting transformation from the international latest scientific and technological achievements to the industry. Build a systematic framework of cooperation to form a long-term cooperation mechanism with the help of “dumbbell” international science and technology cooperation mode. Thirdly, government should focus on the fundamental work of the science and technology management. On the one hand, further improve the aerospace science and industry innovation project library and the construction of the experts database, forming information management platform for all processes of science and technology plans to promote the information sharing. On the other hand, perfect science and technology statistics index system and strictly control the quality of the data to ensure the authenticity, accuracy and integrity of the inventory data. Establish science and technology evaluation organizations, perfect the evaluation index system, rich assessment methods and strengthen the analysis and application of the statistical data vigorously.

(3) Strengthen the absorption and cultivation of innovative talents and establish incentive mechanism of innovation

The government should implement guiding opinion to talents cultivation, focusing on cultivating high-tech talent strategic emerging industry talents.

Firstly, introduce high-level scientific and technological talents according to the enterprise actual need to increase the vitality of enterprises' independent innovation. According to the developing needs of strategic emerging industries, introduce high-level innovative research team and leader at home and abroad, to involve in the key technology directly and form the collaborative innovation made by talents at home and abroad.

Establish and perfect the evaluating and electing system of the chief expert, technological designers, chief technician, focus on training and bringing up the a high level innovating team of talents, high-level innovative scientific and technological talents. Pay attention to the cultivation of young talents; constantly improve the ratio of youth during the constructions of science and Technology Commission and the model team of all levels, and exercise the scientific and technological young personnel in development strategy research and innovative R&D projects, model development research practice. Deepening the introduction of foreign intelligence, continue to vigorously introduce overseas high-level talents through the "one thousand project", and implement the relevant policy and make good use of talents.

Secondly, establish and perfect an effective talent incentive mechanism, fully mobilize the enthusiasm of scientific and technical personnel. Set up an innovation award of science and technology, explore the incentive mode of the equity and options of innovative subject, inspire the entire personnel to participate in innovation, and arouse all kinds of the enthusiasm and creativity. Establish long-term incentive mechanism; really form the significant community between the technical personnel in enterprises and the enterprise, encouraging them to constantly strive to innovate from long-term development strategy. Enterprise should reform the distribution system, and improve the technical innovation personnel incentive mechanism. The key is to do well in R&D personnel incentive [16].

Thirdly, create a comfortable and harmonious working, living and learning environment to build platform and provide the opportunity for the enterprise innovation talents showing ability and cleverness. Further optimize the growth environment of the innovation talents, improve training, use, evaluation and incentive mechanism in favor of the growth and priority development of the innovation talents. Carry out the professional training of scientific administrative cadres, broaden the cadre's practicing exercises and communicating channels, and enhance the fighting force, cohesion and creativity of science and technology management cadres. Implement career management of innovative talents, improve efficiency of success, shorten the growth cycle, and arouse the innovative enthusiasm and creativity of all members.

(4) Promoting the penetration of self-owned brand, enhancing and ensuring the work of science intellectual property

The ability of innovation of a few industries in our country has become a bottleneck restriction of the development with the revolution of science and ongoing intensely international competition which mainly characterized by in innovation and updating technology. The government should conduct the enterprise establishing the brand awareness, to increase invisible asset value. The enterprise also should catch the government scope and expand the developing space of self-owned brand. Meanwhile, they should improve the ability of creation, application, protection and management.

In the first place, the enterprise can support the self-owned brand directly through the government procurement. Self-owned brand product should play an important role in government procurement with the expanding of the technology and scale of aerospace enterprise. Enterprise can get more benefits which can be developed again through the expanding to the market size, which pushes the enterprise to a virtuous circle.

In the second place, the government act as a media carries out the marketing strategy of strategic alliances and finds the economic conversation places [6]. The government establishes the key contacting link, as a technology media or policy media, which starts from the win-win situation, allying with the same medium and small scale enterprise, to establish a powerful and new platform, accelerate the synergy in enterprises, expanding the products through the strategic alliances, meeting the needs of the costumers with more products as well as solving some serious problems of small and media enterprise such as lag in technology, aging equipment, and homogenization of products.

In the third place, the government should increase the education and publicity of the intellectual property protection and protect the technological development innovators' technical expertise property. However, we should prevent the monopolization of some technological approaches which lead to slow growth of technology. At the same time, the government should establish corresponding incentive system of intellectual property of development and creation which awards the innovator and protects the enthusiasm of other technological innovation.

Acknowledgements The scientific research startup project of Nanjing University of Science and Technology, project approval number: 1 AE88304; Independent scientific research project, the project approval number: AE88215.

References

1. Bresson C, Amesse F (1991) Networks of innovators: A review and introduction the issue. Research Policy 20:363–379
2. Ransley DL, Rogers JL (1994) A consensus on best R&D practices. Research Technology Management 3-4:19–26
3. Chiesa V, Coughlan P (1996) Development of a technology and innovation audit. Journal of Product Innovation Management 13:105–136
4. Morrison M, Terziovski M (2001) Quality management practices and the link to potential learning outcomes within the Australian retail sector. Learning Organization 8:176–185
5. Fred Brock book (2000) The U.S. government a major role in technological innovation (the next). Foreign Theoretical Trends 6:7

6. Yang J (2010) The French government role in technological innovation and enlightenment of the world economy in 2010 2:68–72 (In Chinese)
7. Chen TR (2008) The South Korean government in a leading role in technological innovation and inspiration. Scientific Management Research 8:115–120 (In Chinese)
8. Wang ZP (2005) New York state government technology innovation policy system research and enlightenment. Shanghai Administration Institute 3:37–42 (In Chinese)
9. Gu L, Sapienza P, Zingales L (2004) The role of social capital in financial development. American Economic Review 94:526–556
10. Zhang XM (2007) Foreign science and technology policy model of constructing the revelation of the regional innovation system. Science Research 6:62–66 (In Chinese)
11. Kang J, Liu J (2008) Fiscal policy to support independent innovation practice and prospects. Chinese financial 5:22–25 (In Chinese)
12. Liu poor blog (2007) Public expenditure effect encourage innovation and optimal scale. Number of Economic and Technological Economic Research 3 (In Chinese)
13. Li Y (2008) Trend of industrial technology and financial market: Banks and the functioning of markets. Central Finance University 2:35–40 (In Chinese)
14. Gu S, Hung P, Zhang X (2007) Building support for the white main innovative multi-level capital market. China Soft Science 8:7–13 (In Chinese)
15. Long Y (2007) Types of innovation, financing and market strategic relationship — based on empirical research of high-tech enterprises in China. Science 4:852–859 (In Chinese)
16. Zhu PF, Xu WM (2003) Dividing the government incentive policies for large and medium-sized industrial enterprises in R&D investment and its patent output. Economic Research 6:45–53 (In Chinese)
17. Tu J, Li JZ (2006) Researching USA small businesses innovation policy from the triple helix model — Compare the U.S. SBIR program with STTR 3:411–416 (In Chinese)
18. Kuang XP, Xiao JZ (2007) Financial and tax polices of typical innovational-oriented country innovation incentive. Foreign national tax adiministration 11:8–14 (In Chinese)
19. Roger DMA (1996) The challenge of fifth generation R&D. Reaearch Technology Management 39:33–41

Chapter 79
Reason and Trends for Using Packaged Milk in Pakistan — Study of Urban Pakistani Consumers

Asif Kamran and Syed Muhammad Ahsan Rizvi

Abstract Milk is one of the basic commodities and important in one's day-to-day life. Pakistan with current estimates is the 4th largest milk producing countries in the world with 33 billion annual productions. Out of the total milk produced, 97% is in the informal sector like loose milk which is then sold in both rural and urban markets. On the contrary, 3% of the total milk produced is catered by packaged milk producing companies and dominated by leading packaged milk brands like, Nestle MilkPak and Olpers by Engro Foods. Since Milk industry is still dominated by loose milk which constitutes 97% of annual milk production, there are pros and cons associated with the same. The major concern is the health hazard issue linked with the loose milk production till it is delivered to its customers. The process followed by farmers is quite traditional where no measures are taken to improve the current milk production system with regard to un-packaged milk. Our research relates to mixed method approach which has been used as part of the research methodology. Qualitative and Quantitative data will be collected through various research instruments like, survey, focus groups and in-depth interviews with the selected sample size. Results will be analyzed by SPSS tool by using various test types like, descriptive statistics, correlation and Chi Square test. To strengthen the research, case study method will be used as well to identify key players in the market and their strategies to promote the packaged milk brand in Pakistan.

Keywords Ultra High Temperature (UHT) · Compound Annual Growth Rate (CAGR) · Liquid Dairy Product (LDP) · Ready to Drink (RTD) · Engro Foods Limited (EFL) · Milk Production · Descriptive Statistics · Quantitative data · Health Hazard

---

A. Kamran (✉) · S. Rizvi
School of Management and Economics, University of Electronic Science and Technology of China, Chengdu 610054, P. R. China
Management Science Department, Bahria University, Karachi 75260, Pakistan
e-mail: asifkamrankhan@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_79,

79.1 Introduction

Pakistan is the one of the largest milk producing country in the world and has a huge potential to grow and contribute to the economy as far as dairy milk is concerned. The annual production is 33 billion liters of milk, which is worth Rs 177 billion.

Interestingly, 97% of this production is concentrated in what is known as the informal sector. This means that the milk is produced by animals in the villages, and consumed both in the village and the cities. This is also called "open milk" or "fresh milk". There is no branding or formal packaging here. But at the same time, there are also no preservatives involve, hence the term "fresh milk or unpackaged milk" readily available from numerous milk retail outlets across the country [2].

(1) Shortfall in Milk Supply

There are no formal means of milk storage and refrigeration so it can be transported to the urban areas. Since milk is a highly perishable commodity and if not provide with the stated facilities, will result into complete wastages and contamination. Combine this factor with the warm climate of Pakistan, the problem becomes apparent [3].

Milk has a shelf life of only four hours, if it is not properly refrigerated. This at least does explain the atrocious statistic of seven billion liters of milk that is actually documented to be wasted each year because of a lack of facilities.

(2) Poor Distribution Channel

Distribution is another major problem. Since this milk is "open" and not packaged properly, it is tempered to a great extent. Firstly, it is exposed and hence, any amount of water can be added to it by the milk vendor which eventually reduces the quality of milk. Also, there is no guarantee that the water being added to is clean and free of contamination.

(3) Health Hazards

There is various health hazards associated with the fresh milk like, Ice slabs, caustic soda and sometimes formalin is also added to the milk to preserve it, which again poses health hazards and does not go in favor of consumers.

(4) The Existing Supply Chain Model

The stated diagram is the existing retail channel followed by Milk Producing companies, every segment has been clearly identified so that, the delivery channel can be maintained and milk brands can be reached to its consumers more effectively.

(5) Milk Industry

There's a strong heritage (trust and affordability) of fresh milk (88% of the market). All-purpose UHT milk is the largest segment of processed milk and has been built largely on undifferentiated benefits.

"Aggressive entrance of Olpers Milk brought emotion and aspiration to the category" [4]. Nestle MilkPak, the market leader, has started to build differentiation based on its Iron fortification. A number of Small pasteurized players like NurPur Milk, Candia, and Good Milk are emerging in urban centers.

(6) UHT Industry of Pakistan

UHT Industry in Pakistan is highly commoditized built in undifferentiated rational benefits. The entrance of new players has made the competitive environment tougher each day. Nestle MilkPak identified iron deficiency as a gap amongst Pakistani consumers (66% of children under 5 years of age and 50% of women between 20 and 39 years are Iron deficient) and thus decided to launch Fortified MilkPak in October 2008. There were three main objectives for this strategic move:

- Further strengthen the brand equity.
- Create differentiation in the highly commoditized UHT Milk category.
- Address the nutritional needs of consumers.

Though the UHT industry grew by 24% in the last two years, however the UHT industry witnessing the share of Tea Enhancers almost doubling from 15% (in 2008) to 32% (in 2011) while the share of Family Well-being decreased from 80% to 62%. (7) Rural Milk Producer (see Fig. 79.1)

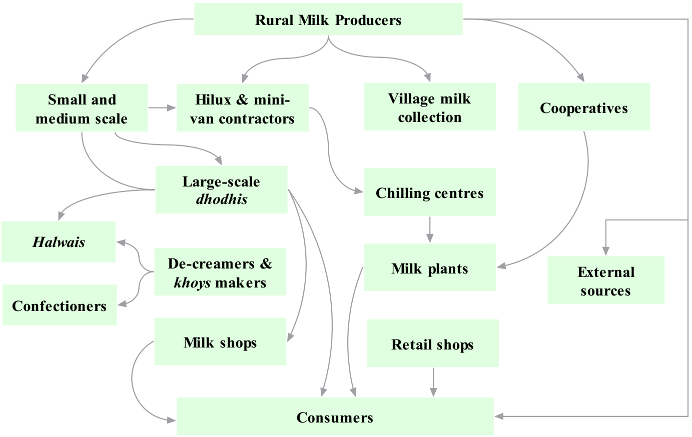


Fig. 79.1 Rural milk producer

(8) Brand Communication Strategy

Marketing plays an important role in building brand awareness and at the same time creates interest in the consumer's mind to choose from a variety of brand assortments [5]. Building a detailed and catchy brand communication strategy has become essential for advertisers and challenge for advertising agencies and media planners/buyers to use the media budget effectively to attain the top of the mind recall. An integrated brand communication strategy is implemented by each packaged milk brands like, Olpers, Milkpak, Haleeb, Good Milk etc. Through a mix and match of TV Commercial, Radio FM, Print Ads, Billboard advertisements and brand activation [6]. The basis of this research will also investigate that, how the marketing campaigns are really helping Milk producing companies to attract the Urban consumers. The key difference between packaged and unpackaged Milk can be seen in Table 79.1.

(9) Statement of Significance

Table 79.1 Key difference between packaged and unpackaged milk

Attributes	Packaged Milk	Unpackaged Milk
Product	UHT Treated	No such treatment
Price	Rs. 60/- for 1 liter	Rs. 70/- for 1 liter
Packaging	6 layered Tetra Pak CAvailable in 250, 500 and 1000ml	Polyethylene bags
Availability	All retail outlets and super stores	Unpackaged milk retail shops
Shelf Life	3 Months	2 days

Milk is an essential commodity and it cannot be avoided in one's day- to- day life. Now a day's several brands are available in market besides the traditional open un-packaged milk. Hence it is important to study which type of milk is preferred by the consumers, open or packaged milk and at what extent consumers are switching from traditional milk to tetrapak milk.

79.2 Literature Review

The literature review is one of the most important parts of the research. It analyzes the previous studies, research work done by various researchers, company reports, articles etc in the area related to our field directly or indirectly. The literature review is divided into sections and each section is interrelated to each other. The below literature review comprises of the industry reports, statistical data from the industry, industry growth pattern, articles related to packaged milk industry its impact on consumers and at the same time the cons of packaged milk are also highlighted.

(1) The Growth Opportunity

"Changing demographics have a great impact on dairy industry when people are more health conscious and aware of all the hygiene and health factors associated with the dairy products" [7]. Few factors like ageing population, urbanization rise in the middle class are driving demand for new types of liquid dairy products (LDP) in both developed and underdeveloped countries. Fig. 79.2 shows the growing trends.

(2) The Change in Consumer Preference due to Urbanization

The world's population is growing at a rapid pace and the number of people living in cities is expected to reach more than 6 billion in 2050 which is a huge size of population. Due to this rise and urbanization, people will be more educated, brand conscious, higher disposable income than their rural counterparts. Companies working on the dairy sector, are religiously working on the same by producing the value added products such as enriched milk keeping in view the hygiene and health factors [8].

(3) The Emerging Middle Class

The rising middle class will also affect the dairy industry and will give an opportunity to milk producing companies to come up with various milk brands, keeping

Fig. 79.2 The growing trends

in view consumers health and hygiene issues. The global middle class is expected to grow from 430 million people in 2000 to 1.15 billion by 2030 which means more purchasing power to afford LPDs Liquid Dairy Products to satisfy new food and drink preferences. The best example is china where marketers target the country's middle class with premium white milk product such as Milk Deluxe from MengNiu.

(4) The Rising LDP (Liquid Dairy Products) Consumption

Worldwide consumption of milk and other LDP is expected to grow at a compound annual growth rate (CAGR) of 2.4% from 2009 to 2012 – reaching 283 billion liters. Worldwide LDP consumption increased year-on-year by 1.8% to 264 billion liters and demand has continued to be strong through the first half of 2011.

Worldwide LDP consumption increased year-on-year by 1.8% to 264 billion liters and demand has continued to be strong through the first half of 2011.

Driven primarily by ready to drink (RTD) ambient (or long-life) LDP – with a forecasted CAGR of 5.4% from 2009 to 2012 – global LDP consumption is expected to reach 283 billion liters by 2012. The strongest growth in the RTD ambient LDP category is expected to come from Asia Pacific (8.7% CAGR), Latin America (7.1% CAGR) and Africa (6.9% CAGR).

(5) Outlook Bright for Packaged Milk in Pakistan

Pakistan's population is growing by 1.7% a year and LDP consumption is expected to grow at CAGR of 2.8% from 2009 to 2012. Milk has always played an imperative role in Pakistanis diet, with the change in demographics, awareness of hygiene and health, preference of packaged milk is now rapidly changing the era of plain white unpackaged milk [10].

(6) Milk production statistics (shown in Table 79.2).

Fig. 79.3 represents data of the LDP market. Liquid Dairy Product market size of slice shows the 72.8 percent of the White milk, 22.3 percent of Tea creamer, 2.4 percent flavored milk, 1.7 percent of liquid cream, and 0.8 percent of Low fat milk.

(6) Market Share of Packaged Milk Brands in Pakistan (see Fig. 79.4)

Market share of the size of slice shows the 45 percent of Milk Pak, 22 percent of Haleeb, 17 percent Olpers, 9 percent of Dairy Queen, 4 percent of NurPur, 1 percent of Good Milk,and 2 percent Other.

(7) Packaged Milk Brands Awareness in Pakistan (see Fig. 79.5).

Table 79.2 Milk production statistics

(Units 000 Liters)	2008-2009	2009-2010	2010-2011
Milk Gross Production	42191	43562	44978
Cow	14437	14982	15546
Buffalo	26231	27028	27848
Sheep	35	36	36
Goat	700	719	739
Camel	787	798	808
Milk Human Consumption	34064	35160	36299
Cow	11550	11985	12437
Buffalo	20991	21622	22279
Sheep	35	36	36
Goat	700	719	739
Camel	787	798	808

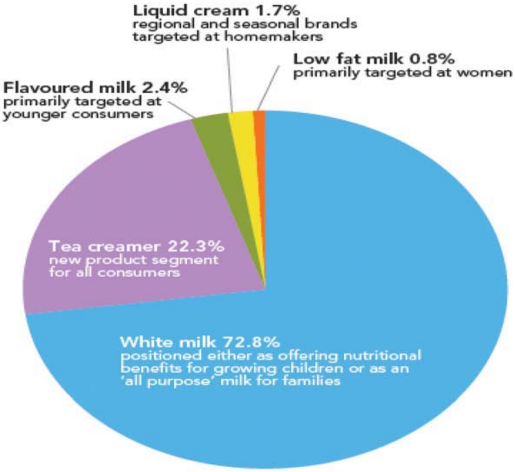


Fig. 79.3 The data of LDP market

Brand Awareness of the size of slice shows the 43 percent of Milk Pak, 38 percent of Haleeb, 9 percent Olpers, 7 percent of Dairy Queen, 2 percent of Good Milk, and 1 percent of NurPur.

(8) Strong Dairy Tradition to Overcome in the Loose Milk Market

Urbanization and demographic shifts cause people to choose the packaged products are now an increasing trend in developing and underdeveloped countries. State of the art technology like UHT (Ultra High Temperature) processing and aseptic packaging provides safe and hygienic food and beverages to the consumers [11]. On the contrary countries like, India, and other Middle Eastern countries have a tradition of loose milk which is sold in milk retail outlets under unhygienic conditions may cause various diseases. Although traditionally consumers do boil the milk but the mixing of water may be contaminated and can cause serious illness and diseases.

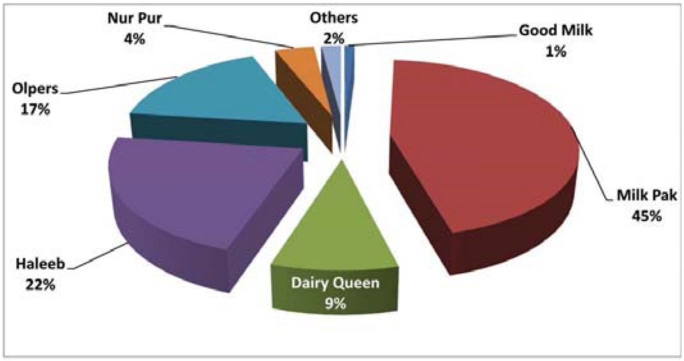


Fig. 79.4 Market share of packaged milk brands in Pakistan

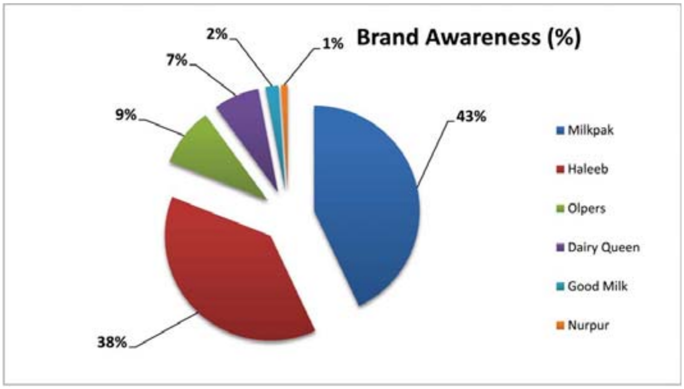


Fig. 79.5 Brand awareness

Greater awareness of milk hygiene means that the decision maker of a family is now more concerned about family health especially children's and now moving towards UHT treated packaged milk which is safer for family's health.

(9) Tetra Packaging Technology

As per [12], milk was initially sold door to door via local milk men. When the dairy companies introduced a concept of milk, it was sold in a glass bottle sealed with foil and as time passes, several changes being made in the packaging state. The concept of tetra pack was introduced whereby milk is stored in tetra pack under ultra high temperature (UHT) which extends the shelf life to 3-4 months of a packaged milk.

As described by Salman [13] there will be a significant growth in the consumption of milk which is 2.2 percent by 2012 and this is due to increase in the market of emerging nation and the change in liquid dairy products which are packaged these days. On the other hand, there is a significant growth in liquid milk consumption which reflects the awareness level among consumers for hygiene and health.

Emerging nations like China, India and Pakistan has grown significantly in the dairy industry and the major reasons are increased population, higher income, new dietary trends and improved accessibility to dairy products. Other than that, the growth is evident due to the changes in the way dairy products are packed. The consumption of packaged milk and other liquid dairy products are growing more quickly than the overall liquid dairy segment and it constitutes 72% of total global consumption by 2012.

The increasing urban populations in Pakistan, emerging middle class, more educated consumers are now shifting towards packaged liquid dairy products by 19% per annum. The era of plain white un-packaged milk is drastically changing whereas the concept of packaged milk is now the growing trends in years to come [14].

(10) The Growth Trend of Major Packaged Milk Brands — the Pakistani Market (shown in Table 79.6)

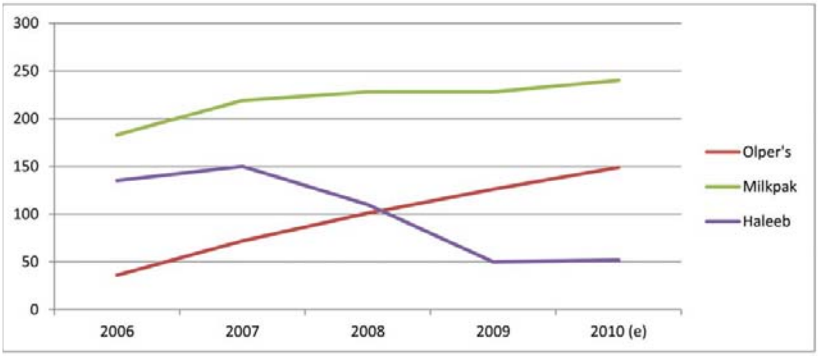


Fig. 79.6 The growth trend of major packaged milk brands — the Pakistani market

(11) How the Process of Producing Fresh Milk is Harmful for the Masses

The open/un-packaged milk is one of the traditional sorts of milk and being vital to the dairy industry. As per [16], milk is a perishable commodity, following is the process followed by traditional fresh milk producer which is quite harmful when it reaches to the masses:

1. Farmer milks the cow at around 4 am.
2. An unrefrigerated tank collects the milk from various collecting points in villages and transports it to the chilling center.
3. Turnaround time to reach the centers is about 5-6 hours.
4. The milk is then processed, pressurized and bacteria's should get eliminated which is not the case due to unhygienic conditions inside the plant.
5. Milk is again packed in pouches and again transported in unrefrigerated vans to shops where it lies in open trays.

The above stated process clarifies where the flaw is and hence proved how open milk is harmful to people's health. In this regard, packaged milk producing companies are taking corrective actions to produce healthy dairy products suitable for the masses to have a better and risk free life [17].

The production of packaged milk is safe though, but there are various evidences being addressed showcasing the harmful elements being part of packaged milk. As per [18], a harmful chemical melamine along with other substances is being added in the packaged milk and this is not only confined to Pakistan only but evidences are also found in the USA, Canada and European countries. The chairman (PSQCA) Pakistan Standards and Quality Control Authority has also confirmed the mixing of melamine in the packaged milk and also allowed a certain percentage of the stated mixture in the packaged milk which is now being challenged in the Lahore High Court.

The role of advertisement is quite evident in the promotion of packaged milk in Pakistan. The competition is intense and packaged milk producing companies are coming up with creative campaigns on various occasions to be in consumers mind. As described by Ali [19], the concept of integrated marketing communication is well implemented by these milk producing companies who are utilizing all the media mixes to attain a good position in the market.

Table 79.3 Top ten categories of second's wise share in terms of percentage where milk and dairy products ranks no. 6

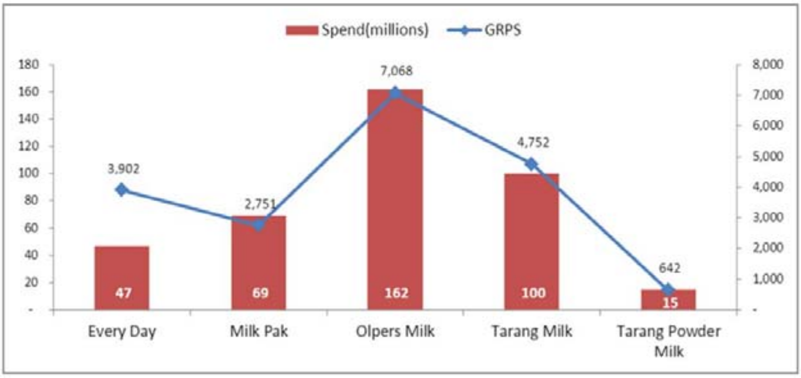
Top Ten Categories of 2010	Seconds	Share %
Mobile Phone Operators	27881972	23.4
Shampoos	7834793	6.58
Detergent Powders	6574873	5.52
Carbonated Soft Drinks	6217617	5.22
Beauty/Medicated Soaps/Face Wash	5374657	4.51
Milk and Dairy Products	4542708	3.81
Construction Companies	4105529	3.45
Cooking Oil and Ghee	2894672	2.43
Juices/Energetic Drinks	2846095	2.39
Tea	2767571	2.32

Table 79.3 is showing top ten categories of second's wise share in terms of percentage where Milk and dairy products ranks no. 6 which was a clear indicator of the amount of money spent on package milk advertisement in 2010. As per [20], the leading packaged milk producing companies like Engro Foods and Nestle are very active in terms of media presence in all media channels. They are heavily spending on Above the Line activities like Television ads, FM Radio, Print ad, hoardings and at the same time, also engaged in trade promotion as well. The phenomenon of brand activation is well implemented by these companies whereby, customer engagement is a vital focus. The objective of these exercises is to build brand awareness, brand loyalty and education to the target market to build awareness of health and hygiene when it comes to liquid milk products.

79.3 Growth Trend of Nestle MilkPak, Market Leader in Packaged Milk Industry of Pakistan

MilkPak has witnessed severe supply related issues during the lean period (April - September) of 2010 and hence has not been able to cash in to the strong demand pull from its consumers. As a result the growth has been negligible compared to last year.

As per [21], the brand team in coordination with other departments has worked to improve the situation of milk supply in 2011 and they are confident to pose a strong recovery next year. However they need to constantly work on ensuring that MilkPak remains the number one choice in target consumer mind.



Source: telephonic interview with the industry participant

Fig. 79.7 Growth trend of Nestle MilkPak, market leader in packaged milk industry of Pakistan

79.3.1 *Research Hypothesis*

"Study of Urban Pakistani Consumers".

79.3.2 *Research Objectives*

Research objectives have been set to understand the reasons that why Urban Pakistani consumers are switching towards packaged milk.

1. To determine the behavior of consumers towards packaged milk.
2. To determine the reasons for switching and not switching towards packaged milk.

3. To understand whether the advertisement of packaged milk is creative and promoting the concept of packaged milk.

79.3.3 Basis of Survey Questions

The survey part of this research will encompass a series of question to be asked from its respondents to fulfill the research objectives. These questions have been designed to determine whether the hypothesis set can be proved or disproved. The questions will be asked on a prescribed format such as qualitative and quantitative survey and will be forwarded to the target market of packaged milk.

79.3.4 Research Beneficiaries

- The packaged milk brands producing companies, their business and overall strategies will have a greater impact from the detailed findings and this will help them to understand the consumer behavior in detail.
- This research will give great benefit to me as well, as this is the first step towards progression in any research area and it will also give me an understanding of procedures, learning of a stated issue and will develop an analytical skill which is required in handling the research phenomenon.

79.3.5 Research Methodology

The research method adopted in this work is a mix of both Qualitative and Quantitative. Quantitative research quantifies the data on which statistical tools can be applied to infer the result whereas Qualitative research approach seeks some insights and deep understanding of the problem setting. The aim of this research is to analyze whether the Urban Pakistani Consumers are switching to Packaged Milk or not. So it was very important to take the inputs from the consumers regarding this and analyze the data gathered from them via following tools:

1. **Research Instruments:** Survey Questionnaire. Focus groups, In-depth interviews.
2. **Case Study:** The stated research methodologies will unfold the research findings and will help the researcher to underpin the results and will provide a detailed analysis of an issue. The stated methodologies will be targeted towards the target market of packaged milk to know their views in shifting or not shifting towards packaged milk.

79.3.6 Methodology 01 — Survey, Focus Group & In-Depth Interviews

The data will be collected through a survey a series of questions to be asked from the target customers, the core objective is to understand and answer the objectives of this research and determine whether the hypothesis developed can be proved or are unfounded.

(1) Data Collection

The most important survey tool used in this research is the Questionnaire. A questionnaire is a formal set of questions, used for obtaining data from the respondents (Naresh K. Malhotra, 2004). This research is an entirely customer focused exercise where the results are entirely dependent on the customers' feedbacks. There are various methods will be used for obtaining data from customers, such as, Personal in-depth interviews, focus groups and extensive survey via questionnaire.

(2) Implementation

The survey will be implemented by the research agency Aftab Associates in Karachi Pakistan. The time frame given to sample is one week to complete the survey and will take around ten minutes to complete the entire questionnaire.

On the other hand, in-depth interviews and focus groups will take one week, since it's a long exercise and takes much time to gather the information from the target audience.

Once the data is collected via survey questionnaire, it will be analyzed through SPSS to produce scientific results and findings.

79.3.7 Methodology No. 02 — The Case Study

Besides gathering data from the stated research instruments, we will also develop a case study to determine whether the hypothesis developed can be proved or disproved.

(1) The Core Idea

The core idea of the case study is to understand the marketing strategies of Liquid Milk Producing companies, as what measures they have taken to convince the consumers to switch from un-packaged milk to packaged milk. In terms of analyzing their marketing strategy, we will be focusing on the marketing mix elements and the integrating marketing communication mix to understand their marketing plan. We will be analyzing their brand attributes, pricing strategy, Promotional mix and distribution channel in detail to understand the force behind the preference of packaged milk.

This case study will unfold two important elements:

- What kind of marketing strategies companies is following so that, urban Pakistani consumers prefer packaged milk over un-packaged milk.
- Why consumers are switching towards a particular packaged milk brand.

(2) Data Collection

The data will be collected via in-depth interviews with the industry participants, key players in packaged milk producing brands of Pakistan; Media planning agencies, industry reports, interviews with retailers to understand the sales of a particular brand, observational study at supermarkets to understand the reasons of purchasing a particular packaged milk brand.

Other than that, data will also be collected via EBSCOHost, Factiva, online journals, articles and related websites to gather the information. The data will cover the following:

- Brand Loyalty.
- Marketing communications Mix.
- Brand activation.
- Consumer Behavior.
- Implementation.

The case study will be implemented by short listing the packaged milk producing companies, meeting their representatives and via a series of questions will gather the desired information.

79.3.8 Sampling for Methodology No. 01

Sampling will be done on the following elements:

- Initial Sample Size: The sample size to conduct this research will be a total of 300 respondents residing in major cities of Pakistan like Karachi and Lahore.
- Sample Unit.
- Households.

79.3.9 Demographics of Sample

- Housewives.
- 22-40 years.
- SEC (Socio Economic Class) A, B and C.

79.3.10 Sampling for Methodology No. 02

The sample size will be the two leading companies producing packaged milk brands in Pakistan, like Engro Foods and Nestle. Data will be gathered via a detailed interview with their marketing/brand managers.

79.3.11 Data Analysis — Methodology 01

The data collected by both questionnaires and interview & will be analyzed to draw a conclusion and there are a series of questions being asked in the survey questionnaire like nominal, Likert Scale and ratio type of questions.

Some parametric data will be collected to answer simple questions such as:

Are you aware of packaged milk brands in Pakistan? Yes, No.

Also a range of non-parametric data will be collected to conduct a more in-depth study into consumer preferences for packaged milk. For example:

Are you willing to pay more to purchase packaged brand milk? 3 = **absolutely,** 2 = **Likely,** 1 = **may be and** 0 = **Not at All.**

These various scales will help to analyze the variety of analyses to draw a certain conclusion. Last but not the least; the data will be analyzed in SPSS by using the variety of test types like Chi Square, Correlation and descriptive statistics.

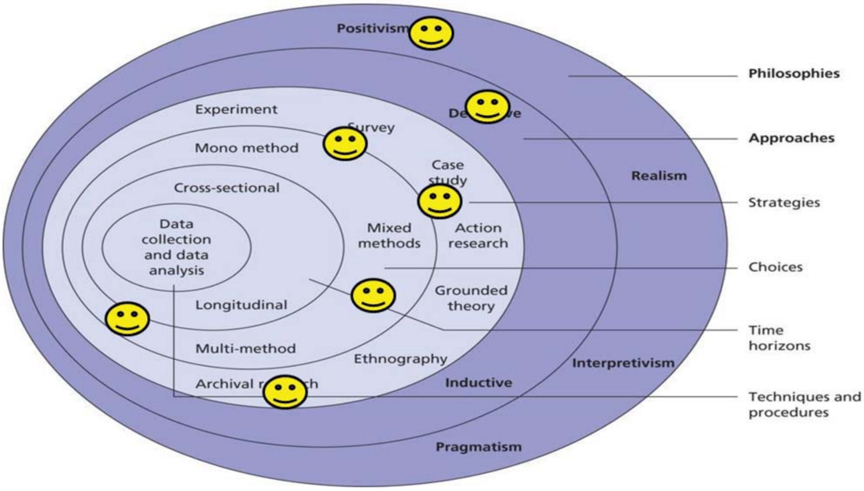


Fig. 79.8 Research design template — the research onion

79.3.12 Data Analysis — Methodology 02

The information collected via detailed interview with the company's representatives will be analyzed and since the outcome will be more descriptive than, results will be analyzed as per the interview questions being asked.

Research Design: In general, the design for this project will be like a Research Onion as incorporated in Saunders. The smile faces have been used to identify the game plan through which research will be finalized and carried out (see Fig. 79.8).

The philosophy of this research will have a positivist approach by using deductive analysis through case study, survey and exploratory method. Other than that, mixed method approach will take on a longitudinal basis for collection and analysis of data.

79.4 Conclusions

This research project will determine the reasons that why urban Pakistani consumers are switching from un-packaged milk for packaged milk. The two components of this research being the case study method and the survey execution will work to present an all-rounded view of the preference of urban Pakistani consumers towards milk and the role of organizations in promoting the healthy milk brands in the country.

Resources to complete this research is well defined and large amount of data will be collected via industry reports, previous research studies on the stated topic, report from media tracking companies, marketing related magazines and updated information will be collected via interviews with the company's representative working on various packaged milk brands. Hence, the information supply chain is well defined to gather the quality data.

References

1. Changing demographics will provide growth opportunities for dairy industry. http://www.tetrapak.com/about_tetra_pak/press_room/news/Pages/Changingdemographics.aspx
2. Demand of packaged dairy product. http://tribune.com.pk/story/31836/demand-of-packaged-dairy-products-grows/
3. Engro Foods Olpers. http://www.scribd.com/doc/7759926/Engro-Foods-Olpers
4. Haleeb Milk. http://www.haleebfoods.com
5. http://www.brandchannel.com/features_effect.asp?pf_id=445
6. Health and Nutrition Seminar. http://www.ameinfo.com/157882.html
7. How safe is the packaged milk. http://www.technospot.in/how-safe-is-the-packaged-milk/
8. Nestle Milk Pak for a stronger home. http://www.nestle.pk/brands/nestle-milkpak.aspx
9. Pakistan Economic Survey 2009-10. http://www.finance.gov.pk/survey/chapter_10/02_Agriculture.pdf
10. Pakistan Dairy Sector. http://www.pddc.com.pk/DairyPakistan-Publication.pdf

11. Packaged milk makes the world go around.
http://www.interpack.com/cipp/md_interpack/custom/pub/content,oid,11638/lang,2/ticket,-g_u_e_s_t/ /_Packaged_Milk_makes_the_world_go_around.html
12. Packaged Milk in Pakistan.
http://www.massmediacell.com/world-news/packaged-milk-in-pakistan/
13. Saunders M, Lewis P, Thornhill A (2009) Research Methods for Business Students. 5th edn. Pearson Education Limited, Essex, England
14. School Milk Day.
http://www.ameinfo.com/157882.html
15. Shakarganj Foods Products Limited.
http://www.shakarganj.com.pk/foods/activity.html
16. The White Revolution.
http://southasia-online.com/features/315-the-white-revolution.html
17. Traditional Milk Collection and Distribution System.
http://www.scribd.com/doc/3169506/Pakistan-Dairy-Industry
18. Telephonic Interview with Habib A (2011) Nestle Pakistan Category Manager Dairy Products
19. Telephonic Interview with Rizvi S (2011) Group M Senior Media Planner Engro Foods
20. Telephonic Interview with Salman S (2011) Engro Foods Senior Brand Manager Olpers Milk
21. The Growing Trends.
www.tetrapak.com
22. IMC Plan for Haleeb Candia Milk 2009.
http://www.amcy5.com/Proposals/marketing/amcy16.htm
23. Saunders M, Lewis P, Thornhill A (2009) Research Methods for Business Students. 5th edn. Pearson Education Limited, Essex, England
24. www.nestle.pk
25. www.haleebfoods.com
26. www.engro.com
27. www.tetrapak.com

Chapter 80
Analysis of Production and Diffusion of Multiple-unit Ownership under Supply Constraints

Yujie Zhong, Tingting Qu and Zhineng Hu

Abstract Multiple-unit ownership of nondurable products is an important component of sales in many product categories. Based on the Bass model, this paper develops a new model considering the multiple-unit adoptions as a diffusion process under the influence of supply constraints. The paper aims to determine the optimal combination of production scales and marketing strategies for a firm. The numerical study shows that multiple-unit purchasing behavior can accelerate the rate of the product diffusion and increase sales to make more profit for a firm. Under supply constraints, the firm can make the best profit when the production scale needn't reach the biggest scale, and should send more samples to attract consumers as the production scales becomes bigger; furthermore, the effect of penetration pricing strategy in the introduction stage is much better than any other pricing strategies.

