Feng Chen
Yisheng Liu
Guowei Hua *Editors*

LTLGB 2012

Proceedings of International Conference on Low-carbon Transportation and Logistics, and Green Buildings

Volume 1

Springer

LTLGB 2012

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Beijing Jiaotong University

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The Hong Kong Polytechnic University

Center for Housing Innovations
The Chinese University of Hong Kong

Academy of Mathematics and Systems Science
Chinese Academy of Sciences

School of Economics and Management
Beijing University of Chemical Technology

Feng Chen · Yisheng Liu · Guowei Hua
Editors

LTLGB 2012

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Preface

This volume contains the "*Proceedings of the 2012 International Conference on Low-carbon Transportation and Logistics, and Green Buildings*" (LTLGB' 2012), held in Beijing, China, hosted by Beijing Jiaotong University, in cooperation with the University of Liverpool, supported by the Shipping Research Centre (SRC) of The Hong Kong Polytechnic University, Center for Housing Innovations of the Chinese University of Hong Kong, Academy of Mathematics and Systems Science of Chinese Academy of Sciences and School of Economics and Management of Beijing University of Chemical Technology, and sponsored by National Natural Science Foundation of China (NSFC) and K. C. Wong Education Foundation.

This conference is a prime international forum for both researchers and industry practitioners to exchange latest fundamental advances in the state of the art and practice of the fields of technology, policy, and management of carbon emission, with three simultaneous tracks covering different aspects, including: "Low Carbon Transportation", "Low Carbon Logistics" and "Green Building". It also had five special sessions and workshops, Low-carbon Technology and Low-carbon Policy, Low-carbon Project Management, Industrial Security under Low Carbon Development, Low-carbon Transportation and Low-carbon Tourism, and Green Supply Chain Management. Papers published in each track describe the state-of-the-art research work that is often oriented towards real-world applications and highlight the benefits of related methods and techniques for the emerging field of low carbon transportation, Low carbon logistics, and green building development.

LTLGB 2012 received 252 paper submissions from 11 countries and regions. One hundred and thirty-three papers were accepted and published after strict peer reviews. The total acceptance ratio is 52 %. Additionally, a number of invited talks, presented by internationally recognized specialists in different areas, have positively contributed to reinforce the overall quality of the conference and to provide a deeper understanding of related areas.

The program for this conference required the dedicated effort of many people. First, we must thank the authors, whose research and development efforts are recorded here. Second, we thank the members of the program committee and the additional reviewers for valuable help with their expert reviewing of all submitted papers. Third, we thank the invited speakers for their invaluable contribution and the time for preparing their talks. Fourth, we thank the special session chairs whose collaboration with LTLGB was much appreciated. Finally, many thanks are given to the colleagues from BJTU for their hard work in organizing this year's event.

A final selection of papers, from those presented at LTLGB 2012 in Beijing, will be done based on the classifications and comments provided by the Program Committee and on the assessment provided by session chairs. Extended and revised versions of the selected papers will be published in special issues of the four international journals.

We wish that you all enjoy an exciting conference and an unforgettable stay in Beijing, China.

Prof. Feng Chen
Prof. Yisheng Liu
Dr. Guowei Hua

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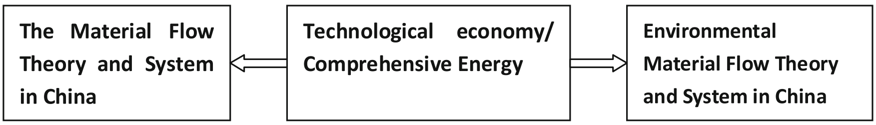
Environmental Material Flow Theory and System in China

Shoubo Xu

1.1 Introduction



1.2 The Material Flow Theory and System in China

- The Material flow theory
- Comprehensive MF theory
- The MF element theory
- The MF nature theory
- The MF science & technology theory
- The MF engineering theory
- The MF Industry Theory

1.3 The hexa-structure theory for the MF engineering

- 6 MF forces

Labor forces; Financial forces; Physical forces; Natural forces; Transport forces; Time forces

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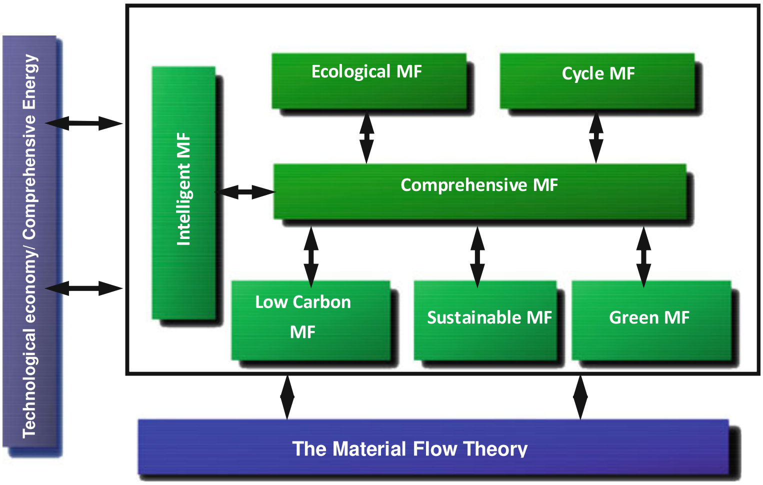
- The 6 MF elements

MF laborers; Objects to be worked on in the MF; Means of labor for the MF; MF work environments; MF labor space; MF labor time

1.4 Environmental Material Flow Theory and System in China



Author Biography

Prof. Shoubo Xu was born in Shaoxing (a city which located at Zhengjiang Province of China). He obtained a Bachelor's Degree in Power Engineering from Nanjing Institute of Technology in 1955. Then he graduated from the Energy Institute of the Academy of Science of USSR in 1960, with an Associate Doctorate Degree of Technological Science. Now he is honored as a professor, consultant and PHD supervisor of Economics and Management school at Beijing Jiao Tong University. And he also works as the Director of China Center of Technological Economics Research, the President of Comprehensive Energy Institute, Honorary Dean of the Material Flow School at Beijing Jiaotong University, and named as Chinese Director of the Sino-Austria Innovation Research Center. At the same time, Dr Xu is also regarded as the Chairman of Professors Association in the Economics and Management department. Besides that, he was the core initiator and co-founder of the Chinese Technological Economics and Comprehensive Energy Engineering, the pioneer of our nation's Comprehensive Material Flow Engineering and the science of Managing According to Reason MR.

For more than 50 years, academician Xu has made 422 achievements in theoretical and application aspects in the three new scientific fields of TE, ETE/CEE and MFTE/CMFE. More than 50 of his achievements have received awards, including the National Science Congress Award, the National Science & Technology Progress Award and various awards from the Chinese Academy of Science, Chinese Academy of Social Sciences, National Development and Reform Commission and City of Beijing, etc., he has received National Science & Technology Progress Award nine times (the first prize provincial, one time National Science & Technology Progress first prize and one time third prize, four times provincial second prize and three times third prize).

Chapter 2
Green Supply Chain Design and Management

Zuo-Jun Max Shen

Increasing environmental awareness has resulted in great interest in supply chain sustainability. Studies have shown that a large proportion of the carbon emission actually comes from the upstream and downstream members of the supply chain, so there is great need to access the greenness of a supply chain as a whole. For example, Wal-Mart found out that 90 % of their carbon emission comes from their suppliers. However, many activities in the supply chain are dependent and thus identifying the carbon emissions from each activity is difficult. To overcome those difficulties, we need to understand the important issues in green supply chains and the state-of-art research. In this talk, I will review various issues in green supply chain design and management and point out some research opportunities.

Author Biography

Prof. Dr. Max Shen obtained his Ph.D. in Industrial Engineering and Management Sciences from Northwestern University. He joined the department in July 2004. Before that he taught at the Industrial and Systems Engineering Department at the University of Florida. His primary research interests are in the general area of integrated supply chain design and management, and practical mechanism design. He has published more than 70 papers, and he is also an associate editor for Operations Research, Naval Research Logistics and Journal Omega, area editor for IIE Transactions, senior editor for Production and Operations Management.

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Chapter 3
Integrating the Environment, Urban Planning, and Transport: Where Does Economics Fit in?

Kenneth Button

This paper considers the role that economics can play in integrating the environment, urban planning and transportation. The main challenge in moving towards sustainable development is in developing the holistic framework that integrates the environment, economy, and social stability highlighted in the Brundtland Report of 1987. There is a frequent misunderstanding that economics is purely concerned with the market and with prices in markets; e.g. the setting of transit prices and the financial viability of airlines. This has never been the case, and indeed, much of the current debate about the environment can be found, albeit in the context of the knowledge of the time in economic writings from at least the 1920s or earlier. The paper highlights some of the contributions that economics can make in the particular case of handing environmental matters when concerned with urban planning and transport. Within this framework we are concerned with matters of social equity as well as narrower, and more traditional notions of efficiency. It will make use of a number of case studies to provide illustrations of where economics has proved useful.

Author Biography

Prof. Kenneth Button is a Professor of Public Policy at the George Mason School of Public Policy and a world-renowned expert on transportation policy. He has published, or has in press, some 80 books and over 400 academic papers in the field of transport economics, transport planning, environmental analysis and industrial organization. Some of his recent books include: Airline Deregulation: An International Perspective (David Fulton Publishing), Flying into the Future: Air Transport Policy in the European Union, Edward Elgar Publishing), Handbook of Transport Modelling, (Pergamon Press); Transport, the Environment and Sustainable Development (E & FN Spon Publishing); Meta-analysis in

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Environmental Economics (Kluwer); Air Transport Networks (Edward Elgar Publishing). He is editor of the leading international academic journals Transportation Research D: Transport and the Environment and of the Journal of Air Transport Management and is on the editorial boards of nine other journals. He is on the scientific committee of the World Conference on Transport Research and the Advisory Board of the Air Transport Research Group.

Chapter 4
The History and Challenges of Japan's Low-Carbon Transportation Systems

Takayuki Morikawa

Japan has been building the rail-based transportation system since the modernization of the nineteenth century. Yet it experienced the motorization starting the early 1970s and has been struggling for the low-carbon transportation system mainly by introducing transportation demand management schemes. The recent car technologies help lower CO_2 emission by applying efficient engines, new generation vehicles and ITS.

The main research of Prof. Takayuki Morikawa concerns the areas of Travel Behavior, Transportation Demand Analysis, Transportation Policies, ITS, etc. And he has published over 150 academic papers in various international journals and conferences.

Author Biography

Prof. Takayuki Morikawa got his Master of Engineering from Kyoto University in 1983 and Master of Science from Massachusetts Institute of Technology (MIT) in 1987. Thereafter, he obtained his Ph.D. under the supervision of Prof. Moshe Ben-Akiva in 1989. In 1991, he began to work as Associate Professor at Nagoya University. From 1996 to 1997, he made his research as Visiting Associate Professor at the Department of Civil and Environmental Engineering, MIT. Since 2000, he has been a Professor at Nagoya University. Now Prof. Takayuki Morikawa is affiliated with Graduate School of Environmental Studies and Green Mobility Cooperative Research Center at Nagoya University.

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Chapter 5
Low Carbon Urban Design

Peter Boelsterli

Abstract Municipalities are administrative entities who manage a full set of key elements that are highly relevant to influence the future carbon-carbon footprint in regional contexts. In various approaches all over the world, cities are taking action and share their knowledge systematically. They combine a systematic change and quality management approach with the development of sector-specific tools as well as policy recommendations. A complete new approach in planning technologies will be needed to fully cope with the challenges, rising by the given growth of complexity in future urban developments. Based on cloud computing solutions, integrative planning can be reached by combining the different key layers into one overall approach that allows rapid prototyping and the parametric development of complex environments.

Author Biography

Prof. Peter Boelsterli was born in 1961 in Winterthur, Switzerland. He studied architecture at ETH Zurich and founded his own practice in 1993; today the company is called X6. X6 started applied research on sustainability in architecture in a time when most people weren't familiar with this term. X6 has created projects from single buildings to urban planning. Since 2008, Peter Boelsterli is the appointed China Delegate of the Swiss Rector's Conference of Universities of Applied Sciences & Art and supports the Development of Sino-Swiss Science and Technology Cooperation's. Today he combines higher education activities with teaching and research. In addition he continues to develop his practice as an architect in themes such as smart urban low carbon planning, future buildings, convenience urbanism, etc. via different networks of collaboration and partners all over the world. Peter Boelsterli is a member of SIA, BSA and RIBA; he is professor of architecture at Bern University of Applied Science & Art. With his wide field of activities he is one of the key persons of the Swiss Higher Education, Architecture and Urban Planning Landscape.

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Chapter 6
Interdisciplinary Behavior Studies for Cross-Sector Energy Policies

Junyi Zhang

It is very difficult to reduce the energy consumption in domestic and passenger transport sectors, where households make use of various in-home and out-of-home energy-powered appliances (in-home: e.g., refrigerator, air-conditioner, and washing machine; out-of-home: e.g., passenger car and motorcycle) to meet their daily life needs. Decisions on the ownership of energy-powered appliances and the resulting amount of energy consumption are behaviorally interrelated with each other from appliance to appliance, from time to time, from household to household, and from context to context. To explain such complicated behavior phenomenon, various decision-making models have been proposed in different research disciplines, which are usually based on different behavioral assumptions. These existing studies will be first reviewed and then it will be argued how important to integrate various scientific insights from different disciplines to represent the household energy consumption behavior. Furthermore, it will be illustrated how different behavioral aspects can be jointly modeled in an interdisciplinary way. For the sake of the understanding, some case studies linked with residential choice, time use, and travel behavior will be introduced. Finally, the issues of behavior studies contributing to the design of cross-sector energy policies will be discussed.

Author Biography

Prof. Junyi Zhang's main research topics include travel behavior survey and modeling, household behavior modeling in transportation, theory of citizen's life decisions and behavior, tourist behavior modeling, household car ownership and usage, integrated urban and transportation modeling,

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sustainable urban development and transportation, intelligent transport systems, traffic safety, public transportation policies, urban and transportation issues in developing countries, city center development and pedestrian behavior, environmental and energy policies in transport sector, and low-carbon urban system design and so on. Prof. Zhang published 266 refereed academic papers and 211 non-refereed papers, and was awarded as Best Paper/Research Awards for 7 times and Outstanding Paper Awards for 3 times by international/domestic associations/conferences.

Chapter 7
International Journal of Shipping and Transport Logistics: An Insider's Perspective

Y. H. Venus Lun

7.1 Impact Factor

- The latest release of the ISI Journal Citation Reports (JCR) by Thomson Reuters reported that *IJSTL* secured an impact factor of 1.844:
  - 46/166 in "Management" category
  - 7/24 in "Transportation" category

7.2 Research Methodologies

Key research methodologies:

- Analytical
- Empirical
- Optimization

  Others: Case Study, Review, Simulation…..

7.3 Hints to Authors

- Originality
  - phenomenon, theory, model, method, review
  - Contribution

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  - academic, practical, managerial
- Significance
  - meaningful, useful, extendable
- Rigour
  - data, analysis, conclusion
- Lucidity
  - clear, logical, smooth, comprehensible

Author Biography

Dr Y.H. Venus Lun is an assistant professor in department of Logistics and Maritime Studies, The Hong Kong Polytechnic University. She is the Director of the Shipping Research Centre, The Hong Kong Polytechnic University and the Deputy Programme Director of MSc in International Shipping and Transport Logistics, The Hong Kong Polytechnic University.

Dr Y.H. Venus Lun is the Editor-in-Chief, International Journal of Shipping and Transport Logistics, and the Editor of Springer Series in Shipping and Transport Logistics.

Chapter 8
The Roles of Railway Freight Transport in Developing the Low-Carbon Society and Relevant Issues

Guoquan Li

With the socio-economic changes, the transport system in developed countries has been formed adequately. Users can freely choose their expected transport means according to relevant needs. Railway transport as one of the most available means with environmental-friendliness has been required to play more important roles in developing eco & low-carbon society. In this study, the situations of surface freight and potential demands to be suitable for railway container are analyzed, and the possible predominance ranges of railway in transport cost are estimated by the comparative analysis between railway and truck freight rates in transport distance. Moreover, by a case study, the effects of railway freight transport in the reductions of logistics costs and CO_2 emissions, and the savings of energy are derived. Finally, the relevant issues concerning the actual conditions are discussed.

Author Biography

Dr. Li Guoquan Dr. Li Guoquan is a senior researcher in the transport planning, at Railway Technical Research Institute, mainly working for the followings.
(1) Infrastructure and railway planning
(2) Freight transport and Logistics system management
(3) Regional public transport system based on the socio-economic changes
(4) Transportation policy and developing strategy
(5) Laws, acts, regulations concerning transportation.
Dr. Li obtained the Ph.D. in Engineering, laboratory of urban system planning from Kyushu University, and joined the laboratory of transport system engineering as an assistant professor in April 1996. He had/has been a senior researcher in the Institute for Transport Policy Studies from 1999, Railway Technical Research Institute from 2005. Also he is a part time teacher in logistics system, at Tokyo City University.

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Chapter 9
Chinese Condition Must be Considered on Developing Green Building in China

Youguo Qin

China is a big developing country in the world. There are huge local differences between different areas in China on the conditions of geography, climate, population and on economical and social development. How to consider the Chinese conditions on developing green building in China is discussed in this paper from seven aspects: pay more attention on ordinary houses; energy and CO_2; "green" not be replace by "low carbon"; solar energy; "footprint" and "ecological value of land"; rethinking of Chinese condition "large population and little land"; insist the policy of architecture design: "applicability, economy, and attention to beauty with possible conditions".

Author Biography

Prof. Youguo Qin is a full professor in school of Architecture, Tsinghua University. He is the Chairman of National Board of Architectural Education Accreditation of China, the Chairman of Architectural Physics Committee, Architectural Society of China, and the Chairman of Green Architecture Committee, Architectural Society of China.

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Part II
Low Carbon Transportation

Chapter 10
Study on Traffic and Infrastructure Construction Performance Assessment Based on Sustainable Development

Jie Zhang, Huibing Xie, Minghui Liu and Kai Liu

Abstract The road transport, as an important part of the whole contemporary transport system, has many advantages such as the flexibility, promptness, good accessibility and so on. However, the contradictions between the traditional development of road transport and natural environment and resource have been apparent. Specifically speaking, there are three aspects: (1) high consumption of resource; (2) land resource wasting; (3) severe pollution. Therefore, the sustainability assessment on transport infrastructures is highly necessary. This paper analyzes four problems of transport infrastructures including natural resource, environment, society and economy, and then a theory of sustainability assessment on transport infrastructures based on the quality and load of transport infrastructures is proposed. The assessment system contains 4 level-one indicators, 14 level-two indicators and 61 assessing criteria. The questionnaire method and AHP (Analytic Hierarchy Process) method are used to define the weights of every indicator. Finally, SDI (Sustainable Development Index) is introduced to express the sustainability of the infrastructure evaluated.

Keywords Traffic and infrastructure construction · Sustainable development · Performance assessment · Index system · Analytic hierarchy process

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10.1 Introduction

The road transport, as an important part of the whole contemporary transport system, has many advantages such as the flexibility, promptness, good accessibility and so on. It is the symbol which can show the level of social economic development of a country or a region (http://www.jttj.gov.cn/shownews.asp?id=1756).

With the improvement of people's living standard, the road transport in China has changed greatly. The contradictions between the traditional development of road transport and natural environment and resource, which can be classified as the following three parts: (1) high consumption of resource; (2) land resource wasting; (3) severe pollution, has become apparent (World Commission on Environment and Development 1987). Hence, it is necessary to assess the sustainability of transport infrastructure projects.

Extensive research is being carried out in this area. Xiong et al. (1999) discussed the relationship between the transport and sustainable economic development from a perspective of sustainable economic development and acknowledges that "the traffic development is closely related to the implementation of the strategy of sustainable development". Zhu (1999) pointed out that an important criterion to measure the sustainable transport is whether the transport system could maintain long-term dynamic social net income or welfare maximum. Qian and Minghuai (2001) analyzed the negative impact of transportation infrastructure on the land and resources and suggested to eliminate the impact of transportation from three aspects of the economic policy, legal management and publicity and education. Zhou Jun (Jun and Yisheng 2005) analyzed the structure of the urban transport infrastructure and its collaborative relationship with the city and internal rules, proposed the integration mode of the sustainable development of urban transport infrastructure.

In this study, a useful assessment framework is established and the importance of the indicators in the framework is analyzed. A good expression of the assessment result is proposed to reflect the sustainability of the infrastructure.

10.2 Indicators for the Assessment System

The Aim of the sustainability assessment of transport infrastructures is to appraise the quality and performance provided by the road transport and the environment loading caused by it, finally propose some suggestions for improvement (Liu 2006). For the sake of assessing from various perspectives, a multi-level indicator system is established, which can reflect the characteristics of road transport and integrate with its sustainability performance.

In the assessment system, the indicators can be divided into two groups: (1) "L"- Load, namely consumption of energy and resource and pollution, which is further divided into LR1 Resource Consumption and LR2 Environment Influence; (2) "Q"- Quality, namely the functions and service provided by transport infrastructures which is further divided into Q1 Social Economy, Q2 Service Quality (Steele and Cole 2003). All assessment criterias, which should be scored as 0–5, are listed hereinafter, by which the meaning of every indicator is reflected.

Table 10.1 Assessment indicators related to society and economy

Secondary indicator	Assessment criterias
Promotion of society (Xiang 2006)	Promotion of job opportunity in local area
	Contribution to infrastructures, road net and transport
	Contribution to the culture, education and sanitation
	Contribution to effectiveness of local transport
Promotion of political stability	Projects complying with the national and regional planning
	Contribution to shorten the gap between urban area and countryside
	Contribution to the resistance to natural disasters
	Contribution to the national defense
Promotion of regional economy	Importance of the infrastructure for the local economic development
	Foundation of regional economy: the level of industrial production, the level of agricultural production, investment on basic infrastructures, the situation of labor productivity, the situation of local finance and etc.
	Resource and technologies: the indicator reflects the potential incidents of economy development, labor, source of construction materials and technologies. It contains water resource, mine resource, tourist resource, labor resource, integrated natural conditions and technologies
	Urban condition: the level of industrial production in urban area, the scale of urban area and the level of infrastructures in urban area
	Comparison among beneficial areas: investment amount, construction duration, period for recovery of investment and indirect beneficial areas

Table 10.2 Assessment indicators related to function of transport

Secondary indicator	Marking scheme
Traffic capacity	Lane capacity
	Safety
	Applicability
Integrate into network	Construction quality of road
	Construction quality of landscape
	Construction quality of safety installation
	Construction quality of monitoring system
	Assess to the road network
Operation	Maintenance planning
	Risk identification
	Risk management

Table 10.3 Assessment indicators related to resource

Secondary indicator	Marking scheme
Land resources (Jianshe et al. 2008)	Utilization of land resource is controlled
	The land selected has not been used
	Measures of land improvement is used
Resource recovery	Recoverability of structure <15 %
	15 % ≦ Recoverability of structure <20 %
	20 % ≦ Recoverability of structure <25 %
	25 % ≦ Recoverability of structure <30 %
	Recoverability of structure ≥30 %
Sustainable wood	0 < Utilization ratio of sustainable wood ≤20 %
	20 % ≤ Utilization ratio of sustainable wood <50 %
	50 % ≤ Utilization ratio of sustainable wood <70 %
	70 % ≤ Utilization ratio of sustainable wood <90 %
	Utilization ratio of sustainable wood ≥90 %
Environmental friendly materials	4 (or more) appointed building materials is used
	3 appointed building materials is used
	2 appointed building materials is used
	1 appointed building material is used
	No appointed building material is used
Material saving	Material saving has not been considered in the structure design
	Material saving has been considered in the structure design
	Material saving has been considered adequately in the structure design

Table 10.1 shows the assessment criterias of the "Social Economy", it mainly contains promoting social development, promoting political stability and promoting regional economic.

Table 10.2 shows the assessment criteria of the "Service Quality", it mainly contains Transport function, Road net and Maintenance.

Table 10.3 shows the assessment criteria of the "Resource Consumption", it mainly contains Land resource, Resource reuse ratio, Environment-friendly timber, environment-friendly construction materials and Consumption of materials.

Table 10.4 shows the assessment criteria of the "Environment Influence", it mainly contains Ecology, Landform and topography and Culture heritage.

10.3 Indicator Weight

Different indicators have different contribution to the assessment system; actually they are not equally important to each other. So they should have different weights in an assessment system. Weights mainly depend on two aspects: one is reliability of indicators; the other is how much attention decision makers pay. In this study, the weight system is established by the questionnaire survey and AHP method.

Table 10.4 Assessment indicators related to environmental

Secondary indicator	Marking scheme
Ecological investigation (Tan et al. 2002)	Taking actions to recover the ecological condition
	Improving the biodiversity
	Establishing the path for animals migrating and breeding
	Not taking any measures to protect the mature woods
	Taking action to protect the existing old trees
	Taking action to protect the other mature trees
	Taking action to improve the condition of existing plants
Landform	Existing plants and topography are suitable for the transport infrastructure construction
	Keeping the original landform as much as possible
	Considering the protection of topsoil
	The surface runoff does not damage land surface
	Taking actions to recover the unavoidable damage to the land surface
Cultural heritage	The protection of heritages
	Making plan for protection heritages
	The selection of road line avoiding unmovable heritages; if the requirement cannot be met, making protection plan
	The permit from the government for moving or tearing down heritages

A total of 60 questionnaires, which aimed at investigate the efficiency and significance of the indicators, had been issued and 49 effective questionnaires were got. The respondents are stakeholders or experts in this field. It is assumed that their standpoints are more effective to reflect the objective condition.

The Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular application in group decision making, and is used around the world in a wide variety of decision situations. In this study the AHP method is applied to analysis the statistic data achieved from the questionnaires to ensure the consistency of the data.

Table 10.5 listed the weight of level-1 and level-2 indicators.

10.4 Assessment Result

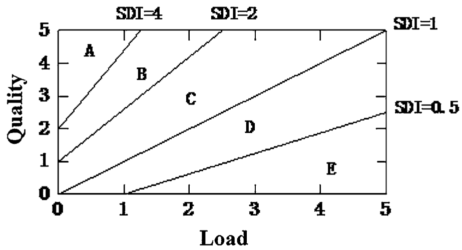
All the qualitative indicators can be assessed quantitatively and integrated based on the weight of every indicator. In order to make the assessment result accessible, the SDI (Sustainable Development Index) is introduced as the result.

$$SDI = Q/L \tag{10.1}$$

Table 10.5 Weight for assessment indicators

First Grade indicators	Weight	Secondary indictors	Weight
Q1 society and economy	0.6	Promotion of society	0.3
		Promotion of political stability	0.2
		Promotion of regional economy	0.5
Q2 service	0.4	Traffic capacity	0.45
		Integrate into network	0.32
		Operation	0.23
LR1 resource	0.4	Land resources	0.6
		Resource recovery	0.15
		Sustainable wood	0.05
		Environmental friendly materials	0.1
		Material saving	0.1
LR2 environment	0.6	Ecological investigation	0.3
		Landform	0.3
		Cultural heritage	0.4

Fig. 10.1 Criteria for classifying of SDI



where Q and L are final score of the Quality and the Load respectively.

According to the Q, L and SDI, the sustainability of transport infrastructures can be divided into 5 categories (A, B, C, D, and E) as can be seen in Fig. 10.1.

Grade A means the best performance of transport infrastructures, while Grade E means the worst one.

The bigger Q is and the smaller L is, the bigger the gradient would be, in other words, which means the better level of sustainability of road transport infrastructures.

10.5 Concluding Remarks

The sustainability of traffic and infrastruction was studied and an assessment framework was established in this paper. Four critical issues about sustainability of traffic and infrastructure construction, named nature resource, environment, society and economy, are analyzed in the assessment framework. A theory of the sustainability of transport infrastructure based on performance and load was proposed and an indicator system was established. Questionnaire was designed and handed out to stakeholders such as managers, designers et al. Analytic hierarchy process was used to determine the weight of assessing criterias valid. Notwithstanding, the weight is not verified by the social investigation, It is meaningful for the late-comer to consult. Finally, SDI is introduced to express the sustainability of the infrastructure evaluated.

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Chapter 11
Sustainable Development of China's Road Transportation Infrastructure: Situation and Prospect

Jie Zhang, Kai Liu and Yurong Zhang

Abstract Along with the rapid development of the national economy, as well as the increasing of transportation on road, China's road traffic infrastructure faces major challenges. It has been already widely accepted that it is imperative to protect the environment in the process of road transportation infrastructure construction and further realize the sustainable development of the transportation infrastructure. In this paper, the current situation of China's road transportation infrastructure is analyzed; and the philosophy and connotation of the sustainable development of road transportation infrastructure is elaborated; at last, the corresponding countermeasures concerning the legal, fiscal and demonstration policies are provided.

Keywords Road traffic infrastructure · Sustainable development · Current situation · Policy countermeasure

11.1 Introduction

Since the twentieth century, the human beings have faced serious environment challenges, including that the resources are increasingly exhausted, ecological destruction and frequent accidents of all kinds of pollution. Therefore, the environmental problems have become one of the global problems which the human beings faced today, countries all over the world have set sustainable development

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as a strategic target; claiming that in order to achieve the harmonious development between human beings and the environment, it is necessary to persist on the sustainable development.

Transportation infrastructure construction is the basic industry of national economy, and it is the support and guarantee for the development of economy and society. The level of transportation infrastructure construction development is directly related to the rate of national economic development. Non-sustainable of transport infrastructure will be a direct result of non-sustainable of urban economic development, environmental and social equity. At present, the Chinese government has been gradually increasing the intensity of investment in the road transportation infrastructure. In 1978, the China's highway mileage was only 890,000 km. However, by 2006, the China's highway mileage has reached 3.457 million km, which is over three times than that before the opening up. In 2008, the newly increased highway mileage of China reached 100,000 km, including 6,433 km expressway which reached 60,300 km, ranking the second longest expressway in the world. And the construction of road infrastructure investment increased by 2.4 % to 664.5 billion Yuan. However, there are still a lot of problems in the road transportation infrastructure of China. Although the road transportation infrastructure can promote the economic and social development, it still had a huge impact on the ecological environment. For example, in 2008, the annual carbon emission of China was about 5 billion tons. And the greenhouse gas emission accounted for about 10 % of the total national greenhouse gas emission. Besides, the construction of road transportation infrastructure will destroy the natural environment, landscape and water resources and cause the natural environment pollution around, especially in some fragile environmental areas. In addition, in recent years, the road accidents happened frequently in China, both in the construction phase and in the operation phase. Among these impacts, the road bridge accidents caused the largest damage, the most serious loss and the most severe social influence.

Therefore, we should establish the concept of circular economy, rely on technological progress and develop high efficiency and low energy consumption transport equipment and new technologies for traffic-related environmental protection. We should conserve resource, reduce energy consumption and protect the environment to build economical transport industry and get to clean transport and green transport, thus achieving sustainable development of road transportation infrastructure in our country.

11.2 The Status of China's Transportation Infrastructure

For a long time, the development of road traffic infrastructure in China shows a model that: Economic scale expansion→Traffic demand to expand→Passive increase of road infrastructure→Re-expansion of the economies→Stimulating traffic demand to expand. In China, with the sustained growth of urban industry and the size of the population, it made the road transport needs growing, which led to the road transportation infrastructure in China relatively weak. It mainly reflected in the following points.

11.2.1 Road Transport Planning is Seriously Constrained by Land

The development of road transport infrastructure has been severely hampered, due to the land constraints. According to the Beijing's land use planning, in the year of 2010, the land for traffic is 434.7 km^2, only accounts for 13 % of the total construction land. In addition, the high cost of land use increased the cost of the transport infrastructure significantly. According to the related statistics, the average price of the land in Tokyo's main block is about 24,000 Yuan/m^2, while it is 34,330 Yuan/m^2 in Guangzhou.

11.2.2 The Lack of Comprehensive Consideration of Transport Infrastructure Planning

Currently, the irrationality of the road network structure is widespread in China, such as the proportion of low-grade highway is large, the road grade is low and the road function is not well defined, all of these making the traffic efficiency greatly reduced. In addition, in China, the rural highway construction task is heavy, and the rural highway maintenance is backward. Therefore, it's urgent to consider the integrated planning of rural transport infrastructure and the construction of custody mechanism.

11.2.3 The Lack of Comprehensive Management Mechanism of Transport Infrastructure

There are still serious traces of the planned economy in our transportation infrastructure management. Owing to the lack of full consideration of the repair and maintenance in the operation period of infrastructure, a lot of infrastructure deterioration problems and greatly reduced the structure life.

In the face of the current status of our urban transport infrastructure, some scholars carried out some related researches for sustainable development in China's transportation infrastructure. In 1998, Xiong Yongjun discussed the relationship between the transport and sustainable economic development from a perspective of sustainable economic development and held that "the traffic development is closely related to the implementation of the strategy of sustainable development" (Xiong and Xiong 1999). In 1999, Zhu Zhongbin pointed out that an important criterion to measure the sustainable transport is whether the transport system could maintain long-term dynamic social net income or welfare maximum (Zhu 1999). In 2001, Chen Qian analyzed the negative impact of transportation infrastructure on the land and resources and suggested to eliminate the impact of transportation from three aspects of the economic policy, legal management and publicity and education (Chen and Wang 2001). In 2006, Zhou Jun, who analyzed the structure of the urban transport infrastructure and its collaborative relationship with the city and internal rules, proposed the integration mode of the sustainable development of urban transport infrastructure (Zhou and Liu 2005).

In addition, some academic activities related to the traffic sustainable development have been carried out, such as Asia-Pacific conference of the sustainable development on traffic and environmental technology, Sustainable Development Strategy and Construction Forum on urban rail transit of China, etc., various types of traffic engineering journals and newspapers such as Chinese Journal of Highway, Chinese Journal of Engineering and Management of Road Traffic have been published. These academic activities have greatly attracted industry experts and scholars, they communicate and discuss on the environment and sustainable development issues in the transport industry, and they promote new theories and new results published.

11.3 The Concept and Connotation of the Sustainable Development of Transportation Infrastructure

11.3.1 The Concept of Sustainable Development of Transportation Infrastructure

In 1987, a report named submitted "Our Common Future" by the World Environment and Development Commission (WCED) put forward a widely accepted definition of sustainable development, i.e. 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987).

Sustainable development of the transport is put forward under the sustainable development theory based on the fact that there are unsustainable factors in the existing transportation system, therefore, the focus of traffic sustainable development is: how to realize the harmonious development of the economy, society and ecology as well as the transportation department's own development according to the basic requirements of sustainability. As a result, we should understand the basic connotation of sustainable transport from the following three aspects.

(1) **Economic sustainable development of transport**
Transport system as a subsystem of the socio-economic system, whose sustainable development is an important part of sustainable social and economic development. The traditional mode of transport development is unsustainable, mainly displays in the discordance among the transportation system supply capacity, resource consumption, environmental and ecological protection with the requirement of economic sustainable development.
Therefore, the economic sustainable development of traffic should include two meanings. First, in the view of the relationship between transport and national economic, the transport system should meet the demand of economic and social development, i.e. the traffic system should coordinate with the national economic and social development; Second, in the view of the internal transport system, it is necessary to realize the transportation efficiency, i.e. the sustainability of the economy of the transport system. The transport system should be ensured that it can improve the people's material condition, provide an economic traffic which can meet the continuous changing needs, pursuit the traffic economic benefits, and achieve the benign circulation of the traffic assets.
(2) **Social sustainable development of transportation**
Traffic social sustainable, i.e., make full use of transportation functions to eliminate poverty, adjust and improve the social justice, and at the same time, all the society members can share the benefits of transport development equally.
To achieve sustainable social development of the transport, we must change our values. i.e. we must shift from the traditional concept of the simple pursuit of the quantity expansion to the new concept of sustainable development which lays emphasis on the comprehensive benefits and the long-term impact; we must shift from the traffic consumption concept of the individual's desire to the public interest; we must shift from the traffic management of a single decentralization to the bilateral control which equally emphasis on the source and flow.
(3) **Ecologically sustainable development of transport**
Ecologically sustainable development of the transportation, which called for promoting the construction and development of transportation systems, meanwhile emphasizing on the protection of the ecological environment and development and utilization of resources reasonably (mainly refer to the non-renewable resources); emphasizing on the expansion of the road network and channel, and at the same time paying attention to the supervision of the transport system, ensuring that the traffic, environment and ecology keep coordination and compatible relationship. Besides, it is necessary to minimize the negative impact of transport development on the environment and ecology, especially the negative impact on the human life and health.

11.3.2 Connotation of Sustainable Development of Transport Infrastructure

Transportation infrastructure system is accompanied by the development of economic systems, social systems and environmental systems, therefore, the development of transport infrastructure must also meet the need for economic and social development at present and in the future, improve resource utilization efficiency, improve the environmental quality, realize the coordination development among transport and economic, society and environment. In the meantime, it is urgent to enhance the security and stability of the transportation system. The basic pattern of the sustainable development of transport infrastructure systems is shown in Fig. 11.1.

In this integrated model, firstly, transport infrastructure system acts as the core part, and then gradually spread to form a stable system including economic, social, and environmental system elements which associated with the transport infrastructure system. Secondly, the structural elements associated with the transport infrastructure of economic, social and environmental systems act as carriers, gathered into a coherent system, and then through the continuous exchange of the elements, a coordinated whole is formed. This integrated structure mentioned above in essence is the basic mode of sustainable development of transportation infrastructure system. This development model will directly promote the economic progress healthily and steadily, and then forma sustainable development situation, finally promote the coordinated development of economy, society and environment.

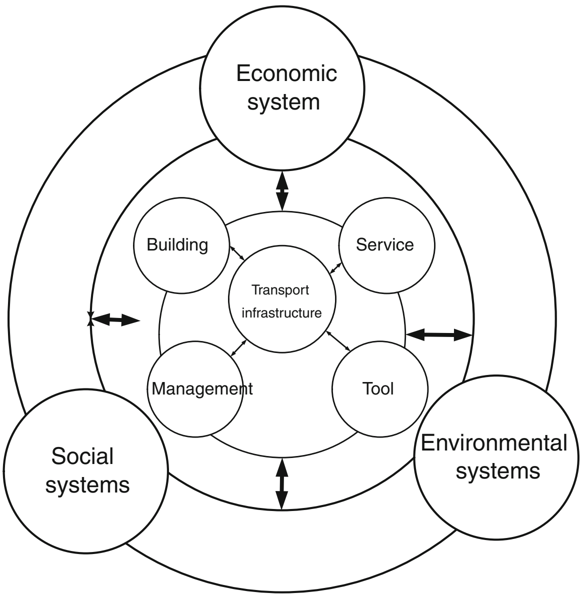

Fig. 11.1 The integrated model of transportation infrastructure sustainable development

11.4 Some Measures of the Transport Infrastructure Sustainable Development

The focus of transport development in future is to expand the capacity, optimize the structure, improve the quality, improve the service, guarantee the safety and protect the environment, which is a very difficult task. To achieve the sustainable development of transport infrastructure, on the one hand, the development of transport infrastructure must meet China's economic and social development needs, and lay the material foundation for sustained, healthy and rapid economic society development; on the other hand, the development of transport infrastructure must adapt to environmental capacity and resources reserves. Therefore, this article puts forward several countermeasures of the sustainable development of transport infrastructure in China.