Keywords Multiple-unit ownership · Supply constraints · Production scales · Product innovation

80.1 Introduction

In the studies of the new product diffusion, the research and application of most new product growth model are based on the Bass model [1]. In recent years, some researchers have relaxed a number of assumptions in the Bass model, and formed a cluster or flexible Bass diffusion model. Mahajan et al analyze the impact of the old brands when new brands entering into the competitive market, and formulates the model (MSB) of brand-level diffusion [2]. Steffens studies the phenomenon of repeat purchase on TV products, and analyzes the differences and similarities about the multiple-unit adoption and repeat purchase [3].

Y. Zhong · T. Qu · Z. Hu (✉)
Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, P. R. China
e-mail: huzn@scu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_80,

An important assumption in the Bass model is that there is no supply constraint, but there is usually shortage or over inventory in actual management. Considering the cost of shortage, inventory and instantaneous purchase cost, Kurawarwala and Matsuo choose PC manufacturers as an example to analyze the problem of short life cycle product [4]. Cantamessa and Valentini point that it is important to determine the production scale and sales strategy, including the delay time to market, increase in inventory and a number of losses before a new product put into market [5]. Ho et al consider a make-to-stock production environment and show that delaying a product launch to build up an initial inventory may be optimal and can be used as a substitute for capacity [6].

Sampling level is very important for a firm. Lammers et al points out that sampling is an effect way of promotion to enhance the sales volume in a short time, keep customer loyalty, and encourage consumers to purchase and repeat purchase, which is highlight in fast moving consumer goods [7]. According to Heiman et al [8], sampling has two effects: the short-term effect on changing in the probability of a consumer purchasing a product immediately after having being sent free samples, and the long-term effect on increasing the consumers cumulative goodwill formation. Jain et al indicate opinion leaders, innovators, or early adopters should be given the free samples because they play a major role in the diffusion process [9].

Except for the sampling, another marketing mix is the price. Horsky gives support to the assertion that price affects the market potential [10]. Sohn et al derive a dynamic pricing model for considering the price change of product itself and the relative price change of competing products. Consumer purchasing behavior is indispensable in the diffusion process; however, there is lack of considering the promotion and the diffusion process of multiple-unit adoptions, which may result that sales managers can not make the decision accurately [11]. Kima and Gupta compare online purchase decision making between potential customers and repeat customers of an Internet vendor from the value perspective based on mental accounting theory and information processing theory across the judgment stage and the decision stage, and view repeat purchase as a purchase decision in the purchase process [12]. Therefore, the repeat purchase should be taken into consideration for nondurable product diffusion.

Based on the diffusion model of multiple-unit ownership, this paper establishes a model group under supply constraints by incorporating the impacts of pricing strategy and repeat purchase, and mainly analyzes the production scales under supply constraints; specifically, the paper makes a comparison of product diffusion under multiple-unit purchase and individual purchase, and the impact of sampling and pricing strategy. The rest of the paper is organized as follows: Sect. 80.2 states the problem and presents the basic model and assumptions. Sect. 80.3 presents the numerical simulation computation for the optimal model group and sensitive analysis. Sect. 80.4 is reserved for conclusions and suggestions for further research and the underlying approach.

80.2 Modeling

For the multiple-unit ownership of new product, this section focuses the model on determining the optimum production scale, the time to market and make-ready time based on Bass model under the consideration of pricing strategy.

80.2.1 Problem Statement

In the presence of a supply constraint, the customer population can be divided into four groups: the adopters who have already received the new product, the adopters on the waiting list, the adopters who are not ready to adopt the product yet, and the potential adopters on demand. During the diffusion process, some potential populations become the current adopters because of the influence of innovation and imitation, and some adopters repurchase the product because of the limited life cycle of non-durable goods have.

For short life-cycle products, the diffusion is influenced by market factors such as pricing strategy and sampling. Backordering and backlogging happen when production capacity is limited; therefore, preproduction provides a substitute for installing capacity and thereby serves as a less costly mechanism for achieving the same life-cycle sales as with a higher capacity (Fig. 80.1). Before the product introduced into the market (t_l), there may be some periods (t_p), which have been based on the percentage of the largest production scale (the maximal sales without supply constraints), for the firm to produce; moreover, the firm may have an announcement about new product in the marketplace (assumed to be time zero). After some time (until t^*) of being fixed produced (r^*), the product is produced on demand.

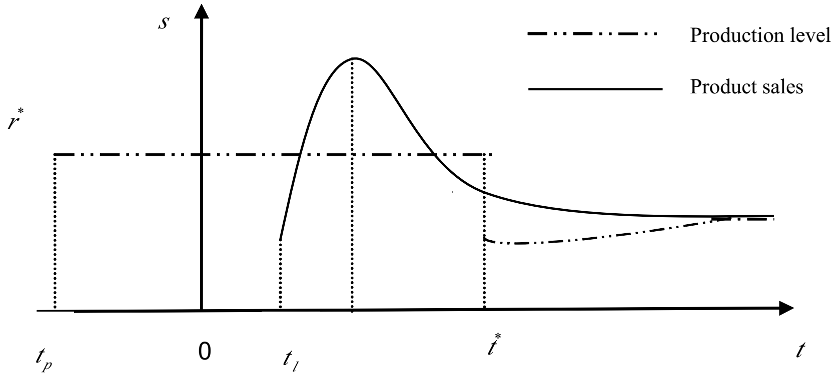


Fig. 80.1 The production diffusion and its sales under supply constraints

Based on the analysis above, some assumptions for the model group are presented below:

1. Diffusion process of a new product is independent of other innovation diffusions.
2. The geographic boundaries of the social system do not change over the diffusion process.
3. Characteristics of a product do not change with the time.
4. Diffusion process includes three stages: the unknown, the adoption, and the purchase.
5. Repeat purchase and multiple-unit purchase are allowed.
6. The cost of inventory, which is instantaneously replenished, does not change with the time.

The notations of the problem are shown below:

t : Period (1 to T);
$\overline{N}$: The upper limit of potential adopters;
a, a_1 : Coefficient of external influence of the product;
b, b_1 : Coefficient of internal influence of the product;
$N(t), n(t)$: Demand rate and cumulative purchasers of the product by time t;
$M(t), m(t)$: Demand rate and cumulative multiple-unit purchasers of the product by time t;
$N_f(t), n_f(t)$: Non-cumulative number rate and non-cumulative adopters get the free sample by time t;
$I(t)$: Inventory at time t;
$D_i(t), D_m(t)$: Cumulative purchase amount of the product by time t;
$d_i(t), d_m(t)$: Purchase of the product at time t;
$W_i(t), W_m(t)$: Waiting customer population at time t;
$w_i(t), w_m(t)$: Variation of waiting customer population at time t;
$L_i(t), L_m(t)$: Lost customers at time t;
$l_i(t), l_m(t)$: Rate of lost customers at time;
$S_i(t), S_m(t)$: Cumulative number of the adopters by time t;
$s_i(t), s_m(t)$: Adopters at time t;
$R_i(t), R_m(t)$: Number of potential repeat purchasers of the product;
r_p, r_m : Repeat purchase rate of the product;
$\gamma_n(t)$: The ratio of new adopters who get the free sample but never adopted the product before;
$r(t)$: Production at time t;
l_i, l_m, l_ri, l_rm : Rate of loss of waiting customers;
c_wi, c_wm : Waiting cost of each product;
c_f, c_h : Sampling and inventory cost of each product;
$c(t)$: Cost of production at time;
h : processing costs of samples;
k : The ratio of multiple-unit adopters;
$\gamma_b(t)$: the ratio of product's potential adopters in the total market;
$\gamma_f(t)$: Approximate specifications translation between samples and production.

80.2.2 Modeling

Based on the Bass model considering the external influence and internal influence of the product, the potential purchase population when diffusion process has no constraint is shown below:

$$\begin{cases} n(t+1) = N(t+1) - N(t) = \begin{cases} a(\overline{N} - N(t)), & t < t_l \\ (a + bN(t))(\overline{N} - N(t)), & t \geq t_l \end{cases} \\ m(t+1) = M(t+1) - M(t) = (a_1 + b_1 M(t))(kN(t) - M(t)), \end{cases} \tag{80.1}$$

where $N(0) = 0, M(0) = 0$ means the amount of product diffusion when $t = 0$, t_l means the time to market.

Sampling is used to demonstrate a product's superiority and to get a potential customer to try the innovation product. Mahajan et al postulated that product sampling can be an effective way to create an initial pool of "adopters" [2]. The goal of product sampling for the firm is not only to initialize the diffusion process, but also to improve brand loyalty. And during the diffusion process, the consumer can be divided into two groups: the group who get the free samples and the group who purchase the product, that is:

$$\begin{cases} n(t+1) = \begin{cases} a(\overline{N} - N(t) - N_f(t)), & t < t_l \\ (a + b(N(t) + N_f(t)))(\overline{N} - N(t)), & t \geq t_l \end{cases} \\ m(t+1) = M(t+1) - M(t) = (a_1 + b_1 M(t))(kN(t) - M(t)), \end{cases} \tag{80.2}$$

where $\gamma_b \gamma_n(t+1) n_f(t+1) = N_f(t+1) - N_f(t)$, $\gamma_n(t+1) = 1 - (N(t) + N_f(t))/\overline{N}$, $\gamma_n(0) = 1$, $N_f(0) = \gamma_b n_f(0)$, especially,$\gamma_f(t) = 1$ means accurate sampling.

Hence, the adopters include purchasers and the people who get the free sample. The sum of the adopters can't exceed the upper limit of the potential adopters, so:

$$N(T) + N_f(T) \leq \overline{N}. \tag{80.3}$$

Parker proposes diffusion models for which either the coefficient of external influence or the coefficient of internal influence alone is influenced by price [13]. Jain and Rao show that price affects the diffusion rate (via the coefficients of external and internal influence) [14].

According to the ideas given by Mesak [15] and Maier [16], the empirical response function $g(p(t))$, whenever a parameter or quantity in the diffusion model, is assumed to depend on one or more of the marketing variables, this parameter or quantity is simply multiplied. Here $p(t)$ is the real (deflated) price index for the average monthly basic rate. It is given by average monthly rate/consumer price index at time t divided by the same quantity at time 1, that is $g(p(t)) = 1$. Following Mesak's opinion [15], the empirical response function is given as $g(p(t)) = (p(t)/p(0))^{-\eta}$, where $g > 0$, $g' < 0$, $g'' - 2g'^2/g < 0$.

Studies derived from skimming pricing strategy assume that price affects the market potential, that is:

$$\begin{cases} n(t+1) = \begin{cases} a(\overline{N}-N(t)-N_f(t)), & t < t_l \\ (a+b(N(t)+N_f(t)))(\overline{N}g(p(t+1))-N(t)), & t \geq t_l \end{cases} \\ m(t+1) = M(t+1)-M(t) = (a_1+b_1M(t))(kN(t)-M(t)). \end{cases} \tag{80.4}$$

The penetration pricing strategy generally assumes that price does not affect the population of potential adopters and produces a multiplicative effect on the rate of diffusion, that is:

$$\begin{cases} n(t+1) = \begin{cases} a(\overline{N}-N(t)-N_f(t)), & t < t_l \\ (a+b(N(t)+N_f(t)))(\overline{N}-N(t))g(p(t+1)), & t \geq t_l \end{cases} \\ m(t+1) = M(t+1)-M(t) = (a_1+b_1M(t))(kN(t)-M(t)). \end{cases} \tag{80.5}$$

The potential purchasers under supply constraints can be divided into three types: people who have received the product, people who would like to buy the product, and the lost people, that is:

$$\begin{cases} (1-k)(N(t)+N_f(t) = D_i(t)+L_i(t)+W_i(t) \\ M(t) = D_m(t)+L_m(t)+W_m(t). \end{cases} \tag{80.6}$$

The number of purchasers in period $t+1$ is:

$$\begin{cases} d_i(t+1) = D_i(t+1)-D_i(t) \\ d_m(t+1) = D_m(t+1)-D_m(t). \end{cases} \tag{80.7}$$

The variation of waiting customers in period $t+1$ is:

$$\begin{cases} w_i(t+1) = W_i(t+1)-W_i(t) = (1-k)(\gamma_b\gamma_n(t+1)n_f(t+1)+n(t+1)) \\ \qquad\qquad -d_i(t+1)-l_i(t+1) \\ w_m(t+1) = W_m(t+1)-W_m(t) = m(t+1)-d_m(t+1)-l_m(t+1). \end{cases} \tag{80.8}$$

The lost customers in period $t+1$ is:

$$\begin{cases} l_i(t+1) = L_i(t+1)-L_i(t) = l_iW_i(t) \\ l_m(t+1) = L_m(t+1)-L_m(t) = l_mW_m(t), \end{cases} \tag{80.9}$$

where $N(0) = D_i(0) = D_m(0) = L_i(0) = L_m(0) = W_i(0) = W_m(0) = 0$; t_l is the time to market; when $t < t_l$, $d_i(t) = d_m(t) = 0$.

Nondurable products, which have a service life τ, are usually repurchased by consumers on demand. Generally, a firm can't expect the repurchase rate is one (1), although which is between zero and one; moreover, the firm usually hope the consumers bring forward the consumption in order that it can make profit sooner and reduce the uncertainty of future sales (such as to avoid uncertain repeat purchase). Therefore, the service life of product can be indicated as $\tau_m (= \omega\tau)$, where $\omega \in [1, +\infty]$, the adoption units by one consumer at a time t, is introduced to represent the average value of quantities according to the statistical significance [3]. Because of the delayed time, potential repeat purchasers at time t are those adopters who adopted by time t and who have repeated purchase in the past $\tau - 1$ periods, so the number of potential repeat purchasers is:

$$R_i(t) = \begin{cases} D_i(t-\tau) - r_i \sum\limits_{j=1}^{\tau-1} R_i(t-j), & \tau > 1, t > \tau \\ D_i(t-\tau), & \tau = 1, t > \tau \\ 0, & t \le \tau. \end{cases} \tag{80.10}$$

Also, the number of potential repeat multiple-unit purchasers is:

$$R_m(t) = \begin{cases} D_m(t-\tau_m) - r_m \sum\limits_{j=1}^{\tau_m-1} R_m(t-j), & \tau_m > 1, t > \tau_m \\ D_m(t-\tau_m), & \tau_m = 1, t > \tau_m \\ 0, & t \le \tau_m. \end{cases} \tag{80.11}$$

Similarly, repeat purchasers can also be divided into three types, and the variation of waiting repeat purchase customers in period $t+1$ is:

$$\begin{cases} w_{ri}(t+1) = W_{ri}(t+1) - W_{ri}(t) = r_i R_i(t+1) - d_{ri}(t+1) - l_{ri}(t+1) \\ w_{rm}(t+1) = W_{rm}(t+1) - W_{rm}(t) = r_m R_m(t+1) - d_{rm}(t+1) - l_{rm}(t+1). \end{cases} \tag{80.12}$$

The lost repeat purchase customers in period $t+1$ is:

$$\begin{cases} l_{ri}(t+1) = l_{ri} W_{ri}(t) \\ l_{rm}(t+1) = l_{rm} W_{rm}(t). \end{cases} \tag{80.13}$$

Considering of repeat purchase, the number of adopters of single and multiple-unit purchase at time t is:

$$\begin{cases} s_i(t) = d_i(t) + d_{ri}(t) \\ s_m(t) = d_m(t) + d_{rm}(t). \end{cases} \tag{80.14}$$

In above equations, $W_{ri}(t) = W_{rm}(t) = d_{ri}(t) = d_{rm}(t) = l_{ri}(t) = l_{rm}(t) = w_{ri}(t) = w_{rm}(t) = 0$ $(t < \tau_m)$.

The inventory in period t is:

$$I(t+1) = I(t) + r(t+1) - s_i(t+1) - \omega s_m(t) - \gamma_f(t) n_f(t+1), \quad t \ge t_p, \tag{80.15}$$

where $I(t_p) = r(t_p) - \gamma_f(t) n_f(t_p)$ $(t_p \ge 0)$, $I(t_p) = r(t_p)$ $(t_p < 0)$, t_p is the make-ready time before marketing, $\gamma_f(t)$ $(= \frac{c_f}{c(t)/r(t)})$ is specifications translation approximation for the samples and products. Production in period t is:

$$r(t) = \begin{cases} r^*, & t_p \le t < t^* \\ \max(s_i(t) + \omega s_m(t) + \gamma_f(t) n_f(t) - I(t-1), 0), & t \ge t^*, \end{cases} \tag{80.16}$$

where $s_i(t) + \omega s_m(t) + \gamma_f(t) n_f(t) \le r^* (t \ge t^*)$.

The production cost is:

$$c(t)=\alpha(r(t))^{\beta}, \quad \alpha>0,\beta\geq 1. \tag{80.17}$$

80.2.3 Objective Function

One may also argue that product sampling is expensive for the firm, so it may not be economical to give free samples to every potential adopter. As a result, serious consideration must be given to the question of how many samples should be distributed. In addition, offering too many free samples will cost the firm's resource. The firm needs to determine the "right" amount of sampling while the waiting cost and inventory cost should be also considered. Then one can get the objective function to maximize of net present value (NPV) of the firm given by

$$\begin{aligned}\pi= &\sum_{t=0}^{T}\frac{1}{(1+i_r)^t}[p(t)(s_i(t)+\omega s_m(t))-c_{wi}(W_i(t)+W_{ri}(t))-c_{wm}(W_m(t)\\ &+W_{rm}(t))-(h+c_f n_f(t))]-\sum_{t=t_0}^{T}\frac{1}{(1+i_r)^t}[c_h I(t)+c(r(t))].\end{aligned} \tag{80.18}$$

80.2.4 Model Group

Taking all factors above into consideration, one can establish a model group to provide an analytical framework for incorporating explicitly the effects of marketing mix variables on new product diffusion; the model group of the sample incorporating dynamic pricing strategy is

$$\begin{cases}\max\ \pi\\ \text{subject to Equations } (80.1)\sim(80.17),\end{cases} \tag{80.19}$$

where the decision variables are t_p, t_l, t^*, $n_f(t)$.

80.3 Numerical Analysis and Results

This section focuses on the numerical study of the model group 80.19, especially focuses on the analysis of production and product diffusion under different scales, and the influence of marketing strategies like sampling and pricing strategy on production scales and profit.

80.3.1 Analysis of Product Diffusion with No Supply Constraints

When the product diffuses without supply restrictions, the firm produces on demand. Assuming that the inventory is instantaneously replenished, product does not need and not have the inventory, or does not subject to the impact of shortage during sales process; therefore, the present value of profit in this case is the largest, and the demand curve, production curve and diffusion curve are the same.

The market potential is 54 million by Jain et al [9], so here the parameters are defined as follows:

1. The coefficient of external influence: $a = 0.03$, $a_1 = 0.3$, the coefficient of internal influence: $b = 0.35$, $b_1 = 0.35$. The elastic coefficient of price response function $\eta = 2$.
2. The potential number of ultimate adopters is$N = 54$ million; the product cycle life: $T = 30$. The numerical study that the diffusion process has stopped before $T = 30$, so the analysis is all based on $T = 30$.
3. Discount rate $i_r = 0.1$, and the price of the product under unchanged pricing strategy and its cost are: $p = \$10$ and $c = \$3$. When discussing the impact of various pricing strategies on the sampling level, the basic price of new product in the market is assumed as \$10. The cost of handling the free sample $h = \$1$.
4. The volume of multiple-unit purchase of the product $\omega = 3$, and the ratio of multiple-unit adopters k is 0.1. The repeat purchase rate of individual purchase of the product r_i is 0.02, and the repeat purchase rate of multiple-unit purchase of the product r_m is 0.01.
5. Relevant parameters of production: $\alpha = 3, \beta = 1.01$.

The product diffusion is near to end at about 30 periods (Fig. 80.2). The sales with multiple-unit purchase are much higher than the sales under individual purchase all the time. The sales under multiple-unit purchase is 20 percent higher than sales under individual purchase. When the potential consumers is determined, Customers with the ratio of k choose to bulk purchase, so it can increase the impact of oral communication as well as single purchase, advance the sales peak, and speed up the diffusion of the product and increase firm's profits.

Fig. 80.3 is the results of product diffusion with repeat purchase; comparing the NPV without repeat purchase, the former one is higher under the same pricing strategy. Since consumers buy more products each time when there exists repeat purchase, the diffusion process is accelerated by the repeat purchase, and then the firm gets a larger profit.

As shown in Fig. 80.3, the sale with repeat purchase is gradually in a relatively stable sales level (as 2.87), after 25 periods while the sale without repeat purchase is 0 after 25 periods. This is because after consumers used the product, they give an evaluation and make a repurchase with a stable rate. The largest sale of single product with repeat purchase throughout the diffusion process is 7.7892, so the scale of production can be determined to be 8. Since repeat purchase can bring more profit for the firm, the following sections will analyze the production and product diffusion with repeat purchase under supply constraints.

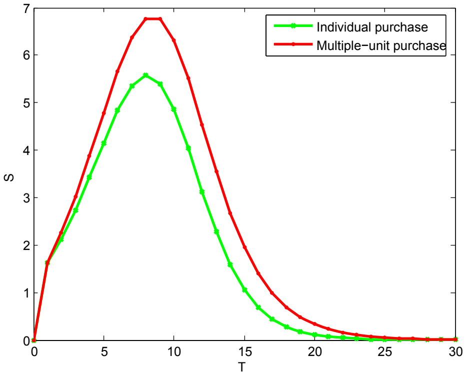


Fig. 80.2 The impact of multiple-unit purchase

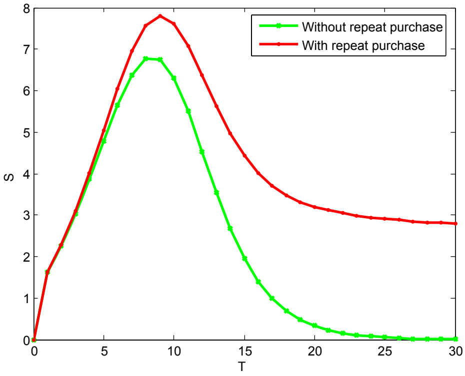


Fig. 80.3 Diffusion with repeat purchase or not

80.3.2 Analysis of Product Diffusion under Supply Constraints

Under the supply constraints, the firm cannot be produced on demand, so there is the emergence of the stock and inventory when the product is sold out. In different production scale, the sales are different. If the production scale is too high, it can make too much inventory, and the production equipments are wasted; in contrast, if the production scale is too low, it can make the demand exceeding supply and lead to the loss of consumers. Therefore, determining the appropriate scale of production and product-market time allows the firm to maximize profits.

To conduct a numerical study on computing the change of corporate's NPV for a given value of capacity r^*, and here consider four different levels of capacity: $r^* = 25\%, 50\%, 75\%, 100\% r_{\max}$, which can find a combination of preparatory period and the best time to market.

As is shown in Fig. 80.4, as r^* gets larger, the NPV gradually become larger, and the growth rate of the NPV is rapidly at periods 1, 2, and 3, then gradually slow down, and does not change when r^* is greater than 6. When the scale of production is too small, it causes great losses due to shortages caused by customers waiting and losing, and then the profits of an enterprise become low. The waiting customers and the loss of customers gradually reduce with the scale of production being gradually larger, when capacity r^* becomes 6, though the scale of production did not reach maximum, the shortage of goods can be satisfied by the pre-inventory. The loss caused by customers waiting and losing and the cost to expand the scale of production is almost equivalent during the process, so the firm can get the maximum profit without expanding the production scale. The optimal preparing and marketing time of each production scale are equal, so it does not require advance production.

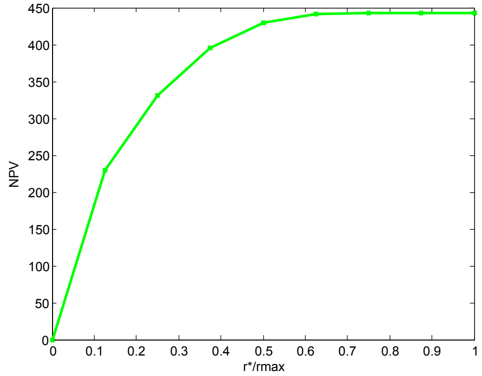


Fig. 80.4 The impact of production scales on NPV

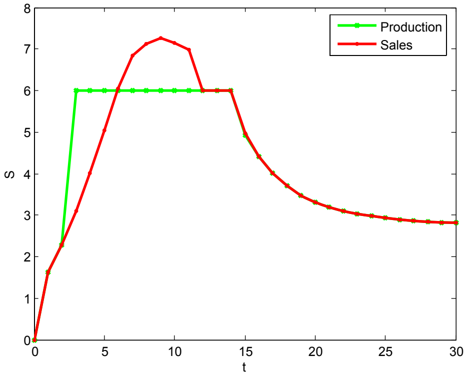


Fig. 80.5 Production and sales under supply constraints

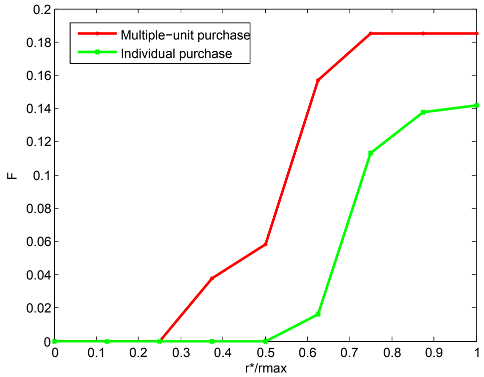
When a given value of capacity r^* is 6, the firm gets the biggest profits. To conduct a numerical study on production and sales volume under this scales.

As is shown in Fig. 80.5, at the beginning of the time to market, the production and sales are the same. Because at initial stage the firm chooses trial production, product sales are small and do not require inventory. The production scale becomes the biggest scale from 3th period and appears inventory. the sales volume is bigger than production from 6th period and production curve and the sales curve coincide from 15th period. Then enterprises product on demand from now and there is not waiting or the loss consumers at all.

80.3.3 The Impact of Marketing Strategies

Fig. 80.6 shows that there is no sampling when the production scales are 1, 2 with multiple-unit purchase and the firm should send samples after 3th period; when there is no multiple-unit purchase, the firm should send samples from 5th period and have no sampling when the production scales are 1, 2, 3 and 4. No matter whether there is multiple-unit purchase or not, sampling at first period is the best choice.

Fig. 80.6 The sampling level under different production scales



Furthermore, the sampling level under multiple-unit purchase is bigger than under individual purchase all the time; the biggest sampling level with multiple-unit purchase is 18.3%. This is because the cost of the samples is somewhat cheap, so the firm can send more free samples to attract the consumers to purchase more units at a time and to attain the consumers' loyalty; therefore, the marginal effect of free samples with multiple-unit adoptions is larger than individual purchase, the firm can get a higher profit.

The sampling level is generally bigger as the scale of production increases, and the trend is becoming slower and slower and finally tends to balance. The sampling level reaches the maximum when the production scale is 6, and never changes as the scale become even bigger; while under individual purchase, the sampling level becomes generally stable when the production scale is 7.

From Table 80.1, Whatever the capacity is, the NPV under penetration pricing strategy is the highest, but the sampling level is the lowest. Therefore, the firm can choose the penetration pricing strategy together a lower sampling level; in contrast, NPV under skimming pricing strategy is the lowest. Moreover, all sampling levels under various pricing strategies don't exceed 20%. Above results confirm that under penetration pricing strategy, the product is put into a low initial price at the beginning of time marketing can attract more customers to try it and then speed up the rate of diffusion of the product, which allows the firm obtain greater profits.

Table 80.1 The sampling level and NPV under different pricing strategies

Pricing strategies	Capacity	F	NPV	Capacity	F	NPV
Unchanged	$r^* = 0.25r_{\max}$	0	330.3432	$r^* = 0.75r_{\max}$	0.185	442.9118
Penetration		0	351.4678		0.149	446.3519
Skimming		0	310.7482		0.193	435.8413
Unchanged	$r^* = 0.5r_{\max}$	0.058	429.0915	$r^* = r_{\max}$	0.185	442.9118
Penetration		0.036	433.0823		0.152	447.8684
Skimming		0.079	412.5509		0.196	436.0341

The profit of when production scales at 6 under penetration pricing strategy and production scales at 8 under penetration pricing strategy is the best combination; therefore, if the firm cannot take the largest production scale, a penetration pricing strategy is able to gain greater profits.

80.4 Conclusions and Limitations

Multiple-unit ownership of nondurable products is an important component of sales in many product categories. However, scent attention has been paid to models for multiple-unit ownership under supply constraints; specially, the studies of promotion strategies and marketing variables in the model have gotten little attention.This paper established a model group of multiple-unit product with supply constraints, and has done a numerical analysis and got some key findings: (1) Comparing the diffusion process under multiple unit purchase and individual purchase, multiple-unit purchasing behavior can accelerate the rate of product diffusion and increase sales to create more profit. (2) Under supply constraints, the firm can make highest profit when production scale need not reach the biggest scale because of the cost of production and inventory. (3) The firm should send more samples to attract consumers as production scales becomes bigger. (4) For nondurable goods, the firm should choose penetration pricing strategy to gain more profit and make a tradeoff between using penetration pricing strategy and expanding the production scale.

This paper considered the cost of inventory and waiting being stale, but they are constantly changing over time. Also, the paper only considered the free samples having positive effects, so an interesting direction of research would be to expand the model by reflecting the negative effects or mixed ones.

Acknowledgements This research is supported by National Natural Science Foundation of China (Grant No. 70971091).

References

1. Bass FM (1969) A new product growth model for consumer durables. Management Science 15:215–227
2. Mahajan V, Sharma S, Buzzell RD (1993) Assessing the impact of competitive entry on market expansion and incumbent sales. Journal of Marketing 57:39-52
3. Steffens PR (2003) A model of multiple-unit ownership as a diffusion process. Technological Forecasting & Social Change 70:901–917
4. Kurawarwala HM (1996) Forecasting and inventory management of short life-cycle products. Operations Research 44:131–150
5. Cantamessa M, Valentini C (2000) Planning and managing manufacturing capacity when demand is subject to diffusion effects. International Journal of Production Economics 66:227–240
6. Ho TH, Savin S, Terwiesch C (2002) Christian Terwiesch. Managing demand and sales dynamics in new product diffusion under supply constraint. Management Science 48:187–206
7. Lammers BH (1991) The effect of free samples on the immediate consumer purchase. Consumer Marketing 8:31–37
8. Heiman HB, Mcwilliams B, Shen ZH et al (2001) Learning and forgetting: Modeling optimal product sampling over time. Management Science 47:532–546
9. Jain DC, Mahajan V, Muller E (1995) An approach for determining optimal product sampling for the diffusion of a new product. Journal of Product Innovation Management 12:124–135
10. Horsky D (1990) A diffusion model incorporating product benefits, price, income, and information. Marketing Science 9:342–365
11. Sohn SY, Moon TH, Seok KJ (2009) Optimal pricing for mobile manufacturers in competitive market using genetic algorithm. Expert Systems with Applications 36:3448-345
12. Kima HW, Gupta S (2009) A comparison of purchase decision calculus between potential and repeat customers of an online store. Decision Support Systems 47:477–487
13. Parker P (1992) Price elasticity dynamics over the adoption life cycle. Journal of Marketing Research 24:358–367
14. Jain D, Rao R (1990) Effect of price on the demand for durables: Modeling, estimation and findings. Journal of Business and Economic Statistics 8:163–170
15. Mesak H (1996) Incorporating price, advertising and distribution in diffusion models of innovation: Some theoretical and empirical results. Computers Operations Researches 23:1007–1023
16. Maier F (1998) New product diffusion models in innovation management — A system dynamics perspective. System Dynamics Review 14:285–308

Part VIII
Ecological Engineering

Chapter 81

Study on the Method for Evaluating Ecological Health of the Main River Network in the Yellow River's Estuary Area

Kesen Chen, Maoru Qian, Benxing Zhu and Maosen Chen

Abstract Based on natural and social conditions of the Yellow River estuary area, this paper presents a 4-layer index system which consists of 20 factors, and to evaluate the river net's health from the aspects of natural functions, ecological functions and social service functions. According to their different features, we utilize different method to evaluate. As for the natural functions and ecological functions, we used single factor evaluating method based on the principle of most pessimistic evaluation. While the social service functions were evaluated with the help of comprehensive evaluating method according the index weight, and different evaluating models corresponding to each layer were thus proposed. It has been proved in case studies that this evaluation method is easy and operable, the results are scientific and reasonable.

Keywords River network · Ecological health · Evaluating method · Index system · The Yellow River estuary

81.1 Introduction

With the rapid development of economy and society in recent decades, the river health problem is getting severe and attracting more and more social concerns all over the world, therefore, the river health evaluation has become the research focus

---

K. Chen (✉)
Department of Environmental Engineering, Shandong Water Polytechnic, Rizhao 276826, P. R. China
School of Civil Engineering, Shandong University, Jinan 250061, P. R. China
e-mail: cks111@126.com

M. Qian
Yanzhou City Water Conservancy Bureau, Yanzhou 272100, P. R. China

B. Zhu · M. Chen
Shandong Province Second Water Conservancy Bureau, Yanzhou 272100, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_81,

today. More and more scholars in and abroad have contributed a lot of researches in this area [4, 5, 8–11]. Geng [6] constructs the river health evaluation system from the aspects of the river's social service functions, environment functions, anti-flood functions and ecological functions. Hu [2] evaluates the downstream's health of the Yellow River by using 8 evaluation indexes based on fuzzy evaluating model. Gao [1] structures the river health evaluation system from such four facets as river's power, water quality, riverbed morphology and river's social functions, thus establishing a multi-layered evaluating model for rive health grounded on fuzzy theory. The hydrological agencies of the Yellow River and the Yangtze River also put up some conceptions of maintaining the two great rivers' health, and they have made some creative explorations in practice [2, 3, 7, 12]. However, the river health evaluation is still a new subject, the scholars haven't come to a common sense in evaluating river health.

This paper is written upon the requirements of the program The Utilizing of Water Resources and the Ecological Revivification in the Yellow River's Estuary Area (No. 20121114-2) funded by the Non-profit Public Industry in The Ministry of Water Resources, P.R.C. And we carry out a series of researches depending on the evaluation method on the river network's ecological health in the Yellow River's estuary area. The Yellow River's estuary area locates at Dongying City, Shandong Province, P.R.C, which is an important cross area of the Bohai Bay Economic Zone and the Yellow River Economic Zone. This area is well known for its rich petroleum, land, ocean and salt resources, but the shortage of water resources, water pollution, land stalinization, river siltation, atrophy of wetlands and shoreline retro gradation are getting serious in the area. Therefore, the study on the Ecological Health Evaluation of this area is of great significance to the utilization of water resources and ecological revivification.

81.2 Evaluation Index System and Its Standards

81.2.1 Evaluation Index System

The health of a river network means not only that the river net is sound naturally, but also can offers a healthy ecological environment and social service function. And these can be reflected correspondingly in the following aspects, i.e. natural function, ecological function and social service function. If any one of the functions is not good enough or lost, this river net can not be seen as a healthy one. Healthy natural functions refer to its complete structure, perfect river motility; while healthy ecological functions refer to its ability to sustain itself and renovation, and can perform its ecological functions well. Healthy social service functions means the river net can meet the reasonable needs of human being. Of these functions, the ecological functions and the natural functions are the river net's nature attribute, the social service functions are its social attribute. This paper selects parameters of these 3 functions of the river net to structure the river net healthy evaluation criteria.

We proposed an index system (Table 81.1) made up of four layers, they are the target layer, the criteria layer, the status layer and the index layer. The target layer is reflection of the level of the river net's health; the criteria layer stands for the river net's natural functions, ecological functions and social functions; and the status layer is described from 8 aspects. The natural functions can be reflected through the index of bank, river morphology; and the Hydrological Features; while the ecological functions are described by water environment and ecological Status; and the social service functions are described by the utilization of water resources, water supply and landscape. This paper brings forward an index layer consisting of 20 evaluation indexes, which based on the requirement of social economic development and the practical situation of the Yellow River's estuary area, such as the shortage of water resources, water quality pollution, heavy water sediment concentration, stalinization of soil, the shrink of wetland, the decrease of animals and plants as well as erosion of coastline.

Table 81.1 Evaluation index system of the river net health in the Yellow River's estuary area

Target Layer A	Criteria Layer B	Status Layer C	Index Layer D
Level of the River Net's Health A	Natural Functions B_1	Bank status C_{11}	Bank Stability D_{111}
		River Morphology C_{12}	Riverbed Stability D_{121} Width Depth Ratio D_{122} Waterways Connectivity D_{123}
		Hydrological Features C_{13}	Bankfull Discharge Ratio D_{131} Ecological Flow Ratio D_{132} Flow and Sediment gearing index D_{133} Watercourse Deposition index D_{134} Sediment Transport changing ratio D_{135} Flood Control index D_{136}
	Ecological Functions B_2	Water environment C_{21}	Water Quality ratio of reaching the standard D_{211} The probability of River cut-off Ratio D_{212} The Stalinization Index D_{213}
		Ecological Status C_{22}	Zoobenthos community Diversity Index D_{221} Planktonic Vegetation Diversity Index D_{222}
	Ecological Functions B_3	Utilization of the water resources C_{31}	Utilization ratio of Water Resources D_{311}
		Water Supply Status C_{32}	Probability of Irrigation D_{321} Probability of Industrial Water Utilization D_{322} Probability of Drinking Water for Humans and animals D_{323}
		Landscape Status C_{33}	Landscape Diversity D_{331}

81.2.2 Evaluation Index Standards

River net health is a dynamic conception bearing both the features of time and features of space, as it reflects the public expectation toward the river net, and the different value orientation under different social background. As for those river nets located in different region, enjoying different size and scale, we can not judge their health upon the same standards. Meanwhile, different group also have different opinions, thus often resulting in different conclusion. Therefore, the health of a river net can only mean its health in a relative angle. It is, in fact, a kind of balance found between humans' demand from river and the sustainability of the river itself. However, the standards of evaluating the health of a river is a dynamic one, reflecting comprehensively the humans' requirements for the river net's natural features and social service functions in a certain area under a certain period and economic environment. At the same time, it can also show the changes occurred in the vicissitudes of society, human ecological value, climate change, geological structure as well as ecological succession.

In this paper, we divide the health level of a rive net into five grades according to the reality of the Main River Network in the Yellow River's Estuary Area, and related national technical standards as well as those foreign grade classification method and research results. The five grades are 1-healthy, 2-sub-healthy, 3-medium, 4-sub-morbid and 5-morbid. Each grade has its corresponding critical value (Table 81.2). As to the index who gets better with its value increases, the critical value in Table 81.2 is the grade's floor limit; as to the index that gets better with its value decreases, the critical value in the table is the grade's top limit.

81.3 Evaluation Method

There are many river health evaluation methods which belong to two major types: one is the forecasting model method, such as RIVPACS and AURIVAS; the other is the comprehensive evaluation model which can be divided as the single index evaluation method and the synthetical evaluation method. Fuzzy comprehensive is a kind of usual comprehensive evaluation method. This method can better resolve those fixed quantity problems of indexes, since they are often obscure in boundary, difficult to be quantified. However, the results acquired from this method is only a comprehensive evaluation conclusion for the river without a detailed description toward regional health, therefore, some minor health problems will be thus neglected. In fact, if some indexes such as bank stability and water quality are not in good shape, even though other indexes are good, the final comprehensive results are good, this whole river is still unhealthy. It is difficult to say that a river bursting often is a healthy one, although its other functions are perfect. This is "Cannikin Law". Given this, separated evaluation method and the comprehensive evaluation method are both employed according to the features of each index in this paper.

Table 81.2 Evaluation parameter and connotation of the main river net health in the Yellow River's estuary area and its standards

Index	Parameters	Standards				
		1	2	3	4	5
D_{111}	Bank Stability	≥ 0.8	0.6	0.4	0.2	< 0.2
D_{121}	Riverbed Deposition Conditions	≥ 0.8	0.6	0.4	0.2	< 0.2
D_{122}	Fluvial Section Conditions	≤ 1	1.1	1.2	1.3	≥ 1.4
D_{123}	Water Continuity and Connection Conditions	≥ 0.8	0.6	0.4	0.2	< 0.2
D_{131}	Runoff Ability of Main Channel %	100	95	90	80	≤ 70
D_{132}	Days of Ecological demand water quantity in controlled river section/365/%	≥ 95	90	80	70	< 65
D_{133}	Water and Sediment blending Ratio	≥ 1	0.9	0.8	0.7	≤ 0.6
D_{134}	Watercourse Sediment concentration	0	0.5	1	1.5	≥ 2
D_{135}	Sediment transport ability %	100	90	80	70	≤ 60
D_{136}	Total storage capacity for flood control /average runoff of river over the years	≥ 0.2	0.1	0.05	0.01	< 0.01
D_{211}	Grade 3 and above one reach Length/ Evaluation River Length %	≥ 90	80	60	40	< 40
D_{212}	Days for Average water cut-off/365/ %	0	5	10	15	> 20
D_{213}	Stalinization Area/Total Area %	0	5	10	20	> 30
D_{221}	Shannon-Weiner Index	> 3.5	2.5	1.5	1	< 1.0
D_{222}	Margalef Index	> 5.0	4	3	1.5	< 1.5
D_{311}	Practical Quantity of water utilization/total Water Quantity %	< 10	20	30	40	> 40
D_{321}	Real Irrigating Water Quantity/ predicted Irrigating Water Demand %	≥ 95	85	75	65	≤ 55
D_{322}	Real Industrial Water consumption/predicted industrial water Demand %	≥ 95	85	75	65	≤ 55
D_{323}	Real Drinking Water/predicted Drinking Water Demand %	≥ 95	90	85	70	≤ 60
D_{331}	Level of Landscape Service %	≥ 90	70	50	30	< 20

It's applicable to take the single factor evaluation method to define the river net's natural functions and ecological functions. This is the application of the most pessimistic evaluation principles by defining health level of its natural functions and ecological functions based on the lowest category of some index. We compare each real index of the river net with those evaluation indexes in index standards to define its health level, and then the lowest index is chosen to be the river's health level.

As for River net's social service functions, a comprehensive evaluation method is proper. As we know that, river net's social service function is affixed by humans being instead of a feature innate in itself, and each social service functions it offers to society are independent and parallel with each other. Therefore, each index has its different importance. One failure occurred in a single function does not lead to the conclusion that the whole river net is unhealthy. Therefore, it is more appropriate to use the comprehensive evaluation method to evaluate each social service functions in a whole manner. According to the above analysis, a evaluation model for each layer of the index system is being established.

(1) Practical Index and Evaluation

All the evaluation indexes can be defined as quantitative indexes or qualitative indexes. Quantitative indexes are obtained by practical measurement, and quantitative indexes are determined by experts' marking. After making comparison between the practical index and the criticality value, we can get the results of grade definition.

(2) The Evaluation Model of Status Layer

- Taking the single factor evaluation method to evaluate natural functions and ecological functions. $C_i = D_{i1} \wedge D_{i2} \wedge D_{i3} \wedge \ldots \wedge D_{in}$, where C_i denotes the evaluation value of status layer i; and D_{in} denotes the index's value n of the status layer i.
- Taking the comprehensive evaluation to evaluate social service functions.

Additive synthesis and Multiplicative model are often introduced in the comprehensive evaluation method. In this paper, we employ the additive synthesis model. $C_i = \sum \omega_{ij} D_{ij}$, where C_i denotes the evaluation value of status layer i; D_{ij} is the index's value j of status layer i; ω_{ij} means the weight average of D_{ij}, confirmed by AHP.

(3) The Evaluation Model of Criteria Layer

$$B_i = C_{i1} \wedge C_{i2} \wedge C_{i3} \wedge \cdots \wedge C_{in}, \tag{81.1}$$

where B_i denotes the evaluation value of criteria layer i; C_{in} is the value of status layer n of criteria layer i.

(4) The Evaluation Model of Target Layer

$$A = B_1 \wedge B_2 \wedge B_3 \wedge \cdots \wedge B_n, \tag{81.2}$$

where A denotes the evaluation value of target layerB_n means the n evaluation of criteria layer n.

81.4 Case Study

Take the C-D section of the Yellow River's Estuary Area as example, and all the parameters obtained in reality and the evaluation process made from above index layer to the lower target layer are listed in Table 81.3. The results shows that the healthy level of C-D sections belong to grade 3- medium. From the table, we can find that the natural functions and ecological functions in criteria layer are grade 3-medium, and its social service functions are grade 1- healthy. Those bank conditions, water supply ability are grade 1- healthy; river morphology, ecological conditions, utilization of water resources, landscape are grade 2- sub-healthy; hydrological conditions and water environment are grade 3- medium. All in all, there are four indexes belong to grade 1, twelve indexes are grade 2 and the other four ones are grade 3.

Based on this evaluation method, we can not only get the comprehensive evaluation, but also the evaluation results for each layer, and the whole process is clear at a glance. From this, we can easily see those factors affecting the river net's health.

Table 81.3 Ecological evaluation on the Yellow River's estuary area (C-D sections)

Index (weight)	Index value	Healthy Level	Status Layer	Healthy Level	Criteria Layer	Healthy Level	Target Layer	Healthy Level
D_{111}	0.86	1	C_{11}	1	B_1	3	A	3
D_{121}	0.82	1	C_{12}	2				
D_{122}	1.1	2						
D_{123}	0.64	2						
D_{131}	96	2	C_{13}	3				
D_{132}	88	3						
D_{133}	0.87	3						
D_{134}	1.24	3						
D_{135}	92	2						
D_{136}	0.18	2						
D_{211}	85	2	C_{21}	3	B_2	3		
D_{212}	4.3	2						
D_{213}	5.6	3						
D_{221}	2.8	2	C_{22}	2				
D_{222}	4.2	2						
$D_{311}(0.21)$	15.2	2	C_{31}	2	B_3	1		
$D_{321}(0.20)$	85	2	C_{32}	1				
$D_{322}(0.25)$	96	1						
$D_{323}(0.29)$	98	1						
$D_{331}(0.05)$	76	2	C_{33}	2				

81.5 Conclusion

The river net health evaluation includes the confirmation of evaluation index, the formulation of evaluation standards and the application of evaluation method. The evaluation index and the evaluation standards are regional and dynamic, so different evaluation index and standards should be applied toward different river, different region and period. Based on the natural and the social conditions of the Yellow River's estuary area, this paper presents a 4-layer criteria system which consists of 20 factors, and make the analysis of the river network health status from the aspects of natural functions, ecological functions and social functions. According to the features of each index, we employed single factor evaluation method and comprehensive evaluation method respectively. As for evaluating river net's natural service function and ecological functions, we use single factor evaluation method upon the principle of the most pessimistic evaluation. As for its social service functions, we use comprehensive evaluation method, bring forward an evaluating model for each layer. By this way, we can not only acquire the comprehensive evaluation results, but also the evaluation results for each layer. It is proved by the case that this evaluation method is easy and operable, the results are scientific and reasonable.

Acknowledgements This paper is supported by a grant from the Ministry of Water Resources' Special Appropriation Line for the Non-profit Public Industry (201201114-02).

References

1. Gao X, Zhao S, Zhang C et al (2009) Index system and method for assessing the health status of river. Journal of Hydraulic Engineering 8:962–968
2. Hu C, Chen J, Sun X et al (2008) Health assessment of river course in lower yellow river and measures for regulation. Journal of Hydraulic Engineering 10:1189–1196 (In Chinese)
3. Zheng J, Shao D, Wang L et al (2007) Study on the index system and integrative evaluation of health in Yangtze river. South-to-North Water Transfers and Water Science & Technology 4:61–64 (In Chinese)
4. Zhang J, Dong Z, Sun D et al (2010) Complete river health assessment index system based on eco-regional method according to dominant ecological functions. Journal of Hydraulic Engineering 8:883–892 (In Chinese)
5. Bian J, Geng L, Fang R (2010) Research on the evaluation system of river health. China Rural Water and Hydropower 9:39–42 (In Chinese)
6. Geng L, Liu H, Zhong H et al (2006) Indicators and criteria for evaluation of healthy rivers. Journal of Hydraulic Engineering 3:253–258
7. Wang L, Shao D, Zheng J et al (2007) Assessment index system of healthy yangtze and standards. China Water Resources 12:12–15
8. Hu X, Yang X, Li J et al (2008) Set pair analysis model for river health system assessment. Systems Engineering Theory & Practice 5:164–170 (In Chinese)
9. He X, Li Q, Song L (2011) Review on ecosystem health assessment of a river. Ground Water 2:63–66
10. Huang Y, Wen H, Cai J (2010) Research progress on river health assessment based on environmental management. Ecology and Environmental Sciences 4:967–973 (In Chinese)
11. Che Y, Wu E, Cai M et al (2011) Discussion of river health assessment on spatial and temporal scale and baseline. Resources and Environment in the Yangtze Basin 6:761–767
12. Xia Z, Guo W (2008) Research advance in river health. Resources and Environment in the Yangtze Basin 2:46–48 (In Chinese)

Chapter 82
Study on Regional Synergetic Development of Low Carbon Technology

Xiaozhong Yu, Yujie Jiang, Sui Gu and Xuxue Chen

Abstract China's low carbon economy has been established and developed under the regional non-equilibrium development state. There's great difference between regions in economic development stage, resources endowment, industry structure and technology level. The difference inordinately restricts the development of regional low carbon technology, and influences the development of regional low carbon economy and the whole country's low carbon economy. From the viewpoint of applied research, this paper uses systematic science method. Based on classification of different types of low carbon technology, it positions and analyzes the constraints in the process of regional low carbon technology development. The study shows that low carbon technology has the public product attributes, and regional synergetic development is the necessary channel to promote the overall and sustainable development of low carbon technology. We can achieve the regional technological synergies through perfecting technology sharing system, advocating multi-side participation, enhancing promotion and utilization.

Keywords Low carbon technology · Synergetic development · Constraints · Synergetic path

82.1 Introduction

Low carbon economy is a new kind of economic and technological paradigm. Relying on technology innovation and policy measures, it establishes an economic development model with less greenhouse gas emissions. Its smoothly implement will

---

X. Yu (✉) · Y. Jiang · S. Gu
Economic and Management School, Southwest Petroleum University, Chengdu 610500, P. R. China
e-mail: sunjuan5@yahoo.com.cn

X. Chen
Sichuan-Changqing Drilling Engineering Co., LTD, Chengdu 646000, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_82, © Springer-Verlag London 2013

eliminate the adverse effect that traditional economic growth mode has influenced on climate, resources and environment, promote sustained harmonious development of human society [1]. China is in the critical period of industrialization and urbanization development, low carbon economy is a profound reflection of disadvantages with the traditional economic development model, which used fossil energy for the main power and had high energy consumption and high pollution and high carbon emissions [2]. Nowadays, changing the economic growth style has become a consensus, and low carbon technology is the key to change the style of economic growth, and realize low carbon development. The National Development and Reform Commission has declared that China will develop and deploy the low carbon technology in the period of the 12th five-year plan, use low carbon technology to transform traditional industries, carry out key projects of energy saving and emission reduction in industry, building and traffic [3]. However, low carbon technology has the public product attributes, with the addition of the great differences between heterogeneous regional economies in China, its development will cause complex regional competition and cooperation. Therefore, overcome the restriction when low carbon technology transfer and low carbon economy development, we will need to rely on regional low carbon technological synergy.

82.2 The Classification of Low Carbon Technology in China

Low carbon technology is a new technology that will effectively control greenhouse gas emissions in power, transportation, building, metallurgy, chemical, petrochemical and other departments, as well as in the fields such as renewable and new energy, coal's cleaning and efficient utilization, oil and gas resources and the coalbed methane exploration and development, carbon dioxide capture and buried. It can be divided into three categories:

(1) Technologies of Energy Saving and Carbon Reduction

Carbon reduction technology is the energy saving and emission reduction technology mainly in the field of high energy consumption and high emissions, high efficiency utilization of clean coal, including coal's cleaning and efficient utilization, oil and gas resources and the coalbed methane exploration and development, etc. During the 11th five-year plan period, China's energy saving and emission reduction had achieved remarkable results, supported an average national economy of 11.2% growth with an average energy consumption of 6.6% growth a year [4]. Among them, energy saving and emission reduction technology in the field of high energy consumption and high emissions mainly reflected in the use of heating and air-conditioning's energy saving, industrial water circulating system's energy optimization, cogeneration, power supply system's energy saving, high efficiency and energy saving boiler, energy-saving heating and refrigeration equipment, transportation hybrid technology, building energy saving technology, energy saving motor and inverter, energy-efficient appliances and energy-saving bulbs, and other energy saving equipment. Secondly, coal, oil and gas resources' highly efficiency utilization, represented by the Integrated Gasification Combined Cycle (IGCC) and Natural Gas Combined Cycle (NGCC).

(2) Technologies of Carbon Free and Low Carbon Energy

Carbon free technology includes nuclear energy, solar energy, wind energy, biomass energy and other renewable energy technology. As a low carbon energy, nuclear power is high yield but cheap. The French third generation water pressure reactor ERP is considered to be the world's most advanced nuclear power technology, its power cost is 30% lower than gas. Besides, in the past 10 years, the world solar cell production is increasing by 38% annually, more than IT industry. The global wind power capacity had grown 28.8% against the financial crisis in 2008. The install base of wind power industry has installed increased by 25% annually in the recent 10 years since 2001.Wind power technology is getting breakthrough, sea wind farm with high-capacity is developing gradually. In addition, biofuels and biodiesel also get development. The United States, Germany, Canada and some other countries have begun to use non-food crops like straw, bagasse and other woodiness cellulosic-based substance replace the original food crops raw materials.

(3) Technologies of Carbon Limitation

The typical carbon limitation technology is carbon capture and sequestration (ccs), refers to the process that collecting carbon dioxide before or after fossil fuel burning, sealling up for safekeeping underground in low quality of structure, deep sea or curdling it in Inorganic carbonate. This method can reduce emissions up to 85%, it is an emerging technology with wide application future among carbon emission-reduction technologies. But with the expensive cost, CCS projects are mainly distributed in North America and Europe, less in Asia [6].

82.3 Constraints of Regional Low Carbon Technology Synergy

82.3.1 Regional Low Carbon Technological Basic Difference

Based on the imbalance of economic development, different low carbon economical regions have different technological condition in China. According to the series research before, using area's per capita GDP and per capita carbon emissions as variables, making variables high and low two states, with the classification of different states combination in qualitative, we will divide Chinese low carbon economical system into four different regions, as Fig. 82.1 [7].

Concern region is the underdeveloped areas at present, with low production value and low carbon emissions. Based on agriculture and forestry and animal husbandry, it has neither high carbon industry nor developed industry and cities. It is lack of technical development environment, and the technical level is backward. Difficult region is typically area with low production value and high carbon emissions. It used to be fast economic growth and high carbon emissions area, mainly relies on high carbon resources and industry, so the structure is single that completely de-

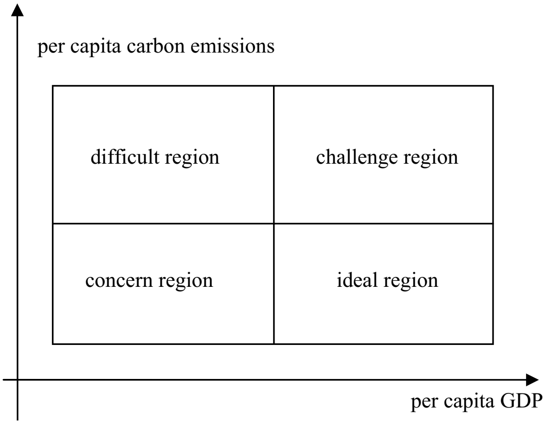


Fig. 82.1 Low carbon economical system in China

pends on high carbon resources exploitation. Thus, technology development is single sided and lack of introduction and use of new technologies.Challenge region is in high speed development, characterized by industrialization and urbanization. It's economic entity with high value high carbon, economic growth and carbon emissions can't be separated. It has great demand and power for energy saving and new low carbon techniques. Ideal region has entered post-industrial era. It's the high-tech economy entity with mature high and new technology and industry. It has obvious technical accumulative advantage.

China's low carbon technology is based on different regions' industrial structure, resources endowment, and economic development level. Different regions have incongruent way to develop economy, so they have difference in the use of technology. The region's unbalanced development state is both the direct reason forming regional technological difference and a big restricted factor in regional low carbon technology coordinated development.

82.3.2 The Difficulty of Regional Low Carbon Technological Transfer

Technology transfer is an economic phenomenon that objectively exists in each country or region. When regional low carbon economy has developed to a certain stage, low carbon technology in developed region would lost comparative advantage. Due to the internal upgrade need, technology will transfer from well-developed region to the developing region. This transfer will form technological diffusion to the disadvantaged regions so as to promote their innovation and upgrading. However, technology transfer is phase of advance; it is firstly spreads to the region that has certain industrial development potential as the key point, then to the others [8].

The acceptation of low carbon technology is relying on its development level in regions, different levels' acception needs different degrees of elements, such as regional material, capital, infrastructure, R&D investment, human capital, environment protection, and regulations. Seeing from inside, in the process of technology transfer, the differences in regional low carbon economic development level makes the ideal region become low carbon technology transfer area. Challenge region becomes the main technical undertake windows due to its technical basis and regional economic development level. Difficult region and concern region are both weak in technical foundation, and inadequate to technology development of industrial supporting ability. They mainly influence by the natural resources distribution, the difference of climate condition, so it's hard for them to accept and digestive high low carbon technologies. Thus, those two regions have a waste of technology resource and face large obstacles in the process of low carbon technologies acception.Seeing from outside, in the transfer of international acception led by ideal region,the huge discrepancy of regional technical level basis makes regions give up advanced international technology which is in strategic position of our country, due to the high cost and the innovation risk. They may accept international industry transfer instead, in which case, they'll fall into the core technology competition trap that is fringe and hollowly.

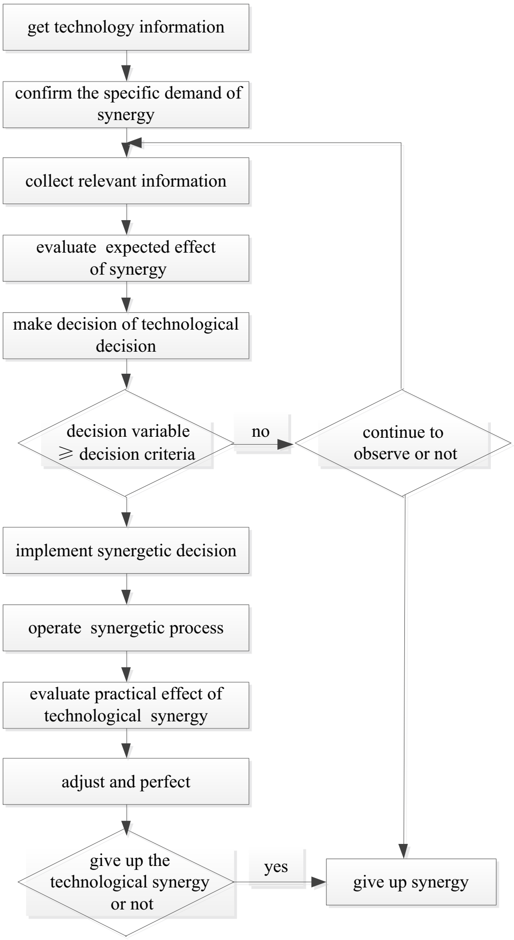
82.3.3 The Complexity of Regional Competition and Cooperation

The low carbon economy development is not about a single regional economic entity.Under economic globalization trend, it is hard for a single city or an economic entity to form comprehensive competitive advantage [10]. With the promulgation and enforcement of China's 12th Five-year Program Planning, promoting regional synergetic development has risen to be national strategy and will provide opportunity and conditions for heterogeneity regions' economy cooperation and win-win development. Integrating regional advantages and strength, balancing the interests of all parties, exploring scientific low carbon development cooperation way and cooperation angle, is the trend of regional economy's synergetic development under global low carbon background.

However, it's complicated for the low carbon economic development in different types of regional entities. There's intricate relationship between them, they are competing while cooperating, interacting while restricting with each other. In China's special conditions, our low carbon economy is based on the development of each different types of region. The central government formulates central policy for the whole country's low carbon economy development, and local government formulates local policy for the region, so as to promote jurisdiction area's low carbon economy development and coordination of regional low carbon technologies.

The current evaluation mechanism for party and government officials is making local GDP and financial revenue as foundation. In this case, regional low carbon technology policy will follow local policy and has the characteristics of downtown cumber, even though the overall direction and thinking is at the same premise. Impacted the factors such as local leaders' utility preference, the rigid ideology, limited rationality formed by bureaucracy, regions will take their own development for primary task. They might be bargaining to realize their own benefit maximization development, competing blindly, setting artificial and technical barriers to the collaborative technology, limiting the flow and share of technology. For example, in the name of intellectual property protection, region may restrict the technology share, and this will hamper its rapid marketization.

Fig. 82.2 Path of regional low carbon technological synergy



82.4 The Synergetic Path of Regional Low Carbon Technological Development

Low carbon technology is an important part in low carbon economy development, its synergy of all regions is the tendency of economic development in market economy condition. The regional economic differences will cause competition and fluctuation, form region's technology attraction. In the perspective of systematics, guiding the attractive power to make it as a driving force to induce the regional technology exchange and flow, will promote technology collaboration and sharing, and eventually keep the system stability, as shown in Fig. 82.2.

82.4.1 Improve the System and Ensure Technology Sharing Mechanism

A good mechanism environment is the premise of regional low carbon economy's collaborative and integrative development. According to economists Douglass C. North, system is kind of artificial restrictions which is drawn up to maintain the relations. By establishing the internal and external force to restrain the behavior, system can influence people's motivations and interest selection in trade. By interacting with each other and eastablishing a relatively satable trade framework, system will prevent the opportuism in the trade and make people pursuit their rational utility maximization under certain conditions. As impeller of regional low carbon technology synergy, government has unreplaceble function in the process [9]. They should match policy tools in technology push and demand pull, study on their transfer mechanism and the actual performance to improve the system.

Government are functional departments, the relevant system they made should be based on the right market demand information, advanced technology transfer and guide. To establish the subject position of regions need on different types of low carbon technology, they'll formulate technological strategy plans and progress goals, find out technology development direction, improve voluntary and autonomy level in adopting new technology. On the basis of current regulations, rules, regulations and technical standards and the corresponding development planning, firstly, government should build constraint mechanism, internalize the different regions' external benefit thourgh system incentive function, so as to make the regional income in the the process of technology transfer close to social benefits constantly, and clean the transfer obstacles objectively. Secondly, government should build incentive mechanism. They should encourage the enterprises or the regions that have achieved benefits in mutual technology sharing process, and promote the sustainable development of technology synergy and sharing. Third, government should build information communication mechanism. They should establish national low carbon technology public sharing platform, release low carbon technical information and show application results in time, increase the marketization degree of low carbon technology and reduce the limitation in its diffusion and transfer.

82.4.2 Multi-side Participation to Ensure Technology Innovation and Transfer

Low carbon technology is both the core of low carbon economy development and the biggest challenge on China's low carbon road. Its transfer has function of economic resources allocation, and is the efficient way to achieve technology synergy in different regions. China's low carbon economy development can't completely invest in technology transfer from developed countries; we should take advantage of independent innovation to realize technology breakthrough and domestic technology initiative transfer in the 3-5 years [10].

To solve the short board and barriers in low carbon technology transfer, we must develop the overall social strength, break human technology barrier between heterogeneity regions, strengthen the organic connections between low carbon technology innovation subjects, structure Chinese characteristics' low carbon technology road comprised by government, enterprises and scientific research institution. Not only safeguard the low carbon technology introduction and innovation, but also provide conditions for regional low carbon technology transfer. First, governments are the main finical surety in technology development and transfer. By building low carbon technology special promotion fund, they can financially support low carbon technology conquering and improve the whole low carbon technology level. Second, universities and research institutions have huge technological group that are specialized in scientific research and technological development. They have strong technical research and innovation abilities, which make them good sources of low carbon technologies. Third, the enterprises are closest to market demands and trends, their prospectively knowing about it may be helpful to oriented research and utilization of low carbon technologies. In a word, the multi-side participation and collaboration is an effective way to promote low carbon technological innovation, an important way to use low carbon technology in time, and a good channel to achieve technology marketization and industrialized application.

In addition, the regional conditions in China are different, so the transfer and utilization are not the same as well. Ideal region has to strength low carbon technological import and research ability, realize technological forward development. Challenge region should take full advantage of technological accumulation; enhance the application of CCS and other carbon technologies while upgrading industrial structure. Difficult region has to pay attention to energy conservation and emission reduction while exploring and using natural resources. Concern region can develop agricultural circular economy, develop ecological agriculture technology, and improve the utilization of biomass energy.

82.4.3 Expand the Cooperation Pattern and Promote Technological Utilization

Low carbon technical generation and development benefits from low carbon technology innovation direction and low carbon technology transfer path. Low carbon technological synergy development is not an one-way or linear process from research to new product, but a matching process for low carbon technology and energy market opportunities [11]. Thus, low carbon technology innovation requires system support. This system involves national, regional, department innovation and technical system and many other aspects. It will make subsystems explore constantly and expand the cooperation pattern in order to promote technology use and development.

First of all, take full advantage of ideal region's strengths in technical accumulation and low carbon technological innovative resources, and make it as technology center to establish scientific research experimental base and achievement base. Through ideal region's headquarters economy technology mode, we'll push the low carbon linkage complementary development of difficult region, challenge region and concern region, and achieve low carbon technological concentration and diffusion effectively. Second, develop the enclaves economic development model [12], rely on different types of regional heterogeneous resources. From the perspective of low carbon economy integration, and based on the principle of resources complement, function complement, advantage complement, we'll provide conditions for low carbon introduction and fusion by integrating the regional administrative management and economic development elements, such as cooperative investment, supply and demand, personnel training and industrial transfer etc.

82.5 Conclusion

The ultimate goals of regional low carbon technological synergy are to promote all regions' low carbon economy development, and to ensure the overall development of the carbon economic system. Our regional low carbon economy is under the non-balanced basis, which makes it difficult for low carbon technology to transfer between regions, and aggravating for regional competition and cooperation. In order to overcome this obstacle series, the government should set up and perfect the relevant system that would guarantee the sharing mechanism. The government, enterprises and research institutes trinity should all be together to ensure the technology innovation and transfer. The enclaves economic development model should be developed to insure the use of technology. Finally, we'll promote Chinese regional low carbon technological synergy development and promote the low carbon economy process.

Acknowledgements Fund project: Sciences Foundation of Humanities and Social of Ministry of Education (Project Approval Number: 10 YJA790235). Philosophy and Social Science "Twelfth Five-Year Plan" in 2011 of Sichuan Province (Project Approval Number: SC11B068).

References

1. Nakata T, Silva D, Rodionov M (2011) Application of energy system models for designing a low-carbon society. Progress in Energy and Combustion Science 4:462–502
2. Cao JH (2010) The framework analysis of technological path in Shanghai low carbon economy development. Chinese Population, Resources and Environment 10:35–40 (In Chinese)
3. The National Development and Reform Commission (2010) To push low carbon technology in the Twelfth Five Years Planning. Chinses Energy Nets 10 (In Chinese)
4. Wen JB (2011) Deploys the energy conservation and emissions reduction during the Twelfth Five Years Planning. Chinese Low Carbon Nets 9 (In Chinese)
5. Haszeldine RS (2009) Carbon capture and storage: How green can black be. Science 5948:1647–1652
6. Huang D (2010) Low carbon technological innovation and policy support. Chinese Science and Technology BBS 2:37–40 (In Chinese)
7. Yu X, Jiang Y, Yang L (2012) Study on the choice of low-carbon economy's behavior pattern for different regional type. Science & Technology Progress and Policy 3:40–44 (In Chinese)
8. Li XG (2007) International industrial transfer and the new road of industrialization in China. China Economy Press, Beijing
9. Zhang Z (2010) China in the transition to a low-carbon economy. Energy Policy 38:6638–6653
10. He Q, Li T (2010) Change the mode of economic development and develop low carbon economy. Price Theory and Practice 6:16–17, 66 (In Chinese)
11. Shi Q, Fan L (2011) Study on countermeasures of low carbon technologies coping with climate change and achieve low carbon development. Marketing Management Review 9:184–185 (In Chinese)
12. Zhang R, Hao B, Ren H (2011) Enclaves economic development model and route choice of cooperating with east. Gansu Social Science, 2:187–190, 204 (In Chinese)

Chapter 83

Construction and Management of Potato Industrial System with Year-round Production and Supply under Multiple Cropping Systems

Xueshan Shen, Huijuan Qu, Nanshan Liang, Xuelan Lu and Gang Huang

Abstract In this paper, based on the development of potato industry in Sichuan province, through the analysis on construction thinking of potato industrial system with year-round production and supply under multiple cropping systems, the research process of that in the past few years were summarized. This paper also puts forward the management measures of potato industrial system with year-round production and supply under multiple cropping systems in Sichuan province, then analysis the pushing effect of that on science and technology progress in industries and the economic benefit and social benefit in its application and popularization.

Keywords Multiple cropping systems · Potato · Year-round production and supply · Industry system · Construction

83.1 Introduction

Potato was known as "healthy food in 21st century" because of its extensive adaptability, high yield, rich nutrition, processing product diversification. China is the biggest production and consumption country in the world. Potato plant area was over

---

X. Shen
Soil and Fertilizer Institute, Sichuan Academy of Agricultural Sciences, Chengdu 610066, P. R. China

H. Qu
Institute of Biotechnology and Nuclear Technology, Sichuan Academy of Agricultural Sciences, Chengdu 610066, P. R. China

N. Liang · X. Lu
Center for Popularization of Agricultural Technology of Sichuan Province, Chengdu 610041, P. R. China

G. Huang (✉)
Sichuan Academy of Agricultural Sciences, Chengdu 610066, P. R. China
e-mail: huanggangsaas@163.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_83,

5.6 million hectares while total yield was more than 80 million tons in China, both about 22 percent of potato area and yield in the world in 2007. Sichuan province is one of main potato production provinces in China while potato is one of main food and cash crops with large increasing yield potential and income potential thus plays an irreplaceable role in ensuring food society, advancing the adjustment of agricultural structures, promoting a steady increase of peasant income and developing agricultural products processing, etc. Meanwhile, potato also is leading industries to ensure ration safety, poverty alleviation and increase income and social harmony of poor mountainous areas and minority areas in Sichuan province [1–4].

In Sichuan province, due to natural ecology condition is superior, rich technical reserves, solid foundation of industrial development, wide market prospect, and tremendous increasing income potential, yield and area potential of potato are tremendous. In addition, the climate condition in Sichuan is complicated, potato could be planted all the year round while most plain and hilly area could provide more than enough heat to produce two harvests, but not enough for three harvests, intercropping system of potato could create favorable conditions for expansion device of area. But, potato industry didn't gain enough attention and the development faced tree contradictions: imbalance between great demand and inadequate production to domestic needs, technology supply constriction between tremendous yield and income potential and deficiency of technology supply, the constriction between great technology demand of and hard popularization of new technology in main area. Therefore, the construction of potato industrial system with year-round pro-

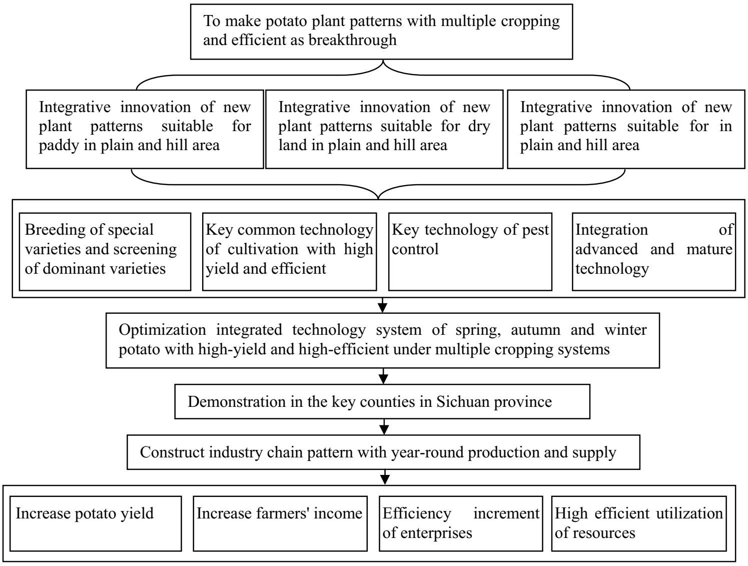


Fig. 83.1 Technical route in the construction of potato industrial system with year-round production and supply under multiple cropping systems

duction and supply under multiple cropping systems would play important roles in the development of potato industry in Sichuan province [3–7]. The construction of potato industrial system with year-round production and supply under multiple cropping systems in Sichuan province were systematical and embedded analysis in this paper, to provide powerful technology support for the development of potato industry in Sichuan province.

83.2 Construction Approaches of Potato Industrial System with Year-round Production and Supply under Multiple Cropping Systems

1. According to the constriction between supply and demand, to take developing intercropping plant and expand potato area as emphasis, create the technology and patterns of high-efficient, spatial and temporal control in multiple potato. Then the development of potato from spring crop to multiple cropping as spring, autumn, and winter, thus construct industry chain pattern with year-round production and supply.
2. According to the constriction of technology support in potato producing, based on creating high-efficient patterns of potato under multiple cropping, through lots of research, to make criteria of potato varieties suit for different cropping patterns, choose suitable varieties, promote six key producing technology, optimization integrated technology system of spring, autumn and winter potato with high-yield and high-efficient under multiple cropping systems.
3. According to the constriction of hard popularization of new technology, to strength innovation and application of extension mechanism, and ensure the implement of technology for plant pattern and key technology high-efficient.

83.3 Main Research Contents and Results of Potato Industrial System with Year-round Production and Supply under Multiple Cropping Systems

83.3.1 Planting Patterns of Potato with Year-round Production and Supply

Through the systematic research and demonstration in a large area for 15 years, to make potato plant patterns with multiple cropping and efficient as breakthrough, extension the plant area of autumn and winter potato, and increase yield and benefits of potato in each season, then made the development of potato from spring crop to multiple cropping as spring, autumn, and winter come true, thus formed industry chain pattern with year-round production and supply. Through the tackle key problems of two factors as the combination and spatial-temporal collocation of multiple crop such as potato and rice, potato and maize, etc, to construct 9 new multiple plant patterns of potato and multiple crop with harmonious symbiosis and year-round high yield and efficient (Table 83.1).

83.3.2 Screening and Layout of Potato Varieties under Multiple Cropping Systems

According to the problem of no clear criterion for potato varieties screening under multiple cropping systems, the potato varieties in disorder, and potato varieties of spring, autumn, winter were confused, to make screening criterion for spring, autumn, winter potato. Then 20 special varieties suit for different area and cropping system were selected, and make reasonable layout base on the ecological area (Table 83.2).

Table 83.1 Reform of potato patterns and their implement effect in Sichuan

Area coverage	Main patterns before the construction of industry system	Main patterns after the construction of industry system	Implement effect
Paddy in plain and hill area	Rice-Wheat (Rape)	Rice-Wheat/Rape Winter potato-Rice-Spring potato	Yield increased by 15.86-53.39% Pure income increased by 63.41 -256.21% Multiple Cropping Index increased by 50%
	Middle rice-Green manure (Idle field)	Rice-Autumn, winter potato	Fresh potato increased 1000-2000 kg per 666.67 m^2 in a year, while the pure income per 666.67 m^2 increased more than 1000 Yuan
Dry land in plain and hill area	Wheat/Rice/Sweet potato	Autumn, winter potato/ Rice/Sweet potato Autumn, winter potato/ Maize/Soybean Spring potato/Maize- Autumn, winter potato Wheat// Winter potato/Maize/ Sweet potato (Soybean) Wheat/ Maize/Sweet potato (Soybean)// Autumn potato	Yield increased by 2.63-7.47%, Pure income increased by 32.57-315.04%
Plateau mountainous area	Potato or maize in sole cropping	Spring potato/Maize	Yield increased more than 18.9% The percentage of changed area from one harvest to two harvests among potato area was above 85%

Table 83.2 Layout of special varieties for spring, autumn and winter potato

Type	Variety	Ecological areas
Spring cropping	Minshu 4, Chuanyu 6, Chuanyu 8, Chuanyu 10, Chuanliangsu 1, Chuanliangshu 2, Chuanliangshu 3, Chuanliangshu 4, Chuanliangsu 5, Liangshu 97, Eshu 5, Weishu 3, Qinyu 30, Hezuo88, Lishu 6	Parts of mountain countys in mountain areas around the Sichuan basin such as Liangshanzhou, Aba, Ganzi, Bazhong, Dazhou, Guangyuan, Mianyang Early spring potato in plain and hill area
Autumn cropping	Chuanyu 56, Chuanyuzao, Chuanyu 5, Eshu 4	Parts of mountain countys in lower mountain of plain and hill area such as Bazhong, Dazhou, Guangyuan, Mianyang Middle of the Hilly Region of Sichuan Basin
Winter cropping	Chuanyuzao, Chuanyu 6, Chuanyu 10, Eshu 3, Hui-2, Chuanliangsu 5	Yibin, Zigong, Luzhou in south Sichuan Lower mountain and river valleys such as Liangshan, Panzhihua Parts countys in middle Sichuan

Table 83.3 Cultivation techniques for high yield of spring, autumn and winter potato

NO.	Traditional techniques	Improved techniques	Improved effect
1	Lower density	Increase density above 1000 plant per 666.67 m^2	Average yield increased by more than 12%
2	Flat-tillage and sparse planting	Planting with ridge tillage and double rows	Average yield increased by 10.85%
3	High nitrogen fertilizing	Balanced fertilization and increase phosphorus potassium	Put forward the technique of nitrogen balanced application and nitrogen application combined with phosphorus and potassium
4	Soil mulching	Soil add film or straw mulching	Average yield increased by 11.5% Average benefit increased by 9.84%
5	Extensive management	Fertilizer stimulation, chemical control and fine management	Yield increased by 9.28-15.66%
6	Passive prevention	Prediction and forewarning timely and integrated control	Average effect was 46.6%-63.5%

83.3.3 Cultivation Technique for High Yield of Spring, Autumn and Winter Potato

According to the main problem exists in potato producing in Sichuan such as lower density, flat-tillage and sparse planting, High nitrogen fertilizing and extensive management, etc, to research Cultivation technique for high quality, efficient of spring, autumn and winter potato, and 6 key common technology were study as an emphasized research and popularization (Table 83.3).

83.3.4 Optimization Technology System of Potato Planting with High-yield and High-efficiency

On the base of the research on 6 key common technology of potato production, to optimize 3 technology systems suit for spring, autumn and winter potato with high-yield and high-efficiency, respectively, and develop 5 local standards.

Table 83.4 Technology system of spring, autumn and winter potato with high-yield and high-efficiency

Technology system	Core technology	Matching technology	Percentage of yield increased
Technology system of spring potato with high-yield and high-efficiency	Planting with ridge tillage and double rows, fertilizer stimulation, chemical control, and control late blight	Middle-late season varieties, virus-free seed potato, beginning sowing at an opportune time early, increasing density, balanced fertilization, pest integrated management	14.78%
Technology system of autumn potato with high-yield and high-efficiency	Eliminate alkali by drainage (paddy), plant with buds and control late blight	Short-life-period varieties, virus-free seed potato, timely speed planting, increasing density, straw mulching, balanced fertilization, pest integrated management	15.45%
Technology system of winter potato with high-yield and high-efficiency	Film mulching to preserve heat, whole course balanced fertilization	Chill-tolerance varieties, virus-free seed potato, beginning sowing at an opportune time early, increasing density, balanced fertilization, pest integrated management	16.39%

83.4 Management and Application of Potato Industrial System with Year-round Production and Supply under Multiple Cropping Systems

Through the integration of the project management mode of potato industry system in Sichuan province, and combined with policy orientation of government and potato development plan, to summarize the management mode of potato industrial system with year-round production and supply under multiple cropping systems, namely use work thought of “four strength and four drive” to strength the creation and application of popularization mechanism.

(1) The combination of administrative promotion and planning guiding

Through the combination pattern of government and technology means government leading, departments combing, agricultural science and education participate in, and take farmer as subject, to quicken the transformation of technique achievements. The research have established "development planning of potato industry in Sichuan province", made clear the development goals, tasks and regional distribution to guiding industry development. 3 three dominant area of potato industry were determined in Sichuan, and 41 core demonstration counties and 20 good species reproduction base counties were established, meanwhile, 1.52 million acres of national standardized production base of the raw material source for green food has been established and obtained national agricultural geographical indication named "Liangshan Potato".