(1) **Update the laws and regulations of transportation infrastructure, then further strengthen the management of environment protection**
In order to promote the sustainable development of the transport infrastructure, the Ministry of Transportation (MOT) has issued a series of laws and regulations, for example "Traffic construction project environmental protection management regulations" (Ministry of communications of the people's Republic of China 2003)," Specifications for Environmental Impact Assessment of Highways"(JTGB03 2006), and " Design Specifications of Highway Environmental Protection" (JTGB04 2010), etc. However, the related standards with the sustainable traffic infrastructure are very limited, there is no description of the design, construction and acceptance specifications about road greening, landscape protection, noise control. Therefore, we should further improve the transportation infrastructure sustainable construction laws and regulations to provide the basis for promoting the sustainable development of the transport infrastructure.

(2) **Improve operational marketization of the transport infrastructure**
Improving the traffic infrastructure marketization helps to create and enhance the value of the transportation infrastructure, and guarantee the normal repair maintenance costs of the transportation infrastructure, so as to achieve the purpose of capital circulation, which is conducive to perfect the regulation of further attract more capital into.

(3) **Increase the propaganda of sustainable development of the transport infrastructure**
Propaganda work is an important means of improving public realization to sustainable development of transport infrastructure, through the use of the media publicity, technical training, the seminar will be held, can effectively improve the social awareness and supervision.

11.5 Conclusion

In view of the present situation and existing problems of China's highway transportation infrastructure development, we should be aware that if we want to achieve highway traffic infrastructures' sustainable development, we must change the traditional traffic models, carry out an integrated transportation infrastructure planning to ease the pressure of resource and environment. The saving transportation industry must be established to improve the quality of transport services, and make the integration of transport to come true, improve the people's living standards and the competitiveness of the national economy. Related industry management must be strengthened to ensure that the transportation infrastructure quality in the design and construction.

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Chapter 12
Energy Demand and Emission from Transport Sector in China

Yin Huang and Mengjun Wang

Abstract This paper aims to present a comprehensive overview of the current status and future trends of energy demand and emissions from transportation sector in China. Firstly, a brief review of the national profile of energy demand and the CO_2 emission is presented to serve as background for this study. Secondly, the current status of Chinese transportation sector, including the energy demand and emission for transportation sector and sub-sector, is analyzed. At last, a conclusion summarizes and analyses the findings from the study, with the aim to raise further discussion or research interests in this area. This study serves as a guideline for further investigation and research to implement and improve the transportation sector.

Keywords Transportation · Energy demand · CO_2 emission · Energy policy · China

12.1 Introduction

Rapid growth in more than two decades has made China the second largest energy-consuming nation after the US. Rapidly growing energy demand and emission from China's transportation sector in the last two decades have raised concerns over energy security, urban air pollution and global warning (Yan and Crookes 2007, 2010). This paper aims to present a comprehensive overview of the current

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status of energy demand and emission from transportation sector in China. It is organized as follows: A brief review of the national profile of energy demand and the CO_2 emission is presented to serve as background for this study; the current status of Chinese transportation sector, including the energy demand and emission for transportation sector and sub-sector, is analyzed; the policies to control transport energy and CO_2 emission are then summarized; after that a discussion section summarizes and analyses the findings from the study, finally conclusions are drawn.

12.2 Current Status of Chinese Transport Sector and Sub-Sector

With the fast-growing economy, transportation has become a crucial component of modern life in China. Urbanization, transport congestion and unbalanced distribution of energy resources and demand have led to the ever-greater passenger and freight mobility, and the transport sector is gaining a rising share in the total (Yan 2008). The energy intensity for transportation sector is equal to the transition intensity multiplied by energy efficiency for transportation sector. The transition intensity, energy efficiency and energy intensity for transportation sector are calculated as follows (See Table 12.1).

The energy consumption in sub-sector for transportation is increasing rapidly. From the trend of energy consumption in sub-sector for transportation from 1990 to 2008, the energy consumption of highways increased with the annual growth of 9.8 %, which is higher than the annual growth rate of the energy consumption for transportation sector—8.3 %. The energy consumption in railways is declined from 1990 to 2008 with the annual growth rate of −0.1 %. The reduction of the energy consumption of the railways is mainly attributed to the phase-out of the steam locomotives. With the development of economics and technology in China, airplane becomes the main transport tool for long journey. The energy consumption of airplane increased rapidly with the annual growth rate of 14.7 % in the period of 1990–2008.

The CO_2 emission has increased steadily over the past 20 years and is still moving upwards. It is estimated there were about 4.93 hundred million tons of CO_2 emission in 2009 which is more than four times from that in 1990 with annual growth rate of 7.8 % (Oh and Chua 2010). It is inevitable that pollutant emission will continue to climb as long as fossil fuels remain as the main contributor in transport sector. Figure 12.1 shows the intensity of carbon and energy in China from 1990 to 2009.

The CO_2 emission of each sub-sector in 2009 is presented in Fig. 12.2. The CO_2 emission of transportation mainly focuses on highways. The CO_2 emission of

Table 12.1 The transition intensity, energy efficiency and energy intensity for transportation sector in China

Year	Transition intensity (km/person)	Energy efficiency (Standard oil (kg)/10,000 ton-km)	Energy intensity (standard oil(ton)/person)
1990	2087.3	134.2	0.028
1991	2187.6	132.2	0.029
1992	2329.1	130.5	0.030
1993	2492.4	133.2	0.033
1994	2664.7	124.0	0.033
1995	2736.7	124.5	0.034
1996	2833.6	203.1	0.058
1997	2728.7	210.3	0.057
1998	2722.0	209.9	0.057
1999	2782.2	215.5	0.060
2000	3129.0	199.2	0.062
2001	3144.4	203.3	0.064
2002	3364.5	200.1	0.067
2003	3521.0	217.8	0.077
2004	4127.8	217.8	0.090
2005	4538.8	217.6	0.099
2006	4993.0	216.9	0.108
2007	5639.8	206.8	0.117
2008	7597.9	159.4	0.121
2009	8069.7	154.4	0.125

The table shows that the transition intensity increased with the annual growth rate of 6.46 % from 1990 to 2009 and the energy intensity increased with the annual growth rate of 6.63 %

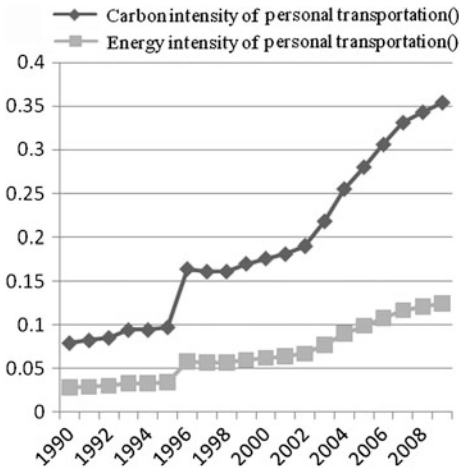

Fig. 12.1 The intensity of carbon and energy in China from 1990 to 2009. (Calculated by author)

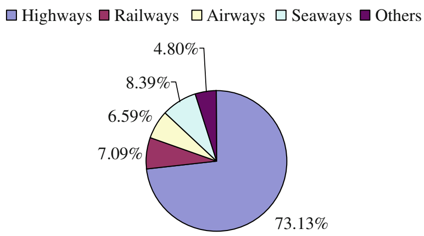

Fig. 12.2 The CO_2 emission of each sub-sector in 2009. *Source* Annual Review of Low-carbon Development in China: 2010

transportation is 456940 thousand ton. Highways transport is the biggest CO_2 emission contributor with a share of 73.13 %, seaways, railways, airways and others, ranked second, third, fourth and fifth, making up 8.39,7.09, 6.59 and 4.80 % of the total respectively. Hence, if the Chinese government wants to control the energy consumption and emission, the first step is to control the energy use of highways.

12.3 Policy Recommendation

The rapid-growing use of transportation energy in China during the 1990–2009 periods raised the question of China's oil security in the early 90s and led to a high priority of oil conservation in China's energy policy. Trucks and private cars accounted for the majority of transport oil consumption in China at that time. Energy conversation strategies for trucks and private cars were thus explored. These included technical improvement of engines, improvement of size composition of vehicles, promotion of diesel vehicles, improvement of highways conditions and transportation management (He et al. 1995).

12.3.1 Fuel Economy Regulation and Emission Standard

Fuel economy improvement is thus considered as an important option to reduce vehicular energy use and emission in 2005. The Chinese government therefore implemented its first vehicle fuel economy standard, targeting light-duty passenger vehicles. Moreover, vehicle emission standards are necessary to promote advanced technologies of emission control technologies for new vehicles (Gallagher 2006). In the 1990s, China implemented 17 standards for vehicular emission based on international control standards in the mid-1970s (He et al. 2002).

12.3.2 Public and Non-motorized Transport

Chinese government adopts a lot of policies to control the number of private cars and promote the public transport for wider usage to meet the goal of reducing energy consumption.

The government has realized the importance of public transport and started to take actions in recent years. At present, urban metro systems exist in 12 Chinese cities and there are plans calling for expanding and upgrading existing systems and building new ones in 15 other cities (Gan 2003; Cervero and Day 2008).

12.4 Conclusion

The problem of the transportation energy and environment are the major challenges faced globally in the twenty first century and are especially serious pollution for China. In this study, energy demand and emission from transport sector in China have been analyzed by considering the energy consumption and emission form sector and sub-sector for transportation. As a result of this study, the following conclusions are reached:

(1) In China, the energy consumption of highways is of the highest increasing mode with the annual growth of 9.8 %.
(2) In China, highways transport was the biggest CO_2 emission contributor, accounting for 73.13 % of total transport CO_2 emission.
(3) Highways transport has dominated Chinese oil consumption and is one of the fastest growing energy users in China. Consequently, CO_2 emission from this sector has also risen in an alarming rate.
(4) There are some economic policies in China implemented for transportation sector to reduce energy consumption.

From the conclusions above, there is an urgent need to adopt suitable energy policy to balance the energy consumption and transport service and reduce the CO_2 emission in transportation sector.

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Chapter 13
Exploring the Effect of Inter-Stop Transport Distances on Traction Energy Cost Intensities of Freight Trains

Xuesong Feng, Haidong Liu and Keqi Wu

Abstract With a computer-aided simulation approach, this research analyzes the change of the traction energy cost intensity of a typically formed Chinese freight train hauled by representative locomotives for different target speeds. It is found that the inter-stop transport distance of a freight train should be longer than 20.00 km to decrease the traction energy cost per unit transport. Moreover, the railway freight transport work should organize heavy load trains hauled by respectively various locomotives with different traction performances which are suitable for different target speeds in view of different inter-stop transport distances.

Keywords Freight train · Target speed · Stop-spacing · Computer-aided simulation · Traction energy cost intensity

13.1 Introduction

Railway is one of the major freight transport modes in China. About 19.50 % of the total 14,183.70 billion freight ton-kilometers (t-km) in 2010 (National Bureau of Statistics of China 2011) are completed by railway freight trains in China and

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these freight trains consume much energy (Li and Mao 2001; Xi and Chen 2006; He et al. 2010). It is well known that the traction energy cost intensity of a train is much concerned with its target speed (Uher et al. 1984; Hoyt and Levary 1990; Liu and Golovitcher 2003; Huang and Qian 2010). Many researchers have been continuously making effort to interpret the relationship between them (Chui et al. 1993; Lukaszewicz 2001; Miller et al. 2006; Bocharnikov et al. 2007; López et al. 2009). However, valuable existing research findings which are in practice incompletely examined by previous studies still cannot clarify the detailed influence of the target speed of especially a (conventional locomotive hauled) freight train upon its traction energy cost intensity in view of the important impacts of multi-factors such as the traction performance of the locomotive, the transport distance between neighboring stops, etc. from a comprehensive perspective. Based on the computer-aided simulations of the freight transports by a typically formed Chinese freight train hauled by respectively various types of the representative locomotives in China on a hypothetically straight and smooth railway line, this study attempts to explore the accurate effect of the length of stop-spacing (i.e. the inter-stop transport distance) on the intensity of the Traction Energy Cost (TEC) (i.e. energy consumed by traction and braking) of the train for different target speeds in a quantificational manner.

The contents of this paper are organized as follows. The formation of the studied freight train in this research and the computer-aided simulation approach utilized in this work to compute the TEC of the train are explained in Sect. 13.2. Next, Sect. 13.3 studies the detailed changes of the TECs per 10,000 t-km of the train with the increase of its target speed for different inter-stop transport distances by utilizing the simulation approach introduced in Sect. 13.2. Finally, Sect. 13.4 draws conclusions, makes some suggestions for the transport work of the freight trains in China and proposes some future research issues.

13.2 Train Formation and Simulation Approach

With referring to the work of Feng (Feng 2011), the general framework of the computer-aided simulation approach shown in Fig. 13.1 is applied in this research to calculate the TEC of the transport of a train.

A typical Chinese freight train today is usually formed by 60 coupled wagons hauled by 1 locomotive. One of the major types of the wagons is the C70. 60 coupled and fully loaded C70 wagons hauled by one locomotive compose the freight train studied in this research. The transport processes of the studied freight train hauled by respectively two major types of the locomotives for the railway freight transport work in China, i.e. the (electric) SS1 and the (electric) SS4, are simulated in this research. The whole trip of the train from one stop to the next is simulated for one calculation interval after another. The traction force and operating condition (i.e. motoring, coasting or braking) of the train are considered to be unchanged in one calculation interval in this research. Various types of

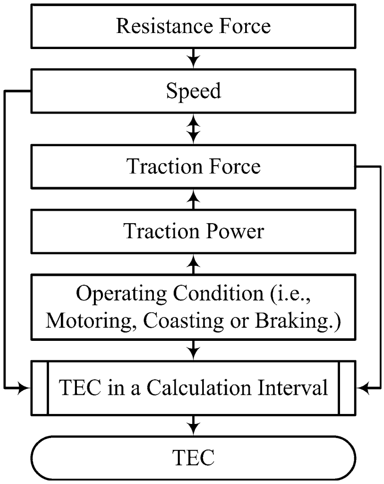


Fig. 13.1 Framework of the simulation approach to calculate the TEC

locomotives have different traction performances to overcome the resistance force in their traction processes on the same rail line for the same transport work and the same target speed at the cost of different traction energy consumption. The TECs of all the calculation intervals of the simulation work from the startup of the train at a station to its stop at another station are summed into the TEC of the trip between these two stops.

13.3 Analysis of Traction Energy Cost Intensity

The TEC per 10,000 t-km is defined by Eq. (13.1) to evaluate its traction energy cost intensity.

$$e_{ij}^{v} = E_{ij}^{v}/PKM_{ij}^{v} \tag{13.1}$$

where,

e_{ij}^{v} TEC per 10,000 t-km of the train with the target speed of v from station i to station j, Unit: kWh/10,000 t-km,

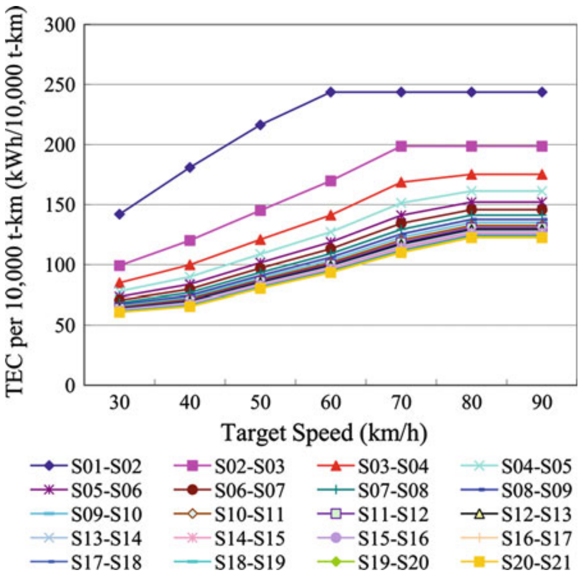
E_{ij}^{v} TEC of the train with the target speed of v from station i to station j, Unit: kWh, and

PKM_{ij}^{v} Passenger-kilometers completed by the train with the target speed of v from station i to station j, Unit: %

The transport distance (Unit: 10,000 km) from the nth stop ($S(n)$) to the ($n+1$)th stop ($S(n+1)$) ($n = 1, 2, \ldots\ldots, 20$) of the hypothetically straight and smooth railway line in this research is interpreted by Eq. (13.2).

$$D_{S(n),S(n+1)} = 5.00 \times 10^{-4} \times n \tag{13.2}$$

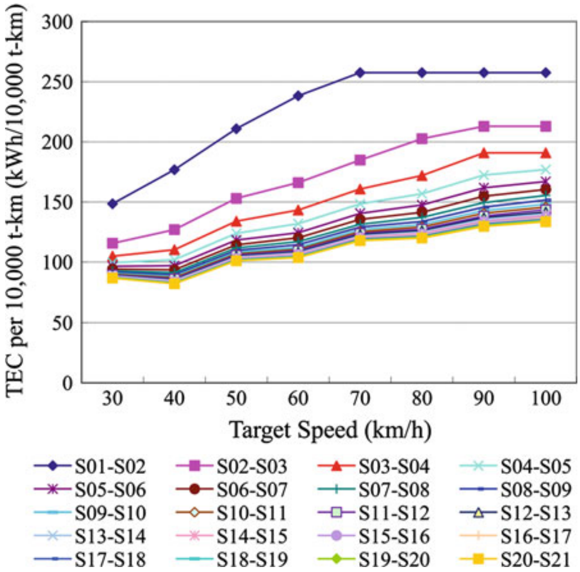
Fig. 13.2 TECs of the freight train hauled by the SS1



The train studied in this work is fully loaded. The changes of the TECs per 10,000 t-km of the freight train hauled by respectively the SS1 and the SS4 with the increases of the target speeds between different neighboring stops are revealed in Figs. 13.2 and 13.3 correspondingly. It is found in these two figures that the TEC per 10,000 t-km is obviously increased with the decrease of the length of stop-spacing from about 20.00 km for the same target speed. Moreover, the increase of the TEC per 10,000 t-km with the improvement of the target speed is accelerated by the decrease of the transport distance between neighboring stops until the inter-stop transport distance or the traction performance of the locomotive starts to prevent the train from achieving a relatively high target speed especially for a comparatively short stop-spacing. It is evidently shown that making stop-spacing shorter than 20.00 km ceases more early the achievement of the target speed and meanwhile the increase of the TEC per 10,000 t-km with the improvement of the target speed. In contrast, the inter-stop transport distances longer than 20.00 km have little effect on the TEC per 10,000 t-km.

It is revealed in Fig. 13.2 that if the target speed of the train hauled by the SS1 is e.g. 70.00 km/h, the decrease of the length of stop-spacing from 20.00 to 10.00 km additionally consumes approximately 50.00 kWh per 10,000 t-km. Because of the restriction of the traction performance of the SS1, the target speed of the train hauled by the SS1 cannot exceed 80.00 km/h. As a result, the TECs per 10,000 t-km become stable for all the transport distances between neighboring stops after the target speed reaches 80.00 km/h. In comparison, the relatively superior traction performance of the SS4 has no impact on the increase of the TECs per 10,000 t-km of the train with the improvement of the target speed for different inter-stop transport distances, as shown in Fig. 13.3. The decrease of the

Fig. 13.3 TECs of the freight train hauled by the SS4



inter-stop transport distance from 20.00 to 10.00 km additionally consumes around 40.00 kWh per 10,000 t-km when the target speed of the train hauled by the SS4 is 70.00 km/h.

13.4 Conclusions

It is empirically confirmed that the TEC per unit transport of a freight train with an unchanged utilization ratio of its loading capacity increases apparently in an enlarging scale with the decrease of the length of stop-spacing from 20.00 km for the same target speed. On the contrary, the increase of the TEC per unit transport with the improvement of the target speed of the train is slightly decelerated by the increase of the transport distance between neighboring stops. Therefore, the inter-stop transport distance of a freight train had better be no shorter than 20.00 km. In addition, the railway freight transport work should organize heavy load trains hauled by respectively various locomotives with different traction performances suitable for different target speeds in view of different inter-stop transport distances.

Only the transports of a typically formed freight train hauled by respectively two major types of the locomotives in China on a hypothetically straight and smooth rail line are analyzed in this research to explore the effect of the length of the stop-spacing on the TEC per 10,000 t-km for different target speeds of the train. The impact of the track alignments on the traction energy cost intensities of freight trains formed by different types of railway freight cars should be studied together with the effect of inter-stop transport distances, traction performances of locomotives, etc. for different target speeds from a more comprehensive viewpoint to further validate the conclusions of this study in the future.

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Chapter 14
A Freeway/Expressway Shockwave Elimination Method Based on IoT

Ling Huang and Jianping Wu

Abstract Shockwave is one of the most complex recurrent traffic flow phenomena on freeway/expressway, whose characteristics are not fully understood. With the field data, we compared the driving behaviors (headways and reaction times) before and during the propagation of shockwaves. The drivers seemed to change their driving strategies when they "recognized" a shockwave, thus a *Fuzzy Logic based Shockwave Recognition Algorithm* was proposed, and last we proposed a shockwave elimination method applying the ideas of the Shockwave Recognition Algorithm and Internet of Things.

Keywords Shockwave · Fuzzy logic · Internet of things

14.1 Introduction

Shockwave is commonly recognized as a sudden compression of traffic flow, which acts as an active or moving bottleneck (Homburger and Kell 1984). Shockwave has a great influence on highway capacity, reducing speeds of traffic flow upstream and downstream. Shockwave also contributes 15 % road traffic accidents (rear-end collisions) in China (Xuan 2000), and cause more fuel consumption, increasing environment damage.

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So far, the studies on shockwave are mainly focused on the following aspects: (1) highway shockwave characteristics based on Improved L-W fluid theory (Kuhne et al. 2000); (2) the highway bottleneck queue length or delay time based on shockwave theory (Smith et al. 2003; Munoz and Daganzo 2002); (3) traffic flow stability with small disturbance by macroscopic continuum model and micro car-following models (Zhang 1999, Jingang et al. 2003); (4) Highway shockwave phenomena and traffic accidents (Golob et al. 2004); (5) shockwave prevention and control measures (Breton et al. 2002, Hegyi et al. 2005). Besides, the recent developments of Internet of Things (IoT) provide new ideas for shockwave solutions. Researchers have evaluated the performance of inter-vehicle communication in a unidirectional dynamic traffic flow with shockwave (Bao et al. 2009), and studied the impact of traffic-light-to-vehicle communication on fuel consumption and emissions (Tielert et al. 2010). Yet, the data used in the above studies mostly were from dual loop detectors, or generated by microscopic traffic flow simulation models. As a major road traffic characteristic, shockwave received relatively less studies by traffic engineers and researchers, because of the lack of effective data.

This paper reports a recent research project and preliminary results on shockwaves by microscopic dynamic vehicle data obtained from video tapes. First introduced the microcosmic dynamic analysis on shockwave; then presented a fuzzy logic based shockwave anticipation algorithm, and based on this algorithm proposed shockwave elimination/reduction method applying Internet of Things technology. Last were the conclusions.

14.2 Microscopic Analysis on Shockwaves

A video image process system—Vspeed—has been developed for video data detection and collection (Bai et al. 2006). In this way, we got about 80 cases of shockwaves and collected moving data of over 1000 vehicles. Then, we made comparative analysis on the driving behavior (time headways and the reaction time) before and during shockwave situations.

14.2.1 Comparative Analysis on Time Headways

Time headway refers to the time that elapses between the arrival of the leading vehicle and the following vehicle at the test point. In normal situations without a shockwave, the average and standard deviation of time headways were both significantly smaller than those during the shockwave propagations (Table 14.1).

Table 14.1 Time headways statistics

Time Headway	Mean (s)	Standard dev. (s)	Max (s)	85 % value (s)	15 % value (s)	Min (s)	Sample size
Normal situations	2.07	0.87	5.89	2.88	1.28	0.62	1479
Shockwave situation	3.40	6.76	22.40	4.48	1.98	0.76	1380

14.2.2 Comparative Analysis on Drivers' Reaction Time

In this case we assumed that during shockwave propagation the rear light of the leading vehicle is the stimuli of the following vehicle, then the reaction time of the driver *i* would be:

$$T_i = (t_s)_i - (t_s)_{i-1} \tag{1}$$

where: $\boldsymbol{T_i}$ is the reaction time of driver i $(t_s)_i$ and $(t_s)_{i-1}$ are the times when the rear lights of vehicle ***i*** and ***i + 1*** become on respectively.

The mean value divers' reaction time in shockwave situations seemed larger than that of the normal situations in other research findings, showing that in shockwave situations the drivers' behaviors changed. The further analysis of the data revealed that in the early stage of shockwave propagation, the average drivers' reaction times were as long as 2.26 s. As shockwaves propagated through about 10–15 vehicles, the average drivers' reaction times dropped dramatically to 1.16 s. It seems that during the propagation, downstream drivers recognize that the upstream vehicles are in shockwave situations and *adjust their driving behaviors according*. Yet our results seem still larger than those Perception-Reaction Time (PRT) in early studies (Koppa 2000) (Table 14.2). The possible explanation is that our measurement of reaction time contains the *movement time* (0.26 s averagely), and in shockwave situations with lower speed and larger headways, drivers are not so "urgent" as those in experiment situations of former studies.

Microscopic data analysis showed that some of the driving characteristics such as the reaction time, time headways were changing during shockwave propagations. As Ranney points out, humans are very adaptable and will develop new strategies for new situations (Ranney 1999). We are reasonable to consider that perhaps

Table 14.2 Comparisons of the reaction time statistics

Reaction Time	Mean (s)	Standard dev. (s)	85 % value (s)	15 % value (s)	Sample size (s)
Reaction time (early stage of shockwave propagation)	2.26	1.88	4.34	6.00	254
PRT in early studies (surprise)*	1.31	0.61	1.87	2.45	NA
Reaction time (later stage of shockwave propagation)	1.16	1.09	1.27	1.35	262
PRT in early studies (expected)*	0.54	0.1	0.64	0.72	NA

drivers are adjusting their driving strategies during shockwave propagation to eliminate/reduce the negative effects. That means the drivers could recognize the propagation of a shockwave by their observations on the front one or two vehicles, which gives inspirations to the elimination of shockwave.

14.3 Fuzzy Logic based Shockwave Recognition Algorithm

For better understanding of the drivers' behaviors when they meet a shockwave, we interviewed more than 100 drivers of different age groups, driving experience and genders in Beijing, March 2006. Most of the interviewees thought that they could recognize a shockwave simply by motions (speed, headway) of the leading car. Early recognition of shockwave propagation is the key to shockwave elimination/reduction (Yuan 2006). Researchers have successfully used dual loops detecting the traffic-flow occupancy (density) to recognize shockwaves. With the development of IoT and intelligent vehicle, more and more cars will equipped with smart devices which could sense situations around, assistant driving and communicate with other intelligent infrastructures and other intelligent vehicles. Thus it is quite reasonable to develop a shockwave recognition algorithm applying fuzzy logic learned from drivers' experience as main method; the flowchart is shown in Fig. 14.1.

The Shockwave recognition fuzzy Inference system has three inputs: v_A—speed of the following car, v_R —relative speed between the leading and the following car and $T_c^{-1} = v_R/R$—the anticipation variable, where R is the space headway; and one output: a—the level of driver's anticipation of the shockwave propagation, $0 \leq a \leq 1$.

The membership functions of the input and output variables are common triangular function distributions, and the fuzzy sets of all variables see Table 14.3.

Fuzzy rules can be summed up from the drivers' practical experience, for example:

IF v_A is Very Fast (V5), v_R is Opening (RV2), T_c^{-1} is Much Too Far, THEN the anticipation of a shockwave (a) is Very Strong (a1).

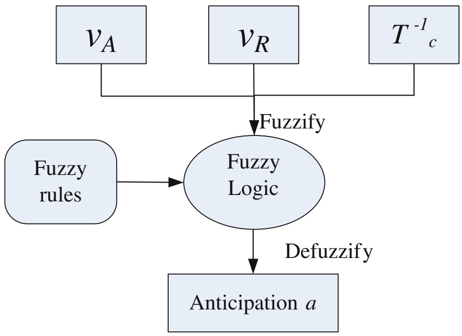


Fig. 14.1 Fuzzy logic flowchart for shockwave recognition

Table 14.3 Fuzzy set terms used in the model

v_A	v_R	$T_c^{-1} = v_R/R$	a
Very slow (V1)	Opening fast (RV1)	Much too far (T1)	Very strong (a1)
Slow (V2)	Opening (RV2)	Too far (T2)	Strong (a2)
Normal (V3)	About zero (RV3)	Satisfied (T3)	Normal (a3)
Fast (V4)	Closing (RV4)	Too close (T4)	Light (a4)
Very fast (V5)	Closing fast (RV5)	Much too close (T5)	Very light (a5)

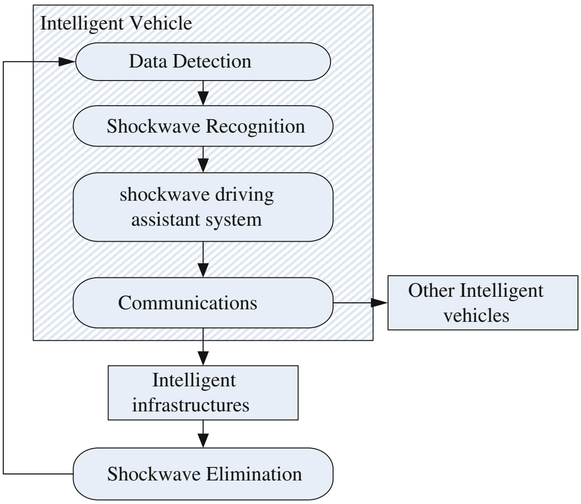
Theoretically there are 125 fuzzy rules, as some of fuzzy rules are not suitable for actual situations; we finally established 85 fuzzy rules, which could be referred to (Yuan 2006).

14.4 Shockwave Elimination/Reduction Method

The Internet of Things (IoT) is a novel paradigm that is rapidly gaining ground in the scenario of modern wireless telecommunications. From the shockwave recognition algorithm of intelligent vehicle device, a shockwave elimination/reduction method based on the IoT technology is proposed in Fig. 14.2.

First, the Intelligent Vehicle (IV) detects dynamic data, using the proposed fuzzy logic based shockwave recognition algorithm, when the level of anticipation (a) reaches to a certain degree, IV will give an alert of shockwave situation, and start the corresponding shockwave driver assistance program (if there any). At the same time to start the communication program, contacting the near downstream IVs and/or Intelligent Infrastructures, sending the information on shockwave recognition, time, location and so on. Hence other IVs would change their driving

Fig. 14.2 Shockwave elimination method based on the IoT



strategy accordingly, and the Intelligent Infrastructures would start the elimination program, for example coordination of variable speed limits (Breton et al. 2002; Hegyi et al. 2005), ramp metering, information releasing by VMS, etc. to reduce the downstream traffic flow density, till the shockwave is eliminated.

14.5 Conclusions

For better understanding the phenomenon of shockwave, we develop specialized VIPS software to obtain the microscopic shockwave data, by comparative analysis on vehicles headways and the drivers reaction time before and during shockwave situations, we found that in the shockwave propagation process the drivers are often able to identify the shockwave and adjust their driving strategy accordingly. Then a fuzzy logic based on shockwave recognition algorithm is developed by interviewing over 100 different drivers, and a shockwave elimination method based on IoT technology is proposed, provide a thought to the future applications of IoT in Intelligent Transportation System.

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Chapter 15
Allocating the Subsidy Among Urban Public Transport Enterprises for Good Performance and Low Carbon Transportation: An Application of DEA

Qianzhi Dai, Yongjun Li, Qiwei Xie and Liang Liang

Abstract This paper proposes a stimulating mechanism for allocating subsidies to urban public transport enterprises. The allocation method is based on data envelopment analysis and the satisfaction degrees of urban public transport enterprises. It first finds the set of subsidy allocation that can keep the Pareto efficient for both the whole urban public transit industry and each urban public transport enterprise to reflect the efficiency principle, and then yields a unique subsidy allocation scheme from the set of subsidy allocations with considering the equity of satisfaction degrees. The allocation mechanism can reflect the market competition regulation on some level and benefit to achieve the goal of Green Transport in urban public transit industry. An example of allocating the subsidy among urban public transport enterprises is illustrated.

Keywords Data envelopment analysis (DEA) · Subsidy allocation · Efficiency · Satisfaction degree · Equity · Low carbon transportation

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15.1 Introduction

The common-weal is one of features in urban public transit industry, which causes the generally losses of urban public transport enterprises. Therefore, most governments provide the financial support, namely subsidy, to these enterprises. However, it is difficult to supervise the totals of actual operating losses and besides, it is also hard to distinguish the actual operating losses caused by the common-weal, thus some problems might be generated, such as higher operating losses, more fuel consumption and lower satisfaction degrees of passengers, etc. In other words, the subsidy may be lead to the many problems, such as resource wastes, high pollution emissions and low operating efficiencies, if it can't be reasonable allocated. Therefore, it is significant to design a scientifically subsidy stimulating mechanism to cultivate the competitiveness of public transport enterprises, which is advantageous to achieve low carbon transportation and Green Transport.

Data envelopment analysis (DEA) (Charnes et al. 1978) is a well-established non-parametric methodology for measuring the performance of peer decision making units (DMUs) with multiple inputs and outputs. There are some studies to measure the performance of transportation system in recent years, such as (Karlaftis 2004; Zhao et al. 2011; Lao and Liu 2009), etc. Furthermore, the equivalence relationship between the DEA efficient and Pareto efficient has been demonstrated (Yan and Wei 2011). However, to our knowledge, there is no previous study to allocate the subsidies among urban public transport enterprises based on DEA methodology. According to DEA methodology, the efficiency is the ratio of outputs and inputs. If the subsidy is regarded as an independent input to impact on the performance of urban public transport enterprises, then the problem of allocating the subsidy can be transferred as the problem of allocating the fixed input (resources or costs), and the latter problem is an important application of DEA. Many previous DEA literatures have studied the problem, such as (Cook and Kress 1999; Cook and Zhu 2005; Beasley 2003; Lins and Gomes 2003; Gomes and Lins 2008; Lozano and Villa 2005; Lozano et al. 2004; Lozano and Villa 2004; Asmild et al. 2009; Avellar et al. 2007; Milioni et al. 2011; Li et al. 2009; Li et al. 2012), etc.

We consider that the subsidy allocation criterion should balance the efficiency and fairness among urban public transport enterprises (i.e., DMUs). Kolm (1971) first demonstrated that there is a fundamental conflict between the two axiomatically criterions. Based on Li et al. (2012), the developed approach in this paper first finds the set of subsidy allocations that can ensure the Pareto efficient for both each DMU and the whole industry to reflect the efficiency principle. Then an efficient allocation interval can be obtained. The interval is directly related to the performance of DMUs. Furthermore, the satisfaction degree is defined based on the efficient allocation interval to evaluate the psychology perception of DMUs. At the end, the allocation approach is proposed with considering the fairness of satisfaction degrees, and a unique subsidy allocation scheme can be generated from the set of efficient subsidy allocations. The subsidy allocation mechanism can reflect the market competition regulation on some level and benefit to achieve the goal of Green Transport in urban public transit industry.

The rest of this study is organized as follows. In Sect. 15.2, we propose the allocation methodology based on DEA and the satisfaction degrees. An example of allocating the subsidy among urban public transport enterprises is presented in Sect. 15.3. Conclusions are given in Sect. 15.4.

15.2 Methodology

Suppose there are n independent rational DMUs, and each DMU_j $(j = 1, 2, \ldots, n)$ consumes m inputs x_{ij} $(i = 1, 2, \ldots, m)$, to generate s outputs y_{rj} $(r = 1, 2, \ldots, s)$. The total of allocated subsidy and the subsidy allocated to DMU_j are denoted as R and R_j $(j = 1, 2, \ldots, n)$ respectively, then the efficiency E_d^{before} for any given DMU_d $d \in \{1, 2, \ldots, n\}$ under evaluation before allocating the subsidy can be calculated by the following model (15.1). It is an input-oriented CCR DEA model, where u_r, v_i are unknown multipliers attached to rth output and ith input respectively. It allows each DMU under evaluation to select a set of input and output weights under the relatively constraints to maximize its efficiency. If $E_d^{before} = 1$, then DMU_d is called efficient.

$$\begin{aligned} & Max \sum_{r=1}^{s} u_r y_{rd} / \sum_{i=1}^{m} v_i x_{id} = E_d^{before} \\ & s.t. \ \sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, \ \forall j \\ & \quad u_r, v_i \ge 0, \forall r, i \end{aligned} \tag{15.1}$$

$$\begin{aligned} & Max \sum_{r=1}^{s} u_r y_{rd} / \left(\sum_{i=1}^{m} v_i x_{id} + R_d \right) = E_d^{after} \\ & s.t. \ \sum_{r=1}^{s} u_r y_{rj} / \left(\sum_{i=1}^{m} v_i x_{ij} + R_j \right) \le 1, \ \forall j \\ & \sum_{j=1}^{n} R_j = R \\ & u_r, v_i, R_j \ge 0, \forall r, i, j \end{aligned} \tag{15.2}$$

Considering the allocated subsidy R, we can easily transfer model (15.1) to model (15.2). E_d^{after} is the optimal efficiency value of DMU_d. Based on the constrains of model (15.2), we can easily obtain the subsidy allocation set ensuring both each DMU and the whole organization CCR efficient under a common set of weights as giving in the following Eq. (15.3) (Li et al. 2012):

$$R_j = \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij}, \forall j$$
$$\sum_{j=1}^{n} R_j = R \qquad (15.3)$$
$$u_r, v_i, R_j \geq 0, \forall r, i, j$$

$$\rho_d = \frac{R_d - \underline{R_d}}{\overline{R_d} - \underline{R_d}}, \forall d \qquad (15.4)$$

We can obtain the interval of efficient allocation by setting "$Max\ R_d$" and "$Min\ R_d$", respectively, as the objective function and Eq. (15.3) as the constraints. Denote the interval as $[\underline{R_d}, \overline{R_d}]$, then we want to obtain a unique subsidy allocation from the interval, i.e., $R_d \in [\underline{R_d}, \overline{R_d}]$. Rational DMU_d is selfish to receive the maximum $\overline{R_d}$, but unwilling to accept the minimal one $\underline{R_d}$, thus we can define the satisfaction degree of DMU_d to the subsidy allocation as given in Eq. (15.4), where $\rho_d \in [0, 1]$. DMU_d satisfies with the allocation completely when $\rho_d = 1$, which means that it affords the maximum $\overline{R_d}$. On the contrary, it affords the minimal one when $\rho_d = 0$. Thus the psychology perception of DMUs can be quantificational evaluated.