(2) The combination of technological innovation and high yield establishment

The establishment of potato with high yield and high efficiency was taken as platform, the power of popularization of agricultural technology and educational and scientific research units were integrated to strength the integration of new model, new varieties and new technique, and use some methods such as bidding and demonstration to strength the connected effect of "new model, new varieties and new technique", matching of "good soil, improved variety, effective system, good method and golden opportunity", improve their extension in a large area and establish lots of multiple potato typical with high yield and efficiency. In 2008, the demonstration area was 300hm^2, while that was 675 hm^2 in 2009; in 2010, the demonstration area was 1200 hm^2.

(3) The combination of scale management and specialized service

To fully play the role of potato specialized cooperative and professional service of plant protection, use unified work methods such as unified supply seed, technology training, agricultural inputs supply, field management and selling products, to strength the service of pre-production, mid-production and post-production, and improve the base establishment of spring, autumn and winter potato.

(4) The combination of technology popularization and industrialization development

Establish the system of scientific and technological envoys contact specialized cooperatives and agriculture enterprise (owners), use the model of "scientific and technological envoys, specialized cooperatives (agriculture enterprise (owners)) and farmer" to accelerate achievement transformation. Through the pattern of "order production, guaranteed price purchase and second rebate", establish stable benefit affiliating mechanism among enterprises and farmers. Based on above, to construct creatively transformation mechanism of agricultural scientific achievements which means "three drive and three breakthrough", that is to say, with experts drive technicians to overcome technology barrier, specialized cooperatives drive farmers to overcome production barrier, and large household drive bases to overcome market barrier.

(5) The combination of personnel training and industrial chain innovation

Through the project resources such as "Sichuan academic elite" personnel training of potato key technology, CIP potato aiding, etc, take technology innovation industrial chain of potato as carrier, to create potato technology innovation team with combined different units and interdisciplinary, and supply intellectual support and technology support for the innovation of potato industrial chain in Sichuan.

(6) The combination of personnel training and industrial chain innovation

Create investment mechanism, and carry out new popularization involvement mechanisms which take financial investment as the guide, social investment as the supplement and farmer investment as the subject.

83.5 The Roles of Potato Industrial System with Year-round Production and Supply under Multiple Cropping Systems on Promoting Industrial Science and Technology Advancement

(1) It promotes the application of multiple potato pattern with high yield and high efficient

To take the lead in establish mew plant patterns of three harvest potato and multiple crops with multiple accretion and multi-cropping and high benefit in the main potato producing area, made the development of potato from spring crop to multiple cropping as spring, autumn, and winter come true, thus formed industry chain pattern with year-round production and supply, increase the resource utilization and production benefit. Provide technology support for the application of multiple potato pattern with high yield and high efficient in the same ecological region.

(2) It enriches the new cultivation techniques of multiple potato with high yield and efficiency

Mainly study the common key technologies such as high planting density, tillage and double rows, balanced fertilization, pest integrated management, etc, and optimize 3 technology systems suit for spring, autumn and winter potato with high-yield and high-efficiency, respectively, and develop 5 local standards. Provide technology support for the enrich of multiple potato pattern with high yield and high efficient in the same ecological region.

(3) It improves the specialization and scientific and reasonable distribution of potato varieties in Sichuan province

It has made screening criterions suit for different cropping system such as spring, autumn, and winter potato. 20 special varieties suit for different area and cropping system was selected, and make reasonable layout base on the ecological area, effectively solved the problem of no clear criterion for potato varieties screening under multiple cropping systems, the potato varieties in disorder, and potato varieties of spring, autumn, winter were confused. Then provide variety basis for the application of multiple potato pattern with high yield and high efficiency.

(4) It extends the new way for transformation of sci-tech achievements of characteristic and advantageous plant industry in China

It has constructed creatively transformation mechanism of agricultural scientific achievements which means “three drive and three breakthrough”, that is to say, with experts drive technicians to overcome technology barrier, specialized cooperatives drive farmers to overcome production barrier, and large household drive bases to overcome market barrier.

83.6 Application, Popularization and Economic Social Benefit of Potato Industrial System with Year-round Production and Supply under Multiple Cropping Systems

(1) It has a good effect on increasing production, and the total production was reached first in China

From 2005 to 2010, the total new increased potato was 5.48 million tons, while the percentage of yield was increased by 88%. Meanwhile, the ranking of total potato production in Sichuan among all the provinces of China was from the fourth in 2004 increased to the first in 2009 and 2010, and the contribution of new increased potato to the new increased grain production of the whole province was more than 30% in recent t three years.

(2) It has been applied widely, and realized multiple planting

From 2005 to 2010, the total new increased potato area was 157.9 million hm2, while the percentage of area was increased by 80%. Meanwhile, the ranking of total potato area in Sichuan among all the provinces of China was from the seventh in 2004 increased to the fourth in 2009 and 2010.

(3) It has gain high economic benefits and excellent effect in helping farmers increase their income

From 2005 to 2010, the net income of total new increased potato was 6.5 billion Yuan. In 2010, the average income of potato for every local farmer has been increased by 65Yuan, and the percentage of average income potato to that of grain and oil crops in whole province was 48.5%.

(4) It has gain remarkable social and ecological benefits benefits, and significant effect in disaster resistance and reduction

Reasonable development of vacant farmlands of autumn and winter were used to increase the resource utilization. The percentage of increased area of potato planting was by 80%, while that of increased multiple cropping index was by more than 50%.

Suitable changing and reseeding potato were used to improve the ability of disaster resistance and reduction. It has improved the adaptability of food industrial structure in Sichuan to multi natural disasters such as drought, freezing injury, flood, etc. thus play important roles in agricultural restoration and reconstruction in great drought in 2006 and hail, rain-snow and earthquake in 2008.

Acknowledgements The authors are thankful to the financial supports of the Twelfth Breeding Project of Crops and Livestock of Sichuan province, Project of Sichuan Potato Innovation Team of National Modern Industry and Technology System, and Construction Project of Potato Fine Variety Breeding System.

References

1. Sun D, Liu H (2009) Develop status and prospects of Chinese potato industry. Agricultural Outlook 3:26–28

2. Xie K, Qu D, Jin L et al (2008) The comparison of Chinese potato production and advanced countries. World Agriculture 5:35–41 (In Chinese)
3. Sun D (2009) The status and develop trend of Chinese potato processing. Agricultural Outlook 11:20–22
4. Lu X, Liang Y (2009) Potato. Sichuan Education Press (In Chinese)
5. Huang G, Xu J (2007) System innovation theory of agricultural science-technology value chain. Press of China Agricultural Science and Technology (In Chinese)
6. Huang G (2012) Principle and application of five grade value increment. Management of Agricultural Science and Technology 1–6 (In Chinese)
7. Qu D, Jin L, Xie K (2010) Review of potato industry in China in the past decade. Press of Science and Technology of China, Beijing (In Chinese)

Chapter 84
A Fitness Test of Cost of Carry Model in Chinese Cotton Future Market

Yong Zheng and Yina Zhang

Abstract The cost of carry model was developed under the assumption of perfect markets and no-arbitrage arguments. However, capital markets are not perfect and arbitrage mechanism cannot be complete, particularly for the emerging market. To examine how well the cost of carry model works in imperfect market, this study proposes a fitness test of the cost of carry model and investigates pricing performance of the cost of carry model for the emerging markets-China cotton futures market. Empirical results indicate that the fitness test of the cost of carry model for the Chinese cotton futures contract is not perfect. Moreover, the pricing performance of the cost of carry model for the cotton futures for the year of 2006 is better than that for the tear of 2005. These results show that the cost of carry model cannot reflect the actual movement of the market at that time, but we can also implied from the results that the cost of carry model is more suitably applied to a market that developed for a relatively long time. Thus, when using this model to estimate the theoretical values of futures, investors should note the market imperfection for the market they participated. At the same time, at the end of the paper the factors which can affect the pricing of the futures greatly are also discussed briefly.

Keywords Cost of carry · Fitness test · Cotton futures market

84.1 Introduction

Pricing is a key issue for traders of the commodity futures and academic researchers. Until now, the basic cost of carry model has been the most widely used model for pricing the futures. This model was developed under the assumption of perfect markets and no-arbitrage arguments. However, capital markets are not perfect and arbi-

---

Y. Zheng (✉) · Y. Zhang
International Business Faculty, Beijing Normal University, Zhuhai 5190085, P. R. China
e-mail: zhengyong2011@bnuz.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_84,

trage mechanism cannot be complete, particularly for the developing futures markets.

Compared with the developed futures markets (such as Chicago Board of Trade), Chinese futures markets were developed so late. Only in 1988, Guided by the China government, Chinese people began to seek the way to develop the futures market. Then, after a 2 years preparation, the first futures exchange market opened in Zhengzhou. But at that time, the market was really mass. Through the market seemed developed quite well from the large trading volume, actually, the market of the trading contracts was full of problems. From 1990 to 2000, the whole futures market was developing under no official rules and management. The futures exchanges rose to 20 all over the country, and the agency of the futures traders were more than 200. Therefore, at that time, the futures market seemed developed quite rapidly, it really can not be seen as a real futures market. While, only after 2000, the futures market's law system became relative complete and the government began to set an official institution -China Securities Regulatory Commission to guarantee the daily operation of the futures market.

However, through cotton futures contracts are the main futures contracts in China futures market nowadays, the history of them is short. The cotton futures contract was firstly introduced in Zhengzhou futures exchange in June, 1st, 2004. Like most other commodity futures contracts in China, the cotton futures contract is the standardized contract, whose underlying asset is the cotton. According to the CZCE, the cotton futures' trading unit is 5 tons per contract, and the expiration months are January, March, May, June, September and December. For the trading time, the last trading day is the 10th day of the contract's expiration month, while the last expatriating day is in the 12th of the contract's expiration month. For the commodity futures, the underlying assets all have their own standard. So, for our Chinese cotton futures, the cotton must satisfy 328B's standard (GB1103-2207). Besides, all the trading contracts should list in the board of Zhengzhou futures exchange.

Just as other commodity futures contract, cotton futures play an important role in the capital market. Generally speaking, the cotton futures contract mainly has 4 roles. They are price discovery, hedge risk, risk investment and resource allocation. By the development of these years, nowadays, the cotton futures market has been widely recognized by the whole capital market, and at the same time, the China cotton futures also can guide the product and consumption of the cotton. Until now, China cotton futures market can greatly influence the global cotton futures market.

Market performance differs among markets. China cotton futures contract only has been trading for 9 years. The average trading volume during the period of study (2005-2006) was lower than other developed countries' futures market. Additionally, the frequency of arbitrage opportunities is a little high, since the arbitrage mechanism is incomplete. But it is still necessary for us to exam how well the cost of carry model works in China's futures market, and how the China futures market performance differs from the theoretical performance. And this study can also show the frequency and persistency of arbitrage by using the cost of carry model.

The paper is organized as follows. Sect. 84.2 reviews the literatures on the relative studies. Sect. 84.3 presents the methodology of testing the cost of carry model.

Sect. 84.4 provides the results of the statistics on the cotton trading data. Sect. 84.5 describes the final results of our test and discusses the implication of the residuals characteristics.

84.2 Literature Review

In the academic researches, several researchers have found significant discrepancies between actual futures prices and theoretical values estimated by the cost of carry model. For instance, Cornell and French [4, 5], Figlewski [8], Modest and Sundaresan [15] and Eytan and Harpaz [6] all observed that the actual stock index futures prices were on average below their corresponding values predicted by the cost of carry model. From the viewpoint of the cost of carry model, the difference between the futures prices and the spot prices should reflect the carrying model, and this carrying cost must be positive. Therefore, the cost of carry model cannot reasonably explain how the real futures market prices the index futures.

Moreover, besides the researches of the index futures, among numbers of studies of the commodity futures, the test of cost of carry model covers several fields. For example, Frenkel and Levich [10] and Branson [1] find no opportunities for arbitrage in currency futures markets after controlling for transaction cost while similar results are found by Randleman and Carabini [20] in the Treasury bill futures market. On the other hand, Klemkosfy and Lasseer [14] fail to find support for the cost of carry model in the Treasury bond futures market. French [9] compares forwards and futures price in silver and copper commodity futures markets and finds a hedging premium. His results imply that the cost of carry model consists if element beyond the risk-free rate of interest. However, analyzing consumption commodity futures markets for corn, soybean and wheat, Chang [2] finds similar results that there is a hedging premium between the forwards and futures prices in these markets and the cost of carry model is not a constant function of the risk-free rate. Hansen and Rodrick [18], Fama [7] also find evidence of a non-constant hedging.

Under the criteria used by Standard & Poor's Emerging Market Database (EMDB) and Morgan Stanley Capital International (MSCI), China futures market is classified as an emerging market, and after China participated in WTO in 2004, the speed of the economy development attracts the attention of the world. But there are few studies to test the cost of carry model in Chinese futures market and show the real pricing performance of the cost of carry model in China futures market. How the real capital market in China acts if it is tested by the cost of carry model and what factors affects the pricing in the Chinese futures market are very important not only for the traders in China, but also for the global economy.

Therefore, in this paper, by investigating the China cotton futures market in 2005 and 2006, we test the cost of carry model in the cotton futures contracts in China and find how the cost of carry model performs the cotton market.

84.3 Methodology and Data

84.3.1 Pricing of Futures Contracts

The cost of carry model has been the standard model for pricing the futures until now. To examine how well the cost of carry model works. Firstly, we need to introduce the model briefly. For the original formula, there are some basic assumptions, the following describes them:

1. Capital markets are perfect, in other words, no taxes and transaction costs, no constraints on short sales, and divisibility of securities.
2. No limits exist on borrowing or lending at the same risk-free rate.
3. The risk-free interest rate is known with certainty.

Then, the futures price can be calculated approximately by:

$$F(s,t) = Ste^{r(T-t)}, \tag{84.1}$$

where St denotes the currents spot price of the underlying assets, r represents the risk-free interest rate, and $(T-t)$ denotes the time to expiration.

But, for the commodity futures agreement, the basic formula needs to be adjusted in order to fit the real capital market. At the first place, it is quite necessary to classify the commodities into two types: the commodity for investment (such as golden and silver) and the commodity for consumption (such as corn, cotton and oil). Since this study examines the performance of the cotton futures, whose underlying assets are classified as the commodity for consumption. Therefore, the cost of carry model can be rewritten as:

$$F(s,t) = Ste^{(r-y)((T-t))}, \tag{84.2}$$

where St denotes the spot price of the cotton, y represents the convenience yield, and $(T-t)$ represents the time to expiration.

Kaldor [13] and Working [21, 22] define the notion of convenience yield as a benefit that "accrues to the owner of the physical commodity but not to the holder of a forward contract." Thus, generally speaking, the y can be decomposed into two components: $y = y' - c$, where y' denotes the benefits from the physical commodity, and c represents the percentage of the storage cost.

However, in China futures market, the benefits from holding the commodity futures are hard to define. Since, in China futures market, the holders of the physical commodity are the large selling agencies. For these agencies, their main purposes are selling the cotton as the futures. Therefore, for these traders, the benefits are clearly not from holding the physical commodity. Thus, the benefit from the physical commodity can be ignored or not be considered in our discussion. So this paper needs to test an adjusted cost of carry model, which can be expressed as:

$$F(s,t) = Ste^{(r-y)((T-t))} or (St+U)e^{r(T-t)}. \tag{84.3}$$

84.3.2 Test Procedures

To examine how well the cost of carry model reflect the behavior of the cotton futures prices for china futures market, this paper first compares the frequency of arbitrage using the theory of the cost of carry model for china market. This study then tests the model fitness and pricing results of the cost of carry model. The following describes the testing procedures.

84.3.2.1 No-arbitrage Boundary

Suppose that the arbitrage positions are held to expiration date of the futures contracts. According to the theory of the cost of carry model and the Chung's no-arbitrage boundary argument [3], when the transaction costs are considered, the no-arbitrage boundary is modified as follows: $F(s,t) - C_1 < AFt < F(s,t) + C_2$, where AFt is the actual price at time t; $F(s,t)$ is the theoretical futures price estimated by the cost of carry model at time t; C_1 is the transaction cost incurred by selling the cotton and buying the futures contracts; and C_2 represents the transaction costs incurred by buying the cotton and selling the futures contracts.

The transaction cost of the cotton futures contracts mainly contains 3 parts. They are the broker's commission, the exchange's commission and the interest of the margin. For the cotton futures, the transaction costs c_1 and c_2 are the same according to the standard cotton futures contract, which is ruled by the Zhengzhou future exchange market.

84.3.2.2 Fitness Test of the Cost of Carry Model

This study proposes a method to test the fitness of the cost of carry model in the real markets. Because of the environment of the Chinese futures markets, then, when testing the fitness of the cost of carry model for china cotton futures contract, this study uses Equation (84.3). The test procedures are as follows:

1. Taking natural logarithm on both sides of Equation (84.3) and rearranging it, we have the following equation:

$$\ln F(s,t) = ln(St + U) + r(T - t). \tag{84.4}$$

2. Equation (84.4) can be used for regression purpose:

$$\ln F(s,t) = \alpha_0 + \alpha_1 \ln(St + U) + \alpha_2(T - t) + \varepsilon t. \tag{84.5}$$

If the cost of carry model is correct, then $\alpha_0 = 0$, $\alpha_1 = 1$ and $\alpha_2 = r$ (if transaction cost are considered, then $\alpha_2 = r + \mathrm{clor}\alpha_2 = r + C_2)$.

3. The coefficients of regression Equation (84.5) are estimated. finally, t statistics are used to test the null hypotheses H0: $\alpha_0 = 0$, H0: $\alpha_1 = 1$, and H0: $\alpha_2 = r$, respectively.

The estimation procedures for regress coefficients of Equation (84.5) are as follows. First, the Durbin-Watson (DW) statistic will be used to examine the autocorrelation in errors of regression Equation (84.4). If the presence of autocorrelation is detected, the regression coefficients of Equation (84.4) are estimated with an iterative Cochrane-Orcutt procedure. If it does not have autocorrelation, OLS will be used to estimate the regression coefficients.

84.3.2.3 Pricing Performance of the Cost of Carry Model

In the first place, by substituting the known risk-free r and the estimated storage cost U, together with the spot price of cotton St and time to maturity $(T-t)$, into the cost of carry model, the theoretical price for the cotton futures can be obtained.

Next, to discover how well the cost of carry model explains the price behavior of the cotton futures, we define the percentage of predication error (Z_t) as follows:

$$Z_t = \frac{AFt - F(s-t)}{AFt}. \tag{84.6}$$

84.3.3 Data Description

For the China cotton futures, the nearest maturity contracts all have significant trading volume. To reduce thin trading problems, only the contracts have significant trading records were considered in this study. The period for the cotton futures contract covered is from January 4th, 2005 (the first trading day for January contract) to December 29th, 2006 (the last trading day for December contract). The daily trading transaction data are used. Note that, in the sample period, the trading time each trading day for the futures listed in Zhengzhou futures exchange begins at 9:00 a.m. and ends at 11:30 a.m., while, at afternoon, the trade starts at 1:30 p.m. and ends at 3:00 p.m.

All the transaction data, extracted from the CMSAR, which is one of the databases of the BNUEP library. The data cover the everyday trading records between 2005 and 2006 clearly. All the basic information is observed from it.

For the cotton futures, the one year central bank interest rates are used as the risk- free rate. The risk -free rate was changed from 2.25% to 2.52% among the study period. However, the transaction cost and the storage cost incurred in futures trade were obtained from the website of Zhengzhou futures exchange.

For the spot price of cotton, the daily China cotton index 328 (the weighted average price of the cotton, which satisfies the standard of 328B (GB1103-2207)) are used. And the historical data of China Cotton Index 328 were searched from the data service of China Cotton Association website. The cotton futures price and the cotton spot price were synchronized everyday, so there is no unmatched data in our study. In addition, spot and futures cotton price vary seasonally within a year. For example, during the winner, the spot and futures price of the cotton tends to rise, while during the summer, the prices are not as high as those in winner.

84.4 Empirical Results

Tables 84.1 and 84.2 present the descriptive statistics for the cotton futures contracts of 2005 and 2006. Clearly, the number of the observations in 2006 is greater than that in 2005. And the actual prices of the cotton futures in both years are, on average, greater than the underlying cotton spot prices and the theoretical futures prices during the period of the study, while the spot price and the futures price of the cotton both show an upward trend during the same time period. Moreover, we can also find that the fluctuations of the three different kinds of prices are quite great both in 2005 and in 2006 from the standard of deviation.

Table 84.1 Descriptive Statistics for the spot prices and futures prices in 2005

	No. of observations	Min	Max	Mean	Std.Dev	Variance
AFt	2408	12050	16000	14487.18	762.655	581643.335
St	2408	11267	14296	13134.96	922.738	851445.269
Ft	2408	11286	14796	13367.59	947.152	897096.696
No. of observations	2408					

If we compare the statistics of the two years, we can find an upward trend in the futures price and the spot price. Moreover, from the standard deviation and the variance, it can be easily obtained that the spot price and the futures price of 2006 do not fluctuate as largely as those of 2006.

84.4.1 Results of Negative Basis and Arbitrage Opportunities

Figs. 84.1 and 84.2 show the frequency of the negative basis for the cotton futures contract. Firstly, the trading data are sorted by their maturity dates. According to the definition of the arbitrage boundary, we can get that in a perfect market, $F(s,t) + TC - AFt < 0$ and at the same time, $F(s,t) + TC - AFt > 0$. However, when the theory applies to the real cotton futures contracts in China futures market, the fitness of the boundary is not very perfect.

From the Fig. 84.1, we can see that, for most time of 2005, the trading records are presenting the negative basis and the results of the upper boundary (that is, the

Table 84.2 Descriptive statistics for the spot prices and futures prices in 2006

	No. of observations	Min	Max	Mean	Std.Dev	Variance
AFt	2250	12655	16240	14588.84	687.743	472990.060
St	2250	12606	14422	13833.23	573.107	328452.191
Ft	2250	12619	14890	14070.55	596.029	355250.012
No. of observations	2250					

Table 84.3 Descriptive statistics on daily trading volume

	No. of observations	Min	Max	Mean
Daily trading volume in 2005	242	45830	156072	89840.34
Daily trading volume in 2006	243	12864	612189	127627.3

short-hedge boundary) test are always below zero. That is to say the actual futures prices are overvalued for most time in 2005. The frequency of the negative basis is persistent in 2005, and seems not a temporary disequilibrium which will be erased over time (as Fig. 84.1).

However, from the Fig. 84.2, we can observe a relatively different test result. The negative basis test show that more trading contracts are below or close to the lower boundary (long-hedge boundary), which situation means that the market is more dynamic and it is moving more rationally with the capital market and the spot cotton market. The frequency of the negative basis is not persistent, and the long time disequilibrium does not exist (as Fig. 84.2).

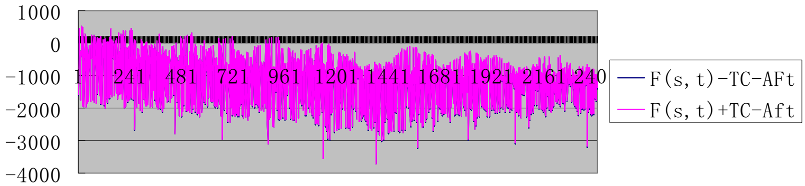


Fig. 84.1 The arbitage test in 2005

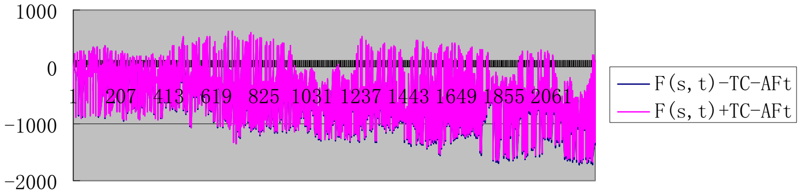


Fig. 84.2 The arbitage test in 2006

When we compare the two charts, we can find that through in both 2005 and 2006, the arbitrage opportunity always exists, the market adjusts all the time and the frequency of violations gradually becomes more stable. The traders of this market are become wiser and rational, since they know how to adjust with the capital markets. Both from the results of the arbitrage boundary test, we can find that in China, the history of the cotton futures market is short, so the arbitrage mechanism is not complete.

However, there is a trend that can be implied that with the development of the market, the arbitrage mechanism will become more complete and the arbitrage opportunities will become fewer. At the same time, from the period of the study, the evidences of the persistent negative basis and the frequency of the violations indicate indirectly that the cost of carry model can not reasonably explain the behavior of the Chinese cotton futures price. The monthly summary arbitrage boundary statistics are listed in the below tables.

Table 84.4 Financial industry cluster competitiveness and growth of the tertiary industry

The monthly summary statistics for the boundary test in 2005			The monthly summary statistics for the boundary test in 2006		
	$F(s,t)-TC-AFt$	$F(s,t)+TC-AFt$		$F(s,t)-TC-AFt$	$F(s,t)+TC-AFt$
Jan	−1491.60	−1472.583	Jan	−1013.34	−990.772
Feb	−1855.771	−1836.628	Feb	−892.8	−871.089
Mar	−2089.333	−2070.10	Mar	−454.095	−433.706
Apr	−2124.147	−2104.064437	Apr	−456.585	−436.923
May	−951.518	−931.5649329	May	−445.909	−426.129
Jun	−827.116	−806.6886507	Jun	−544.731	−523.452
Jul	−791.7399	−771.4253	Jul	−201.939	−182.603
Aug	−266.6936	−247.6884339	Aug	−186.522	−166.883
Sep	−801.303	−780.8215571	Sep	270.5737	290.4997
Oct	−824.1221	−802.7441264	Oct	−491.577	−471.825
Nov	−842.945	−820.6429	Nov	−929.457	−908.466
Dec	−849.0246	−826.9575	Dec	−1189.45	−1167.89

84.4.2 Results of Testing the Fitness of the Cost of Carry Model

The analysis procedures of the fitness tests start by using the Excel to get the basic data: $\ln AFt$, $\ln(St+U)$. Secondly, we use the regression analysis in the SPSS to test the relationship of the Equation (84.5), which we mentioned in the part of methodology and data and test whether the hypothesizes we give is true. By the computer's calculation, Results of testing the fitness of the cost of carry model in the China cotton futures market are summarized in the following tables.

From the tables of 2005, firstly, we use the SPSS to get the relationship of the Equation (84.5). The model summary table tells us that the regression is reasonable,

Table 84.5 Variables entered/removed[b] (2005)

Model	Variables Entered	Variables Removed	Method
1	X_2, X_1^a		Enter

a. All requested variables entered; b. Dependent variable: y.

Table 84.6 Model Summary[b] (2005)

Model	R	R Square	Adjusted R Square	Std.Error of the Estimate	Durbin-Watson
1	.806[a]	.650	.649	.031603055	.150

a. Predictors: (constant), X_2, X_1; b. Dependent variable: y.

Table 84.7 Anova[b](2005)

Model	Sum of Squares	df	Mean Square	F	Sig.	
1	Regression	4.453	2	2.226	2229.110	.000[a]
	Residua	12.402	2405	.001		
	Total	6.855	2407			

a. Predictors: (constant), X_2, X_1; b. Dependent variable: y.

Table 84.8 Coefficient[a] (2005)

Model		Unstandardized Coefficien		Standardized Coefficients	t	Sig.
		B	Std.Error	Beta		
1	(Constant)	5.014	.085		58.767	.000
	X_1	.477	.009	.643	52.980	0.000
	X_2	.089	.003	.428	35.258	.000

a. Dependent variable: y.

since $R = 0.808$ and the Durbin-Watson is 0.15. By analyzing the table of ANOVA, we can get $F = 2229.11$ and $p < 0.001$, which means that the liner regression exists and the regression is reasonable. While, from the table of coefficients, we can get the coefficient of our equation, in which, $\alpha_1 = 0.477$, $\alpha_2 = 0.089$. Therefore, the null hypothesis, H0: $\alpha_1 = 1$, tests if the coefficient of $\ln(St + U)$ is equal to 1. this hypothesis is rejected in our test in 95% level. And the null hypothesis, H0: $\alpha_2 = r$, tests whether the coefficient of $(T - t)$ equals r. This is an important test because the cost of carry model says that α_2 must equal to r. from the coefficients table, we can see that the α_2 is significantly different from r at the 95% level. Moreover, the coefficient of the constant is also not equal to zero, therefore the null hypothesis $\alpha_0 = 0$ is also rejected.

Then, for the tables of 2006, from the table of model summary, we can find that the regression of the test is better in 2006, because $R = 0.818 > 0.806$. While, if we see the table of ANOVA, we find that $F = 2269.372$, and $p < 0.001$, which represents that the liner regression exists and it is reasonable. Finally, from the table of

Table 84.9 Variables entered/removed^b (2006)

Model	Variables Entered	Variables Removed	Method
1	X_2, X_1^a		Enter

a. All requested variables entered; b. Dependent variable: y.

Table 84.10 Model summary^b (2006)

Model	R	R Square	Adjusted R Square	Std.Error of the Estimate
1	.808^a	.669	.669	.027305705

a. Predictors: (constant), X_2, X_1.

Table 84.11 Anova^b (2006)

Model	Sum of Squares	df	Mean Square	F	Sig.	
1	Regression	3.384	2	1.692	2269.372	.000^a
	Residua	1.675	2247	.001		
	Total	5.059	2249			

a. Predictors: (constant), X_2, X_1; b. Dependent variable: y.

Table 84.12 Coefficient^a (2005)

Model		Unstandardized Coefficien		Standardized Coefficients	t	Sig.
		B	Std.Error	Beta		
1	(Constant)	2.757	.130		21.238	.000
	X_1	.712	.014	.640	52.314	0.000
	X_2	.075	.002	.436	35.624	.000

a. Dependent variable: y.

coefficients, we can find that $\alpha_1 = 0.712$ and $\alpha_2 = 0.075$. Through the null hypothesizes are still not been satisfied, compared with the results of 2005, the results of 2006 are more closer to the hypothesis that $\alpha_1 = 1$ and $\alpha_2 = r$. But from the two coefficients, we can get the conclusion that the null hypothesizes are also rejected in 2006.

All in all, the above findings suggest that the cost of carry model applied to the China cotton futures is imperfect, and the model does not fit the actual data for China futures contracts. But from the results of the two years, we can also find a trend that the cost of carry model will become more suitable to the contracts with the development of the cotton futures market for a few years.

Table 84.13 Summary statistics for the percentage errors of the cost of carry model in testing 2005 cotton futures contract

	Trading days	Range	Min	Max	Mean	Std. Dev.
Jan.	20	.045099	.088359	.133457	.11314231	.012045239
Feb.	13	.027646	.120325	.147971	.13469160	.008427630
Mar.	23	.033567	.128280	.161847	.14502977	.009150820
Apr.	21	.104173	.109267	.213440	.14349849	.021799957
May.	17	.048737	.082612	.131349	.11203309	.012619627
June.	22	.039389	.117866	.157255	.13931408	.008986738
July.	21	.032183	.127287	.159470	.14921971	.008746117
Aug.	23	.142421	.071019	.213440	.11554945	.033013437
Sep.	22	.061062	.015463	.076525	.05034439	.015159167
Oct.	16	.024417	.044415	.068832	.05903479	.006840501
Nov.	22	.073583	−.002363	.071219	.03652455	.021656360
Dec.	22	.073156	−.006265	.066891	.03657188	.023400654
Total Mean		.058786	.074689	.133475	.102912	.015153

a. All requested variables entered; b. Dependent variable: y.

Table 84.14 Summary statistics for the percentage errors of the cost of carry model in testing 2006 cotton futures contract

	Trading days	Range	Min	Max	Mean	Std. Dev.
Jan.	18	.013354	.055730	.069085	.06426024	.003422673
Feb.	17	.045344	.033018	.078362	.05647579	.012065027
Mar.	23	.021259	.016929	.038188	.02950784	.006646973
Apr.	20	.024535	.014402	.038937	.02997927	.006248894
May.	18	.031064	.011310	.042374	.02916497	.009197560
June.	22	.034859	.016613	.051472	.03529838	.011497624
July.	21	.020257	.000227	.020484	.01303133	.006110430
Aug.	23	.048252	−.018771	.029482	.01202969	.012692051
Sep.	21	.017762	−.029224	−.011462	−.02025180	.004770402
Oct.	17	.058335	.005047	.063382	.03498953	.020980458
Nov.	22	.030990	.054322	.085313	.06567136	.009291895
Dec.	21	.024925	.065278	.090203	.08213478	.006681276
Total Mean		.030911	.0818740	.049652	.036024	.009133

a. All requested variables entered; b. Dependent variable: y.

84.4.3 Results of Pricing Performance

This subsection presents percentage error to show the performance of the cost of carry model. The percentage error test can tell us the predict capability of the cost of carry model in China cotton futures market.

First, we observe the percentage errors of the cost of carry model in testing the cotton futures contract in 2005. From column (6) of the first table below, we find that for each month the mean percentage error is positive and significantly different from zero. This shows that almost all the contracts exhibit a premium (i.e., the actual futures prices is higher than the theoretical futures price). The largest premium is

0.213 in April and August contract of 2005. But, from the column (4), we find that in both November and December, a small discount (i.e., the actual price is less than the theoretical futures prices) appears. While, actually, such discount just last a few days, because in these month the mean performance errors still appear to be bigger than zero. And the smallest premium is 0.015 in September contract of 2006.

However, both from the mean of the percentage error, we find that the actual prices of the futures are getting closer to the theoretical futures price gradually, because the mean performance errors decrease over the period of study. However, from the standard deviation at the last column, we can find that the prediction performance varies all the time.

Next, we observe the percentage errors of the cost of carry model in testing the 2006's cotton futures contract. From the column (6) of the following table, we find that for each contract the mean percentage error is significantly different from zero. Furthermore, observing the mean percentage errors estimated by the cost of carry model in 2006, we find that the mean percentage error of September is negative, and significantly different from zero. This finding shows that almost all contracts in that time exhibit a large discount.

However, in 2006, the largest premium, which is 0.090, appears in the December contract. And the smallest premium is founded in July, it appears to be 0.0002. Moreover, compared with the result of 2005, the result of the mean performance errors in 2006 is more close to zero. From the standard deviation of 2006, it can be observed that the cost of carry model's prediction performance does not vary as greatly as that in 2005.

Overall, the performance of the cost of carry model in testing the China cotton futures contract appears to be not good. But comparing the results of the two years, we can find that its performance in explaining the prices of 2006 is better than those of 2005,since the mean performance errors are gradually becoming small and close to zero. This result implies that the cost of carry model is more appropriate to be applied to a more developed market.

84.5 Conclusions

Until now, the cost of carry model, based on an assumption of perfect markets and an argument of riskless arbitrage, has been the most widely used model for pricing the futures contracts. However, capital markets are not perfect and arbitrage mechanism cannot be complete, particularly for the developing markets. Several researchers have found significant discrepancy between actual futures price and theoretical values estimated by the cost of carry model. However, there is few studies covered such topic in China market, which is a quite rapidly developing market around the world. To examine how well the cost of carry model works in China this imperfect market, this study proposes a fitness test of the cost of carry model and investigates pricing performance of the cost of carry model for China futures market.

From the above tests, this study finds that arbitrage mechanism works not completely in China cotton futures market. And this study also finds that traditional cost of carry model does not fit the cotton futures contract in China, but there is a trend that the capital market adjusts itself rationally and gradually, and the cost of carry model will become more suitable to the market after years of development. Moreover, the pricing performance of the cost of carry model for 2006's cotton futures contract is better than that of the 2005's futures contract can also approve the above conclusion. Thus, from the above discussion, when using the cost of carry model to estimate the theoretical values of the cotton futures, investors should note the market imperfection for the market they participated.

But what factors affect the actual futures market that can make the cost of carry model cannot reflect the actual futures price in China? The following part will briefly discuss this issue and present some main factors.

We all know that cotton is one of the important crops in our country. China produces a large quantity of cotton and alternates from being an importer to an exporter depending on its crop size and domestic usage. Just like other futures market, the cotton futures market is closely related to the cotton spot market. In the cost of carry model, the spot price is a fundamental factor. However, sometimes the spot price cannot reflect the capital market clearly, since the spot price is time-lagging. Therefore, in the real capital market, numbers of factors will influence the futures pricing. Among these factors, one of the main reasons why the cost of carry model cannot explain the actual futures price is the supply and demand characteristic.

Geman [12] presents that the supply and demand characteristic is the determinant of the commodity pricing. And generally speaking, the supply side of the commodity mainly contains 3 aspects-the beginning stocks, the production and the imports. For Chinese futures market, the first two aspects play the main role in determining the futures price. But the imports of the cotton will also affect the spot price when the price of the spot market fluctuates dynamically. Traditionally, besides the 3 main aspects, there are some other components influences the supply side, such as the capability of production, the weather during the production, the cost of the substitutes and the cotton policies of the government.

Moreover, for the demand side, there are also 3 main aspects. They are the consumption of the country, the exports and the last cycle's ending stocks. In these 3 aspects, the consumption aspect is really hard to define, since it changes with a lot of reasons all the time. These reasons include, for instance, the consumption power of the consumer, the spending of the government and the population's growth and geographical structure change.

In sum, all the factors we mentioned above construct the supply and demand side, but they sometimes can not be reflected in the spot price, and at the same time, in the cost of carry model, these factors also cannot be reflected one by one.

However, in China futures market, the expectation and the behavior of the traders also influence the futures pricing greatly. So, we regard this factor also as a determinate factor. Compared with the developed market, the history of Chinese cotton futures market is too short. In such a market, the arbitrage mechanism is not complete. Thus, in such a market, most of the traders are the arbitragers. For the arbitragers, they are always seeking for the arbitrage opportunities. Sometimes, they behave irrationally and do not obey the basic market rules. Therefore, their behaviors are difficult to understand and expect. From the above discussion, we know why the cost of carry model cannot reflect the actual futures price, because we can not define a variable to calculate the mental activity. And for such a topic, the behavioral economy may have some further study.

Finally, the futures pricing is affected by the macro economy of the market. Some researchers found the problem in pricing the futures, for instance, Hamilton [17], Gilbert and Mork [11] and Mork et al [16] establish the significance of including macroeconomic variables in the study of oil pricing, but they did not give a clear relationship between the pricing and these variables. Implied by the results of their studies, the same issue can be found in pricing the cotton futures. There is no doubt that it is quite hard to include these variables in pricing, because the macroeconomics contains too many things– the economic cycles, the monetary element (i.e., interest rate, inflation rate and exchange rate), and the global economic environment ad so on. The elements are fluctuating all the time, every change of them will influence the futures price. And until now, we cannot find an exact relationship between the futures pricing model and the variables.

Thus, in the future if we will conduct further researches, which are related to this paper, several aspects can be done. In the first place, in this paper we just test the cost of carry model in China cotton futures market, however we do not know how the model perform in other countries' market or in other commodities' futures markets. Therefore, we can do the further research in different market or in different commodity futures and compare the performance of the cost of carry model in different market or between different commodity futures, respectively.

Secondly, most researchers notice the pricing problem of the unconditional cost of carry model, and they adjusted the model and approve some conditional cost of carry models. Therefore, in the further studies, we can test these conditional models in China futures market to find the one that fits the China futures market best.

All in all, the future researches should attempt to further study to examine the cost of carry model in more markets and observe the performance of the model in a long period to make the cost of carry model better fit the reality and the actual futures contract.

References

1. Branson WH (1979) Exchange rate dynamics and monetary policy. In Asser L (Ed.) Inflation and Employment in Open Economics. North-Holland Publishing Company, Amsterdam
2. Chang E (1985) Returns to speculators and the theory of normal backwardation. Journal of Finance 40:193–208
3. Chung YP (1991) A transactions data test of stock index futures market efficiency and index arbitrage profitability. Journal of Finance 46:1791–1809
4. Cornell B, French KR (1983a) The pricing of stock index futures. The Journal of Futures Markets 3:1–14

5. Cornell B, French KR (1983b) Taxes and the pricing of stock index futures. Journal of Finance 38:675–694
6. Eytan T, Harpaz G (1986) The pricing of futures and options contracts on the value line index. Journal of Finance 41:843–857
7. Fama EF (1984) Forward and spot exchange rates. Journal of Monetary Economics 14:319–338
8. Figlewski S (1984) Explaining the early discounts on stock index futures: The case for disequilibrium. Financial Analysts Journal 40:43–47
9. French KR (1983) A comparison of futures and forwards prices. Journal of Financial Economics 12:11–342
10. Frenkel JA, Richard ML (1977) Transaction costs and interest arbitrage: Tranquil versus turbulent period. Journal of Political Economy 85:1209–1226
11. Gilbert RJ, Mork KA (1986) Efficient pricing during oil supply disruptions. Energy Journal 7:51–68
12. Geman H (2005) Commodities and commodity derivatives: Modeling and pricing for agricultural. Metals and Energy 3:161–162
13. Kaldor N (1939) Speculation and economic stability. The Review of Economic Studies 7:1–27
14. Klemkosky RC, Lasser DJ (1985) An efficiency analysis of the T-bond futures market. Journal of Futures Markets 5:607–620
15. Modest DM, Sundaresan M (1983) The relationship between spot and futures price in stock index futures market: Some preliminary evidence. The Journal of Futures Markets 10:1–29
16. Mork KA, Olsen O, Mysen HT (1994) Macroeconomic responses to oil price increases and decreases in seven OECD countries. Energy Journal 15:19–35
17. Hamilton JD (1983) Oil and the macroeconomy since World War ii. Journal of Political Economy 91:228–248
18. Hansen LP, Hodrick RJ (1980) Forward exchange rates as optimal predictors of future spot rates: An econometric analysis. Journal of Political Economy 88:829–853
19. Huang R, Masulis R, Stoll H (1996) The conditional CAPM and the cross-section of stock returns.Journal of Futures Markets 16(1): 1-27.
20. Rendleman RJ, Carabini CE (1979) The efficiency of the treasury bill futures market. Journal of Finance 34:895–914
21. Working H (1948) Theory of the inverse carrying charge in futures markets. Journal Farm Economics 30:1–28
22. Working H (1949) The theory of the price of storage. American Economic Review 39:1254–1262

Chapter 85

Analysis of Stakeholders' Decision-making in Cross-border Water Resource Conflicts Based on an Agent Framework

Liming Suo and Jiacan Wu

Abstract Cross-border water resource conflict is an outstanding problem in decision-making of utilization and development in terms of public resources, because it involves the optimal choice in game among multiple subjects. This paper attempts to utilize the Agent frame and methods to try to solve the complicated decision. Firstly, to analyses the decision-makers and the stakeholders, and their roles in cross-border water resource conflict management in China. On this basis, analyze the application feasibility of Agent framework in our country and its approaches in technique. Another part of paper focuses on analysis framework of administrative network, decision makers, technological capability and other factors in our country's cross-border water resource conflict. Finally, provides some management policy suggestions for the application of this framework.

Keywords Cross-border water resource conflict · Stakeholders · Decision-making · Agent framework

85.1 Introduction

The form of expression of cross-border water conflicts is varied, at the same time, cross-border water conflicts also is an outstanding problem in decision-making of utilization and development in terms of public resources. Now cross-border water conflict management is confronted with some difficulties, such as: market failure caused by multidimensional attribute of water, hierarchical organization failure in administrative jurisdictions of water, etc [1]. According to the cross-border water resources conflict management, water management agencies involved in many departments, among the departments overlapping functions, and lack of unified coor-

---

L. Suo (✉) · J. Wu
School of Political Science and Public Administration, University of Electronic Science and Technology, Chengdu 610054, P. R. China
e-mail: dinastysuo@126.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_85, © Springer-Verlag London 2013

dination; in the relevant decision-making of water resources management, it lack of the common participation of all the stakeholders; water resources property right system is not complete; laws and regulations system is not sound; it lack of effective monitoring and control system [2]. Liu pointed out that it should avoid these problems of the social and cultural conflict, the regional protectionism and department protectionism, the potential crisis in system change and the corruption of Violations of the interest of the disadvantaged in water resources conflict management [3]. At present for cross-border water conflict management, Measures taken in China is the typical market management and hierarchical governance mechanism, but the use of those linear and manual management style can not be the effective management of Cross-border water conflict apparently. In the field of public management, foreign scholars introduced the network governance mode (Provan), and the coordination and cooperation of governance mode stressed in it have positive enlightening significance in innovation water resources sharing and solving the conflict between jurisdictions caused by externality [4]. However, in the building of shared water conflict management mode of our country, because of the new management difficulties caused by information integration of the main body, we will seek a management information technology support platform Suitable for both multidimensional attribute and complexity of cross-border water conflict.

85.1.1 The Cause of Cross-border Water Resources Conflict

The water resources is a complicated public goods, and its attribute of scarcity and irreplaceable lead to seriousness of cross-border water resources conflict, at the same time, cross-border water conflicts also is an outstanding problem in decision-making of utilization and development in terms of public resources. The main forms of conflict also are varied, such as: cross-border water pollution, water, water conservancy project, conflict of sand. At first, it is caused by the society and the environment resources sharing conflict. Li pointed out that space attribute and flow properties of water resource lead to the circulation accumulation of the regional differences, and Water, pollution and the externalities of water conservancy projects lead to conflict because of excessive of water resources development and utilization in the analysis of the cause of cross-border water resources [5]. This is caused by the externality problems of water resource use which does not involve the economy, production, management, etc. Because most of the valley in China have the cross administrative regional characteristics, which makes regional stakeholder become an important part of basin social system, visible. Secondly, cross-border water conflict is caused by the economic resources sharing conflict. To The Yangtze river delta regional cross-border water resource as an example, Wang and Lu think regional cross-border water resource contradictions and conflicts is due to the differences of management system, economic pursuit, culture atmosphere and so on of different administrative regions [6]. Different administrative regions differences are inevitable in the economic, social and cultural, in the final analysis, it is that the economy interests conflict. Water resources allocation efficiency among different industry departments or high transaction costs is enough to cause sharing conflict among industry departments. The water problem involves the issue of optimal choice, in the game among multiple subjects. And their choices are affected by decision-making environment, means and structure.

85.1.2 The Influence of Cross-border Water Conflict

"In the social economic system, water resource involved in the production of goods and services in the form of water entities, and involved in the products processing, manufacturing, sale and consumption in the form of virtual water" [7]. Because the water resources is a kind of public resources with multi-dimensional attribute, the influence of cross-border water resources conflict is considerable, is also widely. It not only affects lasting social stability, at the same time, but also restricts overall regional and each economic development. That is that it have significant impact on the regional economic, environmental, social and political fields. The cooperative and competitive relationship in the sharing is a prerequisite for conflict. The relationship that under the administrative networks structure between these decision makers is respectively affect water resources management decisions from a certain extent. So if want to mitigate the cross-border water resources conflict, we should seek a feasible method to analyze the stakeholders decision problem from these decision makers.

85.2 Applicability Analysis based on Multi-Agent Method

The cross-border characteristics of water resources management became academic research point over the past few years. As an important liquidity resource conflicts management, cross-border water conflict management involves the interests between upstream and downstream subjects, and the interests among development, utilization, use and trade subject.

85.2.1 Characteristics and Present Situation of Cross-border Water Resource Conflict Management

Cross-border water resource management itself exists some characteristics and academic circles has been committed to the research of the adaptive management method and mode, but the peculiar problems and root causes of cross-border water conflict management also need to undertake detailed analysis.

(1) The multidimensional attributes of cross-border water resource conflict management

The ecological attributes of water resource decided the water resource limited, and this is the scarcity of water resources; the multi-function of water resource decided the irreplaceable of water; water resources can be sequential used in theory, so it has a sequential attributes; in addition, its liquidity is what the water resources different from other natural resources is; at the same time the distribution of water resources is uneven. The multidimensional attributes of water resources had decided the water resources in various conflicts, so it will need to establish interdisciplinary management coordination mechanism according to the of in cross-border water resource conflict management. At present, the domestic scholar has gradually introduced the network management mode from the west, and set up each network, coordination and cooperation mode according to China's political, economic and natural conditions.

(2) The complexity of cross-border water resource conflict management

Water problems involving multi-level stakeholders, and multi-level stakeholders decided the decision of water resources also mutiple level. In recent years there are some research foundation of the problems of water resources stakeholder multi-level at home and abroad. Zeitoun and Warner are classified different stakeholders power in the basin, and evaluated the influence of the cross-border water resources conflict from the asymmetric of the stakeholder power [8]. Adopting the classification of the conflict strength of Warner and Zeitoun's, they also explained the strength of the conflict and cooperation of the relationship of cross-border water [8, 9]. Now, in the researching of soluting conflict problems, the game theory and the negotiation theory become important tool [10]. They point out that the cross-border water conflict is a kind of group decision, and knowledge spread and learning premium become the important variable of optimization decision-making.

(3) The conflict between individual rationality and group rationality

In cross-border water resources conflict management, the information a single individual decision subject getting is limited, and based on the mastery of the limited information, their decision goal is to pursue personal benefit maximization, obviously, this is different from group optimal decision which analysed and judged by the master of the information.

(4) The high information processing cost

For the information processing of cross-border water conflict management, it is mostly linear manual processing mode. Using this kind of mode can not process information effectively and Completely, and the defects of information processing greatly influence decisions, which can make its conflict more and more serious. Then, it will need to choose efficient, the optimal technical means to overcome information processing the difficult question.

The solutions of the basin water resource conflict rely heavily on information technology support. Accordingly, need to strengthen the research of water resources conflict resolution decision support system [2]. Most of the water resources conflict management scholars came to this conclusion, so it is imperative to provide decision support system for cross-border water conflict management, and manage water resources with the aid of the information means.

85.2.2 The Applicability and Behavior Mechanism of Agent Methods

As a complex decision, cross-border water resources conflict management decision-making decided to use related technology suitable for complicated decision-making. Agent technology is a distributed artificial intelligence technology that have been developing rapidly and widely application in recent years, and widely used in many fields. Because multi-Agent can describe complex system naturally, capture the phenomenon emerging of system, with the flexibility and practical at a suit, Wang made the research on the multi-Agent technology using in electric power industry decision support [11], Chai and Jin set three dimensional simulation modeling for public emergencies based on Agent [12], He made research on urban traffic control induction system based on Agent and game theory. Agent method has gradually applied to social management and even public management field [13]. The social network analysis method is used in water resources conflict management research, and The characteristics of multi-Agent is suitable for this kind of view that stakeholders stratification. In this paper, we will try to solve it referring the framework and methods of Agent according to the complex decision-making of cross-border water resource conflict stakeholders.

Water resources complex decision-making system is actually the decision-making system that social, economic and ecological environment related to each other, that's social-economy-ecological environment-water complex system. One of the fundamental characteristics of water conflict management decision is complexity. The complexity of the main performance in the following aspects:

1. The elements of decision are multi-level and mass. The water resources system involves hydrology, water conservancy, ecological, social, economic and many other systems, and anyone includes many elements;
2. The relationship between water resources system decision elements or between each subsystem is varied, and performs become nonlinear relationship on the structure.

Agent, the abstract concept provides an appropriate abstract for this kind of complex system description. In recent years, MAS (Multi-Agent system) is wide used in many network computing, such as grid resource allocation, electronic business, cooperation health care, etc. The application result in the emergence of some Open Agent Society (Open Agent Society-OAS), and the Agent in them is developed by different owners, with different purposes and interests, faced with limited rationality and opportunism between the Agent, was asked to show active behavior in a flexible way interaction, but the overall behavior should satisfy the system collaborative

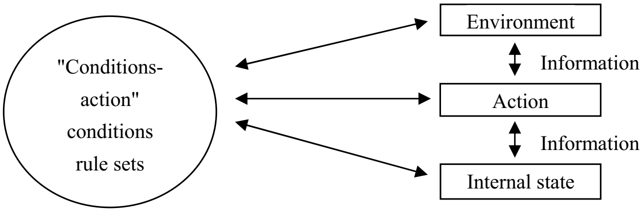


Fig. 85.1 Behavior mechanism of agent

computing needs. To develop the open information system, at present, a lot of theory tools and principle of MAS research is not sufficient.

85.3 Decision-making and Stakeholders in Cross-border Water Resource Conflict Management

For cross-border water resource conflict management, in the use of Agent method, first need to analyse main decision subjects and stakeholders in cross-border water resources conflict management. In 2008, Praovan and Kenis summarized the problems of the regional development governance, and put forward analysis framework of the Network Governance theory. They summarized for three structure mode, namely: Shared Governance (SG), Network Lead Organization (NLO) and Network Administration Organization (NAO) [14]. On this basis, according to institution design China's government system and administrative jurisdiction, the water resources sharing management will be involved in the different region, different departments and the different levels of each department in the same area. Plus China's economic decentralization political centralized administrative system, created complex network governance structure need to be established in this transition period for China, namely, the longitudinal power level according to the traditional top-down structure and the horizontal action rules according to the new kinds of interests group organization. See Table 85.1.

Water resources, as a public goods, its stakeholders involved profit and nonprofit department, private and public sector, NGO and individuals. As is shown in Table 85.1, longitudinal levels of cross-border water resources sharing network can be divided into: the individual level, organizational level and network level.

(1) The individual levels: the private sector

The first level–individual level, is the economic attributes of water resources sharing. Its stakeholders are private sector, namely: the single water user getting economic gains or personal gain utility from the use of the water resources. The private sector, as a representative, pursue economic profit maximization personal effectiveness maximization, follow is the market model based on competition, and in this level, the relations of stakeholders and water resources is economic trade relations based on market, and hence economic attributes of water resources, being

Table 85.1 Multi-level structure of water resources conflict

Level	Water attribute	Stakeholders	Management mode	Management goal
Individual level	Economic attributes	The private sector	Market mode: based on competition	Utility maximization
Social level	Social attribute	Public sector, non-governmental organizations and social organizations, etc	Bureaucratic mode: based on power	Social welfare maximization
System level	Ecological attributes	Ecological system, economic system and social system, etc	Network mode: based on the participation and cooperation	Sustainable development

* Source: Jie Ma, Li-ming SuoThe multi-dimensional of water resources and network governance mode of cross-border water resourse conflict in our country, Chinese administration management [15].

also the cross-border water resources sharing in the conflict in the economic reasons. Hence it is the performance of water resources economic attributes, also the economic reasons in cross-border water resource sharing conflict.

(2) social levels: public sector, non-governmental organizations and social organizations, etc

The second level — social level, is the social attributes of water resources sharing. When social economic activities participated in the form of organization, they form different organizations or departments, such as public sector, non-governmental organizations, and so on, and this is the second stakeholders: public sector, non-governmental organizations and social groups. When the water resources conflict of the upstream and downstream administrative division cause different clash between the groups, the general solution is to put into administrative power and submit to the superior administrative organization. At this time, the power relation of between water resources stakeholders is reflected, so they follow bureaucratic model based on power, put maximization of social welfare as the guidance, and that is non-economic factors in conflict.

(3) system level: the ecological system, economic system and social system, etc

The third level — system level, is the ecological attributes of water resources sharing. Because the function of water resources is not only as a production factor or the source of life, what is more important is maintaining ecological function and maintaining the sustainability of human and the nature. At this level, the water resources stakeholders include not only economic individuals, social organization, and the ecological system, economic system and social system they are composed of, at the same time, for ensuring sustainability, different stakeholders will also contact because of water resources. At this level, it is hard to describe the relationship between a single different stakeholders and the water resources, and harder to judge the size of this association. So, when different jurisdictionss water resourse conflict involving more than one attribute and main subject, it need to use the Internet governance mode transition. They follow the network pattern Based on the participation and cooperation, follow the goal of sustainable development, involves economic and non-economic factors in conflict.

85.4 Agent Analysis Framework Design

Through the above, the first analyse that the cross-border water resourse conflict management is belong to a complex system, and need to analyse using complex adaptive system theory. Next to do the hierarchical analysis of water resources conflict management stakeholders.

Generally speaking, a river basin system is made of three parts: headwaters, such as the rivers, channels, reservoirs and underground aquifers; water requirement outside river, such as irrigation fields, industrial enterprises and cities; river water domestic demand, such as hydroelectric power, shipping, entertainment and environment; intermediary parts, such as pollution treatment plant and the equipment water of reuse and recycling. A specific area by water can be seen as the following several parts:headwaters, such as local rivers, channels, reservoirs, underground aquifer, and foreign water;area water supply system, mainly refers to the water supply company, urban water supply network; water requirement part, mainly including industrial enterprise, the service sector, towns and rural households, agricultural irrigation, ecological environment, which cover the society, economy, environment and other areas; intermediary parts, such as sewage treatment plant and the equipment of water reuse and recycling; management part, including environmental protection, water resources, local government and so on.

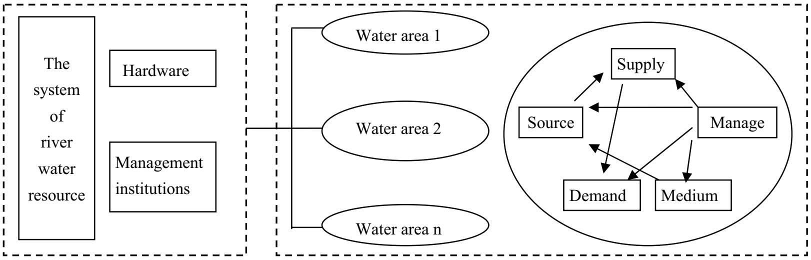


Fig. 85.2 The physical level structure of water resources system

Complex adaptive system theory, pointed out that the structure water resources is made of different levels, and it is distribute a certain number of the main subjects on the different levels. The main subjects of the lower level can be gathered into main subjects of higher levels. The behavior characteristics of high level emerge in the constant interaction of main subjects of the lower level. In that way, the relationship between cross-border water resource conflict management stakeholders and the physical level of water resources needs to be clear first.

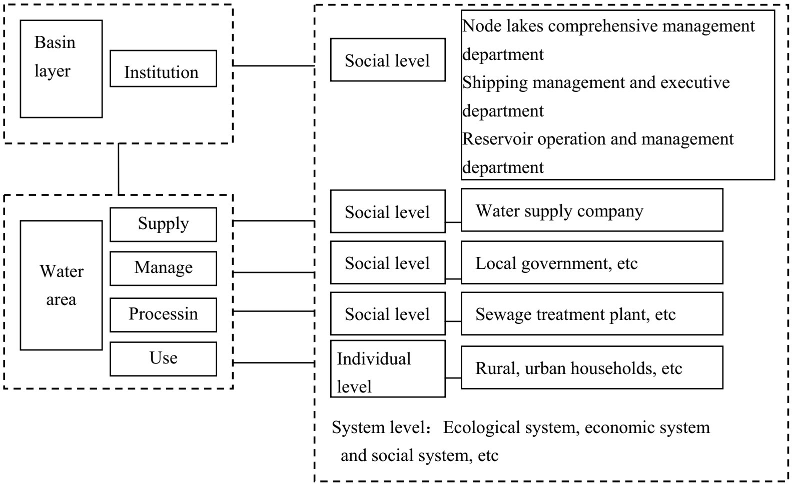


Fig. 85.3 Multi-layer structure between water resources physical level and cross-border water conflict management stakeholders

According to the analysis frame which optimize the cross-border water resources decision-making, and improve the efficiency of the decision, some water resources system Agent classification and basic behavior can be get, such as management Agent, water storage Agent, water supply Agent in basin of the layer, and agricultural Agent, urban households Agent, rural households Agent in Water area. These details of the design can be continued researched later.

85.5 Application Path

First of all, clear the boundary of cross-border water resources conflict management decision-making system, have complexity analysis to cross-border water conflict management decision-making target system, induce cross-border water resources conflict management complexity features, and clear goals and requirements of cross-border water resources conflict management. Then, have theoretical analysis of water resources system decision basic elements (subjects), structure, system elements mechanism and so on by using basic ideas of complex adaptive system, analyze the specific characteristics of objects in cross-border water resources conflict management system, and determine expression according to solid features: object or Agent.

Select abstract levels of cross-border water resource conflict management rationally, to determine the Agent particle size. Set a model according to objects in the complex system which is cross-border water resource conflict management, and make sure that choice of the cross-border water resource conflict management abstract level is sufficient and reasonable, and that the basis of selection is the must system information goal. If the abstract levels too detailed, it's easy to cause the information redundancy, and the redundant information cannot help to achieve the goals; if the abstract levels too little, it will cause insufficient information, and information retrieval is not sufficiently.

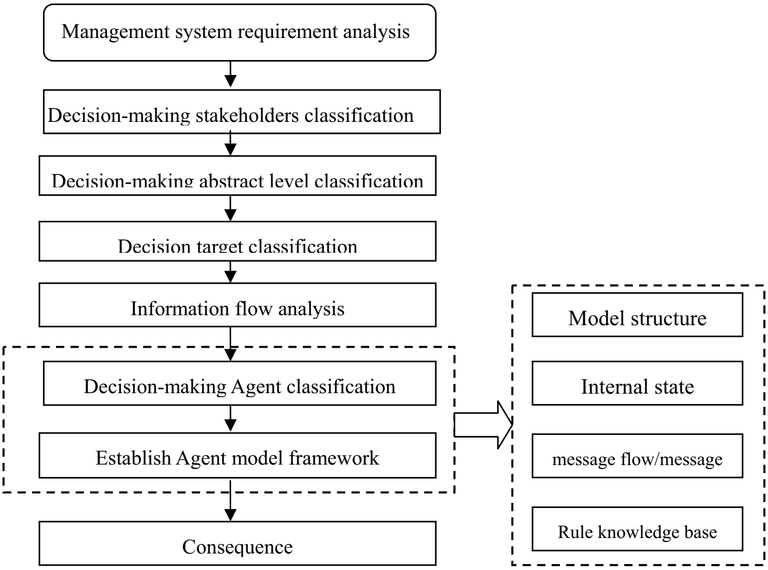


Fig. 85.4 The general flow and path of water conflict management Agent framework

Agent framework is based on the important content of Agent system modeling. Agent system modeling establish Agent model f or each leaf nodes and the nonleaf nodes, including definition of Agent state sets, input information set (including external input and internal feedback input), output information set, rule base, etc. So cross-border water resources conflict management decision-making Agent framework is asked higher requirements.

85.6 Conclusions and Prospect

85.6.1 Summary

This paper analyzes the level of cross-border water resources conflict management decision-making and stakeholders, which is made of individual levels whose main subject is the private sector; social level whose main subjects are public sector, non-governmental organizations and social groups and system level whose main subjects are ecological system, economic system and social system. At the same time also analyzes the roles they in water resources conflict. Water resource problems related to multi-level stakeholders, and multi-levels of the stakeholders determined the mutiple level of water resources decision, so validate cross-border water conflict management is a complex decision. Research on water resources complex decision-making system is actually a research on the decision-making system that social, economic and ecological environment related to each other, that's social-economy-ecological environment-water complex system. Combining with the game theory and the negotiation theory, making the goal of emphasizing the maximization of the economic and social welfare, and ensuring social fairness and sustainability, and according to the requirements analysis of water resources management system and water resources conflict decision-making stakeholders classification, we divided the decision-making abstract level and decision-making target, had a message analysis and water resources decision-making Agent classification, established the steps and path of Agent model framework, studied the water resources decision-making Agent framework, and endeavored to promote the coordinated development and management of water resource.

This study attempts to establish China's cross-border water resources conflict management decision-making frame by using Agent method, which is beneficial exploration for further using Agent modeling analysis to solving cross-border water resource problems. But there also has some shortage. Because of the limited conditions, the proposed Agent framework may neither complete, nor solve problem according to the specific features. For practical use, still need to constantly enrich and develop combining with the characteristics of the basin.

85.6.2 The Prospect of Research

The further research can be going from the following several aspects:

- First, to integrate theory and method of complexity science, optimal allocation of water resources, artificial intelligence, and simulate the behavior and coordination results of water resources conflict.
- Second, structure the relationship between the main entity and the main contradiction which can simulate the real water resources conflict decision system using

Agent system modeling simulation method, and evolution multi-Agent system of overall system behavior.

- Third, according to the cross-border water conflict decision system, simulate complexity coordination process of one of a region in our country between the government of the region based on water resource, and calculate decision-making optimal case.
- Fourth, combining with the popular integrated water resources management (IWRM) framework of our country, put forward innovative management measures, for cross-border water resources conflict management mechanism.

References

1. Ma J, Suo LM (2010) Network governance mode innovation of regional water resources sharing conflict. Journal of Public Management 17:107–114 (In Chinese)
2. Hu Q (2007) Studv on integrated management of water resources conflict of river basin. PhD thesis, Hohai University (In Chinese)
3. Liu R (2007) Research of basin water resources governance in the view of social capital angle. PhD thesis, Hohai University (In Chinese)
4. Keith GP, Patrick K (2008) Modes of network governance: Structure, management, and effectiveness. Journal of Public Administration Research and Theory 18:229–252
5. Li H, Liu T, Huang W (2010) The research on causes and coordination model of cross-border water conflict. Journal of Natural Resources 25:705–712 (In Chinese)
6. Wang H, Lu Y (2010) The Yangtze river delta region cross-border water conflict and solutions. Water Conservancy Technical Supervision 4:11–14 (In Chinese)
7. Xiao S, Xiao H (2011) The heihe river basin water problems nearly 50 years and watershed integrated management. Journal of Desert Research 31:529–535 (In Chinese)
8. Warner J (2004) Blood: On politics, participation, violence and conflict over the Hydro social contract. In: Proceedings of the Workshop of Water aced Politics. Understanding the Role of Politics in Water Management
9. Mirumachi N (2007) Fluxing Relations in Water History: Conceptualizing the Range of Relations in Transboundary River Basins. In: Proceedings of 5th Internationl Water History Associaation Conference on Past and Futures of Water
10. Ma J, Suo LM (2008) The research on the city's ecological development strategy under the restriction of the water resources. Special Zone Economy 200–202 (In Chinese)
11. Ma J, Suo LM (2009) The policy research on the water resource predicament and ecological city construction path. Resources Environment and Development 1:1–5 (In Chinese)
12. Wang Y (2007) The research on multi-Agent technology using for the decision support of electric power industry. PhD Thesis, East China Normal University (In Chinese)
13. Cai X, Jin X (2008) Public emergencies 3D simulation modeling and application based on the agent. Shanghai Jiaotong University Press (In Chinese)
14. He Z (2009) The research on urban traffic control induction system and its key technologies based on multi-agent and game theory. Master Thesis, Central South University (In Chinese)
15. Ma J, Suo LM (2010) The multi-dimensional of water resources and network governance mode of cross-border water resourse conflict in our country. Chinese Administration Management 4:81–84 (In Chinese)

Chapter 86
Aggregate Effect and Structural Effect of Environmental Policy Differences in China

Lili Tan

Abstract In this paper, we set a two region two sector two factor model under a new economic geography (NEG) framework, and in this model, the manufacturing sector is divided into two industries, high pollution and low pollution industries. We discussed effects of environmental policy differences on the regional distribution of the manufacturing sector and structural change of industries in each region. We found that on one hand, the structural changes of industries are very sensitive to the environmental policy differences, while on the other hand, the regional distribution of the manufacturing sector is not as sensitive, which provided a reasonable explanation for China's "Pollution moving westward, production moving eastward" phenomenon. And we also found that it is improper to appeal manufacturing firms by relaxing the environmental policy, even regardless of the externality arising from environmental pollution. It not only attracts the "dirty industry", but also repels the "clean industry", and almost has no effect on share of manufacturing output.

Keywords Environmental policy · Industry distribution · Pollution moving westward

86.1 Introduction

The west region is faced with a severe environmental challenge during economical development. Considering simultaneously this challenge with the industrial structure transformation and up-grading, and industrial regional transferring in the east region, we found that the present "pollution moving westward" phenomenon may soon turn out to be an unavoidable problem. From 1986 to 1995, the COD emission has moved westward for 12%, and sulfur dioxide for 3% [15]. And From 1990 to

---

L. Tan (✉)
College of Economics, Zhejiang University, Hangzhou 310027, P. R. China
e-mail: tanlili@zju.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_86,

2002, the COD and sulfur dioxide emission has moved westward for 4%, while the industrial dust for 9% [14]. In recent years, a series of severe environmental incidents related to high pollution firms moving westward, for example the Feng Xiang Blood-Lead event, have been published, and have caught attention of the public. Given the dominant and recessive environmental policy differences between the east and west region, the west is gradually becoming a “pollution heaven” during the regional industry reconstruction. Of course it is understandable that the west region tries to enlarge the manufacturing scale and promote economical development by sacrificing the environment to some degree. Su suggested that “When the economic degree is low, the environmental pollution has a less and indirect impact on the general welfare of human beings than the food and clothing problem does [16]. So at the “Primary Stage” it is inevitable to utilize resources and to pay prices to meet the basic requirements of human being.” However what happens at the same time of “Pollution moving westward” is that the production is moving eastward. From 1990 to 2002, the concentration degrees of GDP and gross industrial output have ascended to 6% and 3% each in east region [14]. The west region has endured a lasting “pollution immigration”, but this environmental sacrifice didn’t bring back the expected economical scale enlargement and high development speed. We hope to provide a possible explanation for the “Pollution moving westward, production moving eastward” phenomenon from the viewpoint of new economical geography. And we also want to discuss the functional mechanism through which environmental policy differences affect the spacial distribution of industries, to find out whether a relaxed environment policy will get in return a higher manufacturing share, or will it attract only the “dirty” industry, and repel away the “clean” industry, which finally lead to a regional industry restructuring unbeneficial to the local economy.

The new economical geography provided us with a general equilibrium framework, which involves return to scale, differentiated goods, and trade cost. However in a traditional model, the manufacturing sector is considered as a whole rather than several distinct industries. Fujita et al [4, 5] reminded us that as studying the industry agglomeration in perspective of total output is not comprehensive, it is necessary to divide the manufacturing sector into different industries to investigate their interactions and regional industry restructuring. It is especially true when discussing the industry policy. On one hand, the effects on different industries by policies of all kinds are asymmetric. One the other hand, we are usually more concerned about industry restructuring than the gross output. However, there are few researches distinguishing industries in new economic geography model, and even less considering policies [8, 11]. Among those, Zeng found that after dividing the manufacturing sector into different industries according to technology, the regional industrial structure has tremendously changed, from symmetrical distribution of two industries in two regions to asymmetrical distribution of labor intensive industry in one region and capital intensive industry in another, even though the re-dispersion process seems to be similar to the dispersion process, and the general economic output remains symmetric between two regions [11]. In this paper, we set a two region, two sector, two factor model, and we divided the manufacturing sector into two industries with high pollution or low pollution each. Under this model, the environmental policy differences between two regions will cause effects in two aspects: the first is the aggregate effect, which means the gross output distribution of the manufacturing sector in each region; the second is the structural effect, which means the regional industry structural differences and variation raised up by asymmetric distribution of two industries in two regions. These two effects have different sensitivity to the environmental policy differences because they have distinct underlying mechanisms. Therefore, we set a framework to comprehensively analyze the gross distribution of manufacturing sector and regional industry restructuring, and provided an explanation for “Pollution moving westward, production moving eastward” phenomenon.

86.2 Basic Model

86.2.1 Factor Endowment and Market Structure

Study an economic system composed of two regions, one of which is developed and the other one is less-developed. And consider two production factors: skilled labor and unskilled labor. The unskilled labor can choose to work in any of the two industries, but they can not migrate between two regions. The skilled labor can migrate between two regions, but they are professional so they are restricted to one industry. It is easy to understand that the specialized education and training make them difficult to find jobs in another industry. We assume that the labor endowment in developed region is T, and in less-developed region is t. There are two sectors in this economical system: agriculture and manufacture. The agricultural goods are homogenous, and the agriculture sector faces complete competitive market, and the agricultural inter-regional trade has no transportation cost. The manufacturing goods are heterogenous. And the manufacturing sector is in the so-called Dixit-Stiglis monopolistic competitive market, and the inter-regional trade of manufacturing productions require “ice-burg” trade cost$^{\tau}$.

86.2.2 Consumer Utility and the Technology in Each Sector and Each Industry

The utility function of representative consumers holds C-D form between manufacturing and agricultural goods, and CES form in differentiated manufacturing goods.

$$U = C; C = C_M^{\mu} C_A^{1-\mu}, C_M = \left(\int_{i=0}^{N_1+n_1+N_2+n_2} C_i^{1-1/\sigma} di \right)^{1/(1-1/\sigma)}, 0 < \mu < 1 < \sigma. \tag{86.1}$$

C_M and C_A stand for the consumption of differentiated manufacturing goods and agriculture goods. The N_1, n_1 are the species number of heterogenous goods produced by high pollution industry in developed or less developed region, while N_2, n_2 are the species number of heterogenous goods produced by low pollution industry in those two regions. Because every firm produces only one kind of heterogenous goods, so these also are numbers of firms in each region and each industry. μ is the share of expenditure on manufacturing goods. σ is substitution between any two kinds of manufacturing goods. The budget of representative consumer is restricted by average local wage.

The production of agricultural goods requires only non-skilled labor, and the technology is constant return to scale and bares no difference between regions. And considering there is no trade cost of agriculture goods, we got its price $P_A = a_A W_L$. If the production efficiency of agriculture sector a_A and the wage of unskilled labor W_L are 1, then P_A equals to 1. Here we should notice one assumption: it is impossible that the agricultural production of any single region can fulfill the overall requirement. In other words, in each region there must be part of unskilled labor working in the agriculture sector.

The environmental policy has no effect on low pollution industry. However, a stringent environmental policy will increase the marginal cost of local firms in high pollution industry. In consideration of this, we got the cost functions:

High pollution firms in developed region:

$$\theta \times G_1 + (\alpha + \kappa) \times x \times W_L. \tag{86.2}$$

High pollution firms in less developed region:

$$\theta \times g_1 + \alpha \times x \times W_L. \tag{86.3}$$

Low pollution firms in developed region:

$$\theta \times G_2 + \alpha \times x \times W_L. \tag{86.4}$$

Low pollution firms in less developed region:

$$\theta \times g_2 + \alpha \times x \times W_L. \tag{86.5}$$

where θ is the fixed cost of the firm (requires only skilled labor), G_1, g_1, G_2, g_2 are the wages of skilled labor in each region and each industry, x is output, α is the marginal cost of the firm (requires only unskilled labor). k is the additional marginal cost of high pollution industry caused by the rigid environmental policy in developed region (additional pollution control costemission tax et al), which reflects the inter-regional environmental policy differences. As the share of environmental cost is low [9], we assume $\kappa \ll 1$. And we assume $\theta = 1$, which means each firm employ only one skilled labor, and then N_1, n_1, N_2, n_2 are amounts of skilled labor of corresponding industry in each region. Also we assume $\alpha = 1$.

86.2.3 Short-run Equilibrium

We follow the classical NEG setting, which means the product market reaches equilibrium simultaneously, while the migration of the mobile factor is relatively slow. In short-run equilibrium analysis the migration of skilled labor is not considered. From the consumer's utility maximization we can easily derive demand function for the developed region of representative industrial products:

$$C_j = \frac{P_j^{-\sigma} \mu H}{\Theta}, \quad \Theta = \int_{i=0}^{N_1+n_1+N_2+n_2} P_i^{1-\sigma} di, \tag{86.6}$$

where H is the total amount of expenditure in developed region, Θ is the CPI of differentiate goods in developed region. The demand function of less-developed region is:

$$c_j = \frac{P_j^{-\sigma} \mu h}{\Lambda}, \quad \Lambda = \int_{i=0}^{N_1+n_1+N_2+n_2} P_i^{1-\sigma} di, \tag{86.7}$$

where h is the total amount of expenditure in developed region, Λ is the CPI of differentiate goods in less-developed region. We assume that the incomes of skilled labor are repatriated back to home region. So $H/h = T/t$, here we assume $H = rT$, $h = rt$.

Taking this demand function, as well as the fact that the firm needs to maximize profits in Dixit-Stiglitz monopolistic competition market into consideration, the equilibrium sales price of every firm in each region can be derived:

High pollution firm in developed region:

Local price is:

$$P_1 = \frac{1+k}{1-\frac{1}{\sigma}}. \tag{86.8}$$

Foreign price is:

$$p_1 = \frac{\tau(1+k)}{1-\frac{1}{\sigma}}. \tag{86.9}$$

High pollution firm in less developed region:

Local price is:

$$Ps_1 = \frac{1}{1-\frac{1}{\sigma}}. \tag{86.10}$$

Foreign price is:

$$ps_1 = \frac{\tau}{1-\frac{1}{\sigma}}. \tag{86.11}$$

Low pollution firm in developed region:

Local price is:

$$P_2 = \frac{1}{1-\frac{1}{\sigma}}. \tag{86.12}$$

Foreign price is:

$$p_2 = \frac{\tau}{1 - \frac{1}{\sigma}}. \quad (86.13)$$

Low pollution firm in less developed region:
Local price is:

$$Ps_2 = \frac{1}{1 - \frac{1}{\sigma}}. \quad (86.14)$$

Foreign price is:

$$ps_2 = \frac{\tau}{1 - \frac{1}{\sigma}}. \quad (86.15)$$

In the Dixit-Stiglitz monopolistic competition framework, it is easy to know that the operating profit of the firm is the ratio of its sales revenue with σ, px/σ $(or\ PX/\sigma)$. Since every firm employs only one skilled labor, the operating profit of each firm in each region is the corresponding wage of skilled labor G_1, g_1, G_2, g_2. Combining demand functions (86.6) and (86.7), and equilibrium price (86.8) $\sim$ (86.15), we can derive the wage of skilled labor of each firm in each region:

High pollution industry in developed region:

$$G_1 := \beta \cdot \left[\frac{b \cdot T}{b \cdot N_1 + N_2 + \phi \cdot n_1 + \phi \cdot n_2} + \frac{\phi \cdot b \cdot t}{n_1 + n_2 + \phi \cdot b \cdot N_1 + \phi \cdot N_2} \right]. \quad (86.16)$$

High pollution industry in less developed region:

$$g_1 := \beta \cdot \left[\frac{t}{n_1 + n_2 + \phi \cdot b \cdot N_1 + \phi \cdot N_2} + \frac{\phi \cdot T}{b \cdot N_1 + N_2 + \phi \cdot n_1 + \phi \cdot n_2} \right]. \quad (86.17)$$

Low pollution industry in developed region:

$$G_2 := \beta \cdot \left[\frac{b \cdot T}{b \cdot N_1 + N_2 + \phi \cdot n_1 + \phi \cdot n_2} + \frac{\phi \cdot t}{n_1 + n_2 + \phi \cdot b \cdot N_1 + \phi \cdot N_2} \right]. \quad (86.18)$$

Low pollution industry in less developed region:

$$g_2 := \beta \cdot \left[\frac{t}{n_1 + n_2 + \phi \cdot b \cdot N_1 + \phi \cdot N_2} + \frac{\phi \cdot T}{b \cdot N_1 + N_2 + \phi \cdot n_1 + \phi \cdot n_2} \right], \quad (86.19)$$

where $\beta = \mu/\sigma$; and $\phi = \tau^{1-\sigma}$ is the transportation cost, it is in the interval [0,1], closer to zero means higher transportation cost. $b = (1+k)^{1-\sigma}$ is the stringent degree, and it is in the interval $[0,1]$, closer to zero means a more stringent policy in developed region. Because $\kappa \ll 1$, b is close to 1, we assume that the total initial endowments of the regions is 1, $T + t = 1$; the total skilled labor in high pollution industry is 1, $N_1 + n_1 = 1$; the total skilled labor in low pollution industry is 1, $N_2 + n_2 = 1$. N_1, N_2 each stands for the share of high pollution or low pollution industry in developed region, and they are in the interval $[0,1]$. T is the share of initial factor endowment in developed region, and is also in the interval $[0,1]$. It is reasonable to assume that the developed region has more endowment, $T > t$.

86.3 Equilibrium and Stability Analysis

86.3.1 Long-run Equilibrium and Stability

We use the replicator dynamics to characterize the migration of skilled labor:

$$\begin{cases} \dot{N}_1 = (1 \dot{-} n_1) = (G_1 - g_1)(1 - N_1)N_1 \\ \dot{N}_2 = (1 \dot{-} n_2) = (G_2 - g_2)(1 - N_2)N_2. \end{cases} \tag{86.20}$$

This dynamics system is widely applied in NEG literatures [1, 5]. However, simultaneous considering the regional distribution of two industries as described in this paper would make the analysis more complicated.