The equity of satisfaction degrees among DMUs is advantageous to implement the allocation. Several interpretations about the fairness are existed in different research areas, but none of them is dominated accepted. The max–min fairness can reflect the Rawlsian justice and be widely accepted in practice (Bertsimas et al. 2011) (Rawls 1971), thus we use it in this paper. Accordingly, by setting "$\underset{u,v}{Max} \min\limits_{1 \leq d \leq n} \rho_d = (R_d - \underline{R_d})/(\overline{R_d} - \underline{R_d})$" as the objective function and the Eq. (15.3) as the constraints, we can get the allocation model. The allocation criteria are maximizing the environment efficiency and the fairness of satisfaction degrees, which is the efficiency-equity tradeoff. Apparently, the final allocation model is a multi-objective programming. To solve it, we can let $\min\limits_{1 \leq d \leq n} \rho_d = \beta$, and the detailed algorithm can refer to (Li et al. 2012).

15.3 Allocating the Subsidy to Urban Public Transport Enterprises

The original data of seven urban public transport enterprises (DMU A-G) in 2009 is from a Provincial Communications Department. Considering the goal of this paper and the suggestions from several experts in urban public transport area, we select the input and output variables as follows:

Input 1: the number of standardized operating buses. The input 1 of DMU A-G is followed by 3453, 1355, 572, 945, 346, 289 and 261 respectively.

Input 2: the costs per 1,000 km. The input 2 of DMU A-G is followed by 5642.28, 5196.7, 5137.98, 4135.83, 4171.54, 3620.49 and 3534.53 respectively.

Output 1: the satisfaction degrees of passengers. The output 1 of DMU A-G is followed by 60.87, 63.77, 55.56, 50.48, 56.68, 61.83 and 61.93 respectively.

Output 2: the number of transporting passengers per kilometer. The output 2 of DMU A-G is followed by 2.86, 2.92, 2.80, 2.12, 2.47, 1.73 and 1.00 respectively.

Besides, we assume the total of allocated subsidy $R = 10,000$ Yuan.

The relevant results of the proposed approach are shown in Table 15.1. As shown in the last column, there are two groups of efficiencies. The left column is the performance of public transport enterprises before the subsidy allocation, which is obtained by model (15.1). The right one is the efficiencies based on the subsidy allocation, in which we can find that all enterprises are Pareto efficient. The third column is the allocation interval, which shows that it can't allocate the subsidy with the upper bound 17660.04 since it is larger than the total allocated subsidy 10,000. The subsidy allocation is shown in the second column and shows that better performance can generally lead to larger allocated subsidy for public transport enterprises, such as DMU E, F and G. The worst performance, DMU A, causes the lowest allocated subsidy 687.52. Although the performance of DMU B is less than G, however, it is still an enterprise with good performance and besides, the enterprise scale of DMU B is far larger than G. Therefore, it is allocated the third highest subsidy 1739.17. As shown in the fourth column, the satisfaction degrees well reflect the psychology perception of each enterprise and the fairness principle (the interval of satisfaction degree is [0.3811, 0.5595], and the difference is very small). The relatively large difference of the allocated subsidy provides motivation to the enterprises with poor performance to improve their performance by decreasing the inputs and increasing the outputs. Some measures can be taken to achieve the goal, such as purchasing the buses with low carbon technology since this type buses would be obtained a larger weight in the process of calculating the standardized operating buses by China transportation policy; decreasing the administrative cost and other costs to avoid wastes and paying more attention on

Table 15.1 The relevant results based on the proposed approach

DMU	Allocation	Allocation interval		Satisfaction degree	Efficiency	
		Minimum	Maximum		Before	After
A	687.52	0	1803.93	0.3811	0.8561	1
B	1739.17	1071.22	2300.53	0.5434	0.9490	1
C	982.98	18.14	2549.70	0.3811	0.9204	1
D	1058.87	814.76	1376.73	0.4344	0.8797	1
E	2056.14	1378.67	3156.23	0.3811	1.0000	1
F	2214.62	1007.38	3165.07	0.5595	1.0000	1
G	1260.70	0	3307.86	0.3811	1.0000	1
Totals	10000.00	4290.17	17660.04			

high quality service to improve the satisfaction degrees of passengers and increase the attraction of passengers to select their buses. Thus, the proposed subsidy allocation methodology is in favor of stimulating urban public transport enterprises to initiatively decrease the operating losses and benefitting to achieve the goal of low carbon transportation by a way of economic incentives.

15.4 Conclusions

How to improve the performance of public transport enterprises and achieve the goal of low carbon transportation are two difficult problems. This paper first finds the interval of efficient subsidy allocation, which reflects the efficiency principle. Then we define the satisfaction degree based on the interval. To yield a unique subsidy allocation, we consider the fairness of satisfaction degrees, which reflects the equity principle. The relevant results of the illustrated example demonstrates that the subsidy allocation mechanism can provide incentives for urban public transport enterprises to initiatively improve their performance and can provide a guidance to achieve the goal of Green Transport.

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Chapter 16
What Counts in the Bus Use for Commuting? A Probe Survey Based on Extended Theory of Planned Behavior

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Abstract In order to lead people to pro-environmental transportation modes, it is necessary to learn about the psychology and behavior of users. Based on the extended theory of planned behavior—incorporating habit, descriptive norm and personal norm, this paper analyzes the relationship between these elements and intention to use bus, and the influence of habit on intention-behavior. The result of survey conducted in Chengdu City reveals different outcomes from previous study, especially for the attitude and perceived behavior control. In addition, the intention to use bus and habit can explain 41.7 % variance of the bus use ratio to the total travel. However, the interaction of habit and intention is insignificant.

Keywords Extended theory of planned behavior · Habit · Bus use

16.1 Introduction

The global warming and emissions have been the global issue. Public transportation becomes one of the strategies to deal with this problem. However, only when more people are willing to take bus, will the strategy play its role. The demand is closely

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related to people's psychology and behavioral habit. Much research has been done in this field. Theory of planned behavior is one of the most widely used models to tackle the cognitive determinants of mode use. According to this theory, intentions are based on combination of attitude toward the behavior, subjective norm and perceived behavior control; intention has effect on behavior; beliefs about the consequences of behaviors frequently influence attitude (Ajzen 1991). Many researchers have extended this theory by incorporating descriptive norm, personal norm (moral norm), awareness of responsibility for problems, such as (Heath and Gifford 2002; Eriksson and Forward 2011; Gardner 2009; Abrahamse et al. 2009). In addition, empirical study shows that habit has moderating effect on these elements (Eriksson et al. 2008; Klockner and Matthies 2004).

Some research conclusions have been reached. For instance, the influence of attitude, perceived behavior control and descriptive norm on intention to use bus is significant (Heath and Gifford 2002). These conclusions are useful for policy-makers to reduce emissions and lead to more use of public transportation. However, such research is conducted in countries where car is the necessity of family. In China, despite the rapid increase of car ownership, most people have to rely on bus, which may result in different conclusions.

In this paper, we want to explore two questions, (1) the relationship of cognitive determinants with intention to use bus in China; (2) whether bus use habit influences intention-behavior. The motivation to deal with the second question is to explore whether the long time use will have impact on people's mode choice. For example, if the bus use habit would moderate intention-behavior, the authority could encourage people by some policies to use bus for a period to form the habit; then the bus use habit can help them keep on taking bus.

16.2 Method

The study was conducted in Chengdu City, the capital of Sichuan Province, China. As people all need to go shopping despite their ages, employment and travel modes, and people in leisure are more willing to fill the questionnaire, the survey was done in and around Wal-Mart, Parkson and Ren Ren Le supermarkets. Before the final survey, the pilot survey was also conducted. It showed that participants could not clearly distinguish some statements of self-report habit indexes (SRHI) among 13 questions. So we revised some questions and deleted some quite similar statements. In the end, 8 statements are left (see Appendix). In the subjective norm, two items are integrated because many think only one of them have the influence.

In the survey, 200 questionnaires were sent randomly to the people in and around the markets. There were 171 valid response questionnaires. More women than men responded (104 female). 91 participants' age are among 18–25. No participant is older than 65. This is primarily due to the poor vision and limited understanding of senior citizens. People with higher education are more willing to respond (121 with B.S or higher education degree). These phenomena correspond with other studies reporting that female and people with higher education are more willing to answer questionnaires (Eriksson and Forward 2011).

In the questionnaire, participants had to consider the total commute trip number and the bus use number for commuting in the last 2 weeks. Thus, the bus use ratio to the total trip could be obtained. In the measurement of attitude, the combination of behavioral beliefs and outcome evaluations is used (Eriksson and Forward 2011). Participants rated consequences of using bus on a 5-point scale (1 = strongly disagree, 2 = disagree, 3 = uncertain, 4 = agree, 5 = strongly agree). There are 11 behavioral belief items, including “Taking bus is environment-friendly” “Taking bus can reach the destination quickly” “The risk of traffic accident in taking bus is low” “Taking bus costs low” “Walking distance is short before and after taking bus”“It takes a long time to wait for the bus” “It is crowded in the bus” Taking bus risks being stolen” “It is noisy in the bus” “It is inconvenient to transfer the bus” “Taking bus risks bus self-burning danger”. Then participants had to rate the outcome evaluations on a 5-point scale (1 = not important at all, 2 = not important, 3 = uncertain, 4 = important, 5 = very important). There are 8 outcome evaluation items, including environment-friendliness, travel time, safety, travel cost, walking distance, waiting time, comfort, transfer convenience. The attitude can be obtained by multiplying behavioral belief value and outcome evaluation value then dividing 2. So the attitude range is 0.5–12.5. The alpha value of attitude is 0.70. After recoding, the higher value indicates the more positive attitude toward bus.

As for perceived behavior control, participants were asked directly “Taking bus as the main commute mode for me is difficult” and gave their opinion on a 5-point scale (1 = strongly disagree, 5 = strongly agree). The lower the value, the easier it is for participant to use bus as the main mode. In subjective norm, participants were asked that to what extent they agreed with the statement “My friends and family suggest me to take bus for commuting” (1 = strongly disagree, 5 = strongly agree). Descriptive norm was measured in the similar way except that family member and friends are distinguished. In personal norm, participants rated on a 5-point scale for the statement “I think I’m obliged to take bus in order to make my own contributions to the low-carbon society”. Intention to use bus was evaluated by asking “I intend to use bus as the main mode for commuting in the following 2 weeks”. The higher value means more willingness to take bus.

There is only 1 item in perceived behavior control, subjective norm, personal norm and intention, and 2 descriptive norm items, which may reduce the reliability(the descriptive norm alpha = 0.67). However, the pilot survey showed that participants were not able to distinguish the similar items. In addition, one item is commonly used by other research, such as (Klockner et al. 2003; Nordiund and Garvill 2003). The habit measurement includes 8 items, where SRHI is used. The higher value reflects stronger habit of bus use. The alpha value is 0.86.

Table 16.1 Means and standard deviations for attitude, perceived behavior control, subjective norm, descriptive norm, personal norm, intention to use bus and habit

	Mean	SD
Attitude	6.16[a]	3.43
Perceived behavior control	2.78	1.24
Subjective norm	3.46	1.19
Descriptive norm	3.47	1.20
Personal norm	3.96	1.03
Intention	3.82	1.28
Habit	3.48	1.29

[a] Scale: 0.5–12.5, higher value indicates more positive attitude towards bus

16.3 Results

In Table 16.1, citizens' attitude toward bus is almost neutral (M = 6.16, SD = 3.43). Personal norm value (M = 3.96, SD = 1.03) is higher compared to other elements, which means that people tend to think they have obligation to take bus for reducing emissions. The value of habit of bus use is similar to that of intention.

In Table 16.2, the bivariate correlation is conducted. Interestingly, the correlation between bus use ratio and attitude is not significant as other research reveals (Heath and Gifford 2002; Eriksson and Forward 2011). So is the intention. In these studies, attitude is strongly related to bus use or intention to use bus. This difference may result from the different life styles. In western countries, car is the family necessity, and people can make choices according to their attitudes. While in Chengdu, according to the data from Chengdu Vehicle Management Institute and Chengdu Statistics Department, there are about 2.579 million cars and 11.25 million people up to March, 2012. Most people have to depend on bus. So the higher bus use does not mean more positive attitude toward bus. The smaller the value of PBC is, the easier for participant to use bus, the higher bus use ratio will be, which leads to the negative relationship between PBC and bus use ratio.

Table 16.2 Bivariate correlations of bus ratio, attitude, perceived behavior control (PBC), subjective norm (SN), descriptive norm (DN), personal norm (PN), intention to use bus and habit

	Bus ratio	Attitude	PBC	SN	DN	PN	Intention
Attitude	0.045	–	–	–	–	–	–
PBC	−0.186*	−0.066	–	–	–	–	–
SN	0.298**	0.165*	−0.048	–	–	–	–
DN	0.385**	0.078	−0.044	0.492**	–	–	–
PN	0.078	0.124	−0.057	0.385**	0.303**	–	–
Intention	0.589**	0.085	−0.105	0.533**	0.520**	0.387**	–
Habit	0.604**	0.020	−0.156*	0.428**	0.395**	0.246**	0.707**

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Personal norm has insignificant correlation with bus use ratio though it has strong correlation with intention, which means even though people show strong obligation, they not necessarily choose bus in practice. High environmental obligation may not guarantee the environmental action. Subjective norm and descriptive norm both have strong correlation with intention. People who are important to the traveler are closely related with traveler's mode. Of course, this may result from the alternative mode availability. In addition, habit and intention are strongly related. But correlation cannot tell us the casualty. It's hard to say whether people intend to use bus because of habit, or they have no choice but to use bus so the habit forms and they intend to use bus before other modes being available.

In order to predict the intention to use bus, hierarchical multiple regression was conducted. The 3 elements in the conventional TPB entered first, then the habit, finally other independent variables entered.

Before regression analysis, the assumptions were tested. The sample size is 171, the independent variable number is 6. So the ratio of cases to independent variables (28.5:1) is higher than 5:1, and it is also higher than the preferred value 15:1. Kolmogorov–Smirnov values are all between $-1.0 \sim +1.0$; Durbin-Watson value is 2.143, which falls in the interval of 1.50–2.50; tolerance values are larger than 0.10. The results are shown in Table 16.3.

In Table 16.3, the 3 elements in conventional PTB can explain 29.1 % variance in intention to use bus. After incorporating the habit, 56.5 % variance could be

Table 16.3 Attitude (A), subjective norm (SN), perceived behavior control (PBC), habit, descriptive norm (DN), personal norm (PN) as predictors of intention to use bus

	Intention to use bus			
	R^2	ΔR^2	β	t
Step 1	0.291	0.291		6.044
Attitude			−0.008	−0.126
PBC			−0.080	−1.220
SN			0.531	8.029***
Step 2	0.565	0.274		1.848
Attitude			0.006	0.122
PBC			0.001	0.014
SN			0.281	4.901***
Habit			0.586	10.224***
Step 3	0.611	0.047		−0.496
Attitude			0.005	0.104
PBC			0.002	0.043
SN			0.160	2.615***
Habit			0.529	9.419***
DN			0.190	3.272***
PN			0.137	2.561*

***$p < 0.001$
**$p < 0.01$
*$P < 0.05$

Table 16.4 Intention, habit, intention × habit as predictors of bus use ratio

	Bus ratio			
	R^2	ΔR^2	β	t
Step 1	0.347	0.347		
Intention			0.589	9.479***
Step 2	0.418	0.070		
Intention			0.324	3.893***
Habit			0.375	4.505***
Step 3	0.426	0.008		
Intention	–	–	0.545	3.322***
Habit	–	–	0.604	3.580***
Intention × habit	–	–	−0.425	−1.559

***$p < 0.001$

explained, which shows the habit is a significant predictor of the intention. After the inclusion of descriptive norm and personal norm, R^2 only increases slightly compared to the second step. Independent variables all have significant influence on intention to use bus except attitude and perceived behavior control. The insignificant influence of perceived behavior control may come from the "floor effect" or "roof effect", as the individual perceived behavior control on bus differs slightly when almost everyone could easily have access to bus.

Table 16.3 shows that habit is a significant predictor of the intention. Next, the influence of habit on intention-behavior is analyzed. Taking bus use ratio as the dependent variable, the hierarchical regression is executed, where intention entered first, then the habit, intention × habit entered finally.

In Table 16.4, intention explains 34.7 % variance in bus use ratio; intention and habit together can explain 41.7 % variance. But the influence of intention × habit on bus use ratio is not significant. This means that in bus mode, habit has no significant moderation on intention-behavior and the long time bus use may not influence people's intention-behavior. The policy to help citizens form the bus use habit so they can automatically use bus later on will not work.

16.4 Discussion

It is necessary to understand people's behavior of bus use for executing public transportation policy. This paper analyzed the influence of common elements on intention to use bus in Chengdu City based on extended theory of planned behavior. The result shows that people's attitude toward bus is neutral instead of positive. On the other hand, intention to use bus is insignificantly related to attitude. Even people show high obligation to reduce emissions, they may not practice in real. This can be seen from the insignificant correlation between personal norm and intention. The regression result shows that all independent variables significantly influence the intention to use bus except attitude and perceived behavior control. The influence of habit on intention-behavior is insignificant. So the long-time bus use cannot guarantee the insistence on bus use.

This is the preliminary research. Further study has to be done to explain the reason for the inconsistence with previous research conclusions that attitude and perceived behavior control has significant influence on intention. The different results show that travel pattern in China is different from that of other countries and different policies are needed for the specific situation in China. Other factors, such as alternative mode availability and intention to buy a car, have to be closely examined as well.

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Chapter 17
Evaluation Study on the City Bicycle Rental System

Jianyou Zhao, Yunjiao Zhang and Cheng Zhang

Abstract Evaluation study on city bicycle rental system plays an extremely important role in the work of the whole city's transportation. The quality and the service level of the rental system's construction will influence the effects of citizens' using it and the improving of the city's transportation problems. However, there still has not a very independent and perfect evaluation system of the public bicycle rental studies so far in China. Based on the principle of selecting index, this thesis is going to divide the evaluation studies on city bicycle rental system into three index systems, namely the rental network design, infrastructure system and management system, by which it can build a scientific and rational evaluation system. By using the Analysis Hierarchy Process (AHP), transacting qualitative index into quantitative index, confirming every index weight, finally there could be a bicycle rental system evaluation value after a comprehensive analysis. Also proceeding an empirical study from the applicative angle to verify the practicality and the feasibility of this article's evaluation theory and method.

Keywords Public bicycle rental system evaluation · Analysis hierarchy process (AHP) · Weight verification · Verify

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17.1 Introduction

With the rapid development of the social economy, citifying process, continuous enlargement of the scale of the city, the rapid growth of population, our city welcome in the unprecedented high speed development time of the motorization. Take Shenzhen for example, motor vehicle population of this city breakthrough 1,700,000 and the annual growth number of vehicle amounts is over 150,000 (Hou 2012).The fact above led the city's transportation problem became more and more important and the problem mainly includes: road resources' saturation, serious traffic jam, the speed of the vehicle is getting slower, the time of the residents trip is getting longer and so on and all of these is becoming the major problem that restrict the development of the city. Meanwhile the huge amounts of the cars brought up the environment pollution and the resources consumption that had a seriously affect the city's ecological environment, social fairness, life quality and sustainable development.

Since 1922, United Nations conference on environment and development had pass 'agenda of twenty-first century', the agenda had promoted 'sustainable development' to a practical objective that we all human beings should pursuit together. Under its theoretical direction, Chris Bradshaw (Su and Luo 2011) brought up the green traffic idea in the 1994 that we should take the green classification to our transportation means and the priority of the classification from high to low followed as walking, bicycle, public transportation and the last is individual automobile driving. The government or the relative company can set couples of the public bicycle rental stations around the city, the citizens or the tourist can rent the bike at any station and give it back at any other stations after finishing using it (Li 2010). It mainly solves the problem like the citizens 'short haul trip', the 'last mile' after the bus and the tourists visiting problem, etc. Moreover it is still an energy-saving, environment protecting and healthy product that can improve the resource utilization ratio remarkably, relief the pressure of the city's transportation jam and reducing the air pollution, lead to a better place for people to live in the city.

17.2 Establishment of City Bicycle Rental System Evaluation

17.2.1 The Principle of Selecting Evaluation Indexes

An accurate evaluation of the bicycle rental system must be based on the index that can fully reflect the usage rate of the public bicycle. The settings of the index system ought to from the actual conditions and should obey the following rules: (a) Scientific and effectiveness character principle. (b) Comparability and flexibility character principle. (c) The combination of dynamic and static principle. (d) The combination of the qualitative index and the quantitative index principle.

According to the contents of this article, through analysis and combine the character, application scope and the evaluation requirement of the index itself to establish the relevant index system, finally use the confirming of the index weight and Analysis Hierarchy Process (AHP) to calculate all the index value weight so as to confirm the specific level of the evaluation of the bicycle rental system.

17.2.2 Construction of the Evaluation Index System

We should establish a comprehensive and omni-directional evaluation system by cluster analysis that based on all the effective factors of the public bicycle before evaluate the city's bicycle rental system. Based on the functions of the bicycle rental system, it's going to divide the system into three parts, that is, the rental network design, infrastructure system and management system.

The specific evaluation index system of city bicycle rental system shown in Fig. 17.1.

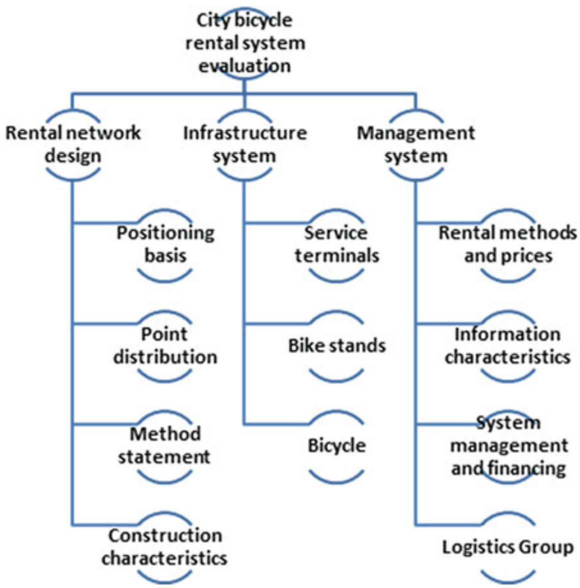

Fig. 17.1 City bicycle rental system evaluation indexes

17.3 The Establishment of the Indexes Weights Based on the AHP

17.3.1 The Overview of Analytic Hierarchy Process

The basic steps to calculate the weight of each index are as follows:

(1) *Building the hierarchical structure*

Based on the investigation and analysis, the range, goals, contained factors and their internal relations of the issue would be figured out. The hierarchical structure could be established.

(2) *Constructing judgment matrix*

By judging a series of twinning factors in each hierarchy, based on certain ratio scale, the judgments were quantified and the comparative judgment matrix was built.

(3) *Determination of hierarchy weights and consistency check*

To measure the reliability and consistency of the evaluation, an index $CR = CI/RI$ was introduced to measure the judgments' deviation. When $CR < 0.10$, the consistency is good.

Each hierarchy index weight could then be $P = \sum_{i,j,k} P_{ijk} \cdot W_{ijk}$ obtained by calculating the weight based on the method shown in the Fig. 17.1.

17.3.2 Comprehensive Evaluation

Corresponding to specific index evaluation criteria, a concrete evaluation conclusion could then be given.

$$\sum_i W_i = 1, \quad \sum_i \sum_j W_{ij} = 1, \quad \sum_i \sum_j \sum_k W_{ijk} = 1$$

where P_{ijk} is the evaluation value of the simple index.

Based on the Table 17.1, by analyzing the evaluation value of the simple index, the detail evaluation of the system in different parts could be obtained. According to the evaluate result, the corresponding countermeasures could be set to improve and enhance the quality of the system.

Table 17.1 City bike rental system evaluation standard

Excellent	Fine	Middling	Qualified	Disqualified
90–100	80–90	70–80	60–70	<60

Table 17.2 Excel algorithm for computing process based on the analytic hierarchy process

City bicycle rental system	Rental network design	Infrastructure system	Management system	According to multiply the line	Open n power	Wi	Awi	Awi/Wi			
Rental network design	1	2	3	6	1.8171	**0.5278**	1.6118	3.0536			
Infrastructure system	1/2	1	3	1.5	1.1447	**0.3325**	1.0153	3.0536	CI=(λ-n)/(n-1)	CR=CI/RI	
Management system	1/3	1/3	1	0.1111	0.4807	**0.1396**	0.4264	3.0536			
					3.4425			3.0536	0.0268	0.0517	
Rental network design	Positioning basis	Point distribution	Method statement	Construction characteristics	According to multiply the line	Open n power	**Wi**	Awi	Awi/Wi		
Positioning basis	1	3	5	7	105	3.2011	**0.5756**	**2 1/3**	4		
Point distribution	1/3	1	3	5	5	1.4954	**0.2689**	**1.1032**	4.1028	CI= (λ-n)/(n-1)	CR=CI/RI
Method statement	1/5	1/5	1	1/2	0.02	0.3761	**0.0676**	**0.2805**	4.1478		
Construction characteristics	1/7	1/5	2	1	0.0571	0.4889	**0.0879**	**0.3592**	4.0853		
						5.5614			4.0985	0.0328	0.0368
Infrastructure system	Service terminals	Bike stands	Bicycle	According to multiply the line	Open n power	**Wi**	Awi	Awi/Wi			
Service terminals	1	2	2	4	1.5874	**0.4934**	**1.5066**	3.0536	CI=(λ-n)/(n-1)	CR=CI/RI	
Bike stands	1/2	1	2	1	1	**0.3108**	**0.9491**	3.0536			
Bicycle	1/2	1/2	1	0.25	0.6299	**0.1958**	**0.5979**	3.0536			
					3.2174			3.0536	0.0268	0.0517	
Management system	Rental methods and prices	Information characteristics	System management and financing	Logistics Group	According to multiply the line	Open n power	**Wi**	Awi	Awi/Wi		
Rental methods and prices	1	1/3	1/4	1/5	0.0167	0.3593	**0.0741**	0.2992	4.0368	CI=(λ-n)/(n-1)	CR= CI/RI
Information characteristics	3	1	3	1/4	2.25	1.2247	**0.2527**	1.2421	4.9163		
System management and financing	2	1/3	1	1/5	0.1333	0.6043	**0.1247**	0.4668	3.7449		
Logistics Group	5	2	5	1	50	2.6591	**0.55**	2.0478	3.733		
						4.8475			4.1078	0.0359	0.0402

Table 17.3 The weights of city bike rental system evaluation index system

Project	Level 1 of evaluation content		Level 2 evaluation content	
	Evaluation index	Weight	Evaluation index	Weight
City bicycle rental system evaluation	Rental network design	0.528	Positioning basis	0.575
			Point distribution	0.269
			Method statement	0.068
			Construction characteristics	0.088
	Infrastructure system	0.332	Service terminals	0.493
			Bike stands	0.311
			Bicycle	0.196
	Management system	0.140	Rental methods and prices	0.074
			Information characteristics	0.253
			System management and financing	0.125
			Logistics Group	0.548

17.3.3 Determination of the System Index Weight

At this thesis, the software Excel was used to calculate the evaluation value of all steps for its powerful operating function (Xian 2012). The simplification of the consistency check and the adjustment of the judgment matrix were realized. The method was called as the Excel arithmetic of the analytic hierarchy process. The calculation results and data of the method were all keep the accuracy of the highest digit and the error was minimized. All steps of the calculation were concise as shown in the Table 17.2.

Table 17.4 the operation process of Excel algorithm based on the AHP.

Then the weight of each evaluation index could be determined as shown in the Table 17.3.

17.4 Case Analysis

From the 1980s to 1990s, most people of Wuhan city use bicycles (3.8 million), other than motors as their daily vehicles. With the rapid devolvement of the economy of the 1990s, more motors ware used to replace bicycles. The number of bicycles in Wuhan city has decreased to 1 million in 2008 (Li et al. 2009). In order to solve the increasingly serious problem of traffic jam, in May 2009, the municipal government of Wuhan City carried out of policy to support the public bicycle rental system, which is very effective. In the thesis, the author gives a comprehensive evaluation of the public bicycle renting system, based on the combination of different index and the usage of leveled analysis, as in Table 17.4.

Table 17.4 Evaluation of PBRS in Wuhan

Item	Level 1		Level 2		
	Index	Value	Index	Conclusion	Value
City bicycle rental system evaluation 82.931	Rental network design	**91.050** (0.528)	Positioning basis	The positioning mentality is total quantity control, classified processing, scale balancing, flexible adjusting. The positioning basis is connected to public transportation, giving service to the short distance and large scale travel	92
			Point distribution	Point distribution mainly for transit point, public point, settlements, recreation point, campus point. Set transit point, public point, campus point as center, the average distance to settlements is less than 300 m	90
			Method statement	Construction manual is relatively perfect, reached the construction design standards	95
			Construction characteristics	Bicycle equipped with diversification, service system point is excessive with big range	85
	Infrastructure System	**80.483** (0.332)	Service terminals	Service terminal facilities are simple. Search function need to be completed	75
			Bike stands	Reasonable designed, the quantity of equipments reach the standard	92
			Bicycle	The bicycle is of convenience, comfort and safety, but lack of management control system device	76
	Management System	**58.118** (0.140)	Rental methods and prices	Residents could open the "Integrity Card" by their ID card for free to rent the bicycle without the rental	95
			Information characteristics	Bicycle information system need to be completed	50
			System management and financing	Operating the company as an enterprise with marketization which benefited by the bicycle body float advertising and carport advertising with indeterminacy for rent. Sources of funds need to be expanded	62
			Logistics group	For less the service hotline, issues of the residents are not resolved in time; Maintenance is not in time, bikes are cumulative loss; Plenty System fault with incomplete stability; have not introduced the wireless network mobile service points yet	56

The value of city bicycle rental system gets 82.931 points in Wuhan. Based on the criterion of Table 17.3, we can say that this is a relatively high value-fine. Specifically, this system has a good designation of network and infrastructure. But there is potential problem in its management system, which need further improvement. The result of the evaluation of city bicycle rental system is in accords with our investment of the real situation, which means that our methods are sound and effective.

17.5 Conclusion

It has been a general tendency and consensus to develop the environmentally friendly public transportation system, such as the bicycle and bus system, and to build their evaluation system. In this thesis, after the consideration the public bicycle system of the main cities in the world, the author chooses the rental grids design, the infrastructure system, the management system as the mean evaluation index. Using analysis hierarchy process, we are able to value the performance of a system in different index precisely, and get a final conclusion by assigning the indexes with different weight. This method not only enables us to analysis the system thoroughly, but also enables us to find the potential problem and come up with an effective solution. And it is a fundamental solution to the city trips "last mile", provide protection for the residents travel, and achieve the fundamental needs of residents of efficient, comfortable, fast, affordable.

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Chapter 18
The Green Traffic Strategy in Low Carbon Community

Zesong Wei, Xia Wang and Xiaolong Pang

Abstract This paper starts from green traffic design perspective of the low carbon community; studies the different layers as followed: planning low carbon traffic, constructing the community mode guided by no motor vehicle, encouraging low carbon transport, using environmental protection fuel and road materials; advocating low carbon traffic etc. The intention of this paper is to develop low carbon life style for city community, to reduce carbon emissions of overall city, and create a healthy, comfortable life environment for the residents.

Keywords Low carbon · Community · Low carbon traffic · Green transportation

18.1 Introduction

Community is the place for people's life and dwelling, it is not only the basic function unit of the city, but also the basic space of realizing environmental change and social low carbon development. Low Carbon Community refers to develop low carbon economy in urban living community, innovate low carbon technology,

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change the way of life, through the land, building, energy, resources, transportation, and other comprehensive method, maximum limit to reduce the greenhouse gas emissions of residential planning construction, and process of use and management, realize clean, efficient and sustainable development of the city residential community.

18.2 Planning Low Carbon Traffic

18.2.1 Realizing Convenient Connection of Public Transportation with Community

It is essential to ensure convenient contact of public traffic system of community and nearby for the low carbon community traffic planning. Community should have at least one or two public transit lines around it, and the distance between the nearest transit site and residential gateway is about 400–500 m (time should be less than 5 min on foot), to promote the resident's will of transportation mode choice with public transport system as the priority.

For example, according to the urban strategy of "living first", Vancouver proposed to develop the complete residential community in foot path scale. Masdar's low carbon community connects traffic with community outside by the planning traffic system of three levels: underground transportation, ground traffic and personal rapid transit system. In the ground walk system, the longest distance that people arrive at the bus site is controlled within 200 m. Personal rapid transit system organized by 1,700 motorized personal rail MRT coaches and automatic control system meets the demand of private travel.

18.2.2 Organizing Mixed Walk Network in the Community

The traditional squares nets road system used for residential house, although convenient to car traffic, but it will be too wasteful, and also against the security and the construction of community's sense. Although ended road style is a single path, and contact shortage, it is quiet, safe and benefit for building the sense of place. The combination of square nets road and ended grid road will be complementary advantages, through the "permeability of filter" principle to form a new network form— Fused Grid. The network structure is discontinuous for the car,but it is linked for pedestrians and bicycle, so can limit motor vehicle traffic but be beneficial to the mobile pedestrians and bicycle. This means that the network loves in positive transportation means, selectively "filter" off the car (Fig. 18.1).

Located in Alberta province, Canada, Calgary Saddlestone Community uses mixed road network. On one hand, optimize the land use streets, encourage

Fig. 18.1 (**a**) Traditional squares grids (**b**) traditional ended type (**c**) fused grid structure

walking, and at the same time actively discourage the short distance driving, to achieve peace and security of the community, increasing the potential of the social interaction. Covers an area of 38 hectares, with a population of 5,500, Vauban District in Germany Freiburg is the world's first "car free community". To a certain extent, resident's walking or cycling is attributed to path planning of mixed road network.

18.2.3 Reducing Parking Volume within Community

The increase of the car parking land must be at the expense of reducing the other land, from the practice of low carbon community, reducing the internal parking of community (or do not set up the parking lot), setting the centralized parking lot in the peripheral is the commonly used methods. This way has significant advantage in the development of public transport, increasing the comfort and security and residential neighborhood communication. For example, there are only two parking spots at residential edge in Germany Vauban District. Walk or cycling is the main means of transportation. There are tramcars leading to the city centre on the Residential traffic main roads; it will take 15 min to reach the city centre. All the houses are layout along the bus route; it takes a few steps to arrive parking lot. "Commuter Formula" covering the range of 60 km radius provides a convenient travel for the community residents.

18.3 Constructing the Community Mode Guided by Non-motorized Vehicle

18.3.1 Constructing Multi-Function Mixed Community

Multifunctional mixed community sets business, entertainment, food and many kinds of function as one, perfects supporting the community living, can provide the mature supporting facilities and reasonable life distance, meets varied life need of residents; it makes the slow transit as the main transportation of the community interior, and reduces the long distanced travel from the source.

Sonoma settlements, located in the north of San Francisco, plan for living range of 5 min from the overall planning of new urbanism, ensure the residents can arrive stores and other supporting facility within five minutes walking distance, and enjoy the local, sustainable, fair trade products and services provided by the community. 60 % of the daily traffic can be solved without private cars. Parking need is also decrease.

18.3.2 Setting Appropriate Residential Scale

Large, adopting the close residential property management pattern, it is not convenient for the residents from home to the bus station, the narrowing of the residential scale, is benefit for people to abandon their travel by private cars. According to research, the closed community, scale in the 200 × 200 m, the area is in 4 ha or so is suitable for residents to choose to travel by walk and bike.

So that appropriate scale community can be seen as one or more live "cells", public transport station can be seen as "nuclear", "cells" layout forms has high adaptability on public transportation service, if we combine many kinds of travel targets for the residents such as going to work, going to school, entertainment, shopping and so on, design them in the same route, the residents can finish a variety of activities at the same time by one trip, to be able to reduce travel times and the distance of the residents.

18.3.3 Advocating the Pedestrians and Bike Oriented Development Mode

By "the public transport oriented development (TOD)" has many advantages, but it is more suitable for big cities with many population; for small and medium-sized community, pedestrian-oriented or bicycle-oriented development (POD, pedestrian-oriented development) (BOD, Bicycle oriented development) have more potential than public transportation as the direction of development. People oriented and the most suitable community for walk and cycling often has the following features:

A center: the community suitable for walk generally has a very strong recognized center, or a shopping area, or a main street, or a public space.

Density: settlements are compact and not the scattered, this makes people more close to the shop and working place, make public traffic be more cost-effective.

Mixed function: work place and home is not far apart, the school and workplace is also very near, and most residents can walk to go.

Public space: having enough public space for residents' assembly or recreation.

The network on pedestrian: network structure provides the most easy environment to walk, it mixes the natural form of residence, commerce, public buildings of the community, mixed walking district can greatly reduce travel times and length, especially car trip.

18.4 Encouraging Low Carbon Transport

18.4.1 Promoting the Use of Low Carbon Transport Tool

Using Low cost zero carbon personal transportation system, such as the using of zero energy consumption electric bicycles, The electric bicycle appearance is different from ordinary electric car sold on the market, it is more similar to bicycle, because it installs two pieces of lithium battery, which can run up to 120 km.

18.4.2 Improving the Green Transportation Supporting Measures of Transport

According to the residential density of road network, reserve bus land, construct land of clean energy vehicle facilities, such as LPG stations, transformer substation, charging field, charging pile, and so on. Planning wide distribution, public bicycles of convenient service, hire point electric car, and combined with public transportation site plan and construct bicycle site. These stop point also has the function to charge and change electricity for electric car. It will install a solar energy photovoltaic panel (Photovoltaic Solar Panels) of tree shape, transformed electrical energy will charge for electric bicycle in time. At the same time, it can also charge for spare lithium batteries stored in the dock point.

18.4.3 Building Friendly Traffic System of Walking and Cycling

Setting walking and bicycle travel system in the community, safe, continuous string priority to the premise should be the first step, second to consider the demand of pedestrian or riding and vegetation gardeners and landscape. Bicycle lanes of Shenzhen Overseas Chinese Town (oct) community can be divided into daily traffic routes and leisure fitness line. The total length of bicycle lanes on traffic routes is 16 km, divided into bilateral respectively driving and unilateral two-way driving, using the ground and mark of different color to distinguish.

18.4.4 Encouraging the Using and Restoring Public Transportation

Encouraging the using or restoring public transportation can effectively reduce the travel of the private cars. For example, an Diego California Housing Works community in the United States, contacts transportation departments and schools, restores the school bus service, there are 120 households benefit from the recovery of public school bus, effectively reduce traffic and corresponding expenses for parents ferrying their children.