Firstly we focus on interior solution, in which N_1, n_1, N_2, n_2 are not equal to 1 or 0. The equations are:

$$\begin{cases} G_1 = g_1 \\ G_2 = g_2 \\ N_1 + n_1 = 1 \\ N_2 + n_2 = 1 \\ T + t = 1. \end{cases} \tag{86.21}$$

From which we got:

$$N_1 = -\frac{2}{b-1},\ n_1 = \frac{1+b}{b-1},\ N_2 = \frac{2b}{b-1},\ n_2 = -\frac{1+b}{b-1}. \tag{86.22}$$

That is:

$$\frac{N_1}{N_1+n_1} = -\frac{2}{b-1},\ \frac{N_2}{N_2+n_2} = \frac{2b}{b-1}. \tag{86.23}$$

It is easy to know when $b \in [0,1], -\frac{2}{b-1} \in [2,+\infty), \frac{2b}{b-1} \in (-\infty,0]$, both of them have no intersection set with interval [0,1] which indicates that the equation has no interior solution. Then we focus on corner solution. There are four cases: both high pollution and low pollution industries agglomerate in developed region ($N_1 = 1$, $n_1 = 0$, $N_2 = 1$, $n_2 = 0$); high pollution industry agglomerates in developed region and low pollution industry agglomerates in less developed region ($N_1 = 1$, $n_1 = 0$, $N_2 = 0$, $n_2 = 1$); high pollution industry agglomerates in less developed region and low pollution industry agglomerates in developed region ($N_1 = 0$, $n_1 = 1$, $N_2 = 1$, $n_2 = 0$); both high pollution and low pollution industries agglomerate in less developed region ($N_1 = 0$, $n_1 = 1$, $N_2 = 0$, $n_2 = 1$). The corner solution is stable if and only if: when the industry entirely agglomerates in one region, the skilled labor's wage of this industry in this region is higher than the other region, which guarantees that the agglomerate-skilled labor won't migrate to the other region. According to this criteria, none of these four corner solutions is stable.

At last we focus on semi-interior solution, which means one industry entirely agglomerates in one region while another distributes in both regions. There are also

four cases: (1) high pollution industry agglomerates in developed region, low pollution industry distributes in two regions ($N_1 = 1$, $n_1 = 0$, $G_2 = g_2$); (2) high pollution industry agglomerates in less-developed region, low pollution industry distributes in two regions ($N_1 = 0$, $n_1 = 1$, $G_2 = g_2$); (3) low pollution industry agglomerates in developed region, high pollution industry distributes in two regions ($N_2 = 1$, $n_2 = 0$, $G_1 = g_1$): (4) low pollution industry agglomerates in less-developed region, high pollution industry distributes in two regions ($N_2 = 0$, $n_2 = 1$, $G_1 = g_1$). The necessary and sufficient condition of semi-interior solution is that for the entirely agglomerated industry, the wage of skilled labor is higher than in the other region, and for the industry that distributed in two regions, around equilibrium ($G_1 = g_1$ or $G_2 = g_2$) the system can recover from shock (that is $\partial(G_1 - g_1)/\partial N_1 < 0$ or $\partial(G_2 - g_2)/\partial N_2 < 0$). According to this criteria, the only stable semi-interior solution is that low pollution industry entirely agglomerates in developed region and high pollution industry distributes in two regions:

$$\begin{cases} N_1 = \frac{-bT-\phi b-\phi^2 b+\phi^2 Tb+1+\phi-T+\phi^2 T}{\phi b^2-\phi^2 b-b+\phi} \\ N_2 = 1. \end{cases} \tag{86.24}$$

In summary, the system has only one semi-interior solution that low-pollution industry entirely agglomerates in developed region and high-pollution industry distributes in two regions.

86.3.2 The Aggregate Effect of Environmental Policy Differences

If considering the manufacturing sector as an integral , regardless of environmental policy and regional differences, and according to the famous Home Marketing Effect [6, 7], the distribution of manufacturing sector N has interior solution, and its function of initial endowment factor is as below:

$$N = \frac{1}{2} + \frac{1+\phi}{1-\phi}\left(T - \frac{1}{2}\right) = T + \frac{\phi(2T-1)}{1-\phi} > T. \tag{86.25}$$

This is the developed region which has superior initial endowment factor, which could attract even more share of manufacturing sector by a higher proportion.

It is interesting that although in our model, we have only one stable semi-interior solution, the shares of manufacturing sector of these two regions are very similar with the aforementioned classical model. The share of developed region is:

$$\frac{N_1+N_2}{2} = \frac{N_1+1}{2} = \frac{1}{2} + \frac{1+\phi}{b-\phi}\left(\frac{1}{2} \times \frac{(1-\phi)(1+b)}{1-\phi b} \times T - \frac{1}{2}\right). \tag{86.26}$$

After careful analysis we found:

$$\lim_{b\to 1}\frac{1}{2}+\frac{1+\phi}{b-\phi}\left(\frac{1}{2}\times\frac{(1-\phi)(1+b)}{1-\phi b}\times T-\frac{1}{2}\right)=\frac{1}{2}+\frac{1+\phi}{1-\phi}\left(T-\frac{1}{2}\right). \quad (86.27)$$

That is to say, when the share of environmental cost is low ($b \to 1$), the environmental policy differences have extremely limited effect on the distribution of the manufacturing sector.

86.3.3 The Structure Effect of Environmental Policy Differences

The impact of environmental policy differences on regional distribution of the total industrial output is fairly limited. However, after the introduction of multi-industry, we found that because of the interaction between the two industries, the regional industry structure can be severely changed, even though the share of environmental cost is small ($\kappa \ll 1, b \to 1$). According to Equations (86.24) and (86.26), we found that on one hand, high pollution industry agglomerates in less developed region where it has lower marginal cost ($n_2 = 0$; $n_1 = 1 - N_1 = 2 - (N_1 + N_2) = n_1 + n_2$). On the other hand, since the high pollution industry agglomerates in less developed region and because of the transportation cost, the price of the goods of high pollution industry is higher in developed region. So under a given expenditure, the goods of low pollution industry has a relatively broader market in developed region, which pushes the low pollution industry entirely agglomerates in developed region, while it is with no disadvantage in less-developed region.

86.4 Conclusions

In this paper, we have set a NEG model, and especially, the manufacturing sector is further divided into two industries: high pollution and low pollution. We found that the environmental policy differences have distinct structural effect and aggregate effect on regional industry distribution. The distinct underlying mechanism of these two effects leads to their differentiated sensitivity towards environmental policy. Especially when the share of environmental cost is low, the environmental policy differences will cause a dramatic regional industry restructuring, while has little effect on the regional distribution of gross output of manufacturing sector.

So far, we have provided a possible theoretical explanation for China's "Pollution moving westward, production moving eastward" phenomenon. On the one hand, there is an obvious regional environmental policy difference in that the east and west region is applying stringent or relaxed environmental policy each. As a result, the high pollution industry was driven westward by the strong structural effect. In other words, "pollution moving westward", and the west region becomes the "pollution heaven". On the other hand, because the share of environmental cost is low, the tiny aggregate effect is not able to change the trend that the gross manufacturing output migrates to the east region which has an advantage of initial factor endowment. In addition, other advantages like market access may intensify this trend. So the gross manufacturing output is not moving westward with high pollution industry, but moving eastward instead.

The results of our paper remind us, that even regardless of the externality of pollution, the policy that to attract the industry by relaxing the environmental policy, or by enlarging the policy differences is wrong. Lowering the environmental standard can hardly increase the industrial share, but will attract the "dirty" industry and repel the "clean" industry. If assume that the "clean" industry usually are higher value-added and prospective, then lowering the environmental standard may on the contrary decrease local industrial share.

References

1. Baldwin R, Forslid R, Martin P et al (2003) Economic geography and public policy. 1st edn, Princeton University Press, Princeton
2. Chamberlin EH (1993) The theory of monopolistic competition. 1st edn, Harvard University Press, Boston
3. Li J (2010) A chance maximization portfolio selection model in fuzzy random environment. In: Proceedings of the Fourth International Conference on Management Science and Engineering Management
4. Fujita M, Krugman P, Mori T (1999) On the evolution of hierarchical urban systems. European Economic Review 43:209–251
5. Fujita M, Krugman P, Venables A (1999) The spatial economy: Cities, regions, and international trade. 1st edn, MIT Press, Boston
6. Krugman P (1980) Scale economies, product differentiation, and the pattern of trade. American Economic Review 70:950–959
7. Martin P, Rogers CA (1995) Industrial location and public infrastructure. Journal of International Economics 39:335–351
8. Takatsuka H, Zeng D (2009) Dispersion forms: An interaction of market access, competition, and urban costs. Journal of Regional Science 49:177–204
9. Walter I (1973) The pollution content of American trade. Western Economic Journal 11:61–70
10. Zeng D (2008) New economic geography with heterogeneous preferences: An explanation of segregation. Journal of Urban Economics 63:306–324
11. Zeng D (2006) Redispersion is different from dispersion: Spatial economy of multiple industries. Annals of Regional Science 40:229–247
12. Zhang L, Yuan Y (2010) A POS-based algorithm for airline crew scheduling problem under uncertainty environment. In: Proceedings of the Fourth International Conference on Management Science and Engineering Management
13. Peng H, Ren R (2003) The environmental policy tool and corperate competitive advantage. China Industrial Economy 89–95 (In Chinses)
14. Yang Y (2008) The comparative study to the eastern and western regions transfer of pollution-intensive industries in China. Ecological Economy 133–147 (In Chinses)
15. Luo H, Wang J, Cao D (2000) Environmental challenge and countermeasures for Great Western Region Development in China. Reasearch of Environmental Sciences 110–127 (In Chinses)

16. Su Y (2005) Very bad and very good-the disadvantages and advantages fo western development of high energy consumption high pollution industry. Northern Economy 237-251 (In Chinses)
17. Tang Y, Xiong X, Wei Y (2009) A study on operational stratey and innovation of implementation model for environment protection in business. In: Proceedings of the Third International Conference on Management Science and Engineering Management

Chapter 87
Research on the Evaluation of Business Ecosystem Health

Xiaoping Li, Xiaowen Jie, Qiang Li and Qi Zhang

Abstract By analyzing the connotation and measurement scale of business ecosystem health on the basis of Ecological theory, Complex Systems theory, Complex Adaptive theory and Business Ecosystem theory, this paper analyzes the basic attributes of business ecosystem from five aspects: ecological attributes, structure attributes, functional attributes, operation mechanism attributes and lifecycle attributes. According to the mechanism of promoting system health, the paper constructs 5 level 2 indexes corresponding to 28 level 3 indexes. Based on the Evaluation model, using the Analytic Hierachy Process (AHP) and the Fuzzy Comprehensive Evaluation Method, the paper evaluates Information Technology Business Ecosystem Health in China.

Keywords Business ecosystem · Health · Information technology business ecosystem · AHP

87.1 Introduction

The business ecosystem featured in industrial convergence and the cyber economy has become a new business operating environment for enterprises. Business ecosystem health influences not only the performance of enterprises, but also their achievements. This is why enterprises always attach great importance to the evaluation and administration of the health of their business ecosystem in new environments.

X. Li · X. Jie (✉) · Q. Li
Business School, Sichuan University, Chengdu 610065, P. R. China
e-mail: jiexw@vip.163.com

Q. Zhang
College of Public Health, Sichuan University, Chengdu 610061, P. R. China

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_87,

87.2 Overview of Business Ecosystem Health

The investigation of Business Ecosystem Health (BEH) was first originated by Iansiti and Levien [1]. They did not concretely define the meaning of BEH but put forward three angles of evaluation, namely from aspects of productivity, vitality and creativity of niche market, though without any specific assessment program.

Guo et al [2] elaborated on five attributes contained in business ecosystem: logical community structure, favorable non-physical environment, efficient system productivity, sustainability and coordination of management mechanism. They interpreted BEH as the capability to efficiently and continuously create more valuable products and services and constructed 16 Level-three indexes based on it. Later studies on BEH by Hu [3] indicated that it should be a dynamic process and thus expanded the indexes to 7 Level-two indexes and 30 corresponding Level-three indexes, these being the abiotic environment, health and similarity of enterprises members, composition diversity, function flow of system, degrees of perfection of operating mechanism, performance of overall system operation and system vitality. Zhang [4] defined BEH as the ecosystem itself as being able to sustain stability and develop continuously with resistibility to external pressure. Accordingly, Zhang proposed 8 evaluatory indicators based on dynamics, levels, creativity, pertinence and cumulative vulnerability of ecological theory. The 8 indicators being energy, vitality, resilience, service to maintain business ecosystem, transmission on innovation, investment reduction, harm to neighbor system and effect on human health.

Li [5] suggested another business ecosystem function whose overall performance index can be divided into power performance, inclusiveness and robustness, which is similar to BEH but with distinct differences. The complexity of business ecosystem and its multi-dimensionally associated factors affecting its health have resulted in disagreement surrounding evaluating system health [6]. The above-mentioned conceptions and indexes of BEH as well as investigations and assessment of its evaluating indicators by domestic and foreign scholars has certainly led to a greater understanding of BEH and completion of its index system, but the BEH index from a metaphoric angle of ecology by those scholars also has limitations.

Business ecosystem as an enterprise managing network has emerged in new business environments with its operation health profoundly affected by structure, function and lifecycle as well as industrial technology and policy. This paper makes an in-depth evaluation of business ecosystem health whilst maintaining a broader research perspective. The paper will investigate the indexes by analyzing the ecology, structure, function, operating mechanism and lifecycle based on ecological and complex system adaptive theories.

87.3 Analysis of Business Ecosystem Health Attributes

87.3.1 Ecological Attribute

Study of ecological attributes of business ecosystem refers to ecology and complex system adaptive theories according to ten characteristics of a complex system: synergetic evolution, exploration of possible space, historic significance, far - from - equilibrium, feedback, path dependence, relevance, interdependence, emergence and self-organization[6, 8]. The authors present four ecological attributes of business ecosystem by integrating the research findings of scholars.

(1) Emergence

The philosophical essence of emergence described by Ouyang Yinzhi as an interactional product demonstrating how the substances are organized[9]. Emergence is the intercoupling and implantation of internal subsystems and mergence with external systems to derive a spill-over function. Business ecosystem as a whole is the total sum of individual attributive logic and functional algebra. The emergence index is manifested in integrating system resources and in promoting system performance by means of an overall strategic arrangement of both basic and expanded enterprises.

(2) Synergetic Evolution

Synergetic evolution theory was established by Haken [14] who expounded that subsystems, which constitute the whole system, can form a dynamic and stable space-time structure by the interaction between nonlinear diffraction and interference, guided by internal order parameters [10]. The synergetic evolution of business ecosystem is reflected in how basic enterprises growing from low-level manufacturers into high-level manufacturers with the guidance of exclusive and ultimate parameters to share value between basic and expanded enterprises, furthermore the Matthew effect on enterprise will cause a ‘Wild Goose’ effect on value sharing enterprise. The index displaying system evolution is the economic spillover effect on the involved enterprises.

(3) Self-organization

Self-organization originated in Prigogine’s Dissipative Structure Theory which studied mutation, namely non-equilibrium phase transition, when a certain parameter fluctuates to the threshold limit value. The theory analyzes the evolution mechanism according to which original disorder chaos evolved into a spatiotemporally multi-level, functionally diverse, dynamically orderly dissipative structure, described as ’fluctuation makes it orderly.’ There are four basic conditions for system self-organization: being open systems, far - from - equilibrium, non-linear interaction and fluctuation, that is, an in-out open system where external energy matter conducts non-linear interaction and fluctuation to achieve far - from - equilibrium [11]. The self-organization of business ecosystem refers to basic enterprises breaking through their original competition channels to become more competitive ones by circulation and modifying through correlative environmental matters and non-material energy among basic and expanded enterprises along with a supporting and complementary mechanism. The index of self-organization is completion level (from price to brand) and competition order (from disorder to orderly) of basic enterprises in the system.

(4) Adaptability

Adaptability was brought forward in Holland's Complex Adaptive System, which was a dynamic system consisting of active agents in a specific node [12, 13]. The complexity of Complex Adaptive System, the core of which is that active agents would learn, accumulate, extract and merge experience selectively and consciously, originates from the interaction between active agents and the environment as well as among agents themselves. The adaptability of business ecosystem refers to basic enterprises being adaptive through new management systems and modes by using each others expanded enterprise programs. Index of adaptability is the constant innovation and management performance along with the internal and external environment of basic enterprises.

87.3.2 Structure Attribute

Components of business ecosystem are divided into five categories in accordance with their subservience to one another and distance to the center when considering their levels and size (see Fig. 87.1).

(1) Basic enterprises

Basic enterprises, being central to business ecosystem, are divided into value sharing, value balancing and value exclusive types according to their value and connective dimensions. Value sharing enterprises serve as the advocators and maintainers for business ecosystem value platform and actually create much more value than what they possess. Likewise, what the value balancing enterprises create is greater

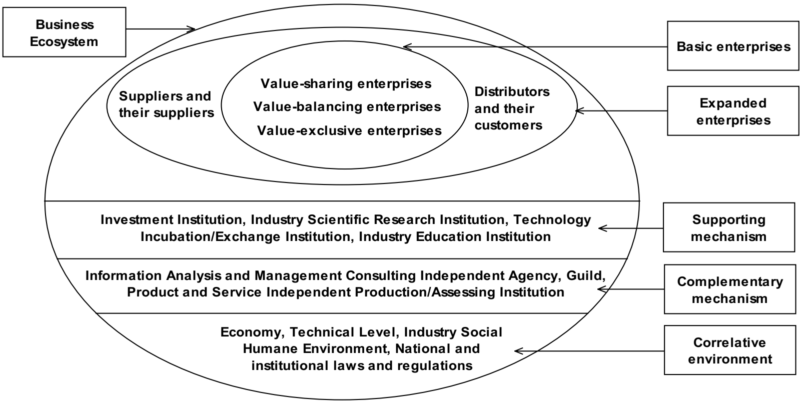


Fig. 87.1 Components of business ecosystem

than what they acquire as they play the role of substance of value and gainer. While the value exclusive enterprises, exist as dependant parasites on the business ecosystem, parasitize on the platform and control the systematic value network node. The value creation ability of basic enterprises can be measured by the number of supporting and complementary enterprises.

(2) Expanded enterprises

As an important composition of business ecosystem, expanded enterprises, on the basis of their value distribution, are divided into suppliers and distributors which are in the upper and lower reaches of basic enterprises respectively. Price control of raw materials (intermediates, semi-finished products) by direct suppliers and the selling price by direct distributors over basic enterprises would influence or even restrict the value creating enthusiasm and quantity of basic enterprises. The evaluating indicator is contributing degree of financial worth created by basic enterprises from direct suppliers and distributors.

(3) Supporting mechanism

Supporting mechanism includes institutions in areas of investment and finance, scientific research, technology incubation/exchange and educational institutions, all of which provide basic resources such as funds, skills and human resource (capital) for the development of business ecosystem. The evaluatory index measurement is comprised of investment prospects by investment and financing institutions, technical accumulation and future attention by scientific research institutions, integrity of technological incubation/exchange mechanisms, training and education of specific required talents by professional organizations.

(4) Complementary mechanism

Complementary mechanism consists mainly of organizations such as trade guilds and associations, information analysts, management consultancies, and product and service promotion/appraisal institutions, all of which favorably promote business ecosystem health by formulating standards, consulting to management, promoting products and services. The quantified index measures scientific standards formulated by guilds and the positive role played by independent organizations to boost management programs, promotion of technology and products from promotion/appraisal institutions.

(5) Correlative environment

The correlative environment is the macro environment that business ecosystems closely depend on and consist mainly of the national economy and technical level as well as national laws and regulations of industry. Circulation is needed between business ecosystem and macro environment in areas such as the national economy and technical level. Accordingly, the national economy and technical level, together with national and institutional laws and regulations of industry, are regarded as the evaluation index.

87.3.3 Functional Attribute

The functional attribute of business ecosystem is to create a value-sharing platform which produces strong financial performance; reinforces its foundation and increases profitability with productivity, vitality and creativity as its measure.

(1) Productivity

Productivity refers to return on investment which reflects the capability to create financial value; it is most crucial in a system health index as it determines whether the system brings financial performance to basic and expanded enterprises. The return on capital in business ecosystem has to be above average as well as sustainable and stable. There are consequently two aspects in measuring productivity: the net assets to income ratio which comprehensively represents profits to investors and reflects the composite income of capital operations; triennial average growth rates of capital which indicate the continuation of capital surplus and long term gain.

(2) Vitality

Vitality means viability and expand ability which represent the ability to exist, robustness, increasing size and strengthening of the system. The four indexes are enterprise survival rate, new enterprise success rate, enterprise growth rate and sustainable growth rate (total assets growth rate).

(3) Creativity

Creativity indicates ability to incubate differentiated markets and increase differentiated product varieties with two measurement indexes: differentiated enterprises growth rate and differentiated products growth rate.

87.3.4 Operating Mechanism Attribute

The operating mechanism attribute is the function node in which the system develops and realizes its functions through reasonable operations. It includes strategic clarity, platform compatibility, platform overlap, contract stability and conflict coordination, through all of which the structure and function attributes are connected.

(1) Strategic clarity

Strategic clarity refers to clear strategic orientation and stable strategic positioning of value-sharing enterprises whose intense and long-term awareness of building a value-sharing platform where evident promise and threat exists; which refers to how interests are threatened in value-sharing strategy when new enterprises find value-balancing and value exclusive strategies profitable in a business environment built on value-sharing. Such a ‘signal delivery mechanism’ leads enterprises into the system and to choice of matching strategies. Strategic clarity is presented transparently to ensuring long term stability of ‘value platform’ strategy in business ecosystem.

(2) Platform compatibility

Platform compatibility is the coupled and embedded commercial opportunity provided by value-sharing enterprises to other basic and expanded enterprises in a business ecosystem. The higher the degree of coupling and embedding, the higher the commercial value opportunities are, and exist in product modules, data interfaces, technical scheme, etc. which are provided to these connected enterprises. The amount of system compatible commercial opportunities is regarded as the index.

(3) Platform jointability

Platform jointability refers to the convenience of access for compatible commercial opportunity. Restricted by sunk and transfer costs, potential basic and expanded enterprises attempt to, or do officially join the system after evaluating commercial value. If their loss outweighs the gain on account of cost and risk that has been paid, the joined platform is certainly ineffective and discourages enterprises. Therefore, the index applies to decide the degree of convenience for system joint.

(4) Contract stability

Contract stability is specified as the mutual understanding and trust among value-sharing and expanded enterprises through an implicit contract with strategic and benefit distribution. The tacit understanding on strategy and cooperation among large-scale enterprises guarantees stable operation of the system; otherwise there will be conflict that leads to turmoil. The measurement index is the level of restriction of the trust mechanism as linked to strategy confirmation and benefit distribution.

(5) Conflict coordination

Conflict coordination is a coordination and solution mechanism for strategic role-conflict among large-scale enterprises when existing dominant value-sharing enterprises are challenged by those converted from value-balancing/exclusive enterprises as the system develops. The system either upgrades or declines when the strategic turning point is reached as multiple value-sharing enterprises appear. The system can only upgrade when good conflict coordination is established during the transition from losing to gaining and conversion of different strategic roles. The index is the measure of the level of coordination for strategic role-conflict and conversion.

87.3.5 Lifecycle Attribute

The business ecosystem has four phases in its lifecycle development course: exploiting, expanding, authority and rallying.

(1) Exploiting phase

In this phase value-sharing enterprises are responsible for conceiving, designing and establishing a value platform and drawing in enterprises with a ‘value schema’ to prospectively provide greater potential value to these enterprises than what they had, which is the key in this phase.

(2) Expanding phase

This phase is where value-sharing and value-balancing enterprises reduce the value platform to benefit basic/expanded enterprises based on ‘value beacons’. The number and scale of basic/expanded enterprises will increase along with alliance and cooperation with suppliers and distributors. It is fundamental for the platform to acquire more expansive market breadth and depth.

(3) Authority phase

Value-sharing enterprises become the core platform in this phase. They draw other enterprises into the new system or disintegrate and annex other systems with their ’centripetal value’. In-fighting over benefits can be avoided by the members. The crucial part here is that value-sharing enterprises become the core value contributors by providing long-term value and value realization vision to basic and expanded enterprises thereby consolidating alliances and cooperation to constantly improve performance.

(4) Rallying phase

Value-sharing enterprises reconstruct the value platform by infusing new ideas or rebuilding technology and investment barriers upon their ‘value prestige’. Otherwise, a declining system will result and either fall apart or be replaced by a stronger business ecosystem. The key role played by value-sharing enterprises is to strengthen the advantage of the visible value platform as well as hidden acquired reputation.

There are two indexes to measure lifecycle attribute: one is the current phase in which the system becomes healthier from exploitation to authority; the other is the national economic and technical development level whose improvement signifies the progress of system.

87.4 Structure of Business Ecosystem Health Index

The five base attributes of business ecosystem are the prerequisites and requirements and work as the principle dynamic to its health. The assessment indicator system of business ecosystem health is structured on its health mechanism 87.1.

87.5 Health Evaluation of Information Technology Business Ecosystem

On the basis of the above discussion about evaluating indicators of business ecosystem health, the following part is going to evaluate business ecosystem health of the information technology business ecosystem using AHP and Fuzzy Comprehensive Evaluation.

87.5.1 Determination of Health Index Weight

This research involves analytical study of four experts in this field — two senior information technology analysts from securities companies and two senior

Table 87.1 Assessment indicator system for business ecosystem health and its supporting theory and attributes

Destination layer	Criterion layer	Target layer	X
Health Level of Business Ecosystem	Ecological Attributes	• Ability to promote performance by strategic arrangement and resource integration • Economic Spillover Effect and ability to utilize it • Completion level (from price to brand) and competition order (from disorder to orderly) • Smooth operation of basic enterprises by innovative management	Emergence Synergetic Evolution Self-organization Adaptability
	Structure Attributes	• Number of supportive enterprises • Number of complementary enterprises	Basic enterprises
		• Financial contribution of direct suppliers to basic enterprises • Financial contribution of direct distributors to basic enterprises	Expanded enterprises
		• Investment prospects and enthusiasm of investment and financing institutions to the industry • Technical accumulation and future attention by scientific research institutions • Integrity of technological incubation/exchange mechanism	Supporting Institutions
		• Rational acceptability of guild to technology and product standard formulation • Promotion of management and products by independent/promotional/appraisal institutions	Complementary organizations
		• Industrial policy and regulatory support by authorities	Correlative environment
	Functional Attributes	• Rate of return on common stockholders' equity • Average triennial capital growth rate	Productivity
		• Enterprise survival rate • New enterprise success rate • Growth rate of enterprise • Growth rate of enterprise assets size	Vitality
		• Differentiated enterprises (products) growth rate	Creativity
	Operation Attributes	Transparency and confirmation of 'value platform' strategy of business ecosystem • Profitability compatible commercial opportunities of value-sharing platform of business system • Convenience of value platform overlap of business ecosystem • Restriction to the trust mechanism of strategy confirmation and cooperative distribution • Level of coordination for strategic role conflict and conversion	Strategic clarity Platform compatibility Platform Overlapping Contracts Stability Conflict coordination
	Lifecycle Attributes	National economy and technical level current phase of business ecosystem	Life Stage Staged development

Sources: collected from this paper. X represents Relevant theory supporting BEH BEH attributes supporting.

executives from information technology companies. They first judged the relative importance of health attribute level 2 indexes, then respectively level 3 indexes of ecology, structure, function, operation and lifecycle attributes. First level judgment matrix and third level judgment matrix are formed based on sequencing relative importance by those experts and their corresponding weight W and W^{kj} $(j = 1, 2, \cdots, n), W^{kj} = \{W_1^{k3} \cdots, W_7^{k3}\}$ are shown in Table 87.2.

Table 87.2 Weighted values of first level judgment matrix and third level judgment matrix

Attribute	Weight									
	W_j^{k3}							$\lambda_{\max}$	CI	CR
Health Attributes W	0.066	0.288	0.486	0.127	0.033	—	—	5.355	0.089	0.079
Ecological Attributes W^{13}	0.406	0.214	0.148	0.102	0.070	0.035	0.025	7.289	0.048	0.036
Structure Attributes W^{23}	0.365	0.254	0.164	0.092	0.057	0.041	0.027	7.22	0.037	0.028
Functional Attributes W^{33}	0.251	0.115	0.027	0.043	0.108	0.371	0.085	7.507	0.084	0.064
Operation Attributes W^{43}	0.527	0.233	0.130	0.069	0.041	—	—	5.078	0.019	0.017
Lifecycle Attributes W^{53}	0.750	0.250	—	—	—	—	—	—	—	—

Note: Judgment matrix $CR_0 = 0.079 < 0.1$, $CR_1 = 0.036 < 0.1$, $CR_2 = 0.028 < 0.1$, $CR_3 = 0.064 < 0.1$, $CR_4 = 0.017 < 0.1$ is consistency test checked.

87.5.2 Marking Health Indexes

The experts marked each index after determining as $\{$bad, not so good, average, good, and very good$\} = (5, 4, 3, 2, 1) = [(0, 20], (20, 40], (40, 60], (60, 80], (80, 100]]$. Vector R_i^k=[$r_{ij}^k \cdots r_{i5}^k$]. r_{ij}^k=$M/7$, M stands for experts agreement on Attribute$k$, Index i and Level j, r_{ij}^k is the mark, R_i^k is the vector composed of marks on Attribute k and Index i. The statistical results are omitted due to limited space.

87.5.3 Health Evaluation Matrix and Results

Level 3 evaluation vector is calculated based on Level 3 evaluation Weight W^{k3} and Level 3 index marks vector R_i^k according to Equation (87.1). Level 3 evaluation vector is calculated according to Equation (87.2) as shown in Table 87.3. The health degree of information technology business ecosystem is obtained by Equation (87.3).

$$B^{k3} = W^{k3} \times \begin{Bmatrix} R_1^k \\ \cdot \\ \cdot \\ \cdot \\ R_i^k \end{Bmatrix} (i = 1, 2, \cdots, 7), \tag{87.1}$$

$$B = W \times \begin{Bmatrix} B^{13} \\ \cdot \\ \cdot \\ \cdot \\ B^{k3} \end{Bmatrix}, \tag{87.2}$$

$$B \times \begin{Bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{Bmatrix} = \{0.420\ 0.351\ 0.194\ 0.035\ 0.000\} \times \begin{Bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{Bmatrix} = 83.14. \tag{87.3}$$

Table 87.3 Level 2 indexes and level 3 indexes evaluation vectors

Indexes B	Evaluation vectors b^{k3}				
	0.420	**0.351**	**0.194**	**0.035**	**0**
B^13	0.412	0.408	0.159	0.021	0
B^23	0.494	0.296	0.192	0.018	0
B^33	0.438	0.366	0.164	0.032	0
B^43	0.194	0.365	0.349	0.092	0
B^53	0.393	0.429	0.143	0.035	0

The combined health evaluation score for the information technology business ecosystem in the Peoples Republic of China based on AHP and the Fussy Comprehensive Evaluation Method is 83.14, which ranks ‘good’. About 22.9% still rank ‘average’ and ‘not so good’ by observation of comprehensive evaluation vectors, which shows the health of the information technology business ecosystem has merely reached ‘good’ but should be further promoted. 21.0% of structure-attribute evaluation ranked ‘average’ and ‘not so good’ as well as 44.1% of strategic attribute. By analyzing Level 2 indexes, these two factors are affecting the overall health of the information technology business ecosystem.

87.6 Conclusion

This paper has shown that it is theoretically and practically significant to build a evaluation system for business ecosystem health. A three-level index system has been constructed by comprehensive fuzzy evaluation based on analysis of business ecosystem attributes to evaluate the health of the information technology business ecosystem in China. It can be empirically concluded that the indexes cover a majority of the health attributes of business ecosystem. However, as there are a good many factors that affect business ecosystem health it is hoped that this paper can will encourage further research into evaluating business ecosystem health.

References

1. Lanssiti M, Levien R (2004) The keystone advantage: What the new dynamics of business ecosystems mean for Mean for strategy, innovation, and sustainability. 1st edn, Harvard Business Press, Boston
2. Hu B, Zhang JR, Shao RJ (2006) Connotation and evaluation index system of the enterprise ecosystem health. Science and Technology Management Research 1:59–61
3. Hu B (2008) Enterprise ecosystem health evaluation based on the fuzzy-grey theory. Industrial Technology & Economy 5:58–61
4. Zhang WH (2007) A study on evaluation method of Business ecosystem health. Modernization of Management 5:40–42
5. Li D (2008) Classification research of business ecosystem founding on its evolution features — The clustering analyses of 33 typical core corporations' ecosystem practices. China Industrial Economics 11:119–129
6. Spiegel JM, Bonet M, Yassi A et al (2001) Developing ecosystem health indicators in centro habana: A community-based approach. Ecosystem Haelth 7:15–26
7. Mitleton-Kelly E (2003) Ten principles of complexity and enabling infrastructures. Mitleton-kelly complex systems and evolutionary perspectives on organizations: The application of complexity theory to organization. Amstern: Elsevier/Pergamon 23–50
8. Zhong GS, Cui ZZ (2009) Theory and its development direction of the business ecosystem. Dongyue Tribune 6:27–33
9. Haken H (1983) Synergetics an introduction: Non-equilibrium phase transitions and self-organization in physics, chemistry and biology. 3th edn, Springer-Verlag,London
10. Prigogine I, Nicolis G (1977) Self-organization in non-equilibrium systems. 1st edn, Wiley, New York
11. Tan YJ, Deng HZ (2001) The study of complex adaptive system theory and it's application. Systems Engineering 5:1–6
12. Li ZJ, Yan AM, Xu XF (2008) Research on complexity and adaptation of business ecosystem. Mining and Metallurgical Engineering 3:124–128
13. Tan YJ (2001) Research on complex adaptive system and application of business ecosystem. System Engineering 5:1–6
14. Haken H (1980) Synergetics. Naturwissenschaften 67:121–128

Chapter 88
Research and Analysis on Green Supply Chain Management of Enterprise

Liming Zhang

Abstract This paper reviews the development of GSCM, and briefly describes the current methods of GSCM that the experts, scholars and implement. In order to implement GSCM comprehensive pertinently, the research attracts into the life-cycle analysis, and proposed GSCM methods which the different types of enterprises should adopt.

Keywords Green supply chain · Life-cycle analysis · Management methods

88.1 Introduction

Nearly a century, the global economy developed rapidly, due to people only pay attention to the importance to economic development, while ignoring the ecological environment protection, exploit of natural resources malignantly, discharge a large number of waste, causing acid rain, greenhouse effect, etc, damage to the environment has been a threat to human survival and development, which is becoming more serious in developing countries. Because of natural resources exhausted and the environmental problems gradually becomes more and more serious, sustainable development-related aspects of green supply chain theory and practice has been unprecedented attention.

So many governments are aware of environmental issues has become a serious challenge to sustainable development, therefore in recent years, lots of countries have issued environmental regulations which are so rigorous to enterprise, and ordered the product manufacturers to be responsible for the entire life cycle, while consumers pay close attention to environmental management. The green production, for corporations, not only increase the enterprise's economic and social benefits, but also improve the competitiveness of enterprises, and eliminate or reduce the

---

L. Zhang (✉)
Business School, Sichuan University, Chengdu 610065, P. R. China
e-mail: zhangliming@scu.edu.cn

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_88,

harm the production process causes to the environment, internalize the corporate social cost, resource conservation and environmental protection, which are mentioned above is the aim of GSCM.

The new contribution of this paper is attracting into the life-cycle analysis and proposed GSCM methods which the different types of enterprises should adopt. By discussing the impact on environment during the life-cycle of different products, this paper also indicates that GSCM applied in different kinds of enterprises, which should be the innovation of this paper.

88.2 Theoretical Development

88.2.1 Background of GSCM

A number of authors have studied GSCM, which is one of the more popular emerging corporate environmental management topics that have arisen over the past decade. In 1994, Webb [1] studied the impact that some products cause to the environment, recommended companies should select the appropriate raw materials by the environmental criteria, at the moment, companies should focus on recycling, and he proposed the concept of green procurement. Michigan State University Manufacturing Research Institute (MRC) carried out a research named "environmentally responsible manufacturing" under the subsidization of U.S. National Science Foundation (NSF) and put forward the concept of green supply chain in 1996, and put the green supply chain as important research content [2].

Meanwhile, the International Organization for Standardization (ISO) launched series of ISO14000 standard in 1996, led to much more active studies about green supply chain. In 1997, Min [3] discussed how to consider environmental factors in selecting the suppliers, and the green procurement's role in reducing waste. In 1998, the professor Sarkis from the United States Clark University proposed the concept of GSCM, and pointed out the green supply chain includes the following major components: internal logistics and procurement, materials management, external logistics, packaging and return logistics [4].

In 1999, Beeman [5] considered the environmental factors in the supply chain model; put forward the more extensive supply chain design mode. He changed some operation indicators, including the recovery rate of resources, the core rate of return, waste, ecological validity, and so on in practical problems in the supply chain. Hock [3] studied how to maintain the ecological balance in the supply chain . Furthermore, there are a lot of international companies carry out the research and implementation about GSCM, including General Motors, which was identified as the model company to implement the GSCM by the U.S. Environmental Protection Agency (US-EPA).

GSCM is designed to incorporate environmental considerations into decision making at each stage of an organization's materials management and logistics functions through post-consumer disposal [6]. Definitions vary,in some cases, GSCM has been defined as a simple green purchasing relationship between a buyer and vendor. In other cases more extensive concepts of ’closed-loop’ supply chains are employed which consider GSCM to be an unending logistics cycle of materials and products use, reuse and management from both an inter- and intra-organizational perspective [7].

88.2.2 GSCM Component Factors and Approach Relevant to The Present Study

When academic world has researched GSCM theory deeply, companies are practice the GSCM widely. According to the process of producing a product, the main method or means of the current GSCM mainly include: reverse logistics, green marketing, green manufacturing and green procurement.

88.2.2.1 Reverse Logistics (RL)

Reverse logistics is an important part of GSCM, also is the most obvious feature to differentiate from the traditional supply chain. Now reverse logistics has become a very important economic entity in the United States, it is a method that put the material, components and products back into the “forward logistics” chain. Its essence is to minimize the waste through reusing, recycling goods, materials and the activities of the upstream business, thus enhance the distribution process efficiency of the forward logistics and the reverse logistics.

Reverse logistics is a complex system; there are many decision-making problems which are the same as the traditional logistics, including the choice of system members, distribution of facilities, transportation modes, inventory levels and production planning etc. In operation, the first thing we should solve is the problem of recycling the material, it is necessary to consider the types of recycled materials, collection and disassembly, transportation mode, working over and its location, landfill sites and so on.

Reverse logistics is considered as a new strategy company can use to win the competition, and is a sustainable development model of modern manufacturing. The implementation of reverse logistics can get the value of recycled products, improve the resource utilization, reduce the resource consumption, reduce or eliminate the environmental pollution; and also can get a variety of real-time information access to product use; the implementation of reverse logistics will bring a better social image to the enterprise, adding intangible assets for the enterprise.

88.2.2.2 Green Marketing (GM)

There is essential difference between green marketing and traditional marketing, green marketing is continuation of traditional marketing to stimulate consumption at a maximum degree. Green marketing requires green management thought running through the whole marketing process. Green marketing is a new stage of marketing development, represents a new thought and operate mode of marketing which promotes company should see sustainable development as the guiding ideology, to take care of the ecological dimension of the new marketing thinking and mode of operation [8]. The development of green marketing is based on the economic ecology, ecological economics, environmental economics and sustainable development, this field mainly studies the relation of eco-system, environmental system and marketing system, and explores the rule of coordinated growth between them, deal with the relation of human beings, environment and development.

We can see the main contents green marketing include as follows:

1. Collecting green information. Green information is an important foundation for enterprises to implement green marketing.
2. Researching green product. Enterprises need to consider the impact that package and transportation, product use and disposal of waste products bring to environment, in addition to the choice of materials, the research of product structure, function, and manufacturing process's decision.
3. Paying attention to green sales promotion. Green marketing requires companies to establish a good green public image, and keep harmonious relation with the environmental protection departments, actively participate in various environment-related matters, in order to expand the green image, and strengthen the impact in the public mind; In addition, companies should also manage marketing channel, green pricing well.