18.5 Using Environmental Protection Fuel and Road Materials

18.5.1 Using the Technology of Warm Mix Asphalt

The so-called Warm Mix Asphalt technology (referred to as: WMA), is through the certain technical measures, make the asphalt can be mixed and constructed at relatively low temperatures, while maintaining its asphalt mixture construction technology not under FIMA using performance. With the warm mix asphalt technology, the road can save 20–30 % heating fuel when construction, can make the carbon dioxide emissions be reduced by 46 %, carbon monoxide reduces about two-thirds, sulfur dioxide reduces 40 %, nitrogen oxide gas reduces nearly 60 %, while toxic "asphalt smoke" when paving to produce, can reduce 80 %, largely protecting environment and construction technical personnel's physical health.

18.5.2 Use Environmental Protection Construction Materials

The increasing use of materials causes a lot of resource waste; we should use environmental protection green building materials in the construction of the road, reduce material energy consumption in the process of constructing, and enhance the recycling use and the use of recycled material ratio. At present, it basically has the following kinds of material saving technology, such as asphalt pavement recycling technology; Cement road surface reconstruction technique that increases laid; waste materials recovery for road using technology; the road consolidation technology with construction waste.

18.5.3 Using Environmental Protection Fuel

In order to alleviate the tension escalated of oil resource and pollution problems, it is an important topic to develop of cheap, clean alternative sources of energy for environmental protection. Samso Island in Denmark, on the one hand, introduces biofuel to gradually eliminate gasoline; on the one hand, set up hydrogen factories to manufacture hydrogen as substitute fuel for car.

18.6 Advocating Low Carbon Traffic

Residents participate in the planning design and developing process of the community is an important link of building low carbon community. The implement of "Public participation", can let people feel "belonging" and "tenderness" by the process of communication, conferring with planning design. In the case of absence of low carbon concept, there may not be conscious low carbon travel behavior, the cultivation of the residents low carbon transport style needs not only increase residents' knowledge of low carbon traffic, but also need to guide them set up low carbon travel view as soon as possible, through policy, education, publicity and many kinds of ways, to improve self-consciousness of the low carbon travel.

18.7 Conclusion

Reducing carbon emissions of city requires long-term efforts, the carbon emissions of city traffic is more than 30 % of the total emissions, resident land of city is more than 30 % of the total land. Advocating residential low carbon traffic is beneficiary for carbon abatement of the whole city, at the same time, it can provide quiet, health, and comfortable life environment for the residents. In the residential planning process, creating conditions for low carbon travel way is the future direction of the residential community planning.

Chapter 19
Discussion on Countermeasures of China's Low-Carbon Tourism Development

Xuefeng Wang and Hui Zhang

Abstract Low-carbon tourism is gradually emerging currently, which caused Extensive attention by the government, academia and society. However, study of low-carbon tourism is still in initial stage. On the basis of reviewing of research progress at home and abroad, this paper analyzes the necessity and realistic foundation of China's development of low-carbon tourism, and finally countermeasures are proposed to promote the development of low-carbon tourism in our country.

Keywords Low-carbon tourism · Connotation · Development of countermeasures

19.1 Introduction

The concept of Low-carbon is proposed in the context of responding to global climate change and advocating reducing the greenhouse gas emissions from living activities of human. As the proposed new concept of "low-carbon tourism", there is a growing concern about energy-saving and emission reduction, which related to the sustainable development of human society. As a kind of low power consumption and low pollution tourism, low-carbon tourism has become the focus of attention of the world tourism industry, and the future direction of tourism recognized.

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Low-carbon tourism, which has brought new opportunities for today's tourism style transformation, is becoming the trend of the future development of tourism. However, a related area of research has lagged far behind in the development of the practice, low-carbon tourism call for an urgent need for theoretical guidance. In this context, through comparison and analysis on domestic and international low-carbon tourism, and summarizing existing research experience, the author investigate the main research directions of low-carbon tourism in the coming period.

In order to seek beneficial inspiration for the domestic low-carbon tourism research and promote the progress of the industry as a whole, ultimately to achieve the strategic goals of sustainable tourism development.

19.2 Research of Low-Carbon Tourism in Domestic and Abroad

Low-carbon tourism-related research is carried out earlier and the literature of which is relatively abundant abroad. Moreover, the foreign study of low-carbon tourism is mainly concentrated in the determination of carbon emissions in the tourism sector and process of the tourism. For example, Becken and Simmons (2002) published a series of articles for depth study of the energy use of tourism from various angles, such as use patterns, energy use and modes of transportation (Becken and Simmons 2002; Susanne Becken 2002).

With the rapid development of transportation technology, there are more and more modes of transportation Available for tourists, and different way to travel has different carbon emissions. According to the World Tourism Organization statistics of carbon dioxide emissions in the tourist sector, the aircraft's carbon emissions by 40 % of the total, accounted for 32 % of car and other transport accounted for 3 %, carbon emissions from the transport sector accounted for 75 % of the total carbon emissions in the tourism sector, so the control of carbon emissions from the transport sector is the key to energy saving.

In the study of New Zealand Tourism traffic, Becken et al. (2003) found that the amount of energy consumed by the cross-border travel is four times the domestic tourism, so change the way of tourist travel can greatly reduce their energy demand and carbon emissions (Becken et al. 2003). Peeters et al. (2007) analyzed the environmental impacts of European tourist traffic—we should focus on reducing the environmental impact of tourism aviation and intercontinental travel in order to reduce the external costs of travel in Europe (Peeters et al. 2007). Measured the carbon emissions of the five national parks' tourist transport in Taiwan, Lin (2010) believes that government departments should take active management measures to reduce the carbon emissions of tourist transport effectively (Lin 2010).

Compared with the tourist traffic's carbon emissions, the tourist destination' structure is more complex, and its determination of carbon emissions is more difficult, therefore, fewer numbers of studies related to tourism destination in carbon emissions. The existing research focused on the determination of travel carbon emissions and the study of tourism destination's carbon footprint. Kelly and Williams (2007) constructed a conceptual framework and energy use model to determine energy consumption and emission levels of the tourism destination, which provides an effective method for the management and decision-making (Kelly and Williams 2007). Dick Sisman and his colleagues carried out system and in-depth research on the carbon footprint of tourism; they think that air travel is clearly the most important part of the tourism greenhouse gas emissions, as for the tourist destination, It is necessary to conduct a detailed review and give sufficient attention on hotel energy consumption and waste disposal (Dick Sisman & Associates 2007).

Domestic research literature on low-carbon travel is less than in foreign. Xiao (2009) first proposed the concept of low-carbon tourism, which should be the target of continuous development of tourism because it has a clear vision and objectives (Xiao 2009).Thereafter, from September 2009, due to the low-carbon concept continues to heat up, sharp increase in reports and research papers on low-carbon tourism, the contents of which are introducing visitors the concept of low-carbon tourism and related knowledge, as well as propagandizing the construction of scenic in low-carbon, in order to guide the tourists to choose a low-carbon tourism. Mature cases are rare because of the low-carbon tourism is still being explored. Huang (2009a, b) described the case of Pinglin in Taipei's and Bama in Sichuan's low-carbon tourism development, and lessons are drawn from the successful experience and proposals for low-carbon tourism development (Huang 2009a, b). Cai and Wang (2010) discussed the low-carbon tourism connotation and proposed the main path of achieving low-carbon tourism on analyzing the elements in the process of tourism development, such as tourist attraction, tourist facilities, tourist experience environment and tourism consumption etc. (Cai and Wang 2010). For the actual situation in the suburb of Beijing, Liu (2010) proposed a corresponding low-carbon tourism development ideal model.

Overall, it can be seen that our stage of low-carbon tourism study is still in its infancy, remain in the level of qualitative analysis through the comparison of domestic and international research. The total amount of relevant literature is rare, and news reports accounted for the majority. In the course of the study, many of them carried out a comprehensive analysis of low-carbon travel in a macro perspective and their research focused mainly on the low carbon way of tourism. Thus, the perspectives of these studies are relatively homogeneous and lack of quantitative research. Although many scholars have carried out positive and useful explorations, and achieved some achievements, but there are many fields remains to be in-depth study and discussion.

19.3 China's Low-Carbon Tourism Development Status and Issues

19.3.1 The Meaning and Characteristics of Low-Carbon Tourism

As the name suggests, Low-carbon tourism is a kind of tourism to reduce the "carbon", that is, tourists try to reduce carbon dioxide emissions in their travel activities. Based on low energy consumption and low-pollution, green travel advocated to minimize the carbon footprint and carbon dioxide emissions in the travel, which is the deep-level performance of eco-tourism. The contents of low-carbon tourism Include environmentally friendly low-carbon policy and low carbon tourist routes launched by the government and travel agencies, environmental baggage carried in personal mobility, live in environmental hotel, choose lower carbon dioxide emissions of transport or a bicycle and on foot.

For travelers, low-carbon tourism is emerging forms of tourism, the tourism industry, is a new management philosophy. The essence of low-carbon tourism is a new type of tourist consumption patterns of low-carbon emission intensity, which performance for low power, low emissions, low pollution, high-grade, high experience and high responsibility. Low-carbon travel applies to all classes of travel activities, including the three key points: First, to change existing travel patterns, and promote public transport and hybrid vehicles, electric cars, bicycles and other low-carbon or carbon-free way, but also rich tourist life, increase tourism projects. Second, to reverse the culture of extravagance and wastefulness, and strengthen the clean, convenient, comfortable and functional, enhance the culture of the brand. The third is to strengthen the tourism development of intelligent, Improve operational efficiency, timely and comprehensive introduction of energy saving technology to reduce carbon consumption, and ultimately form the whole industry chain of circular economy mode.

19.3.2 China's Policy on Development of Low-Carbon Tourism

In 2009, China has committed that the emissions of carbon dioxide per unit of GDP in 2020 decreased by 40–45 % of 2005, so there is huge pressure to reduce emissions in the future. Low-carbon in tourism industry will be an important component of China's emission reduction targets. In conformity with the responsibility of the tourism industry on global climate change, Chinese tourism industry must implement the requirements of "Accelerate the changes of economic growth pattern" that put forward by General Secretary Hu jintao. We should Clear the low carbon responsibility of tourism industry, catch the good development opportunities of low carbon tourism, reduce carbon emissions of tourism and energy consumption, So as to promote the realization of the emissions reduction commitment in our country. We will realize the goals of transformation of the tourism industry's development way and the world's leading tourist destinations in the construction, eventually promote the whole society of common prosperity and sustainable development.

At the government level, in December 2009, in the "Views of the State Council on Accelerating the development of tourism" It clearly pointed out the need to "promote energy conservation and environmental protection, the implementation of the tourism saving energy and water reduction projects", which is the first official energy saving requirements for tourist hotels and scenic spots, and provided policy support for the development of China's low-carbon tourism (State Council 2009). Compared to other industries, tourism is known as a "low-pollution industry" reputation, it belongs to the service sector, characteristics of small footprint and selling environment and culture, which is precisely consistent with the emissions-reduction targets.

19.3.3 China's Practical Basis of the Low-Carbon Tourism Development

Although the low-carbon tourism is a new thing in the world and its concept is just understood by the public, but on a practical level, Chinese folk of low-carbon tourism have long been. Development of green tourism resources, construction of the green tourism products, green tourism operators, the implementation of the Green Tourism management and cultivate a green tourism consumption have become the consensus of the industry and market. As early as in 1997, Ping lin scenic spots in Taiwan, which was created as the first low-carbon tourism demonstration area, tried a lot of new efforts in transportation, consulting, tourism, tourist behavior, etc. Mount Emei Scenic Area, as the old "low-carbon scenic spot", is the pioneer of low-carbon tourism practices. By strengthening the digitization project of the Mount Emei scenic monitoring the area of air and water quality, vegetation, to achieve a co-coordinated development of scenic spots, transportation, hotels, dining, entertainment, travel agencies. Moreover, Years ago motor vehicles were prohibited from entering a lot of tourist attractions like Jiuzhaigou, Yuntaishan, Zhangjiajie scenic spots, Hybrid buses and battery cars were used for scenic transportation to reduce carbon emissions. At the beginning of the year 2010, Yanzi Gou scenic area in western part of Si Chuan first introduced the new concept of the "low-carbon travel", in order to reduce greenhouse gas emissions, reduce the burden of virgin forests to absorb carbon emissions, and strive to build the first low-carbon tourism area of western China. All these successful low-carbon tourism practice provided people with the further development of low-carbon tourism experience (Liu 2011).

19.3.4 Analysis of the Problems of Low-Carbon Tourism Development in China

There are still faced with many problems of low-carbon economy‘s further development. First of all, many tourists do not understand the low-carbon tourism, once mention “low-carbon tourism”, the majority of people in the industry are at a loss. Secondly, in the tourism production enterprises, the higher cost of low-carbon technologies will inevitably lead to many companies reluctant to adopt low-carbon development model; third, low-carbon tourism products will also increase tourists’ travel expenses, so the travel agency designed “low-carbon tourism” products are difficult to promote. For example, it is undoubtedly more low-carbon travel that if the tour group to give up taking the bus transfer to the battery car in the scenic, However, the cost of electric vehicles will be apportioned to the tourist, which is bound to be resisted by tourists; In addition, many travelers’ luxurious habits are difficult to change, and for economic benefits, some tourism enterprises will cater to the preferences of these visitors.

19.4 Countermeasures of China’s Low-Carbon Tourism Development

19.4.1 Governments: To Strengthen the Propaganda of the Low-Carbon Tourism

Government departments are the initiation power to promote the low-carbon economy and low carbon travel. By formulating policies and regulations, government plays an exemplary role in guiding and promoting tourism enterprises to actively introduce and use low-carbon technologies. For example, combined with the region’s own resources characteristics, tourism enterprises provide high-quality low-carbon tourism experience for visitors; at the same time, the government departments’ propagandizing tourism enterprises’ low-carbon products can also promote understanding of the tourists on the concept of low-carbon, thereby increasing the possibility of receiving low-carbon tourism products and the subjective will of them. In turn, the change of the tourists’ chooses can also stimulate and promote enthusiasm for tourism enterprises to launch low-carbon products, thus forming a decisive force (Chen and Mo 2011). If low-carbon tourism to be really implemented, It must be timely introduction of low-carbon tourism industry policies and standards by government, which play constraints for all tourism participants, regulate, guide, adjust, and the role of incentives to develop low-carbon travel incentives and a new industry standard.

19.4.2 Enterprise: To Encourage the Development of Low-Carbon Tourism Products

Tourists decided to travel supply, tourists' tends to low-carbon tourism consumption will ultimately lead to a comprehensive design and development of low-carbon travel experience products for tourism enterprises, which contributing to the full realization of the tourism low-carbon.

First of all, with the low-carbon awareness in-depth public mind, the travel agencies should develop and design new low-carbon travel routes, and introduce the concept of carbon consumption in tourists' food, housing, transportation, tours and other elements; to increase low-carbon tourism project design; for example, you can organize volunteer trips, tree planting and travel. Secondly, to construct low-carbon hotel and carbon offsets to these hotels. Construction of the Low-carbon hotel can be divided into the hotel itself, building materials used in low-carbon and low-carbon services (green hotel is one) in the management process, that is the so-called low-carbon of hardware and low-carbon of software. Last but not least, the tourist attractions should adhere to a low-carbon tourism development, as far as possible construct scenic spots with original ecological materials and introduces intelligent devices to improve operational efficiency, reduce energy consumption, in order to form the circular economy model of the whole industry chain.

19.4.3 Tourists: To Promote Low-Carbon Tourism Consumption

Tourists are one of the most important tourist participants, and whose travel wishes, consumer preferences, travel behaviors play important roles in low-carbon tourism. Low-carbon tourism consumption style refers to the tourists to reduce personal travel carbon footprint through a variety of ways and means in the process of tourism consumption. In the same course of traveling, different tourism consumption style will lead to significant differences of personal travel carbon footprint. Low-carbon tourism has attracted the participation of a number of travel enthusiasts began to personally choose it, such as the use of public transport; when they go out as much as possible to take a carpool; take more walking and cycling in tourist destination. There are a variety of methods to realize the low-carbon development in air traffic, such as cuts in hand luggage, reducing the allowance on the plane; Encouraging airlines to provide free bus or rail rewards mileage, instead of free frequent flyer miles, In order to facilitate passenger choose more environmentally friendly public transport. So, through the public efforts to achieve traffic carbon compensation.

19.4.4 Tourist Destinations: Construction of Low-Carbon Tourism Demonstration Area

Relies on low-carbon tourism city and consists of low-carbon tourism area, Low-carbon tourism destination is a kind of tourist destination which fully implement the concept of low-carbon tourism. The development of a tourist destination can not be separated from the tourist city construction, low-carbon tourism destination should be fully implemented the concept of low-carbon from all parts of the planning and construction, the development strategy, market operations and external marketing.

Build low-carbon tourism destination must strictly follow the circular economy and sustainable consumption principles from planning to production. Implementation of "clean production" for tourism products, and "green marketing" for Tourist destination will contribute to create a "low-carbon tourism image" in the entire tourist destination. In particular, tourism community, tourist attractions and tourist city can adopt different measures to promote low-carbon travel. Promoting low-carbon tourism and priority constructing low-carbon tourism development demonstration areas in a number of conditions are suitable areas are strategic choices to achieve tourism development mode transformation (Dong and Yang 2011).

19.5 Conclusions

With the low-carbon technologies become more sophisticated in the field of socio-economic penetration, And low-carbon lifestyle is widely advocated in the whole society, Low-carbon tourism as a new tourism development, will demonstrate its powerful demonstration effect and guiding values. Low-carbon tourism and low-carbon economy is of the same strain, which emphasis minimizing carbon emissions and reducing their carbon footprint in the tourism process. The core of the low-carbon tourism is to reduce carbon dioxide emissions, which leads a harmonious relation between tourism development and natural environment. On the basis of the protection of the natural environment, low-carbon tourism is intended to ensure the sustainable development of health tourism. Therefore, developing low-carbon travel and building a low-carbon tourism destination is a transformation strategy for tourism development mode.

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Chapter 20
A Study of Vehicle Tax Policy Adjustment Based on System Dynamics in the Background of Low-Carbon Transport

Feifei Xie and Xuemei Li

Abstract Vehicle exhaust emission is one of the main factors which cause global warming. Low-carbon transport should be developed without delay to mitigate global warming. This paper discusses the effect of tax policy adjustment on private vehicle ownership, that is, how tax policy adjustment guide private car consumption and uses, as a result to reduce CO_2 emission and promote the development of low-carbon transport. In the paper with system dynamics model, the extent of tax policy adjustment's effect on private vehicle ownership will be simulated. Finally the important role which vehicle tax policy adjustment plays in the achieving low-carbon transport will be found.

Keywords Low-carbon transport · Tax reform · System dynamic

20.1 Introduction

In order to promote the development of low-carbon transport and reduce the CO_2 emission in China, controlling private travel size and reducing car emissions intensity should play their respective roles. From international experience, both in controlling private travel size as well as on reducing private vehicle emissions intensity, tax-fee pricing policies have a significant impact. Therefore this paper focuses on tax policy reforms' effects on private car ownership, that is, study the effect of adjustment of tax and fee on controlling private travel size and reducing private vehicle emissions intensity. Thus tax and fee adjustment of vehicle's impact on achieving low-carbon transport can be explained.

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Due to vehicle tax adjustment is placed in the low-carbon transport system in this paper, and the relationships between variables of urban low-carbon transport are complex and dynamics, general quantitative research methods are not suitable. System Dynamics can not only solve the dynamic, multiple circuits and nonlinear problem, but also find and study the impact factors of relevant extent in the system proceeding from the overall, and solve non-stability system problem under the incomplete information condition (Liu 2010). This paper will apply system dynamics theory and method to study on the private vehicle consumption system in Beijing and simulate the future development trend of private vehicle ownership based on historical data and planning data. On this basis, we will explore the inside influence and effect mechanism of the reform of taxes and fees on the development of private cars in Beijing, provide a decision-making basis for guiding private car consumption to achieve low carbon transport.

20.2 Vehicle Tax Adjustment Model Based on System Dynamics

Here we study the tax adjustment's influence on private vehicle consumption in Beijing. Private vehicle consumption is not only affected by tax adjustments, but by the combined effect of demographic, economic, environmental policy the consumer environment and many other factors as well. In this article after analyzing system structure and all kinds of factors' cause-feedback relationship, we develop a system dynamics model on a private car consumption system in Beijing, and feedback relationships between factors shows in Fig. 20.1. Arrows in the figure represent causal relationships, and positive and negative signs refer to the positive effects or negative effects.

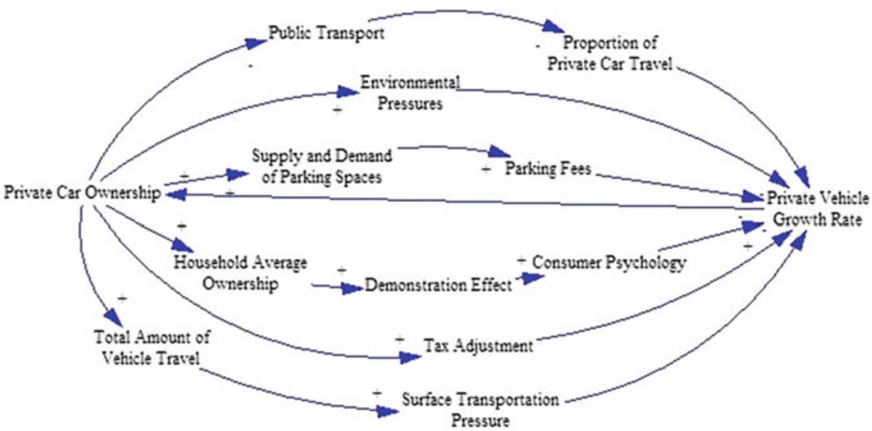


Fig. 20.1 System feedback diagram

20.2.1 Analysis of Causal Feedback

System Causal feedback loops is an effective means of system dynamics approach for constructing system model, and it uses feedback loops to describe dependency relationships among the various factors (Xing et al. 2000).

Taking into account the effect of the adjustment of tax on private car ownership we get loop I: private car ownership → (+) tax adjustment → (−) proportion of private car travel → (−) private vehicle growth rate → (+) private car ownership. The loop is negative feedback. Considering that the government use adjusting the parking cost as an economy means we can get loops II: private car ownership → (−) supply and demand of parking spaces → (+) parking fees → (−) private vehicle growth rate → (+) private car ownership. The loop is negative feedback. Considering ground transport pressure we can set up loops III: private car ownership → (+) total amount of vehicle travel → (+) surface transportation pressure → (−) private vehicle growth rate → (+) private car ownership. The cumulative effect of the loop is negative. Considering the impact of consumer psychological factors on private car ownership, loop IV is established: private car ownership → (+) household average ownership → (+) demonstration effect → (+) consumer psychology → (+) private vehicle growth rate → (+) private car ownership. The loop feedback effect is positive. Considering the effect of environmental factors on private consumption, loop V is established: private car ownership → (+) total amount of vehicle travel → (+) environmental pressures → (−) private vehicle growth rate → (+) private car ownership. The loop feedback is negative. Considering the impact of urban public transport on the development of private cars, we can get loops VI: urban public transport → (−) proportion of private car travel → (+) private vehicle growth rate → (+) private car ownership. The loop feedback also is negative.

20.2.2 System Flow Chart

System flow chart is the organic combination of basic variables and symbols in system dynamics. According to above qualitative analysis, we will establish the SD equation to present the system structure and its feedback mechanism with the DYNAMO language. DYNAMO language uses L, R, A as a description of the type, respectively identifying the state variables, rate variables and auxiliary variables (Zhang and Yu 2010). DYNAMO is split time through system simulation, so each variable has a time subscript and J, K, L represents the past, present and future point in time, JK, KL, said in the past and future sessions.

The system flow diagram is involving many variables and complex relationships with each other, including six loops in Fig. 20.2. Taking account of the per capita disposable income, fuel fees, vehicle purchase price, tax rate and other external economic factors' impact on the demand for private cars, we select the

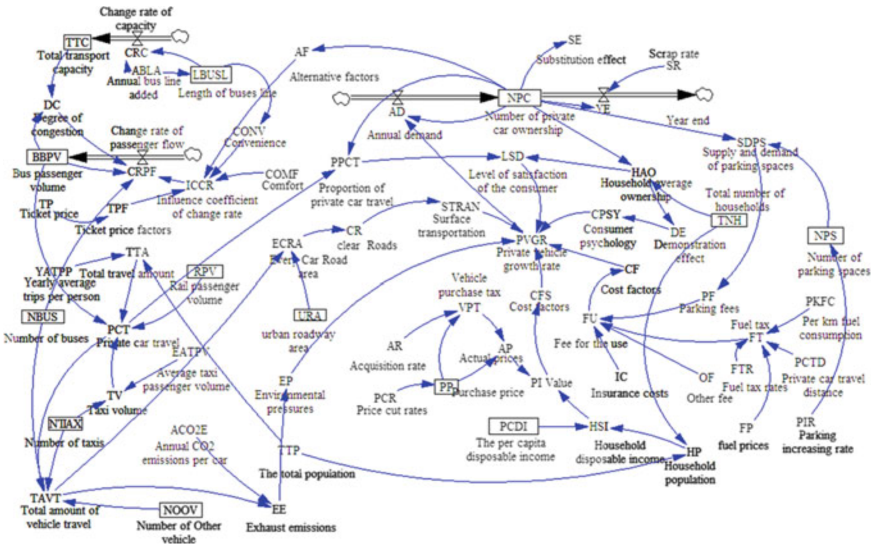


Fig. 20.2 Private vehicle consumption system flow diagram

value of PI(motor vehicle sales price/annual income of households) as Measurable criteria. Feedback loop I contains the main equation as follow one.

$$\text{A FU.K} = \text{IC.K} + \text{PF.K} + \text{OF.K} + \text{FT.K}. \tag{20.1}$$

$$\text{A FT.K} = \text{FTR.K} * \text{PCTD.K} * \text{PKFC.K} * \text{FP.K}. \tag{20.2}$$

$$\text{L PP.K} = \text{PP.J} * (1 - \text{PCR}). \tag{20.3}$$

$$\text{A AP.K} = \text{PP.K} + \text{PP.K} * \text{VPT}. \tag{20.4}$$

$$\text{A PI.K} = \text{AP.K}/\ \text{HSI.K}. \tag{20.5}$$

Control the number of parking spaces and parking fees is one of the important regulation of economic instruments for the consumption of private cars in Beijing, main equation which consists loop II is given below.

$$\text{L NPS.K} = \ \text{NPS.J} + \text{PIR} * \ \text{NPS.J}. \tag{20.6}$$

$$\text{A SDPS.K} = \text{NPC.K} \ / \ \text{NPS.K}. \tag{20.7}$$

$$\text{A PF.K} = 5500 + 2000/\text{SDPS.K}. \tag{20.8}$$

The private vehicle growth rate is mainly decided by economic factors, policy factors, road traffic, rail traffic, use factors, consumer psychology and consumer satisfaction. DT calculates interval time from J to K moment.

Feedback loop III contains main equation as follows.

$$\text{L NPC.K} = \text{NPC.J} + \text{DT} * (\text{AD.JK} - \text{YE.JK}). \tag{20.9}$$

$$\text{R AD.KL} = \text{NPC.K} * \text{PVGR.K}. \tag{20.10}$$

$$\text{R YE.KL} = \text{NPC.K} * \text{SR}. \tag{20.11}$$

$$\text{A PVGR.K} = \text{CF.K} * \text{CFS.K} * \text{CPSY.K} * \text{EEP.K} * \text{LSD.K} * \text{STRAN.K}. \tag{20.12}$$

$$\text{A ECRA.K} = \text{URA.K} / \text{TAVT}. \tag{20.13}$$

Among above equation, the demand growth rate of private cars is decided by fee factors, cost factors, consumer psychology, environmental pressures, consumer satisfaction and ground transportation.

Loop VI displays psychological factors' effect on the consumption of private cars, involving following main equations.

$$\text{A HAO.K} = \text{NPC.K} / \text{TNH}. \tag{20.14}$$

In addition, environmental factors in the environmental pressures module of the private car consumption SD model is reflected by the motor vehicle exhaust emissions. Because of investigation of low carbon transportation system, emissions of pollutants hypothesis CO_2, its column has an effect on environmental protection policy, and the main equation is given below.

$$\text{TTA.K} = \text{YATPP.K} * \text{TTP.K}. \tag{20.15}$$

$$\text{A PCT.K} = \text{TTA.K} - \text{TV.K} - \text{BPV.K} - \text{RPV.K}. \tag{20.16}$$

$$\text{A TAVT.K} = \text{PCT.K} + \text{NBUS.K} + \text{NTEXI.K} + \text{NOOV.K}. \tag{20.17}$$

$$\text{A EE.K} = \text{TAVT.K} * \text{ACEPC}. \tag{20.18}$$

Among above, the buses and taxis are operational nature, travel rate of simple computing is set to 1, bus and taxi travel amount equal to the ownership. With increasing number of bus passenger, public transportation is more and more crowded. As a result, some passengers will chose other modes of transport such as by car. Here bus transport capacity can be partially determined by the length of bus lines which positively correlated with the bus coverage which has a direct impact on the convenience of the public to take the bus. We establish the dynamic equations for loop VI based on historical data as follows.

$$\text{L BPV.K} = \text{BPV.J} + \text{CRPF.JK} * \text{DT}. \tag{20.19}$$

$$\text{L TTC.K} = \text{TTC.J} + \text{CRC.JK} * \text{DT}. \tag{20.20}$$

$$\text{L LBUSL.K} = \text{LBUSL.J} + \text{LBUSL.J} * \text{ABLAR.K}. \tag{20.21}$$

$$R\ CRPF.KL = BPV.K * ICCR.K * (1 - DC.K). \quad (20.22)$$

$$R\ CRC.K = \ ABLAR.K. \quad (20.23)$$

$$A\ DC.K = BPV.K\ /\ TTC.K. \quad (20.24)$$

$$A\ ICCR.K = TPF * COMF * AF * CONV.K. \quad (20.25)$$

$$A\ TPF.K = In(TP.K)/In(TP0.K). \quad (20.26)$$

$$A\ PPCT.K = TAPCT.K/NPC.K. \quad (20.27)$$

20.3 System Simulation

In this paper, system dynamics software Vensim PLE is used to simulate the system and study the effect of the taxes adjustment on Beijing's future consumption of private cars. We set system simulation time from 2003 to 2023 and simulation step for 1 year. The initial values of state variables in the model are determined in accordance with the relevant data of the Beijing Statistical Yearbook and the Beijing traffic Yearbook published. Here, it is assumed that the external environment is not much shock. The value which is on behalf of the rate of change is determined through parameter fitting and regression analysis based on the obtained historical and statistical data. With the help of Eviews, one of the most popular statistical software, we will calculate the growth rate growth rate parameters which show in Table 20.1.

In order to test whether the model can better reflect the true situation, five indicators including private car ownership, number of bus, rail passenger and urban roadway area are selected. Compared between simulation data in 2006 and real data to test the goodness of fit, the results show in Table 20.2. All these errors are less than 5 %, indicating that the analog system and the actual behavior of the system closer, so the model is effective.

Table 20.1 Model parameters

Parameters (growth rate)	Value (%)	Parameters	Value
Urban roadway area	3.7	Fuel tax	1 Yuan/liter
Population	4.7	Average trips per person	2.76 Time/person
The per capita disposable income	6.2	Insurance costs	950 Yuan/vehicle
Total number of households	2.1	Acquisition rate	10 %
Number of parking spaces	9.1	Scrap rate	6.7 %
Bus	3.6		
Taxi	0.9		
Other vehicle	1.2		
Length of bus line	2.2		

Table 20.2 Test of model results

Item	Actual value	Analog value	Absolute error (%)
Private car ownership	3002748	303.718	1.15
Number of bus	21716	21178.7	2.47
Rail passenger	142268	138284	2.80
Urban roadway area	9179	9133.32	4.98

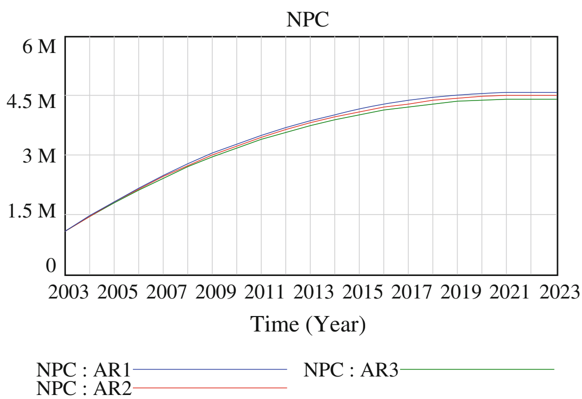
(1) The effect of acquisition tax on private car ownership

Vehicle acquisition tax is an important economic lever to guide private car payment. Figure 20.3 shows the sensitivity analysis of the effect of the acquisition tax on the ownership of private cars. Due to the tax burden is quite heavy in the stage of purchase in China, acquisition tax is not suitable for blindly increasing (Zhang and Liu 2009). Here, only a theoretical analysis of the impact of the acquisition tax adjustment on private car ownership. In fact, the space in increasing acquisition rate is very small, the AR1 here on behalf of the purchase tax rate of 10 %, AR2 on behalf of the purchase tax rate of 12 % and AR3 on behalf of the purchase tax rate of 14 %. It can be seen from the figure, with the increase of the acquisition tax rates, the growth of private car ownership will be suppressed.

(2) The effect of fuel tax on private car ownership

Fuel tax was introduced in early 2009, it adopted quantitative collection. At the same time car tolls and other five charges have been cancelled (Liu 2007). But there is still a lot of room to improve the adjustment function of fuel tax. Figure 20.4 shows the sensitivity analysis of the effect of the fuel tax on the ownership of private cars. FTP1, FTP2 and FTP3 respectively represent the initial state of charge 1, 2 and 3 Yuan fuel tax per liter of petrol. We can see from the figure that with the fuel tax increasing, the growth of private car ownership has been inhibited.

Fig. 20.3 Private vehicle consumption system



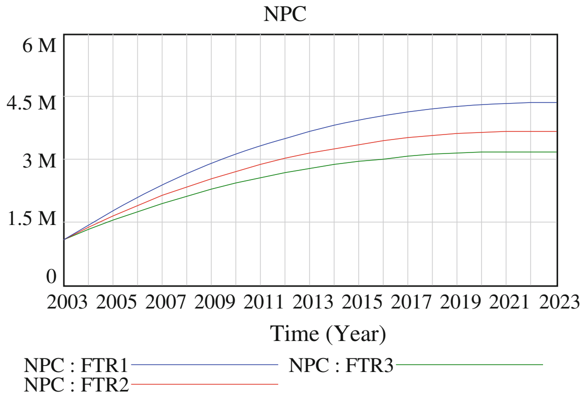


Fig. 20.4 The effect of fuel tax on private car flow diagram ownership

20.4 Conclusions and Recommendations

In summary, the implementation of tax policy adjustments can promote to effectively control the ownership of private cars, make private car consumption achieve a healthy and orderly development. Reasonable tax policy reform, through the reduction of private car travel behavior and control the consumption of private cars, can fully play a function of guiding. Tax and fee reform will guide rational decision-making on the private car consumption. As a result, it reaches its purpose to control the number of road passengers, alleviate traffic congestion, reduce greenhouse gas pollution, and realize the ultimate goal to achieve low-carbon transport.

In this paper, with the help of system dynamics modeling, model of private cars' consumers in transport system is built, and purchase tax and fuel tax adjustment is simulated, then the simulation results strongly suggest that the reform of the tax and fee can promote rationalization of the consumption of private car. However, due to the limit study level of the author, the equation involved in the simulation system is not scientific enough, and further research needs to be rationalization.

In short, considering from the perspective of regulating automobile consumption and energy savings, the relevant departments can try to further improve the ratio of the fuel tax and reduce the toll fees, both to ensure that the local fiscal revenue, and can more effectively reflect the guiding role of the tax on automobile consumption. Automobile tax system should be introduced to more of the criteria in China. For example, it is irrational to decide the consumption tax rate only by displacement, because there are many factors that affect vehicle fuel consumption and emissions. Although there are quite a lot of difficulties in exactly considering these factors, at present it is unfair to develop the related tax policy only by displacement. For the travel tax, in order to play its regulation of automobile consumption's role, the introduction of the existing international tax system may have reference value. So the taxes and fees can be charged by the engine power, cylinder capacity and fuel consumption to greenhouse gas emissions as representative to calculate. In Austria, the travel tax is based on engine power and press the annual payment (Kloessn and Müller 2011). Furthermore, the frequency of use of the vehicle can also be considered, that is, considering the mileage to determine the payable amount. However, these adjustments will greatly increase the cost of collection, so a number of integrated factors are needed to comprehensive study. At the same time, the government can provide the preferential tax policies for the advanced automotive technology thus maximize the function of the tax and fee adjustments as economic levers to achieve low-carbon transport.

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Chapter 21
Economic Evaluation of Energy Saving and Emission Reduction for ETC

Jia-hua Gan, Xiao-ming Zhang and Ze-bin Huang

Abstract We make economic evaluation for ETC energy saving and emission reduction, Firstly, we analysis the mechanism of ETC energy saving and emission reduction. Secondly, we built an index system to evaluate the effect of ETC energy saving and emission reduction. Finally, we verify the feasibility of the evaluation indexes and evaluation methods proposed in this paper through studying atoll station which using ETC.

Keywords: ETC · Energy saving · Economic evaluation · Cost-benefit analysis

21.1 Introduction

ETC can achieve automatic toll collection through e-cards or electronic tags, and it can make all ground transportation achieve automatic toll collection not need parking. Up to March 2012, 26 cities of China have been included in pilot cities of low-carbon transport system. One of major tasks is to construct ETC project, while how to assess its effectiveness and to provide support for future decision makes great difference.

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21.2 The Mechanism of ETC Energy Saving

There are two main charge methods for highway in China, MTC & ETC. MTC requires the vehicle to complete deceleration, idle queue, payment, and accelerating, but vehicles using ETC lanes do not need to slow down and stop, and complete the automatic payment at a faster speed, thereby reducing emissions to achieve energy saving and emission reduction (Cai 2005). According to domestic study, ordinary vehicles which using ETC lanes will emission less NO_x by 16.4 %, HC by 71.2 %, CO by 71.3 %, CO_2 by 48.9 % than using MTC lanes (Gao et al. 2009).

21.3 Evaluation Index System

According to principle of scientific, objective, operability and contradistinctive, we established evaluation model.

The input of ETC consists of 3 main parts, which are construction funds, operation and maintenance input, and user's equipment investment. According to the analysis of the mechanism of ETC in energy saving and emission reduction, the main consideration time saving, energy saving and tail gas emission output.

Based on the above analysis, the establishment of ETC on energy saving and emission reduction economic evaluation index system, shown in the Table 21.1.

21.4 Evaluation Method and Calculation

This paper uses the cost benefit analysis method to evaluate energy conservation and emissions reduction on ETC, with the net present value approach to discrimination (Zavergiu 1996).

Table 21.1 The ETC and MTC average emission factors

First class index	Second class index	Third class index
Input index	Construction fund expenses	Development costs
		Hardware cost
		Software costs
		Installation fee
	Operation maintenance cost	Staff salary expenses
		Equipment maintenance cost
	The user equipment cost	Hand-held devices cost
Output index	Time saving benefit	Save the goods in transit time benefit
		Save passenger travel time benefit
	Save energy efficiency	Fuel consumption saving benefit
	Gas emission reduction benefits	Reducing NO_x, HC, CO, reduce CO_2 emissions benefits

Investment cost computation formula is as follows:

$$C_t = C_{at} + C_{bt} + C_{ct}. \tag{21.1}$$

In formula: C_t—the first t years total cost of ETC, Units: yuan; C_{at}—the first t years construction investment cost, Units: yuan; C_{bt}—the first t years operation maintenance into total cost, Units: yuan; C_{ct}—the first t years users equipment investment total cost, Units: yuan.

Passengers save time output can be measured by GDP, computation formula is as follows:

$$B_{Ct} = \sum_{j=1}^{3} Q_{Cj} W_j I_C \frac{TS}{3600} P \tag{21.2}$$

In formula: B_{ct}—Passengers traveling time output value of saving, Units: yuan/h; Q_{cj}—The first j kind of bus volume of traffic in per hour, Units: car/h; W_j—The first j kind of bus take Passenger in average, Units: people/vehicles; I_c—Each passenger every hour of national income per capita, Units: yuan/people; P—transit passenger who can create value accounts for a percentage. Units: %; TS—After ETC implementation unit vehicle average save time, Units: s.

Save energy consumption with the economic output is due to the speed of travel, the number of parking and parking time reduced the energy consumption bring the economic benefit.

$$B_{Ot} = QFP_y \tag{21.3}$$

In formula: B_{ot}—Energy consumption saving of the benefits, yuan; Q—the traffic number witch Use ETC, car; F—Unit of energy saving is an average vehicle, L/car; P_y—Energy consumption saving of the benefits, yuan/h.

Exhaust emission reduction efficiency computation formula is as follows:

$$B_{Qt} = \sum_{\mathrm{i}=1}^{4} [\mathrm{Q} \cdot (E_1 - E_2) \cdot H] \mathrm{d}_i \tag{21.4}$$

In formula: B_{Qt}—The total profit of greenhouse gas emissions, yuan; Q—Traffic flow, Car/unit time; E1—The greenhouse gases average emission factor before ETC implement, g/km; E2—The greenhouse gases average emission factor after ETC implement, g/km; H—The influence of length by ETC, km; d_i—The first i kind of greenhouse gas average prices, yuan/t.

21.5 Analysis of Cases

There is a Superhighway Toll Station located in the uncrossed position between Xian yang Airport Expressway and the 3rd Ring Road. It leads to the airport and the adjacent provinces and has made 40,000 cars driving daily, as a part of main superhighway in China, no-waiting toll collection system was brought in 2011.

21.5.1 Input Costs Analysis

Construction cost of an ETC lane is about 500,000. The wage costs, equipment replacement cost and software upgrades cost account for 20 % of the project construction cost. The overhaul costs account for 25 % of the investment in fixed assets, which is 250,000. The social discount rate is 8 %. If there is not construction cost, the conversion coefficient of other costs is 1.0. Moreover, it is assumed that the residual value of the no-waiting toll collection system is 0.

21.5.2 Output-Benefit Analysis

The future traffic volume of the toll station and ETC lanes are shown in Table 21.2 (Zhang et al. 2001).

21.5.2.1 Efficiency Savings

We can assume that the average volume of small passenger cars is 2.69 people/vehicles, and the average volume of bus is 21.38 people/vehicles (Jun 2008). Time—saving benefit can be estimated based on the above data and formulas 3.2.

21.5.2.2 Energy Saving Benefits

According to general vehicle fuel consumption, every 3 min idle oil consumption equal to the oil consumption of 1 km uniform speed, and the idle oil consumption of every second is 0.0004 L (Xiang 2001). Then we can get the fuel consumption in Table 21.3 (Zhou 2011).

Table 21.2 Toll station traffic and ETC number of transactions in future

Year	Veh/day			Veh/H					Rate (%)
				Entrance		Exit		Total	
	Entrance	Exit	Total	Car	Bus	Car	Bus		
2012	19,700	20,400	40,100	860	300	880	310	2,350	5.9
2013	21,276	22,032	43,308	1,050	366	1,074	378	2,868	6.6
2014	22,978	23,795	46,773	1,281	447	1,311	462	3,500	7.5
2015	24,816	25,698	50,514	1,563	545	1,600	563	4,271	8.5
2016	26,802	27,754	54,556	1,908	665	1,952	688	5,213	9.6
2017	28,946	29,974	58,920	2,328	812	2,382	839	6,362	10.8
2018	31,261	32,372	63,634	2,841	991	2,907	1,024	7,764	12.2
2019	33,762	34,962	68,724	3,467	1,210	3,548	1,250	9,475	13.8
2020	36,463	37,759	74,222	4,232	1,476	4,330	1,525	11,563	15.6
2021	39,380	40,780	80,160	5,164	1,802	5,284	1,862	14,112	17.6

Average price of gasoline in 2012 is 7.74 yuan per liter and according to formula (3), it can be calculated energy saving efficiency in the future years, as shown in Table 21.4.

21.5.2.3 Emission Reduction Benefits

Emission of NO_X, HC, CO, CO_2 are as shown in Table 21.5.

According to formula 4.4, an entrance ETC lane can reduce CO_2 emission 26.07 tons, an export ETC lane can reduce CO_2 emission 26.9 tons, and the trading price of CO_2 emission takes 8 euro per ton (about 65.79 yuan), the future ten years CO_2 emission reduction benefits as shown in Table 21.6.

21.5.3 Results of Analysis for Economic Evaluation

21.5.3.1 The Cost Flow Table for National Economic Benefit

Cost flow table for National Economic Benefit showed in Table 21.7.

Based on above analysis of results, IRR is 22.06 %, greater than Social benchmark rate of 8 %. The Net present value (the social discount rate is 8 %) is 2346.5 thousands. So using ETC will bring good effect on energy saving and emission reduction.

21.5.3.2 Sensitivity Analysis

The variation of IRR is showed in Table 21.8, given the increased input of the construction cost by 10 % and the decreased benefit by 10 %.

Table 21.3 The average fuel consumption contrast table of general vehicle

Vehicle lane		Deceleration fuel consumption	Waiting oil consumption	Service oil consumption	Leave fuel consumption	Total
ETC		0.0056	0	0.0012	0.0112	0.0180
MTC	Entrance	0.0063	0.0072	0.0024	0.0126	0.0285
	Export	0.0063	0.0168	0.0056	0.0126	0.0413

Table 21.4 Energy saving efficiency (10 thousand yuan)

Year	Energy saving benefits	Year	Energy saving benefits
2012	14.9986	2017	40.6033
2013	18.3043	2018	49.5523
2014	22.3386	2019	60.4736
2015	27.2620	2020	73.8020
2016	33.2705	2021	90.0680

Table 21.5 The average emission factor of MTC and ETC

Type	NO_x (g/km)	HC (g/km)	CO (g/km)	CO_2 (g/km)
ETC	0.61	0.16	6.04	148.2
MTC	0.73	0.56	21.06	289.9
Emission reduction	0.12	0.4	15.02	141.7
Emission reduction percentage	16.40 %	71.20 %	71.30 %	48.90 %

Table 21.6 CO_2 emission reduction benefits (10 thousand yuan)

Year	Emission reduction benefits	Year	Emission reduction benefits
2012	0.3485	2017	0.9435
2013	0.4253	2018	1.1514
2014	0.5191	2019	1.4052
2015	0.6335	2020	1.7149
2016	0.7731	2021	2.0929

Table 21.7 The cost flow table for National Economic Benefit (Ten thousands yuan)

Year	Cost flow	Benefits flow	Net benefits flow	Discounted value of net benefits	Accumulative value of NPV
2011	100	0	−100	−100	−100
2012	20	28.5674	8.5674	7.9328	−92.0672
2013	20	34.8637	14.8637	12.7432	−79.324
2014	20	42.5477	22.5477	17.8991	−61.4249
2015	45	51.9252	6.9252	5.0902	−56.3347
2016	20	63.3694	43.3694	29.5165	−26.8182
2017	20	77.336	57.336	36.1314	9.3132
2018	20	94.3809	74.3809	43.4005	52.7137
2019	20	115.1824	95.1824	51.4241	104.1378
2020	20	140.5686	120.5686	60.3143	164.4521
2021	20	171.55	151.55	70.1970	234.6491
IRR	22.06 %	NPV 234.65	BCR	1.93	Payback period 6.7 years

In the most unfavorable case, IRR is 17.8, greater than social discount rate 8 %. The project has a strong ability to resist economic risk. So using ETC in this toll station is feasible, and it will bring good effect on energy saving and emission reduction.

Table 21.8 Sensitivity analysis for National Economy

IRR (%)		Utilization rate for ETC		
		0 %	−5 %	−10 %
Cost change	0	22.06	20.93	19.78
	5	20.99	19.89	18.75
	10	19.99	18.91	17.80

21.6 Conclusion

We studied the mechanism of ETC energy saving and emission reduction in this paper. Then we built an index system to evaluate the effects of ETC energy saving and emission reduction, we also discoursed the meaning and the calculation method of these index in ETC. Finally, we verify the feasibility of the evaluation indexes and evaluation methods proposed in this paper through studying a toll station which using ETC project.

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Chapter 22
Model Calculating on Integrated Traffic Energy Consumption and Carbon Emissions in Beijing

Ying-yue Hu, Feng Chen, Wei-ming Shen and Qi-bing Wu

Abstract Based on the characteristics of Beijing traffic system, a model is built to calculate the energy consumption of urban road and rail transit and emissions of green house gas and their total amounts are calculated. At the same time, the comparison and analysis have been done to the energy consumption per capita per km and carbon dioxide emissions of different transportation means such as rail transit, public electric cars and social cars and so on.

Keywords Urban traffic · Carbon emissions · Mathematical modeling · Greenhouse gases · Low-carbon transport

22.1 Preface

With the global economic and motor vehicle ownership grew fast, traffic travel has become an important source of carbon dioxide emissions in the city. Energy consumptions per mileage for all kinds of transport modes change a lot, it is urgent

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to find a valid calculating method to compare the real carbon emission values of different modes. Conclusion of this paper can be used to provide decision-making for achieving a low-carbon transport and green-travelling goal for the relevant transport departments.

22.2 Models of Traffic Energy Consumption and Carbon Emissions in Beijing

22.2.1 Models of Traffic Energy Consumption

Models of urban road energy consumption. Energy consumption models of different vehicle types in Beijing are build by the classification according to the applying character, the energy difference and so on. ε, the standard coal conversion coefficient, is introduced to convert all energy consumption into standard coal for unified calculation, which can make a comparative analysis among all of them together. The specific calculation model as follows, Eqs. 22.1 and 22.2.

$$E_r = \Sigma\, E_i \tag{22.1}$$

$$E_i = \begin{cases} Q_{\text{truck}} \times e_{\text{truck0}} \times \varepsilon_{\text{diesel oil}} & (\text{Ifi is truck}) \\ N_i \times S_{i0} \times e_{i0} \times \varepsilon_{\text{k}} & (\text{If i is coach}) \\ e_{\text{road lighting}} \times \varepsilon_{\text{electric energy}} & (\text{If i is road lighting system}) \end{cases} \tag{22.2}$$

E_r is the total energy consumption; E_i is the energy consumption of the Beijing type i vehicle; Q_{truck} is the cargo turnover (in t · km); e_{truck0} is the the lorry average energy consumption intensity (in L/tkm); $\varepsilon_{\text{diesel oil}}$ is the standard coal conversion coefficient of diesel oil; N_i is the ownership of the type i vehicle (in vehicles); S_{i0} is the annual average mileage per car of the type i vehicle (in km); e_{i0} is the energy consumption per kilometer of the type i vehicle (in L, kg or kwh/100 km); ε_k is the standard coal conversion coefficient of each energy; $e_{\text{road lighting}}$ is the electric energy consumption of the urban road lighting system.

Models of urban rail transit energy consumption. The establishment of the energy consumption model as follow.

$$\mathrm{E_s} = \sum_{\mathrm{k}}^{\mathrm{n}} \mathrm{E_{k\ vehicle}} + \sum_{\mathrm{k}}^{\mathrm{n}} \mathrm{E_{k\ station}} \tag{22.3}$$

$E_{kvehicle}$ and $E_{kstation}$ is the total vehicle and station energy consumption of the rail transit line k (million kwh).

22.2.2 Models of Carbon Emissions

Have a classification of the traffic energy consumption in accordance with diesel, gasoline, compressed natural gas (CNG) and carbon emissions models of different energy are set as Eq. 22.4. There is no greenhouse gases emissions using electricity, but a lot of greenhouse gases are generated within the source of the process. The model of upper reaches carbon dioxide emissions need to be constructed as Eq. 22.5.

$$M_x = E_x \times m_x \tag{22.4}$$

E_x and m_x is the consumption and carbon dioxide of energy x. (Note: diesel oil, gasoline emissions parameters directly from the IPCC (2006), the CNG emission parameters obtained through the equivalence relation between the carbon dioxide emission factor (Hao et al. 2009) of CNG buses and the energy consumption per unit distance).

$$M_e = E_e \times \zeta \times \psi \tag{22.5}$$

E_{e} is the traffic electricity consumption (kwh). ζ is the percentage of the national thermal power in the total generating capacity (China Electricity Council 2011). ψ is the carbon dioxide emission coefficient (Ma 2002) within the thermal power production process. The basic parameter values of all the modes can be seen in Table 22.1; the urban rail transit energy consumption shows in Table 22.2. Combined with the parameters of carbon emissions model in Table 22.3, carbon emissions of each energy can be obtained.

22.3 Estimation of Beijing Traffic Energy Consumption and Carbon Emissions

22.3.1 Models of Carbon Emissions

Estimation results of road traffic energy consumption. Access to the road lighting energy consumption from the Beijing Statistical Yearbook, and based on the established road transport energy consumption model, different cars in Beijing, such as social cars, public buses, taxis, trucks and other models as well as the road lighting energy consumption has been estimates, shown in Table 22.4. Seen from the results, social car's energy consumption is much higher than other models.

Estimation results of rail transit energy consumption. Based on the total energy consumption of vehicles and stations of the Beijing urban rail transit lines operating in 2009, urban rail transit gross energy consumption of Beijing can be seen in Table 22.5.

Table 22.1 Basic parameter values of the inertial model of energy consumption of urban road vehicles

Vehicle types	Fuel types	Freight turnover quantity in 2009	Average energy intensity	Consumption	Density	Standard coal conversion coefficient
Truck	Diesel oil	8788.87 million t · km	0.11 L/t · km		0.86 kg/L	1.46 kgce/kg
Bus	–	Operator number in 2009 (vehicles)	Annual average mileage per car	Energy loss per kilometer	Density	Standard coal conversion coefficient
	Diesel oil	15,908	6,740 thousand km	40.12 L/100 km	0.86 kg/L	1.46 kgce/kg
	Electricity	1,717	6,740 thousand km	0.96 kWh/km	——	0.13 kgce/kwh
	Natural gas	3,837	6,740 thousand km	35 kg/100 km	0.714 kg/m^3	1.21 kgce/m^3
Taxi	Gasoline	66,646	11,730 thousand km	7.58 L/100 km	0.73 kg/L	1.47 kgce/kg
Social car	Gasoline	310,340 thousand	1,530 thousand km	7.76 L/100 km	0.73 kg/L	1.47 kgce/kg

Table 22.2 Basic parameter values of the inertial model of energy consumption of urban rail transit (million kwh)

Operating lines	Line 1	Line 2	Line 5	Line 10	Line 8	Line Batong	Line 13	Line 4	Airport line
Station energy	51.82	30.05	55.56	55.49	11.21	9.49	15.92	10.12	18.49
Vehicle energy	74.12	52.05	59.09	39.25	5.25	23.47	49.12	13.63	

Table 22.3 Basic parameter values for the calculate of the model of the carbon emissions generated by various types of energy consumption

Energy types	Diesel oil	Gasoline	Natural gas	Electricity
Carbon dioxide emissions coefficient	2.73 kg/L	2.26 kg/L	3.07 kg/kg	1.019 kg/kwh

In summary, traffic energy consumption has been classified and counted by diesel oil, gasoline, compressed natural gas, electricity, combined with the standard coal conversion coefficient (GB/T 2589-2008 2008) of each energy, the sum traffic energy consumption of Beijing in 2009 is 6.56 million tons of standard coal, shown in Table 22.6.

22.3.2 Estimation of Traffic Carbon Emissions

According to the energy consumption statistics in Table 22.6, combined with the carbon emission coefficient, carbon emissions generated from the energy consumption have been estimated respectively. It's calculated that the total amount of carbon dioxide from Beijing traffic in 2009 is 14.54 billion kg, shown in Table 22.7.

22.4 Comparison of All Kinds of Transportation

Total energy consumption are translated into standard coal quality by various modes of transport, then the contrast of the energy consumption of a variety of traffic traveling can be facilitated. Per capita energy consumption and CO_2 emissions can be calculated and comparatively analysis by combining with the annual passenger traffic of all kinds of transportation as well as the average trip distance. Seen in Tables 22.8 and 22.9.

According to the above tables, rail transit is the most energy-efficient and lowest emissions transportation models to travel. While the energy consumption required of per person per kilometer by taking the social cars is approximately 17 times of by

Table 22.4 Urban road traffic energy consumption of Beijing in 2009

Models	Social car	Bus			Taxi	Truck	Road lighting
Fuel	Gasoline	Diesel oil	CNG	Electricity	Gasoline	Diesel oil	Electricity
Energy consumption	3.69 billion L	0.43 billion L	0.09 billion kg	0.11 billion kwh	0.59 billion L	0.95 billion L	0.30 billion kwh

Table 22.5 Urban rail transit gross energy consumption of Beijing in 2009

Operating lines	Line 1	Line 2	Line 5	Line 10	Olympic line 8	Line Batong	Line 13	Line 4	Airport line	Total
Total energy (million kwh)	125.94	82.10	114.65	94.74	16.46	32.96	65.04	23.75	18.49	555.64

Table 22.6 Traffic energy consumption of Beijing in 2009

Fuel types	Diesel oil	CNG	Gasoline	Electricity
Total energy consumption	1.38 billion L	0.09 billion kg	4.29 billion L	0.97 billion kwh
Standard coal mss	1.73 million tce	0.15 million tce	4.57 million tce	0.12 million tce
Percentage	26.31	2.21	69.66	1.82

Table 22.7 Traffic carbon emissions of Beijing in 2009

Fuel types	Diesel oil	CNG	Gasoline	Electricity	Total
Carbon emissions	3.76 billion kg	0.28 billion kg	9.69 billion kg	0.81 billion kg	14.54 billion kg

Table 22.8 Calculating parameter (per capita travel) of all kinds of transportation of Beijing in 2009

2009	Total energy consumption (million tce)	Carbon emission (million t)	Passenger flow volume (million passengers)	Per capita trip distance (km)
Public bus	0.74	1.55	3861.80	7.27
Social car	3.94	8.35	3409.10	10.78
Taxi	0.63	1.35	948.74	10.78
Rail transit	0.07	0.46	1422.68	7.73

Table 22.9 Energy consumption and carbon emissions per capita of all kinds of transportation of Beijing in 2009

2009	Energy consumption of per person (gce/per person)	Carbon emission of per person (g/per person)	Energy consumption of per person km (gce/per person km)	Carbon emission of per person km (g/per person km)
Public bus	190.74	400.15	26.24	55.04
Social car	1155.29	2448.21	107.17	227.11
Taxi	666.25	1421.35	61.80	131.85
Rail transit	48.01	325.79	6.21	42.15

taking rail transport, the public electric buses is 4 times and the taxis is 10 times. Meanwhile, the carbon emissions of that are 5, 1.3 and 3 times respectively.

22.5 Conclusion

In this paper, the Beijing traffic characteristics model of energy consumption and carbon emissions is built, and the total transport energy consumption in 2009 was 6.57 million tons of standard coal, the energy consumption of bus, social cars, taxis, rail transportation were respectively 0.74, 3.94, 0.63 and 0.07 million tons of standard coal; the total amount of CO_2 generated by Beijing traffic in 2009 was 14.53 million tons, the carbon emissions of bus, social cars, taxis, rail transportation were respectively 1.54, 8.35, 1.35 and 0.46 million tons. The per capita energy consumption and the per capita carbon emissions of social cars is the highest by comparison of all kinds of transportation, were respectively 107.17 g/km of standard coal and 227.11 g/km of standard coal; while the per capita energy consumption and the per capita carbon emissions of rail transport is the lowest, were only 6.21 g/km of standard coal and 42.15 g/km of standard coal; while the carbon emissions of ordinary energy (such as gasoline, diesel) is higher than new energy (such as electricity, CNG).

With the expansion of the city, residents travel distance is increasing, the mechanization has become an inevitable trend, how to establish the dominant position of public transport and how to strengthen demand for cars controlling management is the key to the development of low carbon transport. The implementation of low carbon transport needs to promote from aspects of vehicles, energy technology and environment, the efficiency of traffic needs to be improved, new energy of low carbon transport needs to be developed, the travel environment and public transport infrastructure need to be improved, then various travel modes can be linked up and low carbon transportation of city comes true.

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Chapter 23
Evaluation Indexes of Public Bicycle System

Yue Ma and Xiao-ning Zhu

Abstract With the concept of green traffic given public traffic get more and more attention from the people, through the survey data of the public bicycle rental of Jiangyin city it analyzes simply the characteristics of bicycles, and chooses some indexes of the public system to evaluate, such as for the whole system the indexes are analyzed by quantitative and weight quantitative, for the facilities of system consider the indexes from the utilization and the accessibility.

Keywords Traffic planning · Public bicycle system · Evaluation indexes

23.1 Introduction

The fast development of economy makes the traffic not follow its step. With the concept of green traffic given the public traffic draws more attention, bicycle because of its zero consumption, no pollution and other characteristics becomes the aid of public traffic. It helps to improve the traffic condition and reduce the pollution and energy. Bicycle system can make up the weakness of public traffic, gather and evacuate the passengers. Short distance travel takes up large proportion in medium and small cities, which creates favorable conditions for the development of slow traffic.

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Public bicycle system (PBS) is that company/organization or two together cooperate and set lease points in some areas, such as large residential areas, commercial centers, transport junctions, tourist attractions and other people flow more intensive areas. The system provides bicycles for travelling during a certain time, and charges some fees according to the length of time. Meanwhile the system taking the related service management system and the corresponding network construction as the carrier provides the bicycle travel service for people (Gong and Zhu 2008).

23.1.1 The Advantages of Public Bicycle System

Public bicycle system as transport microcirculation to solve last mile based on the concept of "who use who borrow, publicly use". Public bicycle system has the following advantages. It is zero energy and green traffic providing convenient transport for residents and tourists. It is the trend of urban bicycle in the future. The system reflects the people-oriented sprit without time and line limited. Evacuate the passenger flow easily and efficiently. Pay more attention on the relationship between people and nature using sustainable traffic technology and concept. It has the characters of flexible operation, high accessibility and low investment. Advocate going travel by bicycle frequently due to bicycle occupying less land. It can improve the utilization ratio of road resource and ease road congestion. Widely use the information technology. Public bicycle system is the combination of high technology and traditional manufacture. It makes the traffic facilities more efficient and reasonable, which promotes the rapid development of city (Han et al. 2009).

23.1.2 The Problems Existed in the PBS

The reason of people abandoning using the bicycle is that the bicycles lack of parking garages, but the public bicycle that can solve the trouble of residents improves bicycle travelling proportion. After a period of time the public bicycle has many problems, and the main problem is that the setting scale and position cannot match with the service ability.

The locations of lease points are unreasonable. The locations generally focus on scenic and recreational areas, but in residential and public areas there are less. The way of renting or returning the bicycle is not convenient. The procedure is to be simplified. Short of bicycles' equipment, the number of bicycles is less. The speed of deployment cannot be guaranteed, so that the customers always need to wait a long time, even quit the plan to rent the bicycle. The size of bicycles should consider the difference of customers in height, sex and the people with children. Instruction should be with bilingual signs for foreigners. Propaganda and instruction both contribute to the utilization of bicycles.

23.2 The Characteristics of Bicycle Travel

Bicycle traffic is limited by terrain and climate environment greatly, and due to no protective equipment people directly are affected by environment. So in cold winter bicycle traffic may be largely limited. The distance, time and speed of bicycles are related with the people's strength and physique. Bicycle is not suitable for long distance and time trip (Lai 2007; Liang 2007). Through the survey of travel in JiangYin city analyze the data and understand more about the residents travel characters.

JiangYin whose construction planning "double speed" system—expressway and BRT, total area is about 988 km^2, coordinates the regional transport, makes sure the strategy of traffic development and promotes the development of integrated traffic. According to the survey of residents travel in 2003, travel intensity is 3.05 times. However the result of 2007 is 3.00. With the expansion of urban framework, the travel intensity reduces little, while due to the population increasing traffic demand will increase quickly (Fig. 23.1).

According to the result of survey and the situation of PBS, travel time within 30 min account for 57 %, and the corresponding travel distance is 6 km. PBS is to assist the public traffic system, it benefits travelling. Because the travel purposes are different, the requirements of traffic service are different. Such as time is important for work, while comfort for tourism. Generally speaking, in the center of city, due to the place limited in the work place and school the utilization ratio of car is low, but the public traffic is high. Time is one of the most important factors for the transport means, from origin to the destination there are various transport means, their travel time affects the choice of transports.

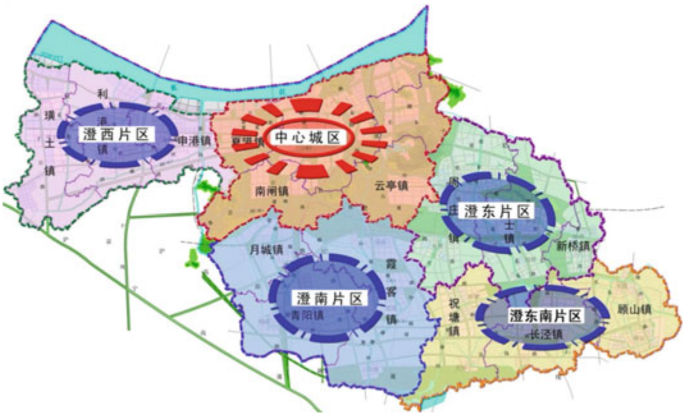


Fig. 23.1 Jiangyin group distribution

23.2.1 Travel Time and Distance

According to the survey statistics in central district bicycle travel time within 15 min takes up 18 %, 15–30 min is 39 %, 30 min–1 h is 26 %, more than 1 h is 17 %. The bicycle travel time within 30 min takes up 57 %, while within 1 h is 83 %. In Jiangyin city bicycle travel distance is within 12 km (Figs. 23.2, 23.3).

23.2.2 Characteristics on Rental One Day

Normally PBS has two peaks, namely the morning peak and evening peak. According to the statistics of implementation of PBS one week, we can see that it has three peaks. The first is the time to go to work (7:00–8:00). The second is the time after work (17:00–18:00), what is more the ratio of evening peak is higher than the morning. Besides that there is another peak (11:00–12:00), during which people maybe go out for dinner. At night rental still continues, but the rental ratio drops gradually until to 1 % during the time of 21:00 and 22:00 (Fig. 23.4).

23.2.3 Weekdays and Weekends

In weekdays there are three peaks in the chart. By contrast the weekends only have two peaks, the morning peak from 9:00 to 12:00 and the evening peak from 16:00 to 17:00. The reason of the difference between weekdays and weekends mostly is that on weekends people go out without working time limited. So the ratio is similar. What is more, the ratio of weekends is lower than weekdays'. Totally speaking the ratio of weekends is more balanced, unliking the weekdays having obvious changes. On weekends 5:00–6:00 (people going out to buy food for one week), 13:00–14:00 (some going out for dinner) and 19:00–20:00 (leisure time after dinner or returning home) all have a small peak (Figs. 23.5, 23.6).

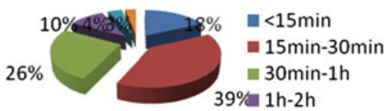


Fig. 23.2 Traffic time

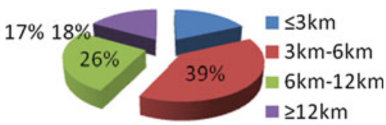


Fig. 23.3 Traffic distance

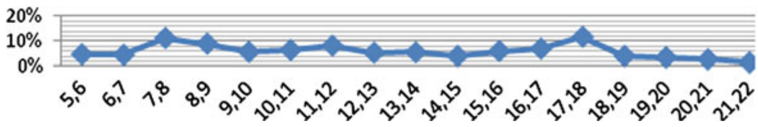


Fig. 23.4 Rental proportion at each hour one day

Fig. 23.5 Rental proportion in weekdays

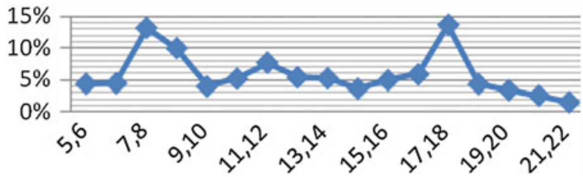
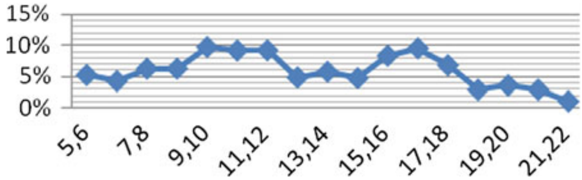


Fig. 23.6 Rental proportion at weekends



23.2.4 Rental Times

Choosing 20 lease points to analyze the ratio of rental and return bicycles, in the chart the ratio of points 1–6 and points 19, 20 are all higher and balanced. We can see that the positions and the functions are more important for the ratio. For example, the function of points 19 and 20 is commuting, where people have many changes in the aspects of living, working, studying and so on because of the emergence of PBS (Table 23.1, Fig. 23.7).

According to the difference of lease points' function choose three typical lease points to analyze. Three lease points are HuaDi department in the central section of downtown, government in the commercial district and HongQiaosan village in the common residential area. Combine with their respective characteristics to analyze (Figs. 23.8, 23.9).

Because of HuaDi department's passenger flow is big both on weekdays and weekends, the rental and return ratios are high. Government's passenger flow is balanced in weekdays, but compared with two others the ratio is lower. And on weekends the rental and return ratios decrease obviously because of personnel furlough. Compared with the two points, residential area has similar changes. During weekdays the rental and return ratios are high because of people going out for work or other reasons, but the ratio is lower than downtown. Many people go out to buy food for a week or entertain, which make the rental and return ratios increase on weekends. The following charms respectively are three points whose rental and return ratios contrast with each other on weekdays and weekends (Tables 23.2, 23.3).

Table 23.1 Lease labels and lease sites

1	2	3	4	5	6	7	8	9	10
TianHe park XingGuo park	HuaDi department	ZhongShan park	XingChun station	YangZi hotel	RenMin	hospital	ChengKang bridge	ShiZheng company	JianJin street
11	12	13	14	15	16	17	18	19	20
Government	Examination and approval center	LiangChen furniture	HuangShanhu park	XiYuan market	JiYang village	FoQiao market	Times square	HongQiao san village	XinYi middle school

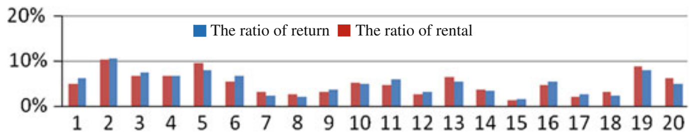


Fig. 23.7 Rental and return ratio of lease points

Fig. 23.8 Rental and return ratio in weekdays

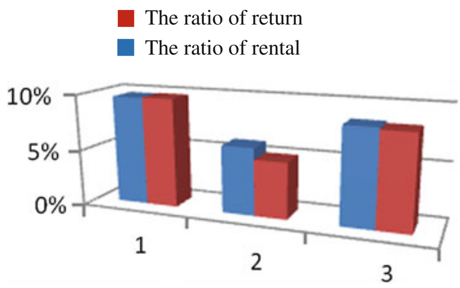
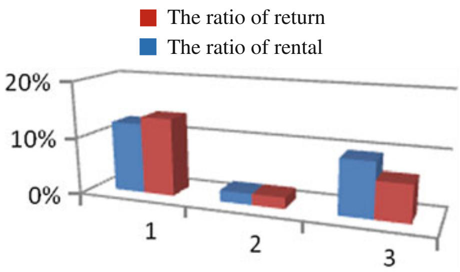


Fig. 23.9 Rental and return ratio at weekends



Many cities in China are single center cities. The radius of city land is within 6–10 km, which makes the bicycle travel have many advantages. According to the economical level and living conditions, single center will maintain a fairly long time. With the urban expansion it will make the bicycle demand transfer to other means of transport, meanwhile it will produce new short travel demands. In order to make PBS better implement, summarize and improve the evaluation indexes of PBS.

23.3 Evaluations of PBS

23.3.1 The View of Users

The main characteristics of bicycle travel is low consumption and zero pollution, benefiting the users' health and mental. At present the traffic congestion is serious in the cities, and people always are stuck in the way with nothing to do. People not

Table 23.2 Rental and return ratios of represented points in weekdays

	Center area of downtown	Commercial	General residential area
Site	HuaDi department (2)	Government (11)	HongQiaosan village (19)
Average rental and return ratio	10, 10 %	6, 5 %	8, 8 %
Performance characteristics	People flow is big, rent frequently all day	Activities concentrate on one day. People flow is big, rent frequently	One of big residential area, many people rent bicycles going out

Table 23.3 Rental and return ratios of represented points on weekends

	Center area of downtown	Commercial	General residential area
Site	HuaDi department (2)	Government (11)	HongQiaosan village (19)
Average rental and return ratio	12, 14 %	2, 2 %	10, 7 %
Performance characteristics	People flow is big, rent frequently all day	Activities concentrate on one day. People flow is small and rental ration is less	One of big residential area, many people rent bicycles going out

only pay attention on the rapid development of economy, but also meanwhile should protect our environment (Li et al. 2008). Bicycle traffic as a part of the green traffic meets people's expectation.

In order to make people use easily, take the characteristics and demands of users into consideration before establishment of the PBS. For example, the users maybe have the phenomenon of one way, which causes the bicycle flow unbalanced need to schedule the bicycle from the surrounding points or the storage bicycles. Make use of the system's advantages and assist the public traffic system.

23.3.2 The View of Operators

The establishment of PBS is to assist the public traffic system, so it should fully consider how to service the people well. The establishment of system is not to pursue the benefits. The main operating cost of system is from the government finance, small part from the advertisement. The establishment of system and the management personnel expenses to guarantee the system operate normally are not a small number. Although the system is a loss project in a short term, it brings many social utilities, environment utilities and so on.

23.3.3 Lease Point

Lease point distribution whether or not reasonable mainly depends on two factors, the number of people to serve (relate with the position of points in the community) and the people flow (relate with the distance to public places, crossing).

The number of bicycles in lease point whether or not reasonable also depends on two factors: static satisfaction (the satisfaction of permanent population) and dynamic satisfaction (the satisfaction of transferring or floating population).

Population density is the population in the unit of land, reflecting the degree of regional population density.

$$\text{regional population density}\rho = \text{the number of regional population/regional area} \tag{27.1}$$

Coverage area and the service number of lease points.

The walking distance is about 300–1,000 m. If the points are set in the center of city, the distance between the points is within 600 m advisably. Namely the service radius of point is 300 m. We can get the coverage area of every point.

$$S = \pi R^2 = 3.14 \times 0.3^2 = 0.2826\,\text{km}^2 \tag{27.2}$$

For the service population of every point in some region P.

When the point is in the regional internal (the range of point is within the area).

$$P_1 = \rho_1 \times S \tag{27.3}$$

When the point is in the regional angle (point is in the angle, $\alpha = 0.25$).

$$P_2 = \rho_1 \times S \times \alpha + \rho_2 \times S \times (1 - \alpha) \tag{27.4}$$

When the point is on the regional edge (the distance from point to the boundary of region is less than 0.3 km, $\beta = 0.5$)

$$P_3 = \rho_1 \times S \times \beta + \rho_2 \times S \times (1 - \beta) \tag{27.5}$$

When the point is outside of region (the distance from point to the boundary of region is more than 0.3 km)

$$P_4 = \rho_2 \times S \tag{27.6}$$

23.3.4 Public Bicycle System

For the evaluation of whole PBS's planning whether or not reasonable, besides that the rationality of position and bicycle distribution, it should consider the followings, whether all the points cover the whole area; whether points distribution are relatively uniform; whether points satisfy all demands.

(1) **Quantitative score**. For $N(L_i)$, if distance is longer than 0.6 km, exceeding the distance of people accepting lead to users give up bicycle travel, the score is 0; if points locate at crossroads, commercial centers, public places and residential areas, choosing bicycle travel is convenient, the score is 10; the score criteria for L_1, L_2, L_3 and L_4.

$$N(L_i) = \begin{cases} 0 & L_1 \geq 0.6 \\ 10 - L & 0 \leq L_1 \leq 0.6 \\ 10 & L_1 = 0.6 \end{cases} \quad (27.7)$$

L_1, L_2, L_3, L_4 separately is the distance with adjacent crossroad, hotel, public places and commercial center. N_n is the number of lease points. R is the position with the adjacent community.

(2) **Qualitative analysis**. When N_n becomes bigger, it indicates that the point density is bigger. In order to benefit the users, the lease points should avoid overlap and improve the distribution rationality. For example, crossover ratio is $S_1/(2 \times S - S_1)$, when S_1 is bigger, the more population covered repeatedly, namely more score deduced.

$$N(N_n) = -10 \times S_1/(2 \times S - S_1) \quad (27.8)$$

The number of bicycles distributed by per ten thousand people in service circle

$$B = \text{the number of bicycles/the number of people in service circle} \quad (27.9)$$

This standard is used to measure the size of the static satisfaction of bicycle's number. When the score of 'position evaluation' of lease point is high, comprehensive evaluation of the location and people flow quantity are high. Namely it can slow down the urban traffic congestion and improve the residents' trips, whose utility is bigger. Therefore, in this lease point we can set more bicycles.

(3) **Weight quantitative**. Each standard with 10 scores cannot distinguish their degree effectively. To make the result of measures more reasonable, give their different weights according to actual condition and personal experiences.
The weights during L_i: because of the population flow of crossroads calculated unwell, it is slightly less than public places through the qualitative analysis and experience. Through the relevant data we can get that $Q(L_1)$:$Q(L_2)$:$Q(L_3)$:$Q(L_4)$ = 45:12:65:8, the sum of weights is 1, so $Q(L_1) = 0.69$, $Q(L_2) = 0.18$, $Q(L_4) = 0.12$.