88.2.2.3 Green Manufacturing (GM)

Green manufacturing can be called as clean production, different manufacturing process plan will decide different consumption of material and energy which are used to produce products, and also will decide different impact to the environment. Green manufacturing requires companies which are on the basis of the actual manufacturing system, try to plan and adopt a more reasonable process plan and operational path in order to reduce material and energy consumption, drop waste emissions and minimize environmental pollution, in the production process, all activities are required to be in line with ISO14000 standard, which means companies should use the overall prevention environmental strategy for the production process, products and services in order to increase production efficiency, reduce risk of human beings and environment. Green manufacturing includes clean energy, clean production processes, clean products; identifying cleaner production technology program is the key to achieving green manufacturing.

88.2.2.4 Green Procurement (GP)

As mentioned above, before the formation of the GSCM, Webb had studied the impact products bring to environment, and proposed the concept of green procurement, as you can see, the concept of green procurement was proposed earlier than the concept of GSCM concepts. However, with the formation and continuous development of GSCM theory, green procurement has become a subset of GSCM. Although the concept of green procurement was proposed earlier, there has not been a uniform definition. This article refers to the definition which was definite by Zsidisin and Siferd (2001): green procurement in which companies establish a series of guidelines, implement a series of actions to deal with issues related to the natural environment, including supplier selection, evaluation and development, supplier operations, internal and external distribution, packaging, recycling, reusing, reducing the use of resource and final disposal of the company's products. Thus, green procurement can bring a significant impact to enterprise's environmental performance in all aspects, meeting the public demand for green products, while it can reduce costs as a whole and bring economic benefits and competitive advantage to company. Currently, many large companies of the world ”green” the whole supply chain through green procurement.

Described above is the main part of GSCM that the experts pay close attention and research at present, it is also the main measures company take to implement GSCM at the moment. It's easy for us to know that the above methods are only research the enterprise in some stage of the product life cycle, but if we want to make the company to achieve the maximum economic and environmental benefits, we must first identify the which stage of the product life cycle stage will cause the maximum influence to the environment, then find the key point and the appropriate methods and measures downstream companies should adopt, and finally make the companies, social and environmental archive benefit they deserved.

88.3 Life-cycle Analysis and GSCM in the Enterprise Application

For the study of green supply chain, most scholars do not get rid of the limitations of the end of treatment, and do not use life cycle analysis and ecological evaluation index system of ecological assessment tools to analyze and assess the environmental impact throughout the supply chain. Called life cycle analysis of life cycle assessment sometimes, this concept was first proposed by the American Coca-Cola's Harry o Disi Li in 1969, which is 20 years earlier than the concept of green supply chain.

Life cycle analysis is one kind of technology and method to analyze the product's impact to environment in its entire life cycle, from raw materials acquisition, production, use to process of after using. The implementation of ISO14000 provides a broad sky to the application life cycle.

Life-cycle analysis's major applications are:

1. to identify products in different life stages to improve the environment,
2. for business, government, non-governmental organizations in decision-making, such as business planning, priority setting, product eco-design, purchasing activities,
3. to select indicators of environmental impact assessment, including measurement and evaluation techniques, the evaluation of environmental labeling products,
4. market, marketing strategies and publicity.

Life cycle analysis is considered as a "cradle to grave" approach, Green supply chain is a management for product from "cradle to grave" by Using life-cycle analysis to analyze the full production life of products, to identify various aspects of the degree of impact on the environment, business can make the appropriate measures to optimize the whole green supply chain.

Life cycle analysis is a mature environment evaluation method; there are a lot of papers detailing the principles of life cycle analysis. This is only a brief description of the life cycle inventory analysis of the basic steps, which shown in Fig. 88.1. According to the steps above, products can be divided into four types, based on the environmental impact: short-term raw material-intensive products (RMI), manufacturing intensive products (MIP), long-term energy resource consumption products (LCP), and products with special handling characteristics of the end of life (EOL). The reason of classification for such products is shown in Fig. 88.2.

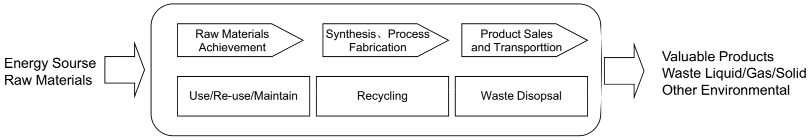


Fig. 88.1 The basic steps of LCIA

Based on the results of Life cycle analysis, products have been divided into four types, in order to facilitate research, the companies are divided into four types, namely: raw materials getting and processing enterprises, equipment manufacturing enterprises, marketing enterprise and product end managing enterprise.

This type of business classification is necessary to make a further explanation. Raw materials getting and processing enterprises has greatest negative impact on the environment during raw material acquisition and processing. This is so to other types of businesses division.

Different types of enterprises should be taken with a different focus of the GSCM approach, in which the author presents business based on life cycle analysis of GSCM system, including corporate GSCM products based on life cycle analysis and classification products based on this division of types of enterprises, enterprises of GSCM, objectives, targets and implementation of GSCM, enterprise content, which are shown in Fig. 88.3.

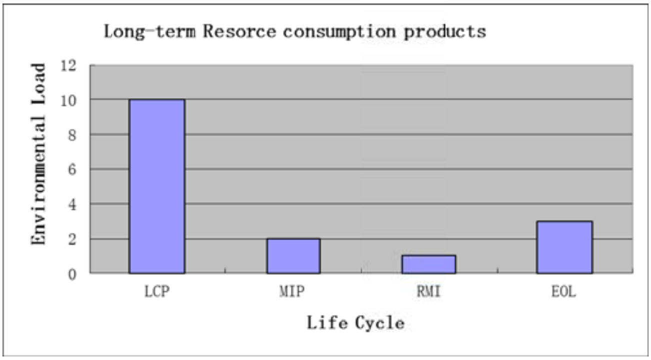


Fig. 88.2 Product category as the result of Life-cycle analysis

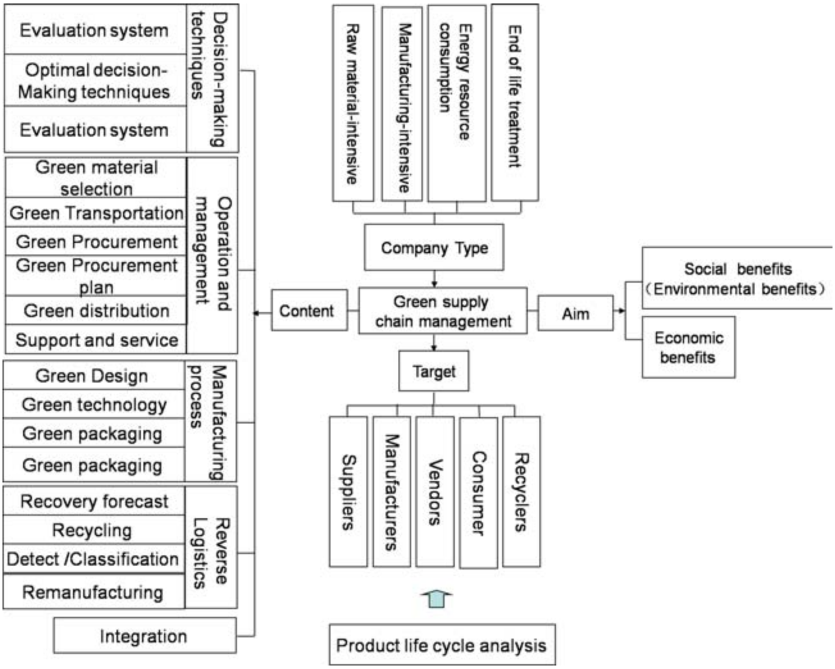


Fig. 88.3 GSCM structure base on life cycle analysis

Life cycle analysis for the enterprise effective implementation of GSCM provides data base and technical support. Through the product division from the analysis of the product life-cycle, four types of enterprise have been divided, types which share the same objectives and targets of GSCM business. In the implementation of specific management of different types of enterprises can take the same decision-making techniques, but aspects of the implementation of green management should be differently focus on.

As raw material-intensive enterprises, obtain and storage for raw materials have the most harmful impact to the environment, so the primary consideration is to procurement, selecting the best partners by optimal decision making methods, using alternative raw materials or component instead of high consumption, thigh-pollution raw materials or components, reduce the maximum possible environmental pollution.

Manufacturing-intensive businesses' biggest environmental problem is in manufacturing process, this type of enterprise should the firstly implement green works of cleaner production, including green design, green technology, green packaging and green handle.

To long-term energy resource consumption businesses, products do not have large impact in production and processing stages, however consuming of large amount of energy and resources energy or resources will occur when the product sold to customers and in long-term use. Although it is not associated with such business in traditional opinion, with more stringent environmental regulations, increasingly brutal market competition, the need of GSCM needs, companies must take measures to take green marketing, product support and services to maximize the reduction of the harm to the environment, so that to establish a corporate healthy, environmental protecting social image.

To products end of life processing enterprise, we must first make product recovery forecasts, product recovery, detection, classification, re-manufacturing or processing. Scrapping the product safety recall, and finally re-manufacture or disposal can scrap products to continue to create economic value, while reduce environmental hazards.

In addition, not only green management should be taken, but also enterprise integration technologies should be used in the life cycle analysis, based on the product life cycle considerations in all aspects of environmental issues, to restrict the upstream business, affect the downstream business strategy, to enhance their environmental awareness, and finally to optimize the economic environment of the whole supply chain.

88.4 Conclusion

Green trade barriers between countries setting, increasingly stringent environmental regulations, and public health issues of widespread concern in the environment, make environmental issues to be an important factor in the fierce market competition. GSCM is an effective environmental management method. In the implementation of GSCM method, by using life cycle analysis tools, enterprises can analyze and identify the various stages of product life cycle, and companies can take countermeasures according to the results of the analysis. In the future, researches on

GSCM, will be focused solution of GSCM for enterprises on the every stage of life cycle.

References

1. Webb L (1994) Green purchasing: Forging a new link in the supply chain. Resource 1:14–18
2. Handfield RB (1996) Green supply chain: Best practices from the furniture industry. Annual Meeting of the Decision Sciences Institute 1295–1297
3. Min H, Galle WP (1997) Green purchasing strategies: Trends and implications. International Journal of Purchasing and Materials Management 33:10–17
4. Joseph S (1998) Theory and methodology: Evaluating environmentally conscious business practices. European Journal of Operational Research 107:159–174
5. Beaman BM (1999) Designing the green supply chain. Logistics Information Management 12:332–342
6. Handfield R, Sroufe R, Walton S (2005) Integrating environmental management and supply chain strategies. Business Strategy and the Environment 14:1–19
7. Simpson DF, Power DJ (2005) Use the supply relationship to develop lean and green suppliers. Supply Chain Management: An International Journal 10:60–68
8. Lippmans S (1999) Supply chain environmental management: Elements for success. Environmental Management 6:172–175

Chapter 89
Synthetical Research for Sustainable Development in Economic Circle of Beibu Gulf based on System Dynamics Model

Minghui Xu and Zhigao Liao

Abstract This paper applies a system dynamics model for the ecological carrying capacity of urban agglomeration in Beibu Gulf of Guangxi. The model consists of three main sub-systems including population, economy and resource, respectively. Three indexes are simulated under the collected data from the year 2003 to the year 2010 to make a prediction between the year 2011 to the year 2023 and the findings are undertaken to verify the model concerning the main indexes through horizontal comparison with the historical data and sensitivity check. This model is aim to test the further development according to the current situation in Beibu Gulf and make comparative analysis among three different schemes to give a suggestion to encourage a good circulation development model and ensure the regional area under a healthy and sustainable development. The modeling results are directly useful to compare different dynamic consequences brought by various policies and decisions, and are thus of great significance to achieve the goal of sustainable development.

Keywords System dynamics · Beibu Gulf · Sustainable development

89.1 Introduction

Under the economic development of globalization, Guangxi Autonomous Regions as one of the many provinces in western China, which is faced with the pressure from the rapid development in Beibu Gulf economic zone consisting of six different cities which include Nanning City, Beihai City, Fangchenggang City, Qinzhou City, Yulin City and Chongzuo City. As the combined part of the South China economic circle, southwest economic circle and ASEAN economic circle, with the geographic advantage of the only coastal area in China's western region, Beibu gulf economic

---

M. Xu · Z. Liao (✉)
Management Department, Guangxi University of Technology, Liuzhou 545006, P. R. China
e-mail: liaoxie_27@sina.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_89,

circle is faced with the unprecedented pressure owing to a rare historical opportunity and following challenge [1]. With the policy of reformation and opening, especially the implementation of the western development, the region's economic and social development has accomplished remarkable achievements and stepped into the history of the best period of development. But at the same time, many potential social and economic problems are emerging gradually with the rapid economic development in the area, while the sustainable development policy is not the nuclear leverage of the political orientation during economic development. And under current situation, we need to take measures to alleviate the unsustainable development model to make a circular economy.

Some scholars have made many analyses about regional sustainable development [2–5]. Some of them prefer to make analysis with the model of system dynamic to discuss the sustainable issue. For example, Ai-sheng Zhang and his people make a summary about the application of SD model in regional sustainable development, and point out some related research orientation in this field [7]. Zheng-zhong Huang and some collaborators construct a SD model about China on sustainable development from the aspect in the territory of society, environment and energy respectively, whose model illustrate some related sub-systems and the internal factors relationship, and make a simulation to some indexes on a changing premise [8–10]. While the study on Beibu Gulf with system dynamic model is not often to be seen, this article is to explain the complicated system construction of the regional economy from the starting-point of SD model, to explore the sub-systems and their elements from the level of system dynamic relationship. This study is aimed at providing an experiment simulation platform to explore the complex and inter-dependent relationships between the various components within the society, economy and energy. The components in this study include population, economy, land resource, energy and the internal relationship between the items above. The study will simulate the regional economic circle on population, economy, and the usage of resources in the medium term, and explore the possible outcomes and other potential problems with three assumptions under the frame of SD model respectively. The findings are expected to assist in the process of government's policy decision making concerning the development pattern of Beibu Gulf.

89.2 System Dynamics Methodology

This paper applies system dynamics techniques to formulate, simulate and validate the sustainable regional development in Beibu Gulf economic circle [11]. System dynamics is especially designed for large-scale, complex socio-economics system. System dynamics is one of the system sciences which are used to analyze and study the dynamic trend of the relevant complicated information feedback system. With distinct characteristics of broad intercrossing, comprehensiveness, materialism, dialecticness and practicality, system dynamics is used broadly in a large range of subjects. Basically, all system dynamics models are made of three kinds of variables: stock, rate, auxiliary, and two kinds of flows, physical/material and information, only through both of which could variables interact and respond to others. Variables, together with flows, consist of the basic structure of one dynamics system, called stock-flow diagram, in which feedback loops, the foremost concept and pivotal role in simulation of the model, could be observed. In system dynamics, simulation is governed entirely by the passage of time and is referred to as "time-step" simulation. The typical purpose of a system dynamics study is to understand how and why the dynamics of concern are generated and to search for managerial policies to improve the situation.

Beibu Gulf economic circle is made up of six areas in Guangxi. To analyze the internal relationship in Beibu Gulf economic circle we classify the whole area into three main sub-systems, including population system, economic system and resource system, thereinto, resource system consists of land resource, energy and water etc. Every sub-system has its independent running model and pattern, and has horizontal relationship with each other. Thereby the entire system is a web of interactive relationship under the complicated and dynamic situation, but we can analyze each sub-system one by one and then have a general view of the main outcomes.

89.2.1 Model Description

The time horizon of the model is 20 years, from 2003 to 2023, with conformation to the development scheme of Government in Guangxi. There are three main sub-systems in this SD model, which are, namely, population sector, economic sector, and resource sector. The interactions/causal-effective relationships between the three sectors are visualized as the diagram below (Fig. 89.1), which is represented at a macro level [12]. The SD model has given a macro view of the relationship of the three main sub-systems, from which we can find out the trend and the development details in some related sectors.

The SD model simulation duration is from 2003 to 2023, and the regional data is derived from 2003 to 2010 with a time-step one year. The benchmark year is 2003, and we make some simulation and compare the simulation outcomes with the real value to analyze the relative error between the corresponding data pairs. If the relative error is controlled under 0.05 according to the confidence level 0.95, we can settle that the established SD model is available and we can make some prediction under this qualification [13]. The model has 4 level variables, 4 rate variables and 28 auxiliary variables. The 4 main level variables includes total population in the regional area, GDP, energy consumption and water consumption, and 4 main rate variables are the variation in one step-time corresponding to the 4 main level variables. Others left are auxiliary variables. The SD methodology is a presentation of the interrelationship between the different variables; the SD model here is to illustrate the dominating correlations of the above variables.

This paper will set three assumptions to make a comparative among the different development schemes. Three schemes are conservative scheme, positive scheme

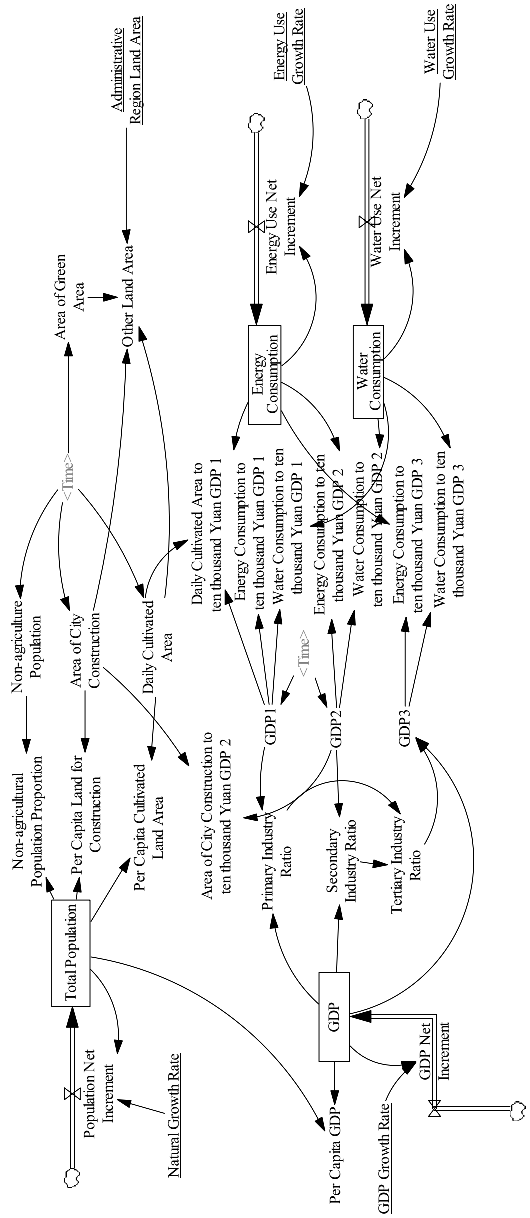


Fig. 89.1 The simulation system model flow diagram of Beibu Gulf

and radical scheme, with different predictions on the main indexes in Beibu Gulf economic circle. By analyzing the changing of main indexes we can make a choice of the satisfactory development scheme to abide the sustainable development policy rather than only one choice between our environment and our economy. The model has many kinds of parameters. Social parameters include population growth rate, non-agricultural population proportion, per capita land for construction and per capita cultivated land area; economic parameters include GDP growth rate, per capita GDP, primary industry ratio, secondary industry ratio and tertiary industry ratio; resource parameters include energy use growth rate and water use growth rate.

89.2.2 Establishment of Quantitative Model

According to the primary statistical data from 2003 to 2010, and with the statistical analysis software SPSS17.0, we make a regression analysis. The first step is to make scatterplot chart on the corresponding numerical sequence, by which we choose the optional mathematical model. By comparison of the several chosen model, we make comparison of adjusted R square, F value and sig value. The one which has the optimal value can be the final model. Here we give an example to illustrate this chosen process on non-agriculture population, and the others are similar to this model chosen process. Table 89.1 is a regression result test, from which we can make a judgment to make the final choice to have the most suitable equation.

Table 89.1 Non-agriculture population and time sequence regression result

Equation	R	Adjusted R square	F	sig
Logarithmic	0.95	0.884	46.528	0.001
Quadratic	0.996	0.987	229.783	0
Cubic	0.996	0.985	131.778	0.001
Power	0.955	0.894	51.863	0.001
Exponential	0.996	0.989	555.05	0

From Table 89.1 we can see clearly that under two-tailed test level of 0.05 exponential equation has the maximum adjusted R square value and maximum F value, at the same time, a minimum sig value. So the most suitable regression equation is exponential. With same method, we can analyze equations to the other indexes. Table 89.2 lists the whole equations available.

89.2.3 Model Simulation and Calculation

89.2.3.1 Data Reliability Analysis and Testing

The reliability analysis and testing is to compare the outcomes from the simulation by the established system model with the regional collected data from the related

Table 89.2 Non-agriculture population and time sequence regression result

Dependent variable (y)	Independent variable (x)	Regression equation
Non-agriculture population (10 000 persons)	Time sequence (Year)	$y = 367.423e^{0.021x}$
Area of city construction (1000 hectares)	Time sequence (Year)	$y = e^{3.387+0.055x}$
Daily cultivated area (1000 hectares)	Time sequence (Year)	$y = 4.7221x^2 + 42.118x + 10225$
Area of green area (1000 hectares)	Time sequence (Year)	$y = 1.262 + 8.304x - 0.353x^2$
Primary industry (100 million Yuan)	Time sequence (Year)	$y = 302.248e^{0.121x}$
Secondary industry (100 million Yuan)	Time sequence (Year)	$y = e^{5.709+0.218x}$

year books from 2004 to 2011 to check if the relative error is under certain standard. The simulation period is from 2003 to 2023, and we get the data from 2003 to 2010 to test the reliability. It is stated that the reliability standard is the benchmark if relative error is under 5% [14]. Here we choose GDP, total population, water consumption, energy consumption, daily cultivated area, and area of city construction as the test indexes in Beibu Gulf economic circle to see whether o not the condition is met with. We choose the data in 2003 as base information, and step-time is one year. We choose 2003, 2007 and 2010 as the test objective. The results are presented in Table 89.3 below.

We can conclude from Table 89.3 that the percentage whose probabilities are under the relative error 1% is 38.9%, and the relative error 5% is 100%. This shows that the simulation result is reliable and we can make simulation on this basis.

89.2.3.2 Establishment of the Simulation Scheme

The data from year books of Guangxi can present the development trend, and we can see the population of the whole economic circle is at a growing trend every year with an average growing rate of 0.827%. And we can make an assumption of Beibu Gulf economic circle with three different development schemes on population growth rate in the next decades, setting as conservative scheme 0.4%, positive scheme 0.9%, and radical scheme 1.4%, respectively. As for the index GDP, we can calculate the average level of GDP growth rate during the reference years from 2003 to 2010. We have the result of GDP index is 17.5% in Beibu Gulf economic circle, and we can also set three assumptions on that index, conservative scheme 18%, and radical scheme 28%, respectively. We have other two main indexes to observe in the simulation model, water consumption and energy consumption. With the same method, water consumption growth rate is set as conservative scheme 1%, positive scheme 5%, and radical scheme 9% under the average level of 4.3%, respectively.

Table 89.3 Test of model reliability

Index	Unit	Year	Real value	Simulation value	Absolute value of relative error
GDP	100 million Yuan	2003	1221.23	1221.23	0
		2007	2516.7	2449.93	0.02653
		2010	4275.38	4129.71	0.03407
Population	10 000 persons	2003	2021.47	2021.47	0
		2007	2141.04	2089.44	0.0241
		2010	2219.67	2141.91	0.03503
Water consumption	10 000 tons	2003	40285	40285	0
		2007	48487	47834.6	0.01346
		2010	54625	54411.5	0.00391
Energy consumption	10 000 tons of SCE	2003	580	580	0
		2007	748.39	716.72	0.04232
		2010	816	840.01	0.02942
Daily cultivated area	1000 hectares	2003	1102.23	1069.34	0.02984
		2007	1420.5	1351.14	0.04883
		2010	1603.32	1661.66	0.03639
Area of city construction	square kilometers	2003	327	312.49	0.04436
		2007	387	389.39	0.00618
		2010	456	459.25	0.00712

The last is energy consumption, with average level of 5.3%, setting conservative scheme 1%, positive scheme 6%, and radical scheme 11%, respectively.

On the base of the four main development indexes, we make three different groups with the four indexes, namely, conservative scheme, positive scheme, and radical scheme, each having a vector expression. For example, three different schemes for GDP are $G = (G_C, G_P, G_R) = (10\%, 18\%, 28\%)$. We make a matrix on the entire indexes and schemes called DM, namely, development matrix.

$$DM = \begin{bmatrix} 0.004 & 0.009 & 0.014 \\ 0.100 & 0.180 & 0.280 \\ 0.010 & 0.060 & 0.110 \\ 0.010 & 0.050 & 0.090 \end{bmatrix} . \tag{89.1}$$

The row vectors are growth rate of population, GDP, energy consumption, water consumption, respectively; the column vectors are conservative scheme, positive scheme, and radical scheme, respectively.

89.2.3.3 Simulation and Analysis of Three Schemes

We change the SD model with some varied indexes value with Vensim PLE, and make dynamic debugging routine to simulation. And we can conclude three simulation schemes on sustainable development of Beibu Gulf economic circle.

Table 89.4 The predication of conservative scheme on main indexes

Year	2010	2015	2023
Population(10 000 persons)	2078.87	2120.86	2189.82
GDP(100 million Yuan)	2456.57	4047.04	8995.64
Water consumption(10 000 tons)	43205.5	45420.3	49202.7
Energy consumption(10 000 tons of SCE)	622.048	653.936	708.391

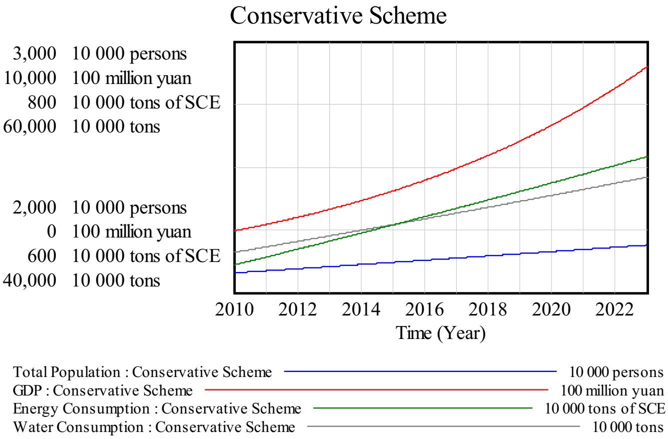


Fig. 89.2 Conservative scheme prediction of Beibu Gulf

With conservative scheme development model, we can find all of the main indexes are increasing year by year. GDP is increasing from 245,657 million Yuan in 2010 to 899,564 million Yuan in 2023; total population in the area is increasing from 20,788.7 thousands in 2010 to 21,898.2 thousands in 2023; water consumption is increasing from 432.05 million tons in 2010 to 492.03 million tons in 2023; energy consumption is increasing from 6.2 million tons of SCE in 2010 to 7.1 million tons of SCE in 2023.Per capita GDP is increasing from 11,816.9 Yuan in 2010 to 41,079.3 Yuan in 2023, around tripped in the decades; during the same period, water consumption per 10,000 Yuan of GDP is decreasing from 17.6 tons to 5.5 tons, dropped three times or so; energy consumption per 10,000 Yuan of GDP is dropped three times or so during the same period; per capita water consumption is dropped around one time, so it is per capita energy consumption. We can list a column vector about the exact numbers, symbol "+" means multiple of increase, symbol "-" has the opposite meaning. We name the column vector *CS*, and $CS = (+3.47, -3.2, -2.8, +1.1, +1.1)$. We can make a comparison with the other two column vector in the following steps.

Table 89.5 The predication of positive scheme on main indexes

Year	2010	2015	2023
Population(10 000 persons)	2152.9	2251.98	2420.08
GDP(100 million Yuan)	4290.17	10525.5	44246.2
Water consumption(10 000 tons)	57151.5	73369.6	109420
Energy consumption(10 000 tons of SCE)	882.391	1190.77	1923.51

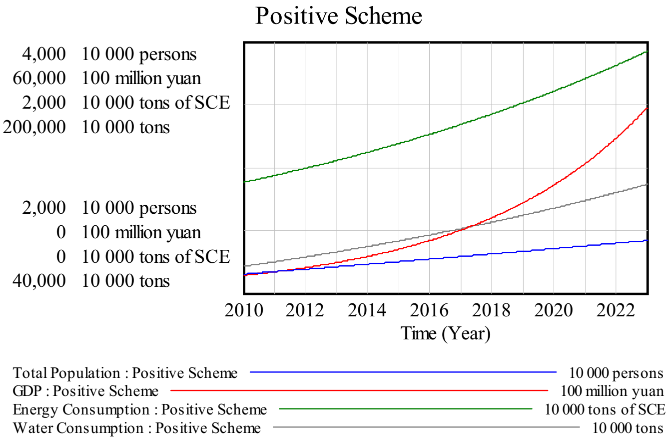


Fig. 89.3 Positive scheme prediction of Beibu Gulf

With the same analysis method, we give this positive scheme a column vector, named *PS*, and $PS = (+9.2, -5.4, -5.25, +1.71, +1.93)$.

Table 89.6 The predication of Radical scheme on main indexes

Year	2010	2015	2023
Population (10 000 persons)	2229.56	2391.18	2674.51
GDP (100 million Yuan)	8596.31	34648.1	322306
Water consumption (10 000 tons)	75572.7	118447	243095
Energy consumption (10 000 tons of SCE)	1251.01	2166.28	5214.8

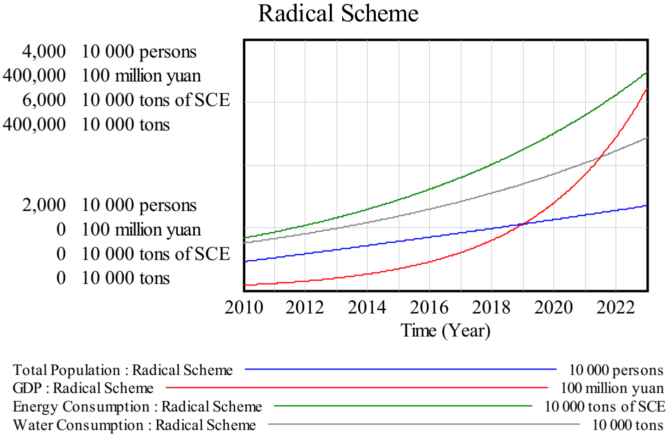


Fig. 89.4 Positive scheme prediction of Beibu Gulf

With the same analysis method, we give this positive scheme a column vector, named *RS*, and $RS = (+31.3, -11.7, -9.4, +2.7, +3.5)$.

89.2.3.4 Comparison and Analysis of the Different Simulation Schemes

Findings can be found when schemes are compared with each other, and we live a world we can't choose between our environment and our economy. From the analysis above, we can find we can have a rapid development if radical scheme is chosen, but also with a rapid consumption of our resources; we can gain a relative stable development scheme but a relative slower development if positive scheme is chosen; conservative scheme is not an optional plan owing to a pessimistic prosperity. The positive scheme is a satisfactory among the three schemes because of the steady and stable model, is a best choice for Beibu Gulf economic circle in its early stage. This scheme is suitable to Beibu Gulf under the current situation, its stable consumption of the resources and the positive growth of GDP and population is a sustainable development in Guangxi. So under a comprehensive consideration, positive scheme is prior to the other two schemes in the long run, which achieves coordinated growth in population, resource and other terms and rapid, continuing and health national economy. The modeling results are directly useful to planners and policy makers by comparing different dynamic consequences brought by various policies and decisions. It is useful in answering questions such as "What if" and is of significance to achieve the goal of sustainable development in Beibu Gulf economic circle.

Acknowledgements This research was supported by the Doctor Foundation of Guangxi University of Technology (No. 11S03) and the Foundation of Research Projects of Department of Education of Guangxi (No. 200911MS117).

References

1. Liu X (2009) On the sustainable development of Guangxi Beibu Gulf economic zone: From the perspective of system dynamics. Journal of Guangxi University for Nationalities 31:92–96
2. Andriantiatsaholiniaina LA, Kouikoglou VS, Phillis YA (2004) Evaluating strategies f or sustainable development: Fuzzy logic reasoning and sensitivity analysis. Ecological Economics 48:149–172
3. Krajnc D, Glavic P (2005) A model for integrated assessment of sustainable development. Resources, Conservation and Recycling 43:189–208
4. Chen L, Wang C (2004) Research on the synergetic mechanism of sustainable development. China Soft Science 3:152–156
5. Song T, Jia S (2008) Research on the regional sustainable development strategy model. Heilongjiang Social Sciences 6:67–69
7. Zhang A, Li F, Kang L (2005) System dynamics and its applications in regional sustainable development reasearch: A review. Arid Meteorology 23:71–72
7. Zhang A, Li F, Kang L (2005) System dynamics and its applications in regional sustainable development reasearch: A review. Arid Meteorology 23:71–72
8. Yan W, Fan D, Huang Z (1998) A system dynamics simulation model for the sustainable development of China: Social sector. Computer Simulation 15:9–11
9. Yan W, Fan D, Huang Z (1998) A system dynamics simulation model for the sustainable development of China: Environment sector. Computer Simulation 15:8–10
10. Yan W, Fan D, Huang Z (1998) A system dynamics simulation model for the sustainable development of China: Energy sector. Computer Simulation 15:11–12
11. Shen Q, Chen Q, Tang B et al (2009) A system dynamics model for the sustainable land use planning and development. Habitat International 33:15–25
12. Dai X (2010) Synthetical research of ecological carrying capacity in Hubaoe urban agglomeration based on system dynamics model 33–40
13. Meng F (2011) Research of environment carrying capacity based on system dynamics and ecological footprint model by the case of Yulin 42–50
14. Qin J, Wang L, Huang G et al (2012) Water demand prediction in Northern Gulf economic zone of Guangxi province based on system dynamics. Hydrpower Science 30:29–31

Chapter 90
A Bi-level Multi-objective Optimization Model of Multiple Items for Stone Industry under Fuzzy Environment

Muhammad Nazim, Abid Hussain Nadeem and Muhammad Hashim

Abstract Traditionally, stone industry is produced essential materials for the construction industry but stone industry is always debated as a high emission industry for stone dust and waste water. This emission has an adverse impact on environment, humans, agriculture and ground water. This paper focuses on how to optimize the stone industry. The government is considered as the leader level which will make a strategy to plan the exploring amount of every stone plant and sustainable development in stone industry to create employment opportunity and economic growth. The stone plants are considered as the lower-level decision-makers which optimize their objective functions under the constraint of leader. The stone plants have individual objectives of maximizing the profit and produce different product according to the demand constraints under the limited exploring amount. Due to the lack of historical data, some emission coefficients are considered as fuzzy numbers according to experts advices. Therefore, a bi-level multi-objective optimization model with possibilistic and predetermined constraints under the fuzzy environment is developed to control the pollution and get sustainable development in stone industry. For some special fuzzy coefficients, the equivalent model is obtained. At the end, a practical case is proposed to show the efficiency of the proposed model.

Keywords Bi-level multi-objective programming · Possibilistic constraint · Stone industry · Fuzzy simulation

90.1 Introduction

Natural and artificial stone industry partly contains the stone quarrying, processing stone, recycling stone and so on. As a result of above processes the stone industry is

---

M. Nazim (✉) · A. Nadeem · M. Hashim
Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, P. R. China
e-mail: nazimscu@gmail.com

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1_90,

produced different sorts of essential material product for the construction industry. Especially the building culture around worldwide is growing very rapidly. The principle rock types used as ornamental stone are marble and granite products. The stone industry supply and demand is increasing internationally. Since a large demand has been placed on building material in the building industry owing to increasing population this has caused a chronic shortage of building material. Accumulation of unmanaged waste especially in the developing country has resulted in an increasing environmental concern. Recycling of such waste as a building material appears to be a viable solution not only to such pollution problem, but also the economical design of building [7]. During the processes of quarrying stone, cutting stone and processing stone, stone industry is emitted huge amount of emission. That why stone industry is blamed as a high emission industry for the stone dust and waste water. During the stone cutting process, water is used for the purpose of cooling and collecting dust. The resulting water is a suspension of limestone powder. The annual amount of waste generated by this process includes 700,000 tons of slurry waste in addition to 1 million tons solid waste. The dumping of this waste in open area has created several environmental problems and negatively impacts agriculture humans and ground water [1]. In addition, destroying vegetation cover, regional topographic changes, soil erosion and disordering landscape are other negative environmental impacts [5]. Currently, waste water is treated in order to recycle the water for reuse, while the produced slurry is being dumped to open areas. The resulting solid waste is mainly limestone powder, which can be recycled in different forms of useful products like those related to construction materials [4]. Ammary [6] proves that stone cutting industry can be modified to convert them into zero discharging industry by recycling the waste water. The sludge can be used for producing bricks when it is in the slurry phase thus eliminating the need for water for producing bricks and the need for sludge disposal. Nasserdine et al [2] use the review of existing practice and jar test experiment to optimize the water recycling and treatment facilities in the stone cutting industry. Almeida et al [3] proposed and an overview of solutions to absorb the stone slurry and demonstrate the technical viability for producing white cement concrete with carbonate stone slurry in order to solve the problem of the waste generated by the natural stone industry. Furthermore, it may be said that marble and granite replacement rendered a good condensed matrix. The increased durability of concrete can be attributed to the glass content and chemical composition of the granite. The results of one study showed that the marble and granite waste aggregates can be used to improve the mechanical properties, workability and chemical resistance of the conventional concrete mixtures [8].

An important milestone in understanding the relationship between economic growth and the environment was laid during the second quinquennium of the 1980s, which recognized the complementarities that existed between them, with an emphasis on the need to mainstream environmental concerns into the planning process in order to ensure sustainable development [9, 10, 20], in their path-breaking work on the potential environmental impacts of the North American Free Trade Agreement (NAFTA), had extended this milestone by providing seminal evidence in support of an inverted U-shaped relationship between economic growth (measured by increases in per capita income) and some indicators of environmental quality. This relationship is the so-called environmental Kuznets curve (EKC).

Bi-level optimization has also been previously used for related applications in process systems engineering, like supply chain planning [11], design of reliable process networks [12] and collaborative design decision making for forearm crutch [13]. Oftentimes, for such problems, the leader and follower objectives are conflicting. At the same time uncertainties in their objectives and constraints exist. However, a satisfactory (near-optimal or satisficing) solution can be reached by providing tolerances in the objective functions and constraints, and by defining corresponding degrees of satisfaction through membership functions to indicate the preference of the decision-makers as is typical of decision-making in a fuzzy environment [14]. For example, Shih et al [15], Sinha [16] and Arora and Gupta [17] developed interactive fuzzy mathematical programming to obtain the best compromise solution, which simultaneously satisfies the upper- and lower-level objectives and constraints. All these techniques are based on the upper-level decision-maker specifying tolerances for his objective and variables, and then allowing the lower-level decision-makers to optimize their objective functions, provided that these tolerances are met. The followers then communicate their results to the leader, who modifies his goals and control variables if the original tolerances are not met. The process continues iteratively until a solution which satisfies the goals of both leader and follower is reached. For the application considered in this paper the decision hierarchy is illustrated with the government as the upper-level decision-maker having the objective of minimizing the emissions, maximize the social employment and economic growth and the stone plants as the lower-level decision makers having individual objectives of maximizing the profit and minimizing emissions. Since the emissions were not constantly monitored in the process of exploring the stone mine and producing the stone products, it results in the lack of the historical data about the emissions of the stone dust and waste water. We have to consider them as fuzzy numbers according to those experts' advice in the stone industry.

The other sections of this paper are organized as follows. In Sect. 90.2, a bi-level multi-objective problem is described. An example is also presented that will help readers to understand the problem background. A possibilistic bi-level multi-objective programming model is developed and it's equivalent model is obtained in Sect. 90.3. In Sect. 90.4, a case study is proposed to show the significance of the proposed bi-level multi-objective programming model with fuzzy coefficients. In the last Sect. 90.5, some conclusions are made.

90.2 Problem Statement

The stone industry is produced essential materials for the construction industry. The construction industry is growing very rapidly that why the stone industry supply and demand is increasing internationally. Stone plants are over exploiting to meet the increasing demand of stone materials. Traditionally, the stone industry partly contains the stone quarrying, stone processing, stone recycling and so on. During this processes the stone industry is emitted huge amount of stone dust and waste water due to quantitative relationship between emissions and the exploring and processing amount. This emission has adverse impact on environment, humans, agriculture and ground water. Here is needed a planing for the stone industry, local government and plants play the important role to perform the responsibilities, respectively.