The weights between R and L_i: according to the general regulation, the connection of the residential areas with the crossroads, hotels, and public places is higher than the connection during crossroads, hotels and public places.

$$\text{Q(residential area)} = \text{Q(hotel)} + \text{Q(crossroad)} + \text{Q(public place)} + \text{Q(commercial center)} \quad (27.10)$$

Based on the population to calculate, K = population in the planning area/total population in the whole area. So the weights of R is$K \times Q$ (residential area), namely 1.99 K. N_n is the measure of overlap in service circle, for P_1 the score is 10. when $S_1 = S$, deducted score is 10. But if they intersect outside the area, the loss population only is P_4. So in order to realize the reasonability of comprehensive evaluations, the weight of N_n is $1 \times P_4/P_1$ when the weight of R is 1.

23.3.5 Index of Lease Point Facilities

(1) **Utilization**. Utilization of lease point d_1 refers to the rental times of public bicycle per hour in the working time.

$$\text{Utilization of lease point } d_1 = \text{Total times of rental times/Total time in working time per day} \quad (27.11)$$

Utilization of bicycles d_2 refers to the rental times of one public bicycle per hour in the working time. All the bicycles in a lease point have the maximum utilization d_{max} and minimum utilization d_{min}, and utilization of bicycles d_2 can be expressed by the average of d_{max} and d_{min}.

$$d_2 = (d_{max} + d_{min})/2 \quad (27.12)$$

Utilization of parking berth d_3 is to point that the ratio of parking berth occupied in the working time. To be specific it is the ratio of the sum of time of all bicycles parking berth occupied and the working time. The formula of unit utilization of parking berth in the working time is

$$d_3 = \sum_{i=1}^{n} t_i/T \quad (27.13)$$

where T is working time(min), t_i is total time of the *i*th parking berth occupied(min), n is the number of parking berths in a lease point.

(2) **Accessibility**. Accessibility is to point the degree of convenience of renting a bicycle from the road network to lease points. When the resources of facilities are in short, accessibility can decide how the resources get reasonable configuration to make the planning layout satisfy the people's travel demands.

23.3.6 Management of Lease Point

The convenience from the view of managers is that generally speaking no matter the users transfer bus or subway, even to do other things, users always take or return bicycle at the nearest point which can save time. Therefore, to realize the convenience of points start when plan. Meanwhile, we can consider from the angle of users. If the formalities are simple and quick, shorten the time of people staying at the lease points, which can affect the indexes of system.

23.4 Summary

The establishment of PBS can solve some traffic problems, and improve the environment and people's physical quality with its own advantages. Through the travel demands and characteristics, analyze the characteristics of bicycles and PBS, and summarize some evaluation indexes expecting for better service for people. With the changes of bicycle transport, the characteristics of bicycles maybe have changes. The evaluation indexes need to be improved in order to make it more systematic and more reasonable.

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Chapter 24
Study on Urban ITS Architecture Based on the Internet of Things

Zinan Yang, Xifu Wang and Hongsheng Sun

Abstract As an important part in the industrial chain of the Internet of Things (IOT), Intelligent Transport System (ITS) has been recognized as one of the priority sectors that IOT fells on the practical application successfully, and it is also the best starting point for government to create wisdom cities through IOT. We analyze the operation law and architecture of IOT, and put forward demands for urban ITS theory and technology on the Internet of Things. Then we combine with the existing urban ITS architecture and the IOT's architecture features, and establish urban ITS architecture based on the Internet of Things.

Keywords ITS · IOT · System architecture

24.1 Introduction

With the economic development and accelerated process of urbanization, the transportation amount increase, and the issue of urban traffic congestion and environmental pollution become worse. The rise of ITS, by increasing traffic operation management level and the utilization rate of road traffic facilities, is the indispensable effective measures to alleviate the contradiction between supply and

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demand in rapidly deteriorating traffic. The emergence of Internet of Things theory, changes the way people understand things status and control, provides a new technical and theoretical support to the development of ITS. Intelligent transportation technology applies to the entire transportation management system in order to establish real-time, accurate, and efficient transportation management and control systems.

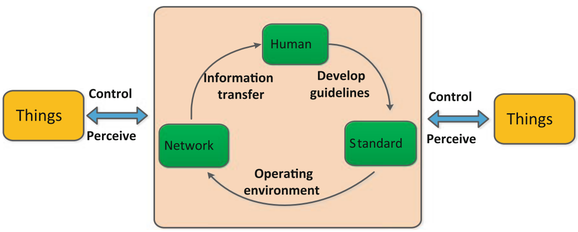
24.2 The Principle and Architecture of the Internet of Things

The Internet of Things is showing a new idea of product tracking in the worldwide, and has a profound effect on the human life. By depth analysis of the Internet of Things' operating rules, the essence is the information exchange between the things and operating environment. "The thing" refers to entity exists of the physical world, also including the entity attributes of human being; "Human being" refers to the human will on control levels, Network and standards are the two important element(s) in the thing running environment, providing external environment support for information interaction (Internet of things and Logistics Digitalization[M] 2011). The regularity of IOT is shown in Fig. 24.1.

IOT combines the three elements organically, to ensure the free circulation of the whole operation process. The system structure of IOT can be divided into three levels: perceptron network, network communication facilities and universal application service support system, namely: the perception layer, network layer, application layer. The architecture diagram of IOT is shown as Fig. 24.2.

Specific functions of IOT three-tier architecture include: the perception layer realize comprehensive intelligent perception, and collect the physical event and data, including all kinds of physical quantities, logo, audio and video data; the network layer achieves input information management and the bearer networks of computer network and communication network; the application layer includes application support services and user application services, application support platform realize information's coordination, sharing and exchanging between cross-sector, cross-application and cross-system.

Fig. 24.1 Regularity of IOT



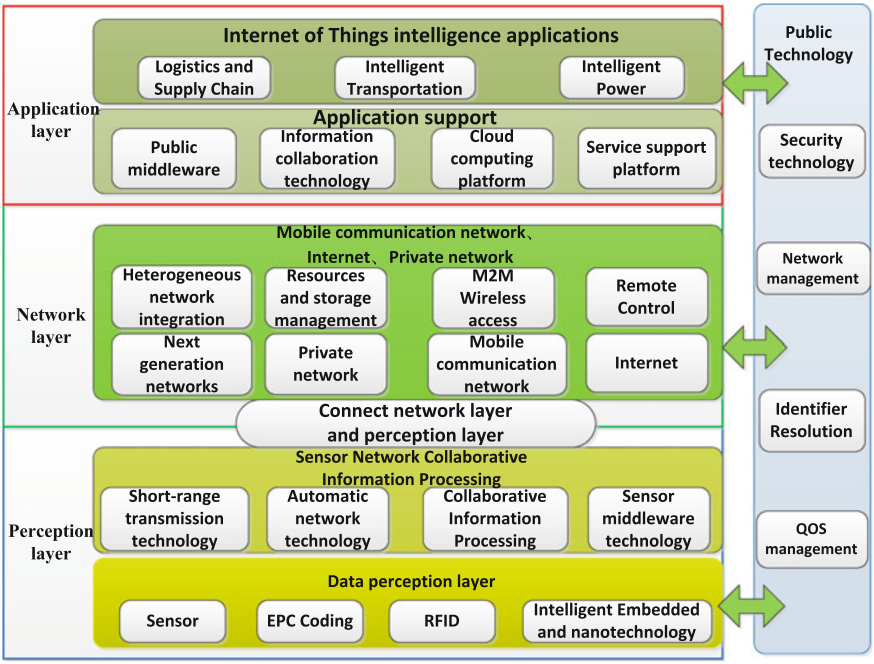


Fig. 24.2 Architecture diagram of IOT

24.3 Urban ITS Demand Analysis for the Internet of Things

Through various information marks and sensing equipment, IOT connect the things into nets to exchange and share information, and finally achieve the real-time and intelligent management network. The system structure and working principle of IOT and ITS is basically the same, based on the operation rule of the existing ITS, present the demand for ITS based on the Internet of Things.

(1) The more thoroughly perception of IOT on urban transport related elements and information management. Data is the basis for the operation of the urban ITS. The basic idea of IOT is the things connected, the road network information can be collected in time, a large number of traffic participant, including information of human and road related facilities would quickly come into IOT (Vahidi and Sayed 2003).

(2) Comprehensive interconnection and interchange on urban traffic information. The new model of transport elements information needed to build to achieve the perception and collaboration among the things in ITS, establish data input and output interface standards on traffic information subsystem, and build the traffic elements information collection system to achieve the interconnection among the information of traffic participants (Takahashi 2008).

(3) More in-depth intelligent collaborative services for urban traffic system. ITS needs to implement two-way transfer of information, not only to achieve coordination among the various intelligent transportation subsystems but also to realize the information collaboration between the uplink and downlink, to achieve the urban traffic unblocked. Decision-making and guidance information can transfer and feedback in time to urban traffic management and urban transport participants.

24.4 ITS Based on Internet of Things Structure

ITS based on Internet of Things mutually integrated by the intelligent transportation systems and the Internet of Things. According to the Internet of Things architecture and demand of ITS, this paper propose a "three layers and one network" architecture (Zhang 2011). "Three layers" refers to the data collection layer, data processing layer and application service layer, "one network" refers to the transmission network in the three layers system, as the Fig. 24.3 shown.

Data collection layer is the basic layer of the ITS based on Internet of Things, through the information collection equipment such as GPS, intelligent sensor, RFID, vehicle terminal and GIS to perceive and collect the information of the urban transportation, the coverage and accuracy of information collection directly determine the effect of the ITS based on Internet of Things. Middle layer is the

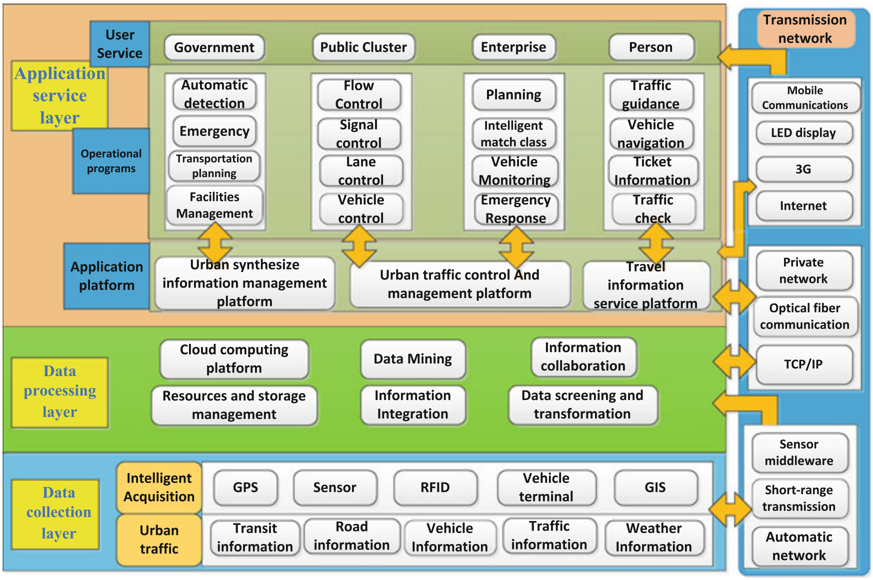


Fig. 24.3 Urban ITS architecture based on the Internet of Things

data processing layer, taking advantage of the Internet of Things technology, to analyze and use traffic information from the data processing layer. The top layer is the layer that people contact daily. Through the urban comprehensive information management platform, urban traffic control platform, urban public transport management platform and travel information service platform, manage and control the urban traffic participant.

The transmission network in ITS network can be seen as the blood vessels of system, undertake the work of traffic information transmission. The processed data transit to the management platform through a private network or optic fiber. Management information delivers to the users. The whole process of information transfer is a two-way, effectively achieve the synergy of information.

24.5 Conclusion

The Internet of Things has risen from a pure technology to an economic form, Internet of Things economic, Internet of Things industry. In the urban ITS, traditional traffic management methods develop to the bottleneck stage. The study provides the basis for the construction of the urban ITS based on Internet of Things. Make the future urban transportation become more convenient and intelligent.

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Chapter 25
The Pedestrian and Cycling Planning in the Medium-Sized City: A Case Study of Xuancheng

Yiling Deng, Xiucheng Guo, Yadan Yan and Xiaohong Jiang

Abstract Walking and cycling are important component in the urban transportation, residents' life and leisure activities, especially in the medium and small cities. Improving the pedestrian and cycling environment is important, and the pedestrian and cycling planning plays an important role in the process. A pedestrian and cycling planning is introduced in this paper, taking Xuancheng, a medium-sized city as an example. Basing on the analysis of the existing conditions and issues of walking and cycling in Xuancheng, and considering the requirement of residents and the visions of upper level plannings, the planning goals including safety, priority and vibrancy are proposed as well as five objects to support these goals. Then, the planning strategies and actions including structure planning, differentiation district control, important district improvement, public transit access and advanced design guidelines are introduced in detail. At last, some suggestions are given to the planning implementation and management.

Keywords Pedestrian and cycling planning · Planning strategies and actions

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25.1 Introduction

Walking and cycling are increasingly recognized as important forms of transportation in China. All people are pedestrians at one time or another, even those who generally use other modes of transportation, such as automobiles or transit. Walking and cycling are important in making intermodal connections as well as being travel modes of themselves. Many other benefits, including travel choice, affordability, reduced road congestion, infrastructure savings, improved health, recreation and enjoyment, environmental protection, are brought to users and nonusers alike by walking and cycling.

A good pedestrian and cycling planning in urban areas would create a more pleasant urban environment and encourage people to walk or cycle. The pedestrian and cycling planning provides a comprehensive vision for improving walking and cycling conditions. The purpose of the planning is to define an approach for the development of a safe, convenient and effective system that requires walking and bicycling as viable transportation options connecting work, shopping, residential, and recreational uses. The planning is also crucial in the plan to project delivery process. Success in construction of pedestrian and cycling facilities will only take place through good plan-to-project delivery process.

Chinese cities traditionally rely on walking and cycling daily travel, and many cities still have relatively low motorization levels despite the current surge in personal vehicle ownership. In the medium and small sized city, the pedestrian and cycling are very important in all forms of transportation, while the mode share of these two forms are always more than 60 % in the whole transportation (Deng et al. 2012). A good pedestrian and cycling planning can help the city become pedestrian and cycling friendly. Taking Xuancheng as an example, the main contents of the pedestrian and cycling planning are introduced in the paper to provide good reference to other medium or small size cities in China.

25.2 Existing Conditions and Issues

Xuancheng is a medium-sized city in the Anhui Province, which is in the middle part of China. The population was 2.76 million and the total area was 12340 km^2 in 2010. The per capita GDP was 21 thousand Yuan. In the central city which is the planning area, the population was 0.43 million. The total area was 565.5 km^2 and urban construction area was 65 km^2 in 2010.

The city recognizes that walking and cycling are currently more inconvenient than ever and dangerous than necessary, which causes unnecessary injuries, discourages non-motorized travel, and imposes economic costs on the community. The city therefore seeks to make walking and cycling safer and more convenient.

According to resident travel survey made in 2010, 39.7 % of trips in the city were made by walking, and 23.7 % were made by cycling. Walking and cycling are key forms of transportation in the city, especially through neighborhoods, around schools, and in business districts.

The planning is based on an assessment of walking and cycling network and a survey of the city's existing walking and cycling conditions. The identification of problems is fundamental in clarifying the goals and objects. The problems are always at different geographical levels, such as districts and local levels, and in various aspects such as connectivity, capacity, safety and comfort. In Xuancheng, four main problems are existed for the pedestrian and cycling:

(1) The right of way cannot be guaranteed which causes the safety of pedestrians and bikers are affected. In some roadway, the widths of sidewalks and bike lanes are too narrow to satisfy the demands for passing or activities. For another reason, the sidewalks and the bike lanes are always occupied by parking because of lacing parking space in the central city. The pedestrians have to walk with bicycles and the bikers have to ride with the automobiles;
(2) Crossing the road is difficulty and unsafe in some districts. The traffic signals in most intersections are two phase controls. The pedestrians or bicycles are in conflict with the right-turn automobiles when crossing the intersection. These phenomena are unsafe especially in some intersections around the schools or kindergartens. In addition, the crosswalks in the roadways are always not enough to meet the crossing demand for pedestrians or located in the improper places, for example, too far away from the bus station or the school;
(3) The number of bicycle parking facilities is insufficient, especially in the commercial area, around the hospital or school. Random bicycle parking always affects the passing of pedestrians and other bicycles;
(4) Xuancheng is a landscape garden city and filled with a lot of hills and rivers. But the waterfront space and the green space are not treating well to supply walking or cycling space for exercise, relaxation and recreation.

25.3 Planning Goals and Objects

When setting the goals of the pedestrian and cycling planning, the requirements of residents and the visions of the upper level planning, including the city general planning, comprehensive transportation planning and other related plannings should be considered. The pedestrian and cycling planning of Xuancheng includes three goals, i.e. safety, priority and vibrancy, to make a friendlier environment for walking and cycling. Then five objects are proposed to support the goals:

(1) Create vibrant public spaces that encourage walking and cycling;
(2) Plan, design, and build pleasant streets to meet the demand of pedestrians and bikers;
(3) Improve the connectivity of the existing pedestrian and cycling routes;
(4) Reduce the number and severity of vehicle crashes involving pedestrians and bikers;
(5) Get more people walking for transportation, recreation, and health.

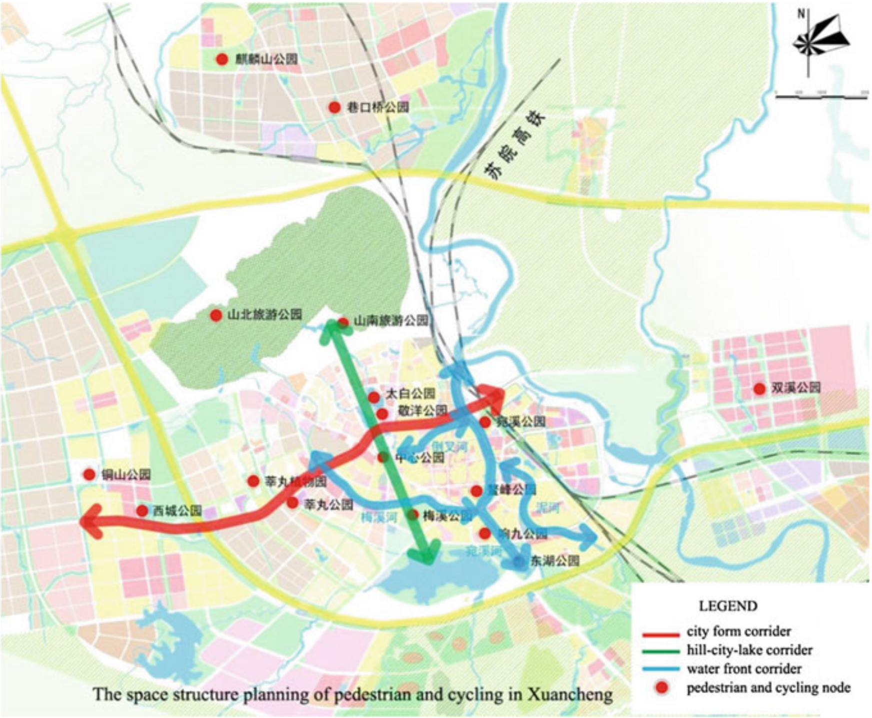

Fig. 25.1 The space structure planning of pedestrian and cycling in Xuancheng

25.4 Planning Strategies and Actions

Appropriate strategies and actions are developed to achieve these objects. The strategies and actions include space structure planning, differentiation district control, important district improvement, public transit access and advanced design guidelines.

Space Structure Planning. The macro pedestrian and cycling spaces includes corridors and nodes. The nodes are the plazas and parks. The corridors are the linear space combined with roadways, hills, rivers, and landscape green belts, which always have good landscape and high quality space for walking and cycling for travel and leisure.

In Xuancheng, twelve plazas and parks are planned with a total area of 4.19 km^2. Three kinds of pedestrians and cycling corridors (total six corridors) are planned, including four waterfront corridors, one hill-city-lake corridor and one city form corridor as Fig. 25.1 shows.

Differentiation District Control. Not all districts in Xuancheng have the same level of demand and the built environment. This strategy is to match the planning standard of pedestrian and cycling facilities to the demand in the different districts.

Table 25.1 The distance between adjacent crosswalks in the roadways (m)

Land usage/intensity	Residential, administration and public service		Commercial and business facilities		Regional transportation	Green space	Industrial, logistics and warehouse
	High	Normal	High	Normal			
Secondary road	200	250	200	300	300	300	400
Major road	250	300	250	350	350	400	500
Express way	300	350	300	400	400	500	600

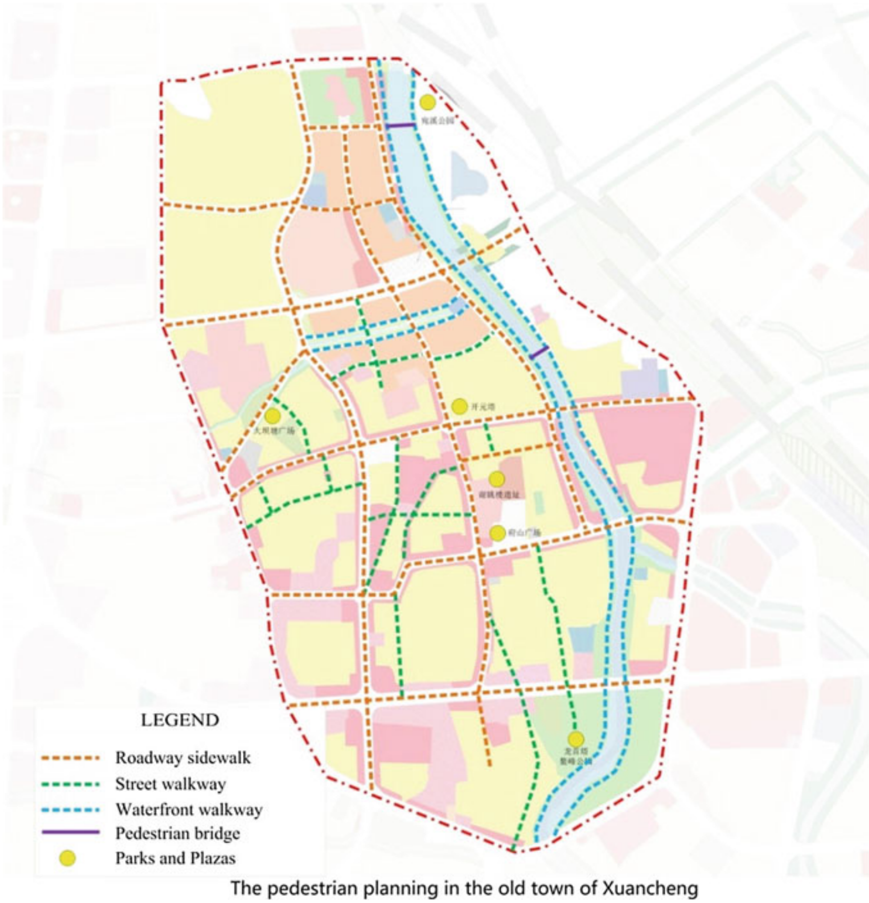

Fig. 25.2 The pedestrian planning in the old town of Xuancheng

The standards are reviewed which are used by city departments that affect walking and cycling conditions. According to the preference survey to the pedestrians and bikers, the new planning and design standards for pedestrian and

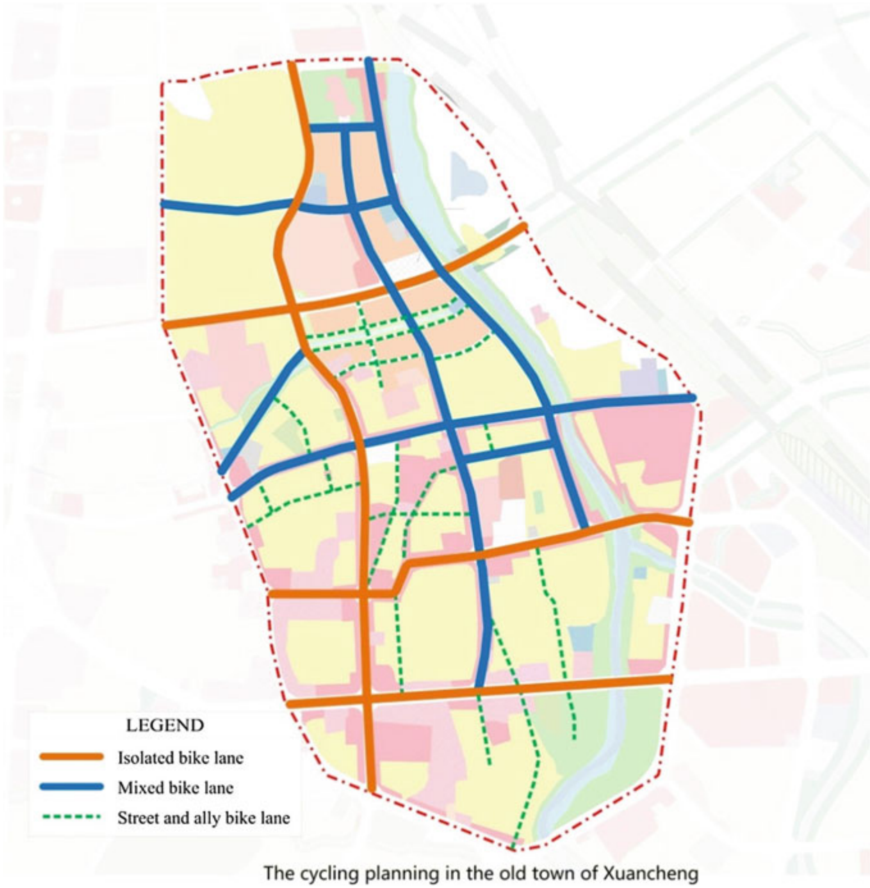

Fig. 25.3 The cycling planning in the old town of Xuancheng

bicycle facilities (e.g. bike lanes, sidewalks and crosswalks) are established. In the old city, all the roadways have already been built, the work is to reallocate the road space to satisfied the demand of pedestrian and cycling. In the new districts, minimum width standards for pedestrian and bicycle facilities (e.g. bike lanes and sidewalks) are proposed which should be obeyed in the roadway planning and design, because most of the roadways are not implemented. The standard of the distance between adjacent crosswalks is reviewed too. The standard mainly depends on the road hierarchy, the land usage and the crossing demand as the Table 25.1 shows.

Important District Improvement. The old town is chosen as the important district to do detail planning for two reasons: (1) the agglomeration of pedestrian and cycling demands; and (2) the most deficiencies of the built pedestrian and cycling facilities. The fundamental issue is how to reallocate space to meet the pedestrian and cycling needs efficiently while maintaining proper vehicular space for parking, local access and through movement, how to systematically retrofit currently deficient of sidewalks and bike lanes, and how to give the pedestrian and bicycle more routs.

In the old town pedestrian planning, except the traditionally pedestrian space, namely the roadway sidewalks, the walkways in the streets and alleys are planned and the corresponding traffic management strategies are proposed to guarantee the walking space. The waterfront walkways and pedestrian bridges are planned combing with the waterfront urban design as Fig. 25.2 shows.

In the old town cycling planning, the bike lanes are classified in isolated bike lane, mixed bike lane and street and ally bike lane. The bike lanes with high bicycle volume are physically isolated with the automobiles, and the street and ally bike lane are proposed to supply more passing space. The on road parking is also coordinated with the bike lane planning as (Fig. 25.3).

Public Transit Access. Accommodating the pedestrian and cycling with the public transit can convenient residents and increase the public transit ridership. Three actions are proposed: (1) make all bus stops conveniently accessible by walking and cycling; (2) integrate cycling into the public transit system by supporting enough bicycle racks and parks; and (3) promote smart land use development surrounding transit facilities to enhance the environment for walking and cycling.

Advanced Design Guidelines. The purpose of advanced design guidelines is to regulate the basic pedestrian and cycling facility design principle and method. The guidelines will provide technical guidance to planners and designers. The design guidelines are not only focus on the transportation function of the facilities, but also emphasize the qualities of the environment, shown in Fig. 25.4.

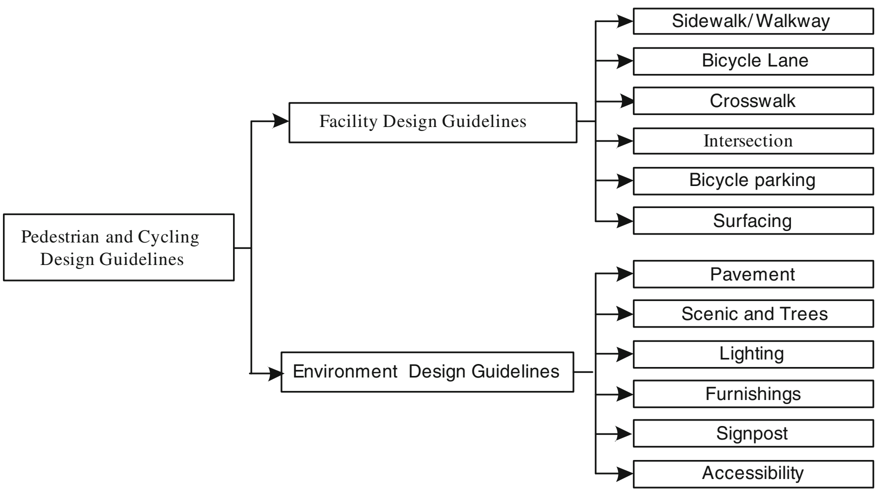

Fig. 25.4 The content of pedestrian and cycling design guidelines

25.5 Conclusions

The pedestrian and cycling planning plays an important role to improve the pedestrian and cycling environment. However, whether a plan, project or program will lead to an improvement of pedestrian and cycling environment, to a large degree, depends on the policy makers and plan executors. The city ought to prioritize the pedestrian and cycling facilities expenditures, based on the reasonable assessment of the funds, obey the standards and the schemes of the pedestrian and cycling planning in implementation.

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Chapter 26
A Model to Evaluate the Modal Shift Potential of Subsidy Policy in Favor of Sea-Rail Intermodal Transport

Xuezong Tao

Abstract This paper is to develop an analysis tool to assess the modal shift potential (MSP) of subsidy policy in favor of Sea-Rail Intermodal Transport (SRIT) between Ningbo Port and East Jiangxi province. Based on random utility theory and stated preference (SP) experiments, two disaggregate models, a MMNL model and a MNL model, are established and estimated. Results show that all attributes have the expected sign and the MMNL model outperforms the MNL model. The analysis of MSR under seven scenarios based on MMNL model suggests that giving a subsidy of 400 RMB/TEU to shippers who use SRIT might be the optimal choice for a cost-effective modal shift. The above methodology and results are useful for policy-makers to make freight transport policy, especially the subsidy policy in favor of SRIT.

Keywords Freight modeling · Mode shift · Sea-rail intermodal transport · Subsidy policy · Disaggregate mode choice model

26.1 Introduction

In 2011, the container throughput of Ningbo port exceeded 14.5 million, making Ningbo Port become the third largest container port in China (world's top 6). But the demand for inland transport of these containerized cargos is mainly met by road, accounting for approximately 84 % of the port container throughput. Exorbitant share of RT in the modal split resulted in ever-increasing adverse

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effects such as accidents, congestion, air pollution and greenhouse gases. Fortunately, Ningbo municipal government has been aware of the urgency of solving this issue and understands that a shifting mode from RT to other sustainable freight transport modes, mainly the SRIT, is a cost-effective way. According to the experience of developed countries, the achievement of modal shift needs the support of subsidy policy. Therefore, it is necessary to develop a reliable analytical tool to assess the MSP of subsidy policy, and the disaggregate mode choice models are introduced to realize this purpose.

Winston (1981) firstly developed a disaggregate model based on Random Utility Maximization (RUM) that attempts to reflect the actual behavior of freight transport decision-makers. From then on, disaggregate mode choice models were increasingly used for analyzing freight transport mode (FTM) choice decisions. Increasing efforts were made to extend the range of factors that could potentially influence the choice outcomes (i.e. transport/non-transport cost, service attributes). The most widely used model form was the multinomial logit (MNL, McGinnis et al. 1981; Nam 1997; Golias and Yannis 1998; Catalani 2001; Shinghal and Fowkes 2002; Chiara et al. 2008).

Despite the popularity of the MNL model, a number of researchers recognized that, in virtue of its independence from irrelevant alternatives property, it imposes potentially unrealistic limitations on the nature of the choice processes it could accommodate. In an attempt to address this problem, Jiang et al. (1999) proposed the use of a nested logit (NL) model. To relax another restricted assumption of the MNL model, the Heteroscedastic Extreme Value (HEV) model has been used in a number of freight mode choice applications (Holguin-Veras 2002; Norojono and Young 2003). This model allows for different scales of error to be associated with different alternatives and produced improved results compared to MNL and NL models.

Nonetheless, most of above studies have focused on competition between modes on national or international non-maritime shipments, applications addressing the mode choice determinants in the inland transport of containerized cargos via seaport being scare. Even if some researches differentiate container traffic in their analysis of intermodal traffic (Jiang and Calzada 1997; Beuthe and Bouffioux 2008), those studies do not yield specific conclusions regarding door-to-port or port-to-door traffic.

Combined with a mixed multinomial logit (MMNL) model and SP techniques, this paper presents a quantitative analysis tool to assess the MSP of different degree of subsidies in favor of SRIT between Ningbo Port and Shangrao city, which is helpful to design the efficient subsidy policy. The remainder of this paper is structured as follows. Section 26.2 presents the modeling framework. Section 26.3 describes data collection campaign and descriptive analysis of results. Section 26.4 estimates the model and discusses the findings. Finally, Sect. 26.5 concludes the paper and identifies possible future work.

26.2 Modeling Framework

According to a standard discrete choice model (McFadden 1974), an freight mode choice decision-maker (i.e., shipper or consignee) i is assumed to select the FTM m for a specified shipment with the highest utility $U_i(m)$ from amongst available freight in a choice set M_i. Considering that the decision-makers' utility cannot completely be observed, it is consequently decomposed into an observable component $V_i(m)$ and an unobservable component $\varepsilon_i(m)$, which can be expressed as:

$$U_i(m) = V_i(m) + \varepsilon_i(m) = U(x_{im}, s_i, \beta_i) = V(x_{im}, s_i, \beta_i) + \varepsilon_i(m) \tag{26.1}$$

where x_{im} is a vector of the measurable attributes characterizing FTM m given by decision-maker i, s_i is a set of socio-economic attributes of the decision-maker i that may also affect utility and β_i is a vector of parameters called tastes of the decision-maker i.

Depending on the assumptions made in regard to the distribution of errors $\varepsilon_i(m)$ and in turn, to the difference of such errors, one choice model or another will be obtained (MNL, Probit, HEV, MMNL or others). If we assume the error terms for all decision-makers i and FTM m are independently and identically distributed (IID) following a type I extreme value distribution, we can derive the most widely used model in freight transport applications, the MNL model. Then the choice probability can be expressed as:

$$P_i(m|M_i) = \frac{e^{V_i(m)}}{\sum_{h \in M_i} e^{V_i(h)}} \tag{26.2}$$

Under the IID assumption, this model displays the independence from irrelevant alternatives (IIA) property, giving rise to limitations when it comes to capturing certain patterns of behavior (Train 2003). The MMNL model (also referred to as Hybrid Logit or Kernel Logit), derived from the recognition that there would be correlation in unobserved information which can be estimated, solves the limitations of MNL. In consequence of this, the error component is partitioned into an unsystematic part $\varepsilon_i(m)$ (i.e., the random term which is IID for all decision-makers i and FTM m) and a systematic part η_i (i.e., the random term whose distribution is characterized by parameters relating to FTM m, decision-makers i or other factors y). The utility function from Eq. (26.1) can then be rewritten as:

$$U_i(m) = U(x_{im}, s_i, \beta_i) = V(x_{im}, s_i, \beta_i) + \varepsilon_i(m) + \eta_i(x_{im}, s_i, y|\phi) \tag{26.3}$$

where ϕ is a vector of parameters that describe the density of distribution, meaning that η_i can take any form of distribution. Since η_i is not given, the choice probability will be expressed as an integration of logit formula over all values of η_i weighted by the density of η_i in Eq. (26.4).

$$P_i(m|M_i) = \int_{\eta_i} L(\eta_i)f(\eta_i|\phi)d\eta_i \tag{26.4}$$

where $L(\eta_i)$ is a logit choice probability conditional on a vector of parameters η_i that are jointly distributed with density $f(\eta_i|\phi)$.

Due to the absence of a closed-form notation for the MMNL choice probabilities, numerical techniques, typically simulation, are required in the estimation and application of this model. Details of the evolution of simulation-based maximum likelihood methods for estimating MMNL models are provided in numerous references including McFadden and Ruud (1994), Brownstone and Train (1999), Bhat (2001) and Hensher and Greene (2003).

26.3 Data Collection

The disaggregate data used in this paper are taken from a SP survey of shippers (sales managers or transport/logistics managers) in Shangrao city. A decision was made not to select a sample randomly but to interview firms: (a) who are export-orientated enterprises taking foreign countries and regions as target markets and (b) whose shipments are mainly transported in container via Ningbo port and potentially suited to SRIT. Unfortunately, for a variety of reasons, firms are often reluctant to be interviewed, so that, like in other similar studies, we were unable to gather a large sample and only 69 firms responded a telephone survey, of which 31 firms agreed to accept our interview. Given that the sample size is not large, to obtain more usable information, we request the respondents to describe two typical transport shipments and make corresponding choice under various scenarios. Even so, 57 experiments were conducted in the end. From the data gathered, five experiments have been removed due to very extreme values. Therefore, the final dataset considered in the following analysis is comprised of 52 valid experiments consisting in 832 choice observations.

Though the telephone surveys, four attributes of FTM are identified as the critical factors influencing firm's choice behavior, which are in order according their frequency mentioned by respondent as follows:

(1) Cost as out-of-pocket door-to-port transport cost, including loading and unloading, mentioned 61 times as first important factor;
(2) Time as door-to-port transport time, including loading and unloading, mentioned 52 times as second important factor;
(3) Punctuality as % of deliveries at the scheduled time, mentioned 49 times as third important factor;
(4) Safety as 100 % minus % of commercial value lost from damages, stealing and accidents, mentioned 45 times as fourth important factor.

The interviews, conducted from April 7 to May 29 in 2012. Table 26.1 reports the descriptive statistics for RT and SRIT service described by shippers.

Table 26.1 Descriptive statistics for typical transport service

Variable	RT				SRIT			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Cost (RMB)	2450	2860	2672	80.779	1812	2265	2076	205.016
Time (h)	10	15	11.4	0.867	24	30	27.5	2.715
Punctuality	92 %	100 %	95.6 %	0.016	80 %	98 %	89.7 %	0.024
Safety	80 %	100 %	89.5 %	0.035	89 %	100 %	95.2 %	0.017
Current market share (%)	98.73				1.27			

In particular, the average costs is 2672 RMB/TEU for RT and 2076 RMB/TEU for SRIT respectively, while the delivery door-to-port takes on average 11.4 and 27.5 h.

26.4 Estimation and Results

One MNL and MMNL were estimated using the LIMDEP version 8.0 package, which was mostly employed to estimate the discrete choice models. The results are presented in Table 26.2.

On one hand, the coefficients of cost and time have a negative sign reflecting a decrease of the marginal utility as the values for cost and time increases. This suggests that reducing the cost or time might be an effective way to achieve the modal shift. Given that it is almost impossible to decrease the transport time with restrictions of transport infrastructure and management system in the short time, an attempt to reduce the transport cost though subsidy becomes the first choice for modal shift.

On the contrary, the more punctual and safe is the freight transport service, the more utility the shippers experience. As expected, the ASC_RT, introduced for RT, is not statistically different from zero indicating that none of the two unlabeled

Table 26.2 Estimates of MNL and MMNL models

Variable	MNL		MMNL	
	Coefficient (β_i)	t-Test	Coefficient (β_i)	t-Test
ASC_RT	−3.6378	−1.10	−8.58782	−1.16
Cost	−0.0145**	−2.11	−0.0195**	−1.97
Time	−0.1737**	−2.53	−0.1981**	−2.01
Punctuality	0.7308	1.43	0.9483	1.08
Safety	0.5624	0.81	0.7852	0.87
AIC	1025.12		1012.74	
Final *LL*	−527.09		−518.36	
Adjusted ρ^2	0.3518		0.3972	

Note ** → Significance at 5 % level

Table 26.3 Market share of RT, SRIT and the MSP (Unit: %)

Scenario	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7
Market share of RT	98.73	96.98	95.07	93.19	89.36	88.34	87.41	86.59
Market share of SRIT	1.27	3.02	4.93	6.81	10.64	11.66	12.59	13.41
Total MSP	/	1.75	3.66	5.54	9.37	10.39	11.32	12.14
ΔMSP	/	1.75	1.91	1.88	3.83	1.02	0.93	0.82

Note $\Delta MSP_{i+1} = MSP(S_{i+1}) - MSP(S_i)$; $i = 0, 1, 2, 3, 4, 5, 6$; S_0—Current situation

FTM has been preferred a priori. Besides, punctuality and safety are also not statistically significant. This indicates that the shippers in Shangrao city have greater tolerance towards punctuality and safety and it will not provide enough room to alter the sensitivity of Shangrao shippers to this variable.

In terms of model fits, we note that MMNL model outperforms MNL model, with an improvement in the final LL of 8.73 points giving a statistically significant log-likelihood ratio test. The AIC statistic and the Adjusted $\rho 2$ further support MMNL model against MNL model. Therefore, we choose the MMNL model to analyze the MSP (MSP) under different subsidy policy.

According to Eq. (26.4), we calculated the Total MSP and Δ MSP under seven scenarios: S_1 means a subsidy of 100 RMB/TEU to shippers who use SRIT service; S_2 means a subsidy of 200 RMB/TEU; S_3 means a subsidy of 300 RMB/TEU; S_4 means a subsidy of 400 RMB/TEU; S_5 means a subsidy of 500 RMB/TEU; S_6 means a subsidy of 600 RMB/TEU and S_7 means a subsidy of 700 RMB/TEU. The market share of RT, SRIT and the MSP is presented in Table 26.3.

Table 26.3 shows that total MSP increase with the amount of subsidy to shippers. Specifically, a 100 RMB/TEU increase in subsidy will result in an average of 1.73 % increase in MSP. When it comes to ΔMSPi+1, it presents a similar growing trend but begins to decrease from S_5 scenario. In particular, all the values of ΔMSP5, ΔMSP6 and ΔMSP7 are below the average increase value of 1.73 %. It reveals that if to achieve a cost-effective modal shift, giving a subsidy of 400 RMB/TEU to shippers who use SRIT will be a relatively optimal choice.

26.5 Conclusions

To assess the MSP of different degree of subsidies in favor of SRIT between Ningbo Port and Shangrao city, this paper established a MMNL model and a MNL model based on random utility theory and SP techniques. The results show that all attributes have the expected sign and the MMNL model outperforms the MNL model. A negative sign for cost and time indicates that the overall marginal will be reduced with the increase of cost and time, but this is opposite for punctuality and safety. In view of the restrictions of transport infrastructure and management system in the short time, making subsidy policy to indirectly reduce shipper's transport cost becomes an effective means for achieving modal shift from RT to

SRIT. The results also show that neither RT nor SRIT has been preferred a priori and there is not enough room to alter the sensitivity of Shangrao shippers to punctuality and safety. Besides, the findings suggest that giving a subsidy of 400 RMB/TEU to shippers who use SRIT might be the optimal choice for a cost-effective modal shift.

The methodology performed in this study can also be applied to other segments of the freight market or other regions. Given that the SP data may lead to potential biases, establishing a RP/SP combined model will be the future direction of our research.

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Chapter 27
Study of Training System Applying on Energy-Saving Driving

Haili Yuan, Bin Li and Wei Wang

Abstract In this paper, the importance of energy saving on urban railway transportation and inevitability of energy-saving training are emphasized. To improve the energy-saving performance in the process of train operation, we propose a driver training system based on CBTC simulation test platform. In this system, driver's energy-saving awareness can be strengthened. Besides, an energy-saving strategy, coasting driving, is researched and verified in this system as well. The driver training system with 3D video simulation technology and actual driving platform provides nearly practical driving experience. In this way, drivers get trained in an energy-saving form compared to the traditional form in the field.

Keywords Energy-saving driving · 3D video simulation · Energy consumption · Coasting position

27.1 Introduction

Low-carbon economy, a basic way to coordinate the development of society and economy, is gradually being paid more attention in the whole world. Moreover, it also plays a significant role in ensuring energy security and responding to climate

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change. As a worldwide problem, it has brought new challenges to all walks of life. Urban rail transportation, as one of energy intensive consumers, must meet the challenge of Low-carbon economy and achieve the energy-saving goal.

Under normal circumstance, line conditions have effects on energy consumption from a certain extent, especially the gradient of a line. In addition, temporary speed restriction also has a significant impact on energy consumption (Wang 2008).

Besides of line conditions, the patterns of driving a train are also relevant in energy consumption (Liu and Mao 2007). So, it is necessary to build drivers' awareness of energy-saving and develop energy-saving operation habit. An efficient method for drivers to learn energy-saving driving is to operating the simulation train using 3D video simulation technology. During the driver's operation, this driver training system can compute the energy consumption, which is the criteria used to tell a driving habit is energy-saving or not. By this way, a driver can develop his energy-saving habit without consuming much energy in the field.

27.2 System Design

The driver training system introduced in this paper is based on CBTC simulation and test platform (Wang 2010), which is independently researched and developed by State Key Laboratory of Traffic control And Safety Beijing Jiaotong University.

27.2.1 Composition of Driver Training System

Driver training system consists of 3D video simulation module; energy consumptions display module and bridge module (see Fig. 27.1).

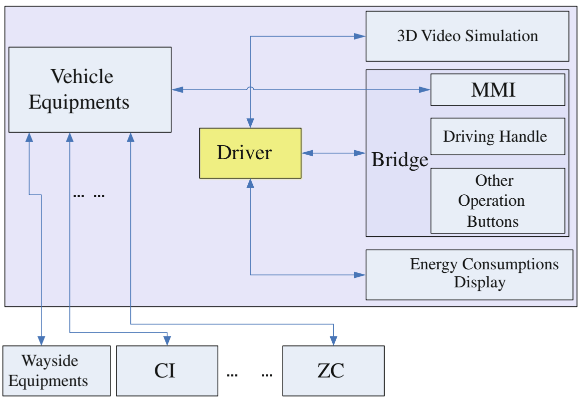

Fig. 27.1 The composition of driver training system

3D video monitor is settled in front of locomotive, and energy consumptions display monitor is settled on the bridge. During the training, with the operational handles, operational buttons and 3D video, driver can get a verisimilar feeling, just like driving a real train in a real line.

27.2.2 3D Video Module Design

The design process of 3D video module is shown in Fig. 27.2. It includes three parts: line data processing, 3D environment modeling and 3D scene displaying. Line data processing and 3D environment modeling are two preparatory stages. 3D scene displaying provides basic data for 3D environment modeling and 3D scene displaying. With the data, 3D modeling software generates railway lines, and combine the lines and 3D scenes. At last, 3D scene models and basic data are loaded to 3D scene driving program, and then the work is done.

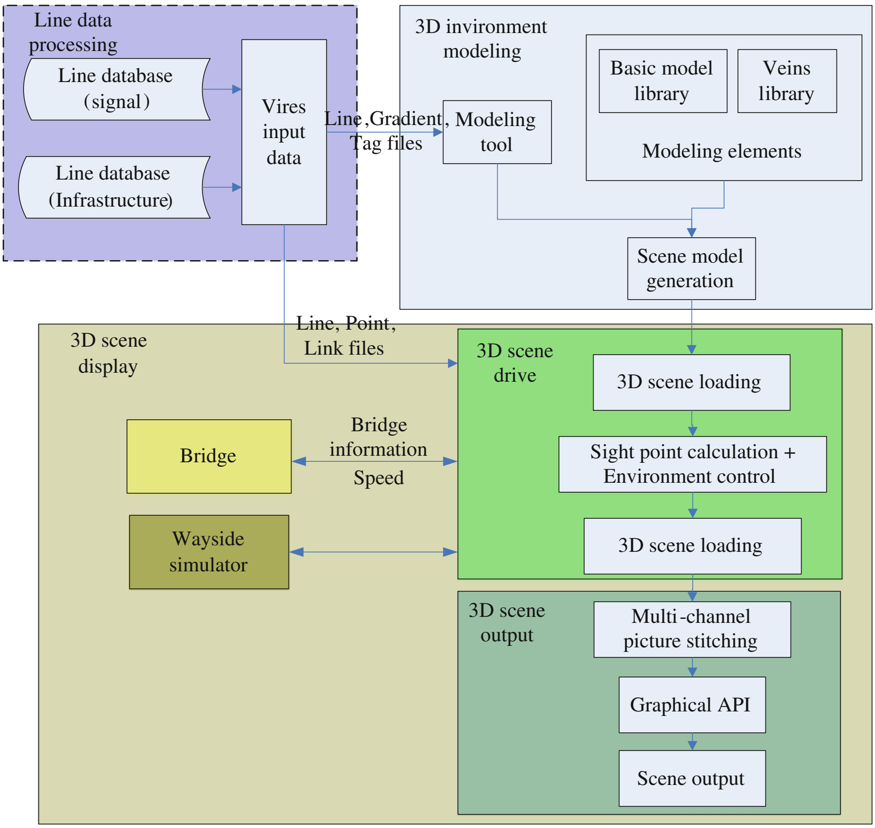

Fig. 27.2 3D video module design process

27.2.3 Energy Consumption Module Design

For simplifying the computation, this module does not take factors of infrastructure conditions and line environment into consideration. And other conditions will not change in the process of simulation, such as locomotive, line, dynamic and braking techniques. In this paper, energy consumption mainly involves three parts: start and stop energy consumption, moving energy consumption, coasting energy consumption (Xue et al. 2007).

Start and stop energy consumption E_1:

$$E_1 = 0.5nA\left(\sum Q\right)V^2 / (3.6^3 * 1000) \tag{27.1}$$

In the formula, A is coefficient of rotary inertia; Q is mass of the train; v is velocity, n is start and stop times of the train in the corridor, which is assumed to be 1.

Moving energy consumption E_2:

$$E_2 = 9.81/3600 * (\Sigma Q.w)S \tag{27.2}$$

ω is unit resistance of the train, S is running distance.

Coasting energy consumption:

$$E_3 = B * E_2 \tag{27.3}$$

Here B is control coefficient.

The total energy consumption is.

$$E = E_1 + E_2 + E_3 \tag{27.4}$$

27.3 System Function Simulation

27.3.1 3D Video Simulation

Figure 27.3 shows the development process of 3D video simulation. The left part shows daytime pattern, the right shows nighttime pattern. We can change patterns through button "L". During the operation of simulation train, we can see the scene of the train moving forward in video screen from one termination, and see the scene of the train moving backward in video screen from the other termination.

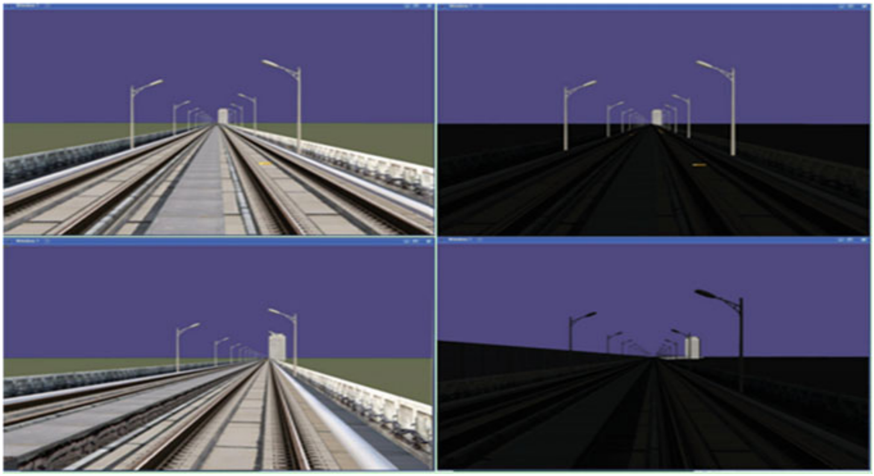

Fig. 27.3 3D video simulation display

27.3.2 Energy Consumption Display

Minimum of energy consumptions produced during the training are recorded in energy consumption list. Pick the minimum energy consumption from the list, and find its corresponding coasting position, which turns to be the optimal coasting position at present, that is proposed coasting position. See in Fig. 27.4.

In our simulation, the simulation train travels from Xi'erqi station to Beiqinglu station. Energy consumption list shows energy consumptions with different coasting positions. The unit of energy consumption is 1000000 KW/h. Column in the middle shows corresponding coasting positions which is the distance from Xi'erqi. And current energy consumption shows real-time energy consumption of the train and its distance from Xi'erqi station. If there is no coasting driving,

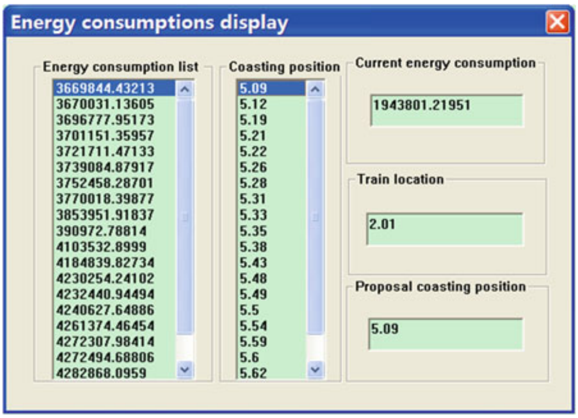

Fig. 27.4 Energy consumptions display

energy consumption is about 4.2838 KW/h, the current optimal coasting driving seen from the list consumes about 3.6698 KW/h. The difference between the two situations is obvious. Here comes the conclusion: coasting from an opportune position can contribute to saving energy.

27.4 Conclusions

This paper proposes a driver training system based on the CBTC simulation and test platform out of the view of energy saving, and it is verified on Changping Line partly. However, our simulation is based on an assumption that infrastructure conditions and line environment don't change in the process of simulation. In fact, real energy consumption involves complex factors, including traction and braking techniques, environmental change, temporary speed restriction, and the handling of emergency situations, which need to be studied later.

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Chapter 28
The Outlook of Low-Carbon Transport System: A Case Study of Jinan

Qiang Han and Yong Zhou

Abstract Jinan, the capital of Shandong province, is located at coastal regions in east China. It is troubled with large traffic demand as many other cities do. Transport industry has been one large energy consumer, which carbon emission accounts for nearly 10 % of all the industries. In this situation, low-carbon transport with low energy consumption, low CO_2 emission and low pollution is an increasing concern. This paper disclosed the relevance between transport and economy in Jinan by grey relational analysis, and described the causal relationship among several factors involved with low-carbon transport system. The making of low-carbon transport system in Jinan was discussed from short term and long term. The former was on the basis of energy saving potential, while the latter was based on scenario analysis. According to Jinan's target for CO_2 emission reduction, two key uncertainties, transport socialization and sustainability, are adopted as the axes to generate four future scenarios. To achieve the fourth scenario in favor of carbon reduction, much propulsive policies about structure adjustment, new energy use and public traffic travel mode have been put forward.

Keywords Low-carbon transport · Causal relationship in transport system · Scenario analysis

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28.1 Introduction

China's economy is moving onward in surprising speed. Affected by this trend, many cities of China are also developing rapidly. Transport is one fundamental, leading and service business for the development of national economy and the society. During their rapid ongoing process, they are facing critical and worsening transport problems, including traffic jam, increasing energy consumption and excessive carbon emission (Chen et al. 2009). This urban transport crisis results from continuing population growth, suburban sprawl, rising incomes and increased motorization and use (Pucher et al. 2007).

Jinan, south to Mount Tai and neighboring the Yellow River on the north, is an eastern coastal opening city and one of the 15 nation-authorized deputy provincial cities in China. It is the capital of Shandong province, and also the province's political, economic, cultural, science and technology, educational and financial center. The total area of Jinan is 8177 km^2 and the urban part occupies 3257 km^2.

The possession of motor vehicles is 1.31 million by the end of October, 2011, in which there are 0.91 million cars. Private cars have occupied vast majority share, reaching 0.76 million. As a result, Jinan is confronted with huge traffic demand. Transport industry has become a big energy consumer, which CO_2 (carbon dioxide) emissions take up 10 % of the city, and this ratio is on the increase. Traffic jam, air pollution and traffic safety it caused have greatly influenced economic efficiency and life quality of Jinan. Building up low-carbon transport system is valuable for Jinan and other cities in China.

Low-carbon transport is one transport development mode with low energy consumption, low CO_2 emission and low pollution. It aims to reduce the carbon emission of vehicles and achieve the sustainable development of transport system. A target for transport emission reduction in Jinan can be derived to help explore the likely required scales of change. In 2009, as a participant in the Copenhagen Accord, China pledged to reduce its economy's carbon intensity by 40–45 % by 2020 compared to 2005 levels. Jinan's potential transport CO_2 intensity target is based on an equivalent aspiration to the national target.

28.2 Relevance Between Transport and Economy in Jinan

As one important power to push economy forward, development of transport industry will produce a series of results, such as increase of new job opportunity, strengthening of regional self-development ability, and much possibility to increase income. So, the meaning of transport industry development is not merely to prolong the road length, but also bring positive effect for industry development, economic structure, etc. On the other hand, different factors also influence economy development in varying degree.

We adopt the Grey Relational Analysis method (Deng 1987) to seek the relevance between transport and economy in Jinan. According to the principle of authenticity, completeness and availability, we select GRP (gross regional product) to indicate economic growth, and passenger-kilometers, freight tonne-kilometers, length of highways in operation and possession of civil vehicles to describe the transport system.

The result is that Jinan's economy has strong relevance with transport. All the indices present positive correlation. Among them, the relation with possession of civil vehicles is most close, the next is freight tonne-kilometers, the following are passenger-kilometers and length of highways in operation.

Transmission mechanisms between transport industry and economic growth go as follows. First of all, output of some transport infrastructure industry constitutes part of the national economy. Second, the main utility of transport infrastructure is its function. The growth of the national economy is supported by contribution of such final production elements as labor, capital, and land. As a specific form of production elements, transportation infrastructure accommodates these final elements objectively, which plays the irreplaceable role to the entire economic growth. Third, transport infrastructure investment directly stimulates the growth of the national economy by multiplier effect, and the conduction process complies with the general investment principle. At last, from the feedback perspective, transport infrastructure keeps adjusting itself in certain sensitivity to achieve the harmonious development with national economy according to the sensitivity of economic growth.

28.3 Causal Relationship in Low-Carbon Transport System

Building low-carbon transport system is not a simple and separated task, but a systematic engineering involved with complex factors, which must be reflected comprehensively in macroscopical decision level, mesoscopical management level, and microscopic technology level. These factors include economy development, population size, ecological environment, transport infrastructure, investment, policy and technology level, etc. Their causal relationship is demonstrated in Fig. 28.1, in which the arrow shows their causal relationship, plus sign means positive effect, and minus sign expresses negative effect.

Main feedback loops are as follows:

(1) Transport Operation $\xrightarrow{+}$ Economy Development $\xrightarrow{+}$ Investment Increase $\xrightarrow{+}$ Transport Infrastructure $\xrightarrow{+}$ Transport Operation

(2) Transport Operation $\xrightarrow{-}$ Ecological Environment $\xrightarrow{+}$ Economy Development $\xrightarrow{+}$ Technology Level $\xrightarrow{+}$ Transport Operation

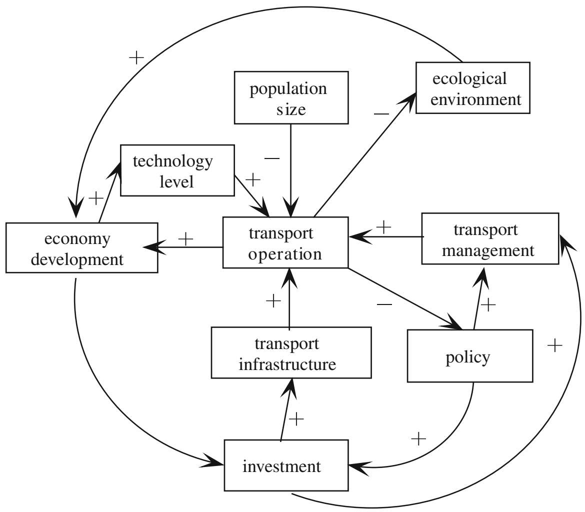

Fig. 28.1 Cause and effect diagram of transport system

(3) Transport Operation $\xrightarrow{-}$ Policy $\xrightarrow{+}$Transport Management $\xrightarrow{+}$ Transport Operation

(4) Transport Operation $\xrightarrow{+}$ Economy Development $\xrightarrow{+}$ Technology Level $\xrightarrow{+}$ Transport Operation

(5) Transport Operation $\xrightarrow{-}$ Policy $\xrightarrow{+}$ Investment $\xrightarrow{+}$ Transport Infrastructure $\xrightarrow{+}$ Transport Operation

In addition, Jinan city is still in the rapidly developing stage, the trend of increasing population is more and more obvious. It constitutes negative polarity for transport operation.

28.4 Jinan's Short-Term Transport CO_2 Emission Based on Energy Saving Potential

We take international and internal advanced level as the benchmark and the time internal is from 2005 to 2015.

Energy saving potential of Jinan under efficiency convergence in 2008 is 35.1 %. This means that Jinan has a rather large space to reduce energy consumption, and so does the CO_2 emission.

In Jinan, transportation industry is the second petroleum product consumer, only next to manufacturing industry, and its consumption is one third of the society. Transport system is Jinan's primary industry for energy saving and carbon emission reduction.

Until now, Jinan has achieved much in energy saving of transport. From 2005 to 2010, gross production of transport industry has risen from 11.22 to 23.68 billion RMB Yuan, and annual average growth rate is 13.25 %; corresponding to this, Jinan's energy consumption has increased greatly from 2.79 million tce (ton of standard coal equivalent) in 2005 to 4.07 million tce in 2008,[1] and its annual average growth rate is 13.46 %. Energy consumption of transport accounts for 10.23 % of the total in 2005, reaching 12.61 % in 2008. Between 2005 and 2010, energy consumption per 10,000 RMB Yuan of transportation output value has reduced from 2.48 to 2.00 tce/10,000 RMB Yuan, annually 3.65 %. Learning from the historic experience of transportation industry in developed regions and combining with its basic trend in Jinan, it can be concluded that the increment speed of production and energy consumption of Jinan's transportation industry during 12th Five-Year Plan will slow down, at the rate of 11 %[2] and 8 %,[3] respectively.

According to national development and reform commission of China, burning 1 tce will produced 2.62 tonnes CO_2. So, 4.92 Mt (million tonnes) CO_2 emissions would have been reduced by 2015.

28.5 Jinan's Long-Term Transport CO_2 Emissions Based on Scenario Analysis

There has no definite CO_2 reduction goal for each industry in China. As a participant in the Copenhagen Accord, however, China has pledged to reduce its economy's carbon intensity by 40–45 % by 2020 compared to 2005 levels. Here, we assume that Jinan's potential transport CO_2 intensity goal keeps in step with the national.

Future scenarios can be generated in view of likely trends and uncertainties, and be used to help assess likely progress against aspirations. Two key uncertainties, sustainability (Banister et al. 2000) and transport socialization, are used to generate the two axes within the classic dilemma scenario matrix (Mahoney 2000). Among these scenarios, the first correspond to BAU (Business As Usual) and the fourth is the best expectancy. Scenario II and III are not unlikely to take place.

Scenario I assumes large transport input, along the road of North America. It is based on a high level of public transport, but also a lower level of sustainability. There are still so many conventional petrol cars, with little efforts to car limit (Bonsall and Young 2010) and technology innovation (Cerry et al. 2009). In this scenario, transport CO_2 emissions rise from 5.93 Mt in 2005 to 137.25 Mt in 2030. This also will result in the increase of per capita transport emissions from 0.99 tonnes in 2005 to 16.76 tonnes in 2030.

[1] No more latest data about energy consumption of Jinan is available from official mission.

[2] It is based on the equivalent economic growth rate of Jinan in issued 12th Five-Year Plan.

[3] It is obtained by trend extrapolation.

Scenario IV assumes much increased level of sustainability and transport socialization. It is based on a high level of public transport, as well as a high level of sustainability. There is less conventional petrol car, with much effort to car limit and public transport promotion (Hao et al. 2011). Under this scenario, transport CO_2 emissions rise from 5.93 Mt in 2005 to 91.63 Mt in 2030, and person transport emissions rise from 0.99 tonnes in 2005 to 5.02 tonnes in 2030. Although this scenario seems optimistic, the 45 % carbon reduction in intensity target would not be achieved. Compared with 2005 levels, carbon emission intensity rises by 8.97 %. So, accomplishing the task satisfactorily would require much more propulsive policies, which include advance structure adjustment of transport capacity and organizing, improve actual load rate of coaches, popularize oil consumption supervisory device and focus on vehicle maintenance (Sperling and Gordon 2009; CAI-Asia 2009), and develop convenient public traffic travel mode (Darido et al. 2009; Paulley et al. 2006).

28.6 Conclusions and Future Works

Transport is related with economy and environment. The problem before us is how to develop transport and economy while reducing carbon emission. It can be seen from the cause and effect diagram of transport system that technology and positive policy will be helpful. In short term, energy saving potential can be dug out by technology progress. In long term, however, the CO_2 emission reduction depends more on macro policies, such as structure adjustment, bus priority, etc. Then, in the next step, we should determine the contribution degree and implementation difficulties of different measures, which will be really valuable for decision makers.

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Chapter 29
The Logit Model in the Urban Low Carbon Transport and Its Application

Zinan Yang and Xifu Wang

Abstract At present, low-carbon problems have become a hot spot at home and abroad, particularly in the field of transportation low-carbon transport is an important part of energy saving and emission reduction. This paper research the low-carbon factors impact on other transport modes in the city, and study the change of various transport modes share rate. A Logit model which is broadly applied in the transportation research was used for the study which selected economy, speed, convenience, comfort, safety and low-carbon as its 6 index. The share rate model of various transport modes is created according to the relevant research data and the maximum likelihood estimation method. Finally, the share rate considering the low-carbon factors are calculated and contrast the share rate value of before and after low-carbon factors.

Keywords Low-carbon · Logit model · Share rate

29.1 Introduction

The Logit model is a widely used model in the urban transport share rate. Logit model can express all aspects of travel choice influencing factors, to improve the prediction accuracy and practicality of the model (Jia et al. 2007). In this paper, the research of urban transport share rate use the Logit model especially considering

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the impact of share rate in the future low carbon transport. First, establish the generalized cost function of the various transport modes without considering the carbon emission factors, and calibrate the model parameters based on actual survey, and then study the share rate of the various transport modes when considering the carbon emission factors.

29.2 Model Building

According to research, in the generalized cost function, set the economy, speed, convenience, comfort, safety and low-carbon six service characteristics. The service characteristics of various transport modes quantified as follow.

(1) Economy (E_i). The public transport use various transport modes fares as measurement index, private transport use the price of fuel consumption as the measurement index of economy.
(2) Speed (F_i). Use the ratio of the average travel distance (L) and the average travel speed of all transport modes (v_i) as the measurement index of speed (F_i).

$$F_i = L/v_i \tag{29.1}$$

The travel time in the survey in fact include: pure driving time, parking time, waiting time and transfer time. According to the resident survey data and related literature (Ma et al. 2006), propose the value of the average travel speed of the various transport modes, shown as Table 29.1.

(3) Convenience (C_i). The public transport uses the average waiting time; Private transport considers the average parking time as the measurement index of convenience. Combined with the actual situation, propose the average waiting time, shown as Table 29.2.
(4) Comfort (M_i). In order to reflect the comfort features of the various transport modes in the generalized cost function, need to quantify the comfort. Comfort indicator related to travel time, expenses, psychological needs, personal space and so on, the base value take the 8 % of the various transport modes freight (Zhao et al. 2008). The specific values are shown in Table 29.2.

Table 29.1 Average travel speed of various transport modes

Transport mode	Average travel speed/(km/h^{-1})
Bicycle	10
Battery vehicle	14
Motorcycle	16
Bus	20
Taxi	25
Private cars	18

Table 29.2 Various transport modes service characteristics of the Binhai New Area

Transport characteristics	Economy (E_i)	Speed (F_i)	Convenience (C_i)	Comfort (M_i)	Safety (S_i)
Bicycle	0	0.90	0.05	0.16	0.99
Battery vehicle	0	0.64	0.05	0.40	0.98
Motorcycle	2.4	0.56	0.05	0.64	0.98
Bus	2.0	0.45	0.17	0.48	0.98
Taxi	16.3	0.36	0.08	1.28	0.97
Private cars	4.0	0.50	0.08	1.44	0.98

(5) Safety (S_i). According to the number of the various transport modes vehicle accidents and security arrangement law set in the literature (Jia et al. 2007). The specific values are shown in Table 29.2.

(6) Low-carbon (R_i). The Values of low-carbon factors (R_i) use the ratio of the average travel per capita CO_2 emissions (A_i) as a reference value. The formula is (29.2).

$$R_i = 1 - \frac{A_i}{\sum_{i=1}^{n} A_i} \tag{29.2}$$

Now actually does not consider the low-carbon factors, so take the value 1.

Due to the E_i and C_i are based on the time value, so need to multiply by the value of travel time (V(T)). M_i has subjective factors, and therefore set up separate coefficient. S_i and R_i are the characteristics can't measure by the time and price value, it should be the separate proportional, thereby establishing the generalized cost function (He et al. 2006; Zeng 2007).

$$V_i = \frac{\theta U_1 - \xi M_i}{S_i \cdot R_i} \tag{29.3}$$

$$U_i = E_i + (F_i + C_i) \cdot V(T) \tag{29.4}$$

A_i is the comprehensive cost of the various transport mode, $V(T)$ is the local average time value, θ and ξ are characteristic coefficient.

Use Logit model to calculate the urban various transport modes share rate. Consider the relationship with various parameters, and improve the Logit model as follow.

$$P_i = \frac{\exp(-V_i)}{\sum_{i=1}^{n} \exp(-V_i)} \tag{29.5}$$

29.3 Example Calculation

TianJing Binhai New Area is situated in the north of the north China plain and very close to the two megalopolises of Beijing and Tianjin, with a vast area of hinterland. Binhai New Area proudly occupies the core position of the Bohai Rim economic circle, facing Japan and the Korean Peninsula across the sea, and directly encountering Northeast Asia and the rapidly rising Asian-Pacific economic circle.

29.3.1 Parameter Calibration

According to the trip research of Binhai New Area in June 2011, the he average trip distance of traveler in Binhai New Area is 8.57 km, considering the distance loss, set the travel distance at 9 km. Various transport modes service characteristics of the Binhai New Area is shown as Table 29.2.

And the average time value formula is: V(T) = GDP ÷ The local population × The average labor time. Calculated the results: V(T) = 32.61yuan/h. According to the travel choice survey, get the existing urban transport share rate. It is shown in the Table 29.3.

Suppose there are N travelers, choose M kinds of transport of modes. It can be seen as N times Bernoulli trials, using the maximum likelihood estimates.

$$f(\theta|P) = P(N_1, N_2, \ldots, N_m|\theta) = \frac{N!}{N_1!N_2!\ldots N_m!}\Pi P_i^{N_i} \tag{29.6}$$

Though calculate the partial derivative of θ and ξ, to make derivative values to 0. And input the parameter, N = 9950, M = 6, get the results. $\theta = 0.1203, \xi = 0.08769$. And then input the θ and ξ into generalized cost function, obtained Binhai New Area travel cost function model.

$$V_i = \frac{0 \cdot 1203U_i - 0 \cdot 08769M_i}{S_i\hbar R_i} \tag{29.7}$$

$$U_i = E_i + 32.61(F_i + C_i) \tag{29.8}$$

Table 29.3 The share rate of various transport modes

Transport mode	Bicycle	Battery vehicle	Motorcycle	Bus	Taxi	Private cars
Number	793	1647	1890	3428	750	1442
Share rate (%)	7.97	16.55	18.99	34.55	7.54	14.49

Table 29.4 The share rate of various transport modes after considering the low-carbon factors

Transport characteristics	Economy (E_i)	Speed (F_i)	Convenience (C_i)	Comfort (M_i)	Safety (S_i)	Low-carbon (R_i)	Share rate (P_i)
Bicycle	0	0.90	0.05	0.16	0.99	1	11.62
Battery vehicle	0	0.64	0.05	0.40	0.98	1	30.85
Motorcycle	2.4	0.56	0.05	0.64	0.98	0.79	14.80
Bus	2.0	0.45	0.17	0.48	0.98	0.93	37.46
Taxi	16.3	0.36	0.08	1.28	0.97	0.74	3.03
Private cars	4.0	0.50	0.08	1.44	0.98	0.54	2.24

29.3.2 The Share Rate After Considering the Low-Carbon Factors

The implementation of urban low-carbon transport operating strategy will make each properties of Binhai New Area transport improve greatly, and use Logit model to calculate the share rate of various transport modes in the future. The data is shown in Table 29.4.

29.4 Conclusion

Logit model is an effective way to research variety of transport modes share rate. In this paper, the model studies the reasonable share rate of various transport modes in the future, considering the low-carbon factors. According to the results of model calculations, the share rate of bicycle, battery vehicle and bus increase, the share rate of taxi and private cars descend. It meets the low-carbon cities policy to encourage clean energy and public transport. With the increasing attention on low-carbon economy at home and abroad, low-carbon factors will become more frequent consideration to the transport field.

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Chapter 30
Comprehensive Evaluation of Highway Traffic Modernization Based on Low-Carbon Economy Perspective

Linlin Zheng, Yongbo Lv, Li Chen and Le Huang

Abstract The comprehensive evaluation index system of highway traffic modernization is established on the basis of the long-term plan for highway energy-saving of China. The AHP-Entropy method is expounded for quantifying the weight of evaluation index. In order to make up for the deficiencies of the present highway traffic modernization evaluation method, the multi-level extensible evaluation model is developed with the extension method as the core. Jiangxi Province is studied as an example, indicating that the new method is applicable to highway traffic modernization evaluation.

Keywords Low-carbon economy · Highway traffic modernization · Index system · Multi-level extension

30.1 Introduction

In recent years, the highway traffic facilities and management facilities are improved significantly, while the situation of energy saving and environmental protection is very severe. As a huge traffic system involving multi-participation of

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people, vehicle and road, the highway traffic is the most important field of energy saving and emission reduction that accounted for over 80 % energy consumption is concentrated in this area (Li 2011, Hu 2008). So establishing an evaluation index system with the embodiment of scientificity and applicability is imperative, through the evaluation of highway traffic development by the index system, the decision makers can recognize the gap between the current situation and the requirements of modern highway traffic system, discern the weak links and clear the focal point of development in the future.

30.2 Evaluation Index System

On the basis of analysis of influencing factors (Unified Plan Department of the Ministry of Transport of the People's Republic of China 2008, Han et al. 2011) of low-carbon highway traffic modernization, this paper establishes the highway traffic modernization index system from four aspects namely structural low-carbon, technical low-carbon, management low-carbon and policy low-carbon, as shown in Table 30.3. All of the indexes, scored by 100-point system, are divided into three grades as shown in Table 30.1.

The quantization method of each index is shown in Table 30.2. The quantization of quantitative indexes, using the planning value of highway traffic energy-saving index of our country (Unified Plan Department of the Ministry of Transport of the People's Republic of China 2008) as a standard, is determined with the comprehensive consideration of variation range and implementary difficulty; the quantization method of qualitative indexes is determined after consultation with experts.