Government is considered as a leader in this paper. As a leader level, the government has responsibility to insure the local environment from pollution. Natural and artificial stone industry, imitates large volume of stone waste that's why stone industry is always regarded as a high-emission industry for the stone dust and waste water. The greatest waste concerns in the stone industry are the stone dust and waste water. Both are significantly affected the environment and local system, badly ruin the vegetations and pollute the air and rivers. Government has duty to make a suitable plan to avoid over-exploitation and the pollution of environment. Therefore, planning a reasonable exploring limitation for every stone plant is very important for the government to ensure the local environment. Governement usually, want a sustainable development to overcome employment issue and also economic growth. In the following level, every stone plant has their predetermined level of profit. They are wanted to achieve their predetermined level of profit under the limited amount of exploring stone waste. Stone plants have responsibility to keep the environment unpolluted according to the plan of government. Stone plants should also increase their investment to attain the sustainable development according to the increasing demand and supply of stone products. Stone plants try their best to overcome the problem of unemployment according to their capacity under the policy of government and economic growth. So it is clear that the problem mentioned above is considered as a bi-level optimization problem. In this bi-level model government acts as a leader and stone plants are followers. It is assumed here, that there is perfect exchange of information among all the participants such that objective functions and constraints are known.

For the stone industry which contains several plants, these are the objectives of the government authority (upper-level decision-maker) to minimize the environmental pollution, and maximize the social employment and economic growth. This can be achieved by optimizing the design of exploring amount of the stone resources between the participating plants, which are assumed to cooperate among themselves and thus act as a lower-level decision-maker. Note that industrial symbiosis implicitly requires cooperative behavior of the participants [16, 19]. The government can influence the stone plants by imposing disincentives in the form of assigning different exploring amounts to plants according to their scale of production and clean technology. The plants operate independently of each other.

Since the emissions were not constantly monitored in the process of exploring the stone mine and producing the stone products, it results in the lack of the historical data about the emissions of the stone dust and waste water. We have to consider them as fuzzy numbers according to those experts advice in the stone industry. In this paper, the coefficient of stone dust and waste water amount cannot be estimated by the statistical method and hence they are regarded as fuzzy numbers.

90.3 The Optimal Model

The problem of optimizing the stone industry is formulated as a bi-level multi-objective optimization problem with fuzzy coefficients, in which the government is taken as the leader level decision maker and the stone plants are taken as the followers level decision maker.

90.3.1 Assumptions and Notations

(1) Assumptions

1. Government has considered a possibilistic level of pollution that environment can be tolerate.
2. Emission of a stone dust is directly proportional to the amount of stone mine that explores and the amount of stone which is used to process into different kinds of product.
3. Emission of waste water is directly proportional to the amount of stone which is used to produce different kinds of product.
4. Employment is directly related to the amount of production.
5. Variable cost is directly proportional to the amount of production.
6. Every plant has their predetermined level of profit.

(2) Notations

Indices

Φ : set of stone materials, i is an index, $\Phi = \{1,2,\cdots,m\}$;
Ψ : Set of stone plants, j is an index, $\Psi = \{1,2,\cdots,n\}$;
Ω : set of product k is an index, $\Omega = \{1,2,\cdots,w\}$.

Parameters

$\widetilde{Ed}_{ij}$: coefficient of emission of stone dust when plant j explores stone mines i;
$\widetilde{ed}_{ijk}$: coefficient of emission of stone dust when plant j produce k kind of product by using stone mines i;
$\widetilde{ew}_{ijk}$: coefficient of emission of waste water when plant j produced k kind of product by using stone mines i;
p_{ij} : coefficient of employment that stone plant j explores stone mine i;
P_{ijk} : coefficient of employment that plant j produce k sorts of product with stone mine i;
$\bar{f}ep$: predetermined employment level;
c_k : unit price of product k;
C_{ijk} : unit veritable cost that plant j produce product k;
h_{ij} : holding cost that plant j hold the remanent stone materials i;
θ_{ijk} : transfer rate that plant j produces product k by using stone material i;
Y_{ij} : the amount of stone mine i that explore stone plant j;
X_{ijk} : the amount of product k that produced stone plant j by stone mine i;

$\bar{f}_p$: predetermined level of profit of plant;
$\overline{PC}_j^U$: upper limitation of production cost of plant j;
$\overline{D}_k$: forecasted future demand of product k;
ED^u : upper limitation of total emission of stone dust in this region;
EW^u : upper limitation of total emission of waste water in this region;
$\overline{Y}_{EC}$: predetermined level of economic output;
IV_j^U : upper limitation of the inventory for stone plant j;
t_{ij} : coefficient of exploring cost that bear stone plant j to explore stone mine i;
t_{ijk} : coefficient of processing cost that bear stone plant j to produced product k by stone mine i;

Decision variables

Y_{ij} : amount of stone mine i that government allows the stone plants j to explore;
X_{ijk} : the amount of product k that produced stone plant j by stone mine i;
Z_{ijk} : binary variable; 1, the plant j produces the product k; 0, otherwise.

90.3.2 Model Formulation

The bi-level multi-objective optimization programming model under fuzzy environment of multiple items in stone industry can be mathematically formulated as follows.

(1) Government model (leader)

Government is leader in this model. As a leader level the government has debt instrument to ensure the local environment and sustainable development in stone industry, solve the employment issue and economic growth. The following objectives are counted by the government.

- To get the minimum emission including the stone dust and waste water when all the plants explores the stone mine and produce different sorts of stone products.

$$\min F_1 = \sum_{i\in\Phi}\sum_{j\in\Psi}\widetilde{Ed}_{ij}Y_{ij}+\sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega}\left(\widetilde{ed}_{ijk}X_{ijk}+\widetilde{ew}_{ijk}X_{ijk}\right),$$

where $\widetilde{Ed}_{ij}$ is a coefficient of emission of a stone dust when plant j explores stone mine i and Y_{ij} is an amount of stone mine i that explores plant j. The $\widetilde{ed}_{ijk}$ and $\widetilde{ew}_{ijk}$ are the coefficient of emission of stone dust and waste water respectively when plant j produces product k of amount X_{ijk} by using stone mine i.

Atypically, it is very hard to get the precise amount of minimum emission and decision makers only need the minimum objective under a certain possiblistic level. Therefore above objective is normally converted into a possiblistic constrained.

$$\begin{cases} \min \overline{F}_1 \\ \text{s.t. } Pos\left\{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\widetilde{Ed}_{ij}Y_{ij}+\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}(\widetilde{ed}_{ijk}X_{ijk}+\widetilde{ew}_{ijk}X_{ijk})\leq\overline{F}_1\right\}\geq\delta_1^U, \end{cases} \tag{90.1}$$

where *Pos* is the possibility measure proposed by Dubois and Prade [18], and $\geq \delta_1^U$ is the possibilistic level which respects the possibility that decision makers get the minimum objective.

- To get the maximum employment the government has obtained the following objective function.

$$\max F_2 = \sum_{i\in\Phi}\sum_{j\in\Psi} p_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} P_{ijk}X_{ijk},$$

where p_{ij} is the employment that plant j explores the stone mine i and P_{ijk} is the employment that stone plant j produced product k by stone mine i.

To maximize employment is the second objective of government. Government is proposed predetermined amount of employment to maximize the employment. So that above objective is converted into constraint as follow.

$$\begin{cases} \max F_2 \\ \text{s.t.}\left\{ \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} p_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} P_{ijk}X_{ijk} \right\} \geq \bar{f}_{ep} \end{cases} \tag{90.2}$$

- Government want to maximize their economic output than that of predetermined level.

$$\sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \theta_{ijk}X_{ijk} \geq \overline{Y}_{EC}. \tag{90.3}$$

- The stone dust and waste water should be less than the predetermined levels in order to guarantee the air and water quality. We get two constraints under the possibilistic levels.

$$Pos\left\{ \sum_{i\in\Phi}\sum_{j\in\Psi} \widetilde{Ed}_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \widetilde{ed}_{ijk}X_{ijk} \leq ED^u \right\} \geq \delta_2^U, \tag{90.4}$$

$$Pos\left\{ \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \widetilde{ew}_{ijk}X_{ijk} \leq EW^u \right\} \geq \delta_3^U. \tag{90.5}$$

(2) Plant Model (followers)

As a follower level, the stone plants have their own objectives to get the highest profit and sustainable development for increases production to meet the increasing forecasted demand of stone materials. The following objectives are considered by stone plants.

- Maximizing their profit is the first objective of plants, that is obtained follow.

$$\max H_1 = \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} c_k\theta_{ijk}X_{ijk} - \sum_{i\in\Phi}\sum_{j\in\Psi} f(Y_{ij}) - \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} f(X_{ijk})$$

$$-\sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} C_{ijk} - h_{ij}\left(Y_{ij} - \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} X_{ijk}\right),$$

where $c_k\theta_{ijk}X_{ijk}$ is the total revenue of stone plant j, $f(Y_{ij})$ is the cost that plant j occurs to explore stone mine i, $f(X_{ijk})$ is the cost occurs when stone plant j produce product k by mine stone i, C_{ijk} is the constant cost of stone plant j and $h_{ij}(Y_{ij} - \sum X_{ijk})$ is the holding cost of the remnant of stone mine i that hold the stone plant j, where $f(X)_{ijk}$ is the production caste function as follows,

$$f(X_{ijk}) = \begin{cases} t_{ij}Y_{ij} + t_{ijk}X_{ijk} + C_{ijk}Z_{ijk}, & \text{if } X_i jk \geq 0 \\ 0, & \text{if } X_i jk = 0. \end{cases} \tag{90.6}$$

Maximizing profit is the first objective of stone plant. To get the maximum profit stone plants have predetermined level of profit. Profit should not be less than the predetermined level of profit. This is right constraint of above objective. Which is stated as follow.

$$\begin{cases} \max \overline{H}_1 \\ \text{s.t.} \sum\limits_{j\in\Psi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} c_k\theta_{ijk}X_{ijk} - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} f(Y_{ij}) - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} f(X_{ijk}) \\ \quad - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} C_{ijk} - h_{ij}\left(Y_{ij} - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} X_{ijk}\right) \geq \bar{f}_p. \end{cases} \tag{90.7}$$

- Maximizing production is the second objective of stone plant, which is stated as follow.

$$\max H_2 = \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \theta_{ijk}X_{ijk}.$$

In the postponement literature, most researchers assume that product demand in each period are random and are independent across time. Especially in developing country, product demand increase with the passage of time. As a result of these assumptions, the stone plants plane to forecast future demand of market and increase their production according to it. So the aggregate demand for time period t is right constraint of above objective. That is as follow,

$$\begin{cases} \max H_2 \\ \text{s.t.} \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} X_{ijk} \geq \overline{D}_k \end{cases} \tag{90.8}$$

- Production cost should not exceed the predefined level of cost.

$$\sum_{i\in\Phi} t_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{k\in\Omega} t_{ijk}X_{ijk} + \sum_{i\in\Phi}\sum_{k\in\Omega} C_{ijk}Z_{ijk} - h_{ij}\left(Y_{ij} + \sum_{i\in\Phi}\sum_{k\in\Omega} X_{ijk}\right) \leq \overline{PC}_j^U. \tag{90.9}$$

- Inventory should not exceed the maximum limitation.

$$Y_{ij} - \sum_{i \in \Phi} \sum_{k \in \Omega} X_{ijk} \le IV_j^U . \tag{90.10}$$

90.3.3 Global Model

As a complicated system, both the leader and the followers should simultaneously consider the objectives and constraints with each other and then make the decision. Therefore, from Equations (90.1) $\sim$ (90.10), the whole bi-level optimization model under fuzzy environment should be given as follows,

$$\left\{\begin{array}{l}
\min \overline{F}_1 \\
\max \overline{F}_2 \\
\text{s.t.} \left\{\begin{array}{l}
Pos\left\{ \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \widetilde{Ed}_{ij} Y_{ij} + \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} (\widetilde{ed}_{ijk} X_{ijk} + \widetilde{ew}_{ijk} X_{ijk}) \le \overline{F}_1 \right\} \ge \delta_1^U \\
\sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} \theta_{ijk} X_{ijk} \ge \overline{Y}_{EC} \\
Pos\left\{ \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \widetilde{Ed}_{ij} Y_{ij} + \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} \widetilde{ed}_{ijk} X_{ijk} \le ED^u \right\} \ge \delta_2^U \\
Pos\left\{ \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} \widetilde{ew}_{ijk} X_{ijk} \le EW^u \right\} \ge \delta_3^U \\
\sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} p_{ij} Y_{ij} + \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} P_{ijk} X_{ijk} \ge \bar{f}_{ep} \\
\max H_1 \\
\max H_2 \\
\text{s.t.} \left\{\begin{array}{l}
\sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} c_k \theta_{ijk} X_{ijk} - \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} f(Y_{ij}) - \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} f(X_{ijk}) \\
- \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} C_{ijk} - h_{ij} \left(Y_{ij} - \sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} \sum\limits_{k \in \Omega} X_{ijk} \right) \ge \bar{f}_p \\
\sum\limits_{i \in \Phi} \sum\limits_{j \in \Psi} X_{ijk} \ge \overline{D}_k \\
\sum\limits_{i \in \Phi} t_{ij} Y_{ij} + \sum\limits_{i \in \Phi} \sum\limits_{k \in \Omega} t_{ijk} X_{ijk} + \sum\limits_{i \in \Phi} \sum\limits_{k \in \Omega} C_{ijk} Z_{ijk} - h_{ij} \left(Y_{ij} + \sum\limits_{i \in \Phi} \sum\limits_{k \in \Omega} X_{ijk} \right) \\
\le \overline{PC}_j^U \\
Y_{ij} - \sum\limits_{i \in \Phi} \sum\limits_{k \in \Omega} X_{ijk} \le IV_j^U .
\end{array}\right.
\end{array}\right.
\end{array}\right. \tag{90.11}$$

90.3.4 Equivalent Model

As we all know that, it is hard for decision maker's to find optimal strategies for the multi-objective programming with fuzzy coefficients. In this paper we had possibilistic constraints to get the minimum objective, so without membership functions we cannot convert the model into crisp equivalent model. According to expert's experience in stone industry we are used L-R membership functions. $\widetilde{Ed}_{ij}$, $\widetilde{ed}_{ijk}$ and

$\widetilde{ew}_{ijk}$ ($i \in \Phi = 1,2,\cdots,m$; $j \in \Psi = 1,2,\cdots,n$; $k \in \Omega = 1,2,\cdots,w$) are fuzzy numbers with L-R membership functions in this paper.

Lemma 90.1. *Assume that $\widetilde{Ed}_{ij}$, $\widetilde{ed}_{ijk}$ and $\widetilde{ew}_{ijk}$ ($i \in \Phi = 1,2,\cdots,m$; $j \in \Psi = 1,2,\cdots,n$; $k \in \Omega = 1,2,\cdots,w$) are L-R fuzzy numbers with the following membership functions,*

$$u_{\widetilde{Ed}_{ij}}(t) = \begin{cases} L\left(\frac{Ed_{ij}-t}{\alpha_{ij}^{Ed}}\right), & t < Ed_{ij},\ \alpha_{ij}^{Ed} > 0 \\ R\left(\frac{t-Ed_{ij}}{\beta_{ij}^{Ed}}\right), & t \geq Ed_{ij},\ \beta_{ij}^{Ed} > 0, \end{cases} \tag{90.12}$$

$$u_{\widetilde{ed}_{ijk}}(t) = \begin{cases} L\left(\frac{ed_{ijk}-t}{\alpha_{ijk}^{ed}}\right), & t < ed_{ijk},\ \alpha_{ijk}^{ed} > 0 \\ R\left(\frac{t-ed_{ijk}}{\beta_{ijk}^{ed}}\right), & t \geq ed_{ijk},\ \beta_{ijk}^{ed} > 0, \end{cases} \tag{90.13}$$

$$u_{\widetilde{ew}_{ijk}}(t) = \begin{cases} L\left(\frac{ew_{ijk}-t}{\alpha_{ijk}^{ew}}\right), & t < ew_{ijk},\ \alpha_{ijk}^{ew} > 0 \\ R\left(\frac{t-ew_{ijk}}{\beta_{ijk}^{ew}}\right), & t \geq ew_{ijk},\ \beta_{ijk}^{ew} > 0. \end{cases} \tag{90.14}$$

where α_{ij}^{Ed}, β_{ij}^{Ed} are positive numbers expressing the left and right spreads of $\widetilde{Ed}$, α_{ijk}^{ed}, β_{ijk}^{ed} are the positive numbers expressing the left and right spreads of $\widetilde{ed}$, and α_{ijk}^{ew}, β_{ijk}^{ew} are positive numbers expressing the left and right spreads of $\widetilde{ew}$, ($i \in \Phi = 1,2,\cdots,m$; $j \in \Psi = 1,2,\cdots,n$; $k \in \Omega = 1,2,\cdots,w$). Reference functions $L,R : [0,1] \longrightarrow [0,1]$ with $L(1) = R(1) = 0$ and $L(0) = R(0) = 1$ are non-increasing, continuous functions. Then we have

$$Pos\left\{ \sum_{i\in\Phi}\sum_{j\in\Psi} \widetilde{Ed}_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} (\widetilde{ed}_{ijk}X_{ijk} + \widetilde{ew}_{ijk}X_{ijk}) \leq \overline{F}_1 \right\} \geq \delta_1^U,$$

if and only if

$$\begin{aligned} \overline{F}_1 \geq\ & \sum_{i\in\Phi}\sum_{j\in\Psi} Ed_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} (ed_{ijk} + ew_{ijk})X_{ijk} \\ & -L^{-1}(\delta_1^U)\left(\sum_{i\in\Phi}\sum_{j\in\Psi} \alpha_{ij}^{Ed}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} (\alpha_{ijk}^{ed} + \alpha_{ijk}^{ew})X_{ijk} \right). \end{aligned}$$

Proof. Let $w \in [0,1]$ be any positive real number and

$$L\left(\frac{Ed_{ij}-x}{\alpha_{ij}^{Ed}}\right) = L\left(\frac{ed_{ij}-y}{\alpha_{ijk}^{ed}}\right) = L\left(\frac{ew_{ijk}-y}{\alpha_{ijk}^{ew}}\right) = w,$$

then from Equations (90.12), (90.13) and (90.14) we have

$$x = Ed_{ij} - \alpha_{ij}^{Ed}L^{-1}(w),$$

$$y = ed_{ijk} - \alpha_{ijk}^{ed} L^{-1}(w),$$
$$z = ew_{ijk} - \alpha_{ijk}^{ew} L^{-1}(w).$$

For any

$$Y_{ij},\ X_{ijk} \geq 0,\ (i \in \Phi = 1,2,\cdots,m;\ j \in \Psi = 1,2,\cdots,n;\ k \in \Omega = 1,2,\cdots,w),$$

it is easily follows that,

$$\begin{aligned} t = & \sum_{i\in\Phi}\sum_{j\in\Psi} xY_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega}(yX_{ijk} + zX_{ijk}) \\ = & \left[\sum_{i\in\Phi}\sum_{j\in\Psi} Ed_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega}(ed_{ijk} + ew_{ijk})X_{ijk}\right] \\ & - \left[\sum_{i\in\Phi}\sum_{j\in\Psi} \alpha_{ij}^{Ed}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega}(\alpha_{ijk}^{ed} + \alpha_{ijk}^{ew})X_{ijk}\right] L^{-1}(w). \end{aligned}$$

Therefore, we have

$$L\left(\frac{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} Ed_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}(ed_{ijk} + ew_{ijk})X_{ijk} - t}{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} \alpha_{ij}^{Ed}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}(\alpha_{ijk}^{ed} + \alpha_{ijk}^{ew})X_{ijk}}\right) = w. \qquad (90.15)$$

It is also proved by the same method that,

$$R\left(\frac{t - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} Ed_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}(ed_{ijk} + ew_{ijk})X_{ijk}}{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} \beta_{ij}^{Ed}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}(\beta_{ijk}^{ed} + \beta_{ijk}^{ew})X_{ijk}}\right) = w. \qquad (90.16)$$

Hence, it is easily found that

$$\sum_{i\in\Phi}\sum_{j\in\Psi} \widetilde{Ed}_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega}(\widetilde{ed}_{ijk}X_{ijk} + \widetilde{ew}_{ijk})X_{ijk}$$

is also a L-R fuzzy number with the left spread

$$\sum_{i\in\Phi}\sum_{j\in\Psi} \alpha_{ij}^{Ed}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega}(\alpha_{ijk}^{ed} + \alpha_{ijk}^{ew})X_{ijk}$$

and right spread

$$\sum_{i\in\Phi}\sum_{j\in\Psi} \beta_{ij}^{Ed}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega}(\beta_{ijk}^{ed} + \beta_{ijk}^{ew})X_{ijk}.$$

According to the definition of possibility measure proposed by Dubois and Prade [18], it can be obtained as follows,

$$Pos\left\{ \sum_{i\in\Phi}\sum_{j\in\Psi} \widetilde{Ed}_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} (\widetilde{ed}_{ijk}X_{ijk} + \widetilde{ew}_{ijk}X_{ijk}) \leq \overline{F}_1 \right\} \geq \delta_1^U \tag{90.17}$$

$$\Leftrightarrow L\left(\frac{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} Ed_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} (ed_{ijk}+ew_{ijk})X_{ijk} - \overline{F}}{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} \alpha_{ij}^{Ed}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} (\alpha_{ijk}^{ed}+\alpha_{ijk}^{ew})X_{ijk}} \right) \geq \delta_1^U \tag{90.18}$$

$$\Leftrightarrow \frac{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} Ed_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} (ed_{ijk}+ew_{ijk})X_{ijk} - \overline{F}}{\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} \alpha_{ij}^{Ed}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} (\alpha_{ijk}^{ed}+\alpha_{ijk}^{ew})X_{ijk}} \leq L^{-1}\delta_1^U \tag{90.19}$$

$$\begin{aligned} \Leftrightarrow & \sum_{i\in\Phi}\sum_{j\in\Psi} Ed_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} (ed_{ijk}+ew_{ijk})X_{ijk} \\ & -L^{-1}\delta_1^{(U)}\left(\sum_{i\in\Phi}\sum_{j\in\Psi} \alpha_{ij}^{Ed}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} (\alpha_{ijk}^{ed}+\alpha_{ijk}^{ew})X_{ijk} \right) \leq \overline{F}_1. \end{aligned} \tag{90.20}$$

This completes the proof.

From Lemma 90.1 and its proof, apparent that the possibilistic constraint can be transformed into crisp one. So that, the remaining result can be easily calculated according to Lemma 90.1 as follow,

$$Pos\left\{ \sum_{i\in\Phi}\sum_{j\in\Psi} \widetilde{Ed}_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \widetilde{ed}_{ijk}X_{ijk} \leq ED^U \right\} \geq \delta_2^U$$

is equivalent to the following equation:

$$\begin{aligned} & \sum_{i\in\Phi}\sum_{j\in\Psi} Ed_{ij}Y_{ij} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} ed_{ijk}X_{ijk} \\ & -L^{-1}\delta_2^U\left(\sum_{i\in\Phi}\sum_{j\in\Psi} \alpha_{ij}^{ED} + \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \alpha_{ijk}^{ed} \right) \leq ED^U. \end{aligned} \tag{90.21}$$

$$Pos\left\{ \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \widetilde{ew}_{ijk}X_{ijk} \leq EW^u \right\} \geq \delta_3^U$$

is equivalent to the following equation,

$$\sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} ew_{ijk}X_{ijk} - L^{-1}(\delta)_3^U \sum_{i\in\Phi}\sum_{j\in\Psi}\sum_{k\in\Omega} \alpha_{ijk}^{ew} \leq EW^U. \tag{90.22}$$

$$
\left\{\begin{array}{l}
\min F_1^* = \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} Ed_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}(ed_{ijk}+ew_{ijk})X_{ijk} \\
\qquad -L^{-1}\delta_1^{(U)}\left(\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\alpha_{ij}^{Ed}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}(\alpha_{ijk}^{ed}+\alpha_{ijk}^{ew})X_{ijk}\right) \\
\max F_2 = \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} p_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} P_{ijk}X_{ijk} \\
\text{s.t.}\left\{\begin{array}{l}
\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} p_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} P_{ijk}X_{ijk} \geq \bar{f}_{ep} \\
\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}\theta_{ijk}X_{ijk} \geq \overline{Y}_{EC} \\
\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} Ed_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} ed_{ijk}X_{ijk} \\
-L^{-1}\delta_2^U\left(\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\alpha_{ij}^{ED} + \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}\alpha_{ijk}^{ed}\right) \leq ED^U \\
\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} ew_{ijk}X_{ijk} - L^{-1}(\delta)_3^U\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega}\alpha_{ijk}^{ew} \leq EW^U \\
\left\{\begin{array}{l}
\max H_1 = \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} c_k\theta_{ijk}X_{ijk} - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} f(Y_{ij}) - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} f(X_{ijk}) \\
\qquad - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} C_{ijk}{-}hij\left(Y_{ij} - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} X_{ijk}\right) \\
\max H_2 = \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} X_{ijk} \geq \overline{D}_k \\
\text{s.t.}\left\{\begin{array}{l}
\sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} c_k\theta_{ijk}X_{ijk} - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi} f(Y_{ij}) - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} f(X_{ijk}) \\
- \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} C_{ijk}{-}hij\left(Y_{ij} - \sum\limits_{i\in\Phi}\sum\limits_{j\in\Psi}\sum\limits_{k\in\Omega} X_{ijk}\right) \geq \bar{f}_p \\
\sum\limits_{i\in\Phi} t_{ij}Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{k\in\Omega} t_{ijk}X_{ijk} + \sum\limits_{i\in\Phi}\sum\limits_{k\in\Omega} C_{ijk}Z_{ijk}{-}hij\left(Y_{ij} + \sum\limits_{i\in\Phi}\sum\limits_{k\in\Omega} X_{ijk}\right) \\
\leq \overline{PC}_j^U \\
Y_{ij} - \sum\limits_{i\in\Phi}\sum\limits_{k\in\Omega} X_{ijk} \leq IV_j^U .
\end{array}\right.
\end{array}\right.
\end{array}\right.
\end{array}\right.
\tag{90.23}
$$

90.4 Case Study

In this section, a practical example in Pakistan is considered to show the whole process of the modeling, that is proposed as follow.

90.4.1 Background Review

Pakistan is the sixth largest country in term of natural stone resources, especially marble and granite. Pakistan has major deposit of high quality marble and granite in a wide range of colors, shades and patterns. Almost all provinces in Pakistan have natural stone resources. Initial estimation indicates 166 billion tons of marble and wide rang of granite are reserved across Pakistan. It can be processed into many kinds of useful products mainly include marble products, granite sand, granite slabs, man made slabs, nano calcium carbonate, natural building material, artificial stone products and etc. Although Pakistan is rich in stone resources, the stone industry is not well developed. There are some reasons that are mentioned below.

- Stone plants have old and poor quarrying technique. At present most of stone quarries are operating with old technique of blasting and do not have basic machinery and equipment. They explore stone mine in a disorder way and it results in waste of natural stone resources and also causes air pollution, water pollution and vegetation deterioration.
- On the processing side there are very few units with a complete rang of machinery and equipment capable of processing stone in according to international standard. Most of stone plants have old technology and skill its result in lower production rate, waste of natural stone resources and environment pollution.
- Stone plants are producing many common products. They haven't produced high valuable products. It means that stone industry doesn't provide high economic growth and enough employment.
- Government has no long term policy about exploring stone mine and also no strategy to prevent environment by the pollution of stone industry.

Table 90.1 Parameters of granite for every stone plant j which explores stone mine i

Granite stone plant	Parameters					
	$\widetilde{Ed}_{ij}$ (kg/m^3)	P_{ij} (Person)	t_{ij} (PKR/m^3)	h_{ij} (PKR/m^3)	IV^U_{ij} (M m^3)	$\overline{PC}^U_j$ (M PKR)
Master	(32.7,33.2,34.5)	120	120.45	7.50	2.7	25000
Shabir	(33.8,35.4,37.2)	133	115.34	6.85	1.3	24500
Hanam	(34.5,35.8,36.9)	122	118.23	6.50	1.8	26000
Norani	(29.6,31.7,34.5)	112	110.55	5.80	1.2	22300
Mir	(31.7,33.5,37.3)	105	112.70	4.6	.8	22000

90.4.2 Data and Computation

Pakistan Stone Development Company (PASDEC), a public limited company and subsidiary of Pakistan Industrial Development Corporation, has initiated many projects to uplift the existing set-up of marble and granite sector. Despite over 166 billion tons of reserves, more than 70 types of marble and granite available, 1,225 operational mines and more than 2,000 processing factories, the marble and granite industry in Pakistan is quite underdeveloped. Pakistan's marble and granite industry is determined to achieve one goal: extraction of squared blocks. In the long run the industry's vision is to establish itself among the socially responsible and globally competitive dimension stone industry in the world. For this Pakistan is taking necessary steps to overhaul the value chain. Next it plans to invest in more advanced processing capabilities to build on the upgraded raw materials.

Table 90.2 Parameters of marble for every stone plant j which explores stone mine i

Granite stone plant	Parameters					
	$\widetilde{Ed}_{ij}$ (kg/m^3)	P_{ij} (Person)	t_{ij} (PKR/m^3)	h_{ij} (PKR/m^3)	IV_{ij}^U (M m^3)	$\overline{PC}_j^U$ (M PKR)
Master	(24.7,25.2,26.5)	105	118.45	10.50	1.7	28000
Shabir	(24.8,25.4,27.2)	115	116.34	11.85	1.5	25000
Hanam	(24.5,25.8,26.9)	122	120.23	9.50	1.	26000
Norani	(25.6,26.7,27.5)	100	125.55	13.80	1.2	29000
Mir	(25.7,26.5,27.3)	105	119.70	10.6	1.8	27000

Table 90.3 Parameters for every granite stone product

Parameter	Granite stone products			
	Marble chips	Marble blocks	Marble slabs	Marble tiles
c_k	12000 (PKR/ton)	400 (PKR/m^2)	550 (PKR/m^2)	650 (PKR/m^2)
$\overline{D}_k$	12.5×10^{10} (ton)	3.5×10^5 (m^2)	5.5×10^8 (m^2)	10.5×10^{12} (m^2)

Table 90.4 Parameters for every marble stone product

Parameter	Marble stone products			
	Nano calcium carbonate	Granite slabs	Granite sand	Man mad composite slabs
c_k	12000 (PKR/ton)	400 (PKR/m^2)	550 (PKR/m^2)	650 (PKR/m^2)
$\overline{D}_k$	12.5×10^{10} (ton)	3.5×10^5 (m^2)	5.5×10^8 (m^2)	10.5×10^{12} (m^2)

All the emission coefficients of the stone dust are considered triangular fuzzy numbers listed in Tables 90.1 and 90.2 by the expert's advice, so it is easy to convert the fuzzy model into crisp form. As the demand and the price of the marble and granite stone products sharply increase, the government requires that their output from all the plants should at least satisfy the basic market demand $\overline{D}_k (k \in \Omega = 1, 2, \cdots, w)$, is a future forecasted demand of granite and marble products by stone plants which are found in Tables 90.3 and 90.4. The unit price of every stone products can be found in Tables 90.3 and 90.4. The upper limitations of the inventory and production for every stone plant are also listed in Tables 90.1 and 90.2. The possibilistic level δ_j^L that plant j want to obtain the minimum emissions can be found in Tables 90.1 and 90.2. Since every plant has the different capacities in controlling the emissions, the fixed and unit variable cost, emission coefficients and constant costs are different from each other, which can be found in Tables 90.5 and 90.6. The transform rate θ_{ijk} and the lower limitation of the product k in plant j are also listed in Tables 90.5 and 90.6.

Table 90.5 Parameters for granite stone product *k* which is produced stone plant *j* by stone mine *i*

Stone plant	Granite stone products	Parameter					
		P_{ijk}	C_{ijk}	t_{ijk}	θ_{ijk}	$\widetilde{ed}_{ijk}$	$\widetilde{ew}_{ijk}$
Master	NCC	4	230	850	5.0	(4.50,6.45,7.23)	(15.50,16.50,17.90)
	GSl	2	310	260	235.20	(25.42,26.65,29.23)	(12.2,13.90,14.90)
	GSa	2	45	130	105	(28.56,30.2,33.15)	(0.56,0.90,1.20)
	MmS	3	380	190	25.5	(2.65,3.90,5.20)	(3.20,3.85,4.25)
Shabir	NCC	3	240	870	5.50	(3.90,5.10,6.42)	(4.35,4.95,5.25)
	GSl	1	290	255	240.50	(24.23,26.10,27.95)	(25.69,26.24,27.56)
	GSa	1	60	135	2.00	(30.45,32.50,34.65)	(0.78,0.98,1.45)
	MmS	4	370	195	27.00	(2.90,3.75,4.60)	(3.70,4.41,5.45)
Hanam	NCC	3	235	880	4.70	(4.65,5.90,7.10)	(4.30,5.10,6.25)
	GSl	2	300	265	220.00	(25.90,26.5,27.56)	(25.36,26.45,27.10)
	GSa	2	55	145	1.00	(27.90,28.60,29.65)	(0.70,1.10,1.75)
	MmS	3	380	185	24.00	(2.50,3.70,4.20)	(3.45,3.95,4.58)
Norani	NCC	4	245	855	5.00	(4.65,5.45,6.87)	(4.65,5.14,5.85)
	GSl	2	285	270	230.5	(25.23,26.40,27.90)	(25.45,26.10,27.23)
	GSa	2	65	140	0.00	(27.90,28.70,29.89)	(0.58,0.97,1.25)
	MmS	3	390	170	24.5	(2.60,3.95,4.59)	(3.85,4.15,4.89)
Mir	NCC	3	240	865	4.5	(4.60,5.70,6.75)	(4.30,5.10,5.95)
	GSl	1	320	265	215.00	(25.90,26.75,27.89)	(25.20,26.45,27.10)
	GSa	1	50	140	1.00	(28.45,29.74,30.56)	(0.50,095,1.45)
	MmS	3	365	135	26.00	(2.56,3.87,4.50)	(3.25,3.95,4.58)

Table 90.6 Parameters for marble stone product *k* which is produced stone plant *j* by stone mine *i*

Stone plant	Marble stone products	Parameter					
		P_{ijk}	C_{ijk}	t_{ijk}	θ_{ijk}	$\widetilde{ed}_{ijk}$	$\widetilde{ew}_{ijk}$
Master	MBCs	3	250	650	55.0	(14.50,16.45,17.23)	(15.50,16.50,17.90)
	MBBs	4	180	470	5.50	(15.42,16.65,19.23)	(8.2,9.90,10.90)
	MBSs	3	150	250	20	(18.56,20.2,21.15)	(9.56,10.90,11.20)
	MBTs	3	240	550	25.5	(25.65,26.90,27.20)	(26.20,27.85,28.25)
Shabir	MBCs	4	260	640	50.50	(13.90,15.10,16.42)	(14.35,15.95,16.25)
	MBBs	4	170	465	4.50	(14.23,16.10,17.95)	(8.69,9.24,10.56)
	MBSs	3	145	245	22.00	(18.45,19.50,20.65)	(10.78,11.98,12.45)
	MBTs	4	250	560	27.00	(24.90,25.75,26.60)	(26.70,27.41,28.45)
Hanam	MBCs	3	255	660	54.70	(14.65,15.90,17.10)	(14.30,15.10,16.25)
	MBBs	4	175	460	3.00	(15.90,16.5,17.56)	(8.36,9.45,10.10)
	MBSs	3	145	250	21.00	(17.90,18.60,19.65)	(10.70,11.10,12.75)
	MBTs	3	250	565	24.00	(25.50,26.70,27.20)	(26.45,27.95,28.58)
Norani	MBCs	4	260	656	52.00	(14.65,15.45,16.87)	(14.65,15.14,15.85)
	MBBs	3	165	460	2.5	(15.23,16.40,17.90)	(8.45,9.10,10.23)
	MBSs	3	140	250	20.00	(17.90,18.70,19.89)	(10.58,11.97,12.25)
	MBTs	3	250	565	24.5	(25.60,26.95,27.59)	(26.85,27.15,28.89)
Mir	MBCs	4	240	665	50.5	(14.60,15.70,16.75)	(14.30,15.10,15.95)
	MBBs	4	165	455	4.00	(15.90,16.75,17.89)	(8.20,9.45,10.10)
	MBSs	3	140	264	21.00	(18.45,19.74,20.56)	(10.50,11.95,12.45)
	MBTs	2	270	570	26.00	(25.56,26.87,27.50)	(26.25,27.95,28.58)

90.5 Conclusion

In this paper, we have developed a bi-level multi-objective optimization model with fuzzy coefficients and possibilistic constraints under the fuzzy environment. In the model, the government was considered as the leader level for minimizing the emissions of the stone dust and the waste water and maximizing the employment and economic growth and stone plants were considered as the followers level for maximizing the profit, sustainable development and minimizing the emissions. In this paper, the developed model has been converted into the crisp equivalent one to deal with some special fuzzy numbers. At the end, a practical case was presented for the proposed model.

References

1. Al-Jabri M, Sawalh H (2002) Treating stone cutting waste by flocculation-sedomentation. In: Proceeding of the Sustainable Enviromental Sanitation and Water Services Conference, 28th WEDC conference, Calcutta, India
2. Nasserdine K, Mimi Z, Bevan B et al (2009) Environmental management of the stone cutting industry. Journal of Environmental Management 90:466–470
3. Almeida N, Branco F, Santos JR (2007) Recycling of stone slurry in industrial activities: Application to concrete mixtures. Building and Environment 42:810–819
4. CH2MHILL (2002) Herbon industerial waste water controle and pretreatment fesibility study. Task 10, unpublisheed report
5. Montero MA, Jordan MM, Almendro-Candel MB et al (2009) The use of a calcium carbonate residue from the stone industry in manufacturing of ceramic tile bodies. Applied Clay Science 43:186–189
6. Ammary BY (2007) Clean production in stone cutting industries. International Journal of Enviroment and Waste Managment 1:106–112
7. Algin HM, Turgut P (2008) Cotton and limestone powder wastes as brick material. Construction and Building Materials 22:1074–1080
8. Hebhoub H, Aoun H, Belachia M et al (2011) Use of waste marble aggregates in concrete. Construction and Building Materials 25:1167–1171
9. Pearce DW, Warford JJ (1993) World without end: Economics, environment and sustainable development. Oxford University Press/World Bank, Oxford
10. Grossman GM, Krueger AB (1991) Environmental impacts of a North American free trade agreement. Discussion Paper No. 158, Woodrow Wilson School, Princeton University, Princeton, NJ
11. Ryu JH, Dua V, Pistikopoulos EN (2004) A bi-level programming framework for enterprise-wide process networks under uncertainty. Computers and Chemical Engineering 2:1121–1129
12. Takama N, Umeda T (1980) Multi-level, multi-objective optimization in processing engineering. Chemical Engineering Science 36:129–136
13. Teresa W, Som S, Mengqi H (2011) The application of memetic algorithms for forearm crutch design: A case study. Mathematical Problems in Engineering, Doi:10.1155/2011/162580
14. Bellman RE, Zadeh LA (1970) Decision-making in a fuzzy environment. Management Science 17:141–164.
15. Shih HS, Lai YJ, Lee ES (1996) Fuzzy approach for multi-level programming problems. Computers and Operations Research 23:73–91

16. Singh A, Lou HH (2006) Hierarchical Pareto optimization for the sustainable development of industrial ecosystems. Industrial and Engineering Chemistry Research 45:3265–3279
17. Arora SR, Gupta R (2009) Interactive fuzzy goal programming approach for bi-level programming problem. European Journal of Operational Research 194:368–376
18. Dubois D, Prade H (1978) Operations on fuzzy numbers. International Journal of System Sciences 9:613–626
19. Lim SR, Park JM (2008) Cooperative water network system to reduce carbon footprint. Environmental Science and Technology 42:6230–6236
20. World Commission on Environment and Development (WCED) (1987) Our common future. Oxford University Press, New York

Author Index

J. Xu et al. (eds.), *Proceedings of the Sixth International Conference on Management Science and Engineering Management*, Lecture Notes in Electrical Engineering 185,
DOI: 10.1007/978-1-4471-4600-1,