30.3 Evaluation Method

30.3.1 Determining Weights by AHP-Entropy

The method of determining index weight in this paper is using Entropy to modify the initial weight determined by AHP, which can effectively reduce subjective

Table 30.1 Grading standard of modernization degree

Grade	Interval	Modernization degree
1	≥ 75	High
2	60–74	Middle
3	≤ 59	Low

Table 30.2 The quantization of modernization evaluation index

Evaluation index	Attribute	Quantization method
Proportion of second-class highway and above C_{11}	Quantitative	75 points when it reaches 21 %, plus(minus) 1 point per 0.5 % more(less)
Rate of road pavement C_{12}	Quantitative	75 points when it reaches 75 %, plus(minus) 1 point per 1 % more(less)
Proportion of diesel passenger cars C_{13}	Quantitative	75 points when it reaches 73 %, plus(minus) 1 point per 1 % more(less)
Proportion of diesel freight cars C_{14}	Quantitative	75 points when it reaches 90 %, plus(minus) 1 point per 0.5 % more(less)
Proportion of alternative fuel of passenger cars C_{15}	Quantitative	75 points when it reaches 6 %, plus(minus) 1 point per 0.2 % more(less)
Average tonnage of freight cars C_{16}	Quantitative	75 points when it reaches 4.5 tons, plus(minus) 1 point per 0.2 ton more(less)
Proportion of large-scale freight cars C_{17}	Quantitative	75 points when it reaches 80 %, plus(minus) 1 point per 1 % more(less)
Coverage of ETC C_{21}	Quantitative	75 points when it reaches 60 %, plus(minus) 1 point per 1 % more(less)
Technical condition of in-use vehicles C_{22}	Qualitative	Whether strengthening in-use vehicles' periodic detection, repair and maintenance or not, improving technical condition of commercial vehicles
Application of on-board energy-saving equipment C_{23}	Qualitative	Application and popularization of automobile energy saving technology and products, such as radial tire, baffle, fan clutch
Coverage of travel information system C_{24}	Quantitative	75 points when it reaches 80 %, plus(minus) 1 point per 1 % more(less)
Proportion of tractor-trailer transportation C_{31}	Quantitative	75 points when it reaches 15 %, plus(minus) 1 point per 0.5 % more(less)
Actual loading rate of passenger transportation C_{32}	Quantitative	75 points when it reaches 74 %, plus(minus) 1 point per 1 % more(less)
Degree of traffic congestion C_{33}	Qualitative	The degree of energy consumption because of congestion, whether taking effective measures to ease the traffic congestion
Utilization of freight mileage C_{34}	Quantitative	75 points when it reaches 67 %, plus(minus) 1 point per 1 % more(less)
Proportion of energy-saving driving C_{35}	Quantitative	75 points when it reaches 70 %, plus(minus) 1 point per 1 % more(less)
Standard formulation C_{41}	Qualitative	Relevant standards of highway traffic based on the perfect degree of carbon intensity and total carbon index
Low-carbon subsidies C_{42}	Qualitative	The subsidy of purchasing new energy vehicle, scrap-purchasing, etc.
Access and withdrawal institution C_{43}	Qualitative	Establishment and perfection of the access and withdrawal system based on carbon intensity

uncertainty, so as to determine the index weight more reasonably, its calculating steps as follows:

(1) Constructing the judgment matrix $\overline{\overline{A}} = \{\overline{a}_{ij}\}_{n\times n}$, and we can obtain the weight coefficient of initial index $\theta_j = (\theta_1, \theta_2, \cdots, \theta_{\mathrm{n}})^T$ through AHP.
(2) After uniformization of judgment matrix $\overline{\overline{A}} = \{\overline{a}_{ij}\}_{n\times n}$, we can obtain the canonical judgment matrix $A = \{a_{ij}\}_{n\times n}$, where $a_{ij} = \frac{\overline{a_{ij}}}{\sum_{i=1}^{n} \overline{a_{ij}}}$.
(3) The entropy E_j of index j can be got by $E_j = -\frac{(\ln n)^{-1}}{\sum_{i=1}^{n} a_{ij} \ln a_{ij}}$, $(0 \le E_j \le 1)$.
(4) Then the deviation degree d_j of index j can be calculated by $d_j = 1 - E_j$.
(5) After former step, calculate the correction coefficient $\mu_j = d_j \Big/ \sum_{j=1}^{n} d_j$.
(6) By using correction coefficient μ_j, we can correct the weight coefficient of initial index $\theta_j = (\theta_1, \theta_2, \cdots, \theta_{\mathrm{n}})^T$ from AHP method through $\theta_j^{'} = \mu_j\theta_j \Big/ \sum_{j=1}^{n} \mu_j\theta_j$.
(7) Finally, we get the combination weight $\omega_j = (\omega_1, \omega_2, \ldots, \omega_m)$ by $\omega_j = \rho\theta_j + (1-\rho)\theta_j'+$, where ρ is 0.5.

By using the energy saving potential of all indexes as main reference for index comparison, we can obtain the judgment matrix of each level of the evaluation index system through 1–9 comparable scale method, then calculate the weight of each level indexes relate to the higher level index, the result is shown in Table 30.3.

30.3.2 Multi-Level Extensible Evaluation Model

Extensible evaluation model is one of the main applications of extension theory. The core idea of extension theory is matter-element theory. Matter-element is an ordered three-dimensional, which is composed of matter, characters and the matter's quantity value about the characters, and denoted by R = (matter, characters, quantity value) = (U, C, V) (Pan et al. 2011). It is consistent with the thought of mapping relationship between the index system would be established for modernization evaluation and the evaluated matter. The concrete steps are as follows:

(1) The determination of classical field and segment field

Let grade field of modernization is $U = \{U_j, j = 1, 2, \cdots, m\}$; evaluation factor set of first level index is $C = \{C_i, i = 1, 2, \cdots, n\}$.

Table 30.3 Evaluation index of modernization and values

Target level N	First level index C_i (Weight W_i)	Secondary level index C_{ik} (Weight W_{ik})	Actual value	Score V_{ik}	Correlation degree $j = 1$	$j = 2$	$j = 3$
Highway traffic modernization	Structural low-carbon (0.252)	Proportion of second-class highway and above (0.251)	15.42 %	64	–0.100	0.125	–0.234
		Rate of road pavement (0.179)	49.93 %	50	0.250	–0.167	–0.333
		Proportion of diesel passenger cars (0.098)	77.6 %	80	–0.500	–0.200	0.333
		Proportion of diesel freight cars (0.173)	87.9 %	71	–0.275	0.160	–0.121
		Proportion of alternative fuel of passenger cars (0.076)	4.8 %	69	–0.225	0.240	–0.162
		Average tonnage of freight cars (0.123)	4.05	66	–0.150	0.214	–0.209
		Proportion of large-scale freight cars (0.100)	79.2 %	74	–0.350	0.040	–0.037
	Technical low-carbon (0.198)	Coverage of ETC (0.121)	38 %	53	0.175	–0.130	–0.319
		Technical condition of in-use vehicles (0.403)	medium	74	–0.350	0.040	–0.037
		Application of on-board energy-saving equipment (0.319)	medium	68	–0.200	0.280	–0.179
		Coverage of travel information system (0.157)	54 %	49	0.289	–0.183	–0.347
	Management low-carbon (0.346)	Proportion of tractor-trailer transportation (0.102)	8.6 %	63	–0.075	0.088	–0.245
		Actual loading rate of passenger transportation (0.278)	79.4 %	80	–0.500	–0.200	0.333
		Degree of traffic congestion (0.233)	good	77	–0.425	–0.080	0.095
		Utilization of freight mileage (0.301)	73.1 %	81	–0.525	–0.240	0.462
		Proportion of energy-saving driving (0.086)	52 %	57	0.075	–0.065	–0.295
	Policy low-carbon (0.204)	Standard formulation (0.366)	medium	65	–0.125	0.167	–0.222
		Low-carbon subsidies (0.288)	good	75	–0.375	0.000	0.000
		Access and withdrawal institution (0.346)	medium	63	–0.075	0.088	–0.245

Tips: The relevant data of Jiangxi Province is from *The Long-term Plan for Highway and WaterCarriage Energy-saving of Jiangxi Province (2008–2020) and Jiangxi Statistical Yearbook*

Define

$$R_j = (U_j, C, V_j) = \begin{bmatrix} U_j & c_1 & \langle a_{j1}, b_{j1} \rangle \\ & c_2 & \langle a_{j2}, b_{j2} \rangle \\ & \vdots & \vdots \\ & c_n & \langle a_{jn}, b_{jn} \rangle \end{bmatrix}, R_U = (U, C, V_U)$$

$$= \begin{bmatrix} U & c_1 & \langle a_{U1}, b_{U1} \rangle \\ & c_2 & \langle a_{U2}, b_{U2} \rangle \\ & \vdots & \vdots \\ & c_n & \langle a_{Un}, b_{Un} \rangle \end{bmatrix}$$

where V_j is a classical field and V_U is segment field of U.

(2) The establishment of correlation function and calculation of correlation degree

Then we obtain the correlation degree of the secondary level index of evaluating matter relate to modernization grade $j(j = 1, 2, \cdots, m)$ $(j = 1, 2, \cdots, m)$, which can be expressed as:

$$k_j(c_{ik}) = \begin{cases} \dfrac{\rho(v_{ik}, V_j)}{\rho(v_{ik}, V_U) - \rho(v_{ik}, V_j)} & \rho(v_{ik}, V_U) - \rho(v_{ik}, V_j) \neq 0 \\ -\rho(v_{ik}, V_j) - 1 & \rho(v_{ik}, V_U) - \rho(v_{ik}, V_j) = 0 \end{cases}$$

where $\rho(x, \langle a, b \rangle) = \left| x - \frac{a+b}{2} \right| - \frac{1}{2}(b - a)$, and $k_j(c_{ik})$ is correlation degree of the kth secondary index of the ith first level index relates to modernization grade $j(j = 1, 2, \cdots, m)$.

(3) First level evaluation

We obtain the association degree matrix of each first level index relates to each modernization grade $k(c_i)$ by

$$k(c_i) = (k_j(c_i)) = \left[w_{i1}, w_{i2}, \cdots, w_{ip} \right] \cdot \begin{bmatrix} k_1(c_{i1}) & k_2(c_{i1}) & \cdots & k_m(c_{i1}) \\ k_1(c_{i2}) & k_2(c_{i2}) & \cdots & k_m(c_{i2}) \\ \vdots & \vdots & \cdots & \vdots \\ k_1(c_{ip}) & k_2(c_{ip}) & \cdots & k_m(c_{ip}) \end{bmatrix}$$

(4) Secondary level evaluation

In the same way, we obtain the association degree matrix of the evaluating matter relates to each modernization grade $k(N)$ by

$$k(N) = [w_1, w_2, \cdots, w_n] \cdot \begin{bmatrix} k_1(c_1) & k_2(c_1) & \cdots & k_m(c_1) \\ k_1(c_2) & k_2(c_2) & \cdots & k_m(c_2) \\ \vdots & \vdots & \cdots & \vdots \\ k_1(c_n) & k_2(c_n) & \cdots & k_m(c_n) \end{bmatrix}$$

Then if it satisfies $k_{j0}(N) = \max\limits_{j=\{1,2,\cdots,m\}} k_j(N)$, the evaluating matter N is considered as belonging to modernization grade j.

Define $\underset{j}{\tilde{k}}(N) = \frac{k_j(N) - \min\limits_j k_j(N)}{\max\limits_j k_j(N) - \min\limits_j k_j(N)}$, then $j^* = \sum\limits_{j=1}^{m} j \cdot \tilde{k}_j(N) / \sum\limits_{j=1}^{m} \tilde{k}_j(N)$ is the level variable eigenvalue of highway traffic modernization, that is a degree of belonging to a certain modernization grade.

30.4 Case Study

The actual value of each index of Jiangxi Province in 2007 and the quantization score got through the method mentioned above are shown in Table 30.3. According to Tables 30.1 and 30.2, we establish the highway traffic modernization evaluation's grade field $U = \{U_1, U_2, U_3\} = \{\text{High}, \text{Middle}, \text{Low}\}$ and factor set $C = \{C_1, C_2, C_3\} = \{$Structural Low-carbon, Technical Low-carbon, Management Low-carbon, Policy Low-carbon$\}$ a_n, and determine the classical field and segment field of each index. Then through formulas above, we calculate the correlation degree of the first and secondary level indexes respectively, the results are shown in Tables 30.3 and 30.4.

Finally we determine the modernization grade, as shown in Table 30.4, the highway traffic modernization degree of Jiangxi Province in 2007 is second grade, indicating that the degree of modernization is middle, furthermore, we obtain the value d_1.

Table 30.4 Evaluation result of multi-level extension

	Index	Correlation degree			First level weight	Modernization grade j
		$j = 1$	$j = 2$	$j = 3$		
First level	Structural low-carbon	–0.148	0.058	–0.148	0.252	2
	Technical low-carbon	–0.165	0.061	–0.138	0.198	2
	Management low-carbon	0.204	–0.143	–0.397	0.346	1
	Policy low-carbon	–0.166	0.092	–0.180	0.204	2
Target Level	Highway traffic modernization	–0.238	–0.003	–0.033	–	2

30.5 Conclusions

On the basis of long-term plan for highway energy-saving of China, this paper established the evaluation index system of highway traffic modernization in low-carbon economy perspective, which has the realistic significance, then further putted forward a reliable and useful method of index quantification. This paper also described the calculation steps of index weight by AHP-Entropy combination method and the multi-level extensible model's application in highway traffic modernization evaluation. Jiangxi Province highway traffic modernization evaluation of 2007 was studied as an example, indicating that the new method is applicable for highway traffic modernization evaluation which has a better realistic meaning to promote the construction of highway traffic modernization in China.

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Chapter 31
Traffic Congestion Measurement Method of Road Network in Large Passenger Hub Station Area

Yu Han, Xi Zhang and Lu Yu

Abstract Making correct assessment on traffic congestion intensity of road network of the large passenger hub station area, has great significance in improving the traffic condition of the road network and ensuring passengers' promptly arrival. This paper proposes a hierarchical evaluation method as section-road-network. Firstly, it determines the road section congestion intensity based on microcosmic simulation, then put the road connectivity as the weigh, to develop the weighting models for measuring traffic congestions. Finally, it conducts a case for Beijing South Railway Station by measuring congestion condition of the station area road network.

Keywords Traffic congestion measurement · Road connectivity · Traffic congestion intensity · Weighting model

31.1 Introduction

The large passenger hub station is the intersection of various transportation networks. It attracts large numbers of traffic and has a wide range radiation. It undertakes more traffic pressure than normal urban traffic road network. The main characteristics are, peak period is long and scattering, different kinds of vehicles are blended and driving in bad order. Therefore, the road network in large passenger

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hub station area is the weak point of urban traffic system. Making correct assessment on traffic congestion intensity of it has great significance in improving the traffic conditions of the road network and ensuring passengers' promptly arrival.

Presently, the majority of traffic congestion measurement methods are against the single section of the road. They select some indices and quantify them, using a certain evaluation methods such as fuzzy evaluation method (Long and Tan 2011) to calculate. Few methods were proposed to evaluate the whole road network, The research for the road network in large passenger hub station area is even nearly blank. This paper proposes a road connectivity-based weighting model for measuring traffic congestion intensity, take Beijing South Railway Station as a case to verify the model.

31.2 The Evaluation Index of Traffic Congestion Intensity

31.2.1 The Hierarchical Traffic Congestion Intensity of Road Network

The traffic congestion intensity (TCI) characterizes the congestion degree of a specific section, road, network. TCI is calculated gradually according to the order of section-road-network. The traffic congestion intensity of road section is represented by $TCI_{section}$, it is a discrete variable and its value ranges from 1 to 5. The equation is shown as follow:

$$TCI_{section} = \begin{cases} 1 \ very\,fluent \\ 2 \ fluent \\ 3 \ slight\ congestion \\ 4 \ moderate\ congestion \\ 5 \ severecongestion \end{cases} \tag{31.1}$$

By using the weighting method, we can get TCI_{road} and $TCI_{network}$. The equations are:

$$TCI_{road} = \frac{\sum_{i=1}^{n} A_i \times TCI_{section_i}}{\sum_{i=1}^{n} A_i}, \ TCI_{network} = \frac{\sum_{j=1}^{m} B_j \times TCI_{road_j}}{\sum_{j=1}^{m} B_j} \tag{31.2}$$

In the equation, $TCI_{section_i}$ represents the traffic congestion intensity of section i in this road level, TCI_{road_j} represents the traffic congestion intensity of the road in j level, A_i and B_j are the weigh of section i and road j. n represents the section amounts of the road in a certain level, m represents road level number of the road network.

Table 31.1 Traffic congestion intensity level standard

TCI	Very fluid	Fluid	Slight congestion	Moderate congestion	Severe congestion
Value range	(1, 1.5)	(1.5, 2.5)	(2.5, 3.5)	(3.5, 4.5)	(4.5, 5)

The corresponding relation between TCI_{road}, $TCI_{network}$ and traffic congestion intensity degree is defined as follow: (Table 31.1).

31.2.2 Determination of $TCI_{section}$ Based on Microcosmic Simulation

The characteristic of section's congestion is that vehicles are in low speed and the lag time is long. In previous studies (Zhang and Yu 2008), the determination of $TCI_{section}$ needs large-scale surveys and calculations. It has low efficiency and bad application. This paper introduce a method based on microcosmic simulation, which is simple and practical.

In traffic microcosmic simulation software Vissim, by entering the traffic flow data, road geometry data and signal timing of the intersection, we can get many indices which can reflect congestion degree such as average travel speed, average lag time and so on.

We choose average travel speed, average delay time, degree of saturation three indices as the variables to determine $TCI_{section}$. The evaluation standard of these indices are shown in the following tables. The equation of $TCI_{section}$ is:

$$TCI_{section} = \frac{Index_1 + Index_2 + Index_3}{3} \tag{31.3}$$

$Index_1$ represents the $TCI_{section}$ reflected from average travel speed. $Index_2$ represents the $TCI_{section}$ reflected from average lag time. $Index_3$ represents the $TCI_{section}$ reflected from degree of saturation (Tables 31.2, 31.3, 31.4).

Table 31.2 Average travel speed evaluation reference standard (Zhang 2011)

Congestion level	Very fluid	Fluid	Light congestion	Moderate congestion	Severe congestion
Average travel speed (km/h)	>45	(35, 45)	(25, 35)	(15, 25)	(0, 15)

Table 31.3 Unit mileage average lag time reference standard (Zhang 2011)

Congestion level	Very fluid	Fluid	Light congestion	Moderate congestion	Severe congestion
Average lag Time(s)	0	(0, 23)	(23, 64)	(64, 160)	>160

Table 31.4 Degree of saturation evaluation reference standard (Zhang 2011)

Congestion level	Very fluid	Fluid	Light congestion	Moderate congestion	Severe congestion
Degree of saturation	≤0.4	(0. 4, 0. 6)	(0. 6, 0. 7)	(0. 7, 0. 8)	>0. 8

31.3 Connectivity-Based Traffic Congestion Measurement Model

In the road network, every section is not isolated. Different sections have different extent of impact when they have different connectivity. We define the section connectivity to be the number of sections connected to the aim road section, the road connectivity to be the number of sections connected to the road in aim level. They were expressed by SC and RC.

We construct the model with $TCI_{section}$ as the index and road connectivity as the weigh. According to the three levels of traffic congestion measurement, we get the equation of TCI_{road} and $TCI_{network}$ as follows:

$$TCI_{road} = \frac{\sum_{i=1}^{n} SC_i \times TCI_{section_i}}{\sum_{i=1}^{n} SC_i} \tag{31.4}$$

$$TCI_{network} = \frac{\sum_{k=1}^{m} RC_k \times TCI_{road_k}}{\sum_{k=1}^{m} RC_k} \tag{31.5}$$

In the equation, RC_k represents the connectivity of road in k degree, m represents the amount of road degree.

31.4 The Example

We take Beijing South Railway Station as the case. The research object is the station area road network. The structure of the road network is as follow in Fig 31.1.

The red line represents fast-speed road, the blue line represents arterial road, the yellow line represents minor arterial road, the green line represents primary distributor road. According to the road network structure, we count the section connectivity and road connectivity as follow in Table 31.5.

We surveyed 15 min traffic volume of the sections above at several representative period, converted them into hourly traffic volume. According to the simulation result, we worked out $TCI_{section}$ and bring the result into the model. The variation of $TCI_{network}$ is shown as the following (Fig. 31.2).

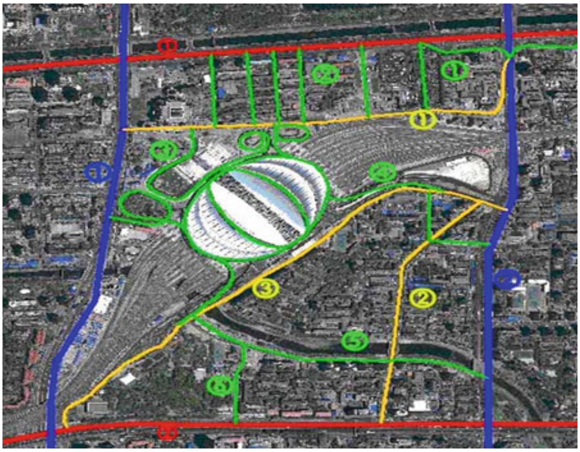

Fig. 31.1 Road network of Beijing South Railway Station

Table 31.5 The connectivity of road section in road network

Section number	Section connectivity	Road connectivity
Arterial road 1	6	16
Arterial road 2	10	
Fast-speed road 1	10	17
Fast-speed road 2	7	
Minor arterial road 1	9	21
Minor arterial road 2	6	
Minor arterial road 3	7	
Primary distributor road 1	3	12
Primary distributor road 2	2	
Primary distributor road 3	6	
Primary distributor road 4	3	
Primary distributor road 5	5	
Primary distributor road 6	2	

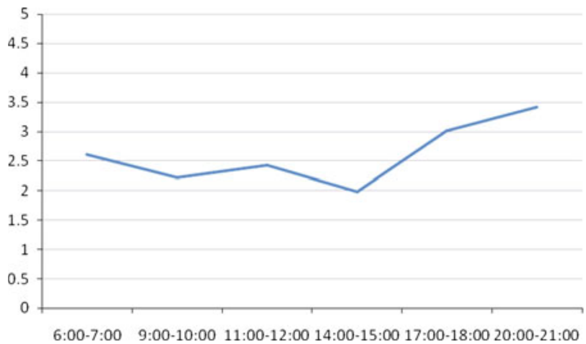

Fig. 31.2 The variation of road network congestion

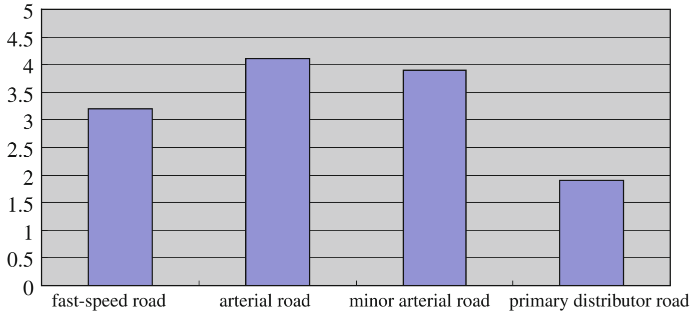

Fig. 31.3 Road congestion intensity of peak hour

From the Fig. 31.2 we can conclude that the variational regularity of traffic congestion intensity in large passenger hub station area is different to normal urban traffic road network. It has no apparent morning and evening peak period, but has great relationship with the departure and arrival of the train. 6:00–7:00 is the morning peak of urban traffic, but the station has only three trains to depart in this period. Therefore, the $TCI_{network}$ of this period is smaller than the period of 20:00–21:00, with 12 trains to depart and 5 to arrive.

We picked out the maximum of $TCI_{network}$, 20:00–21:00, to make further analysis. TCI_{road} of this period is shown as the following (Fig. 31.3).

From the Fig. 31.3 we can see that the main road and the secondary road are in moderate congestion, but the primary distributor road is fluid. To alleviate the congestion, we should guide the traffic to the unimpeded primary distributor road.

31.5 Summary

This paper proposes a road connectivity-based traffic congestion measurement model. Firstly, we determine the traffic congestion intensity of road section through microcosmic simulation results. Then put the road connectivity as the weigh, to calculate the traffic congestion intensity of the road network. This paper chooses Beijing south railway station as the example and evaluate its traffic congestion of road network. However, limited to the lack of data, this paper only makes brief analysis of the road network. More detailed works still need to do afterwards.

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Chapter 32
The Governance of Urban Traffic Jam Based on System Dynamics: In Case of Beijing, China

Haoxiong Yang, Kaichun Lin, Yongsheng Zhou and Xinjian Du

Abstract This paper starts with the phenomenon of urban traffic jam, summaries the existing measures for the governance of urban traffic jam from the perspective of urban residents travel and urban logistics. On the basis of summarizing the plugging measures as well as considering the actual situation of our country, this paper establishes the system dynamics model of the management of urban traffic jam with the method of system dynamics. In the last place, this paper takes Beijing as an example, simulates the effect of the typical plugging measures in Beijing, and reaches the suggestions for China to solve urban traffic jam.

Keywords Urban traffic jam · Residents travel · Urban logistics · System dynamics

32.1 Introduction

As an important and essential condition of normal operation of city life, urban traffic can not only improve the living and travel conditions of urban residents, but also drive economic development and improvement of functional layout of the whole city. The urbanization process of China continues to accelerate under the background that economic construction developed rapid, the original city traffic system is increasingly failing to keep up with the demand of the urban development.

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The contradiction between supply and demand of urban traffic of China have become increasingly prominent under these two factors, and within some drawbacks that gradually revealed, one of the most prominent and general is urban traffic jam. The solution of this problem closely related to the improvement of urban modernization, urban economic development and urban living standards of residents. Therefore, studying urban traffic jam and finding effective measures for plugging cannot delay.

The study of traffic jam is abundant at present: In the cause of urban traffic jam, Taylor (1992) from an economic perspective, looking for the cause of traffic jam. McKnight, Eurlng (1993) thinks the control of purchase and use of private cars can solve the problem of traffic jam; In the governance of urban traffic jam, the theory of it goes through three development stages: (1) strengthen the construction of urban traffic infrastructure facilities to meet the increasing traffic demand; (2) TSM—Traffic System Management; (3) TDM—Traffic Demand Management. Nowadays, there are three mainly governance patterns of traffic jam: the increase supply mode, the demand management mode and the complete institution mode; In the studying urban traffic by application of system dynamics, the relatively famous research is the urban dynamics model of professor Forrester and the travel produce model of professor Shirazian.

This paper starts with the phenomenon of urban traffic jam, summaries the existing measures for the governance of urban traffic jam from the perspective of urban residents travel and urban logistics. On the basis of summarizing the plugging measures as well as considering the actual situation of our country, this paper establishes the system dynamics model of the management of urban traffic jam with the method of system dynamics. In the last place, this paper takes Beijing as an example, simulates the effect of the typical plugging measures in Beijing, and reaches the suggestions for our country to solve urban traffic jam.

32.2 System Dynamics Model of Urban Traffic Jam Governance

In order to alleviate the state of urban traffic jam, improve living and production environment of residents, several countries and regions are adopted some measures to govern plugging, and have achieved some effects. On the basis of combination actual condition of itself, China continues learning successful experience of other countries and looking for the effective measure.

The urban traffic system consists of two components, residents travel and urban logistics. Residents travel include urban private traffic and urban public traffic, urban logistics is the cargo professional transportation within city. In China, the measures of residents travel mainly include advocating public traffic, limiting travel policy and limiting vehicles purchase policy; the measures of urban logistics mainly include limiting freight travel policy, establishing logistics park and development of urban public truck system (urban freight taxi).At present, the plugging measures of China is various, all kinds of measures has their own different characteristics, so there is a trend to mix using some of them, but the plugging effect is the most important, which the choice and evaluation of the measures should based on, at the same time, cost and the condition of the city should be considered.

In order to analyze different plugging measures, simulate the implementation effect of the influence towards urban traffic operation, this paper puts some typical measures into the original system dynamics model, and gets the system dynamics model of urban traffic jam governance.

32.2.1 The Determination of System Boundary

The modeling purpose of this paper is to analyze the internal structure of urban traffic from the perspective of urban residents travel and urban logistics, find out the feedback mechanism of influence between the operation of urban residents travel and urban logistics and urban traffic condition, and analyze the implementation effect of different plugging measures according to the change of related policy variables, simulate the influence of these measures towards urban traffic operation, thus provide reasonable goal and feasible suggestion to optimize traffic structure.

According to the research purpose of this paper, the final scope of the research system has been determined. Residents travel system include the amount of private cars, growth rate of private cars, scrap rate of private cars, traffic volume of private cars, the amount of bus, travel rate of bus, the amount of other motor vehicles, traffic volume of other motor vehicles, total volume of urban motor vehicles, traffic volume of urban motor vehicles and the plugging measures that related to residents travel; urban logistics system include urban logistics volume, the amount of urban freight vehicles, traffic volume of urban freight vehicles, growth rate of urban logistics, increment of urban logistics and the plugging measures that related to urban logistics; the others include urban GDP, growth rate of GDP, urban environment (NO_2 stock), annual average NO_2 emissions volume of each motor vehicles and contribution rate that motor vehicles towards environment pollution.

32.2.2 The Analysis of System Causality

The urban traffic system is a complex dynamic development system that influenced by multiple comprehensive factors, the causality between factors within system of this paper is shown in Fig. 32.1.

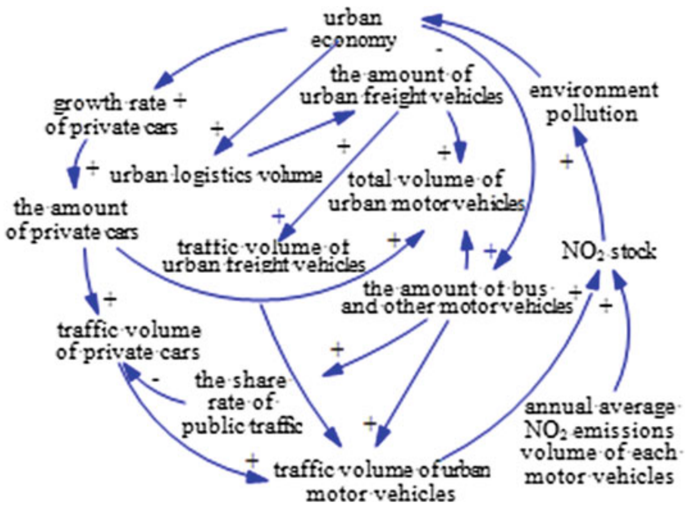

Fig. 32.1 Causality of urban traffic system

32.2.3 The Establishment of System Model

In order to analyze different plugging measures, simulate the influence of implementation effect towards urban traffic operation, this paper puts some typical measures into the stock and flow model of urban traffic system which is established by using Vensim, and gets the system dynamics model of urban traffic jam governance, as is shown in Fig. 32.2.

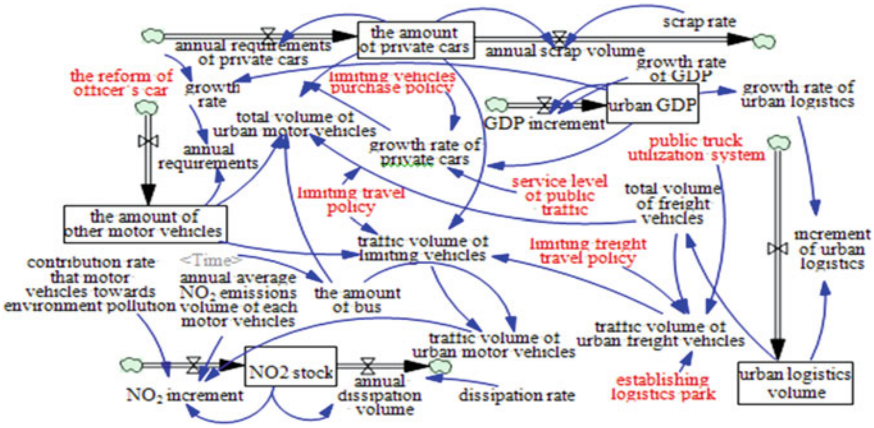

Fig. 32.2 System dynamics model of urban traffic jam governance

32.3 Model Simulation and Empirical Analysis: In Case of Beijing

Beijing is the capital of China, the study towards urban traffic jam and its governance has significant value. This part use policy optimization function of system dynamics to analyze the influence of the changes of policy variables of the model towards urban traffic status of Beijing, which is the effect of current plugging measures of Beijing towards its governance of traffic jam.

32.3.1 The Policies of Residents Travel

In Beijing, the current plugging measures that greatly influence residents travel including: limiting travel policy by tail number, limiting vehicles purchase policy by license plate lottery, advocating public traffic travel, etc. In order to ensure that the model is real and effective, this paper synthetically considers the implementation of these polices when simulate the model.

Limiting travel policy can relieve urban traffic jam, but it needs to base on the powerful urban public traffic system. If limiting travel policy is long-term implemented but the public traffic service level cannot satisfy the travel demand of residents, there will be more people choose to purchase a second car with different tail number to reply this policy. The comparison of traffic volume of urban motor vehicles between before and after the implement of limiting travel policy is as shown in Fig. 32.3.

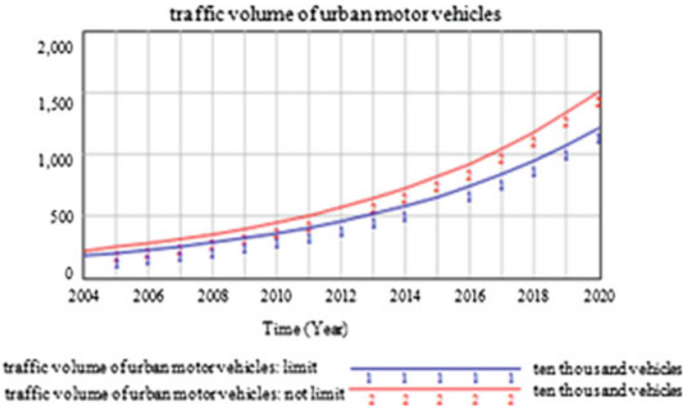

Fig. 32.3 Comparison of traffic volume of motor vehicles between before and after the implement of limiting travel policy under natural growth rate

Conclusion one: When motor vehicles grow under natural growth rate, limiting travel policy by tail number can relieve the urban traffic jam to some extent.When there are 3 % people purchase a second car, the comparison of traffic volume of urban motor vehicles between before and after the implement of limiting travel policy is as shown in Fig. 32.4.

Conclusion two: Because of the stimulation of limiting travel policy, when a small number of people purchase a second car with different tail number, the policy is short-term effective, but in the long term, it will have the opposite effect.Through the sensitivity analysis, gradually increase the proportion of purchase a second car, when there are 6.25 % people purchase a second car, the comparison of traffic volume of urban motor vehicles between before and after the implement of limiting travel policy is as shown in Fig. 32.5.

Conclusion three: When there is enough people purchase a second car, the effect of limiting travel policy will gradually disappear.The government should strive to develop public traffic, after advocating public traffic travel, the traffic volume of urban motor vehicles is as shown in Fig. 32.6

Conclusion four: Compared with limiting travel policy, public traffic priority policy can effectively relieve urban traffic jam.Considered the increasing serious traffic jam, the government of Beijing decided to take license plate lottery as a method to limit the purchase of vehicles, and take, the limiting travel policy at the same time. Therefore, according to the actual conditions, simulate the implement of these two plugging measures, and

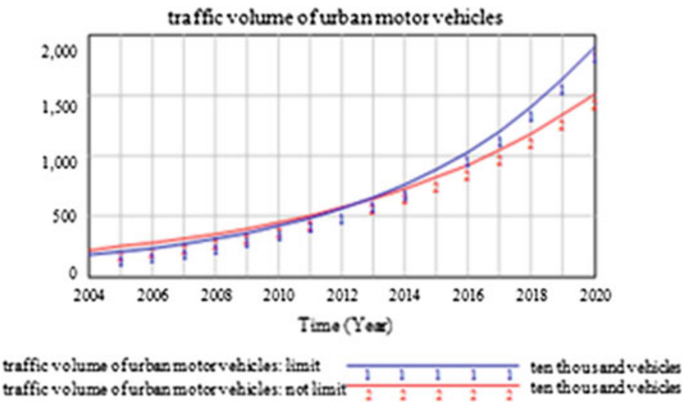

Fig. 32.4 Comparison of traffic volume of urban motor vehicles between before and after the implement of limiting travel policy when there are 3 % people purchase a second car

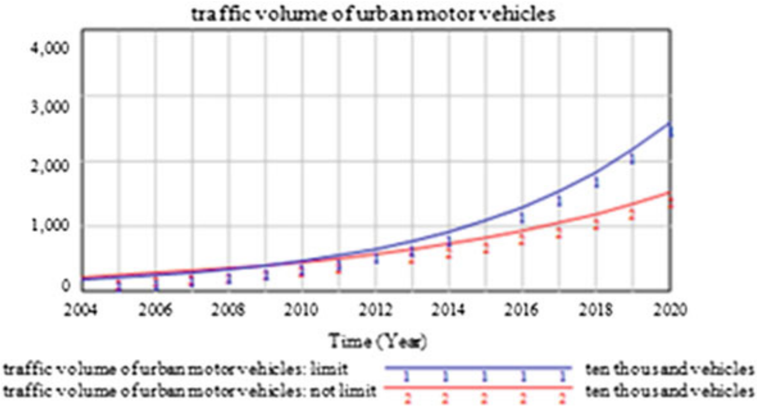

Fig. 32.5 Comparison of traffic volume of urban motor vehicles between before and after the implement of limiting travel policy when there are 6.25 % people purchase a second car

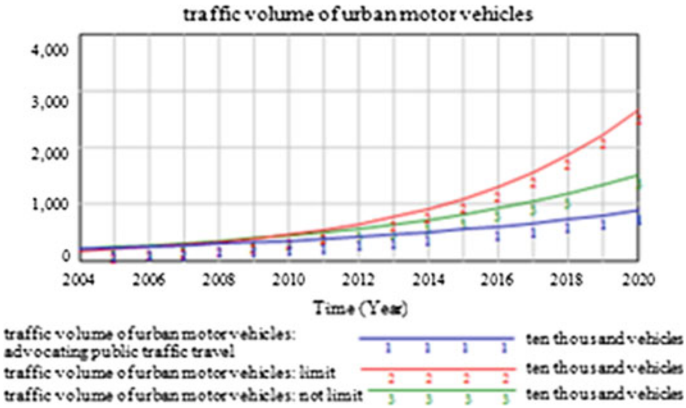

Fig. 32.6 Comparison of traffic volume of urban motor vehicles between before and after improving public traffic service level

compared them with the implement effect of limiting travel policy. The simulation result is as shown in Fig. 32.7.

Conclusion five: Do not consider other discontent factors that caused by limiting vehicles purchase policy by license plate lottery, the policy relieves the urban traffic jam to some extent.

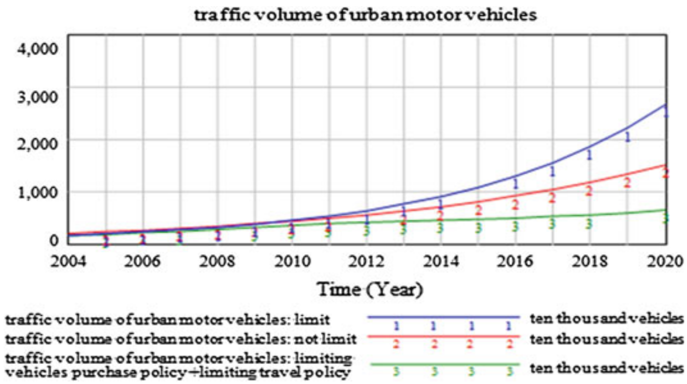

Fig. 32.7 Comparison of traffic volume of motor vehicles between before and after the implement of limiting vehicles purchase policy by license plate lottery

32.3.2 The Policies of Urban Logistics

In order to limit freight vehicles traveling in city and relieve urban traffic jam, Beijing puts forwards some relevant plugging measures to relieve urban traffic jam and improve urban environment, but which at the same time influence the normal operation of urban logistics, so whether should limit freight vehicle travel and the degree of limiting arouse much attention. The comparison of traffic volume of urban motor vehicles between before and after the implement of limiting freight vehicles travel policy is as shown in Fig. 32.8.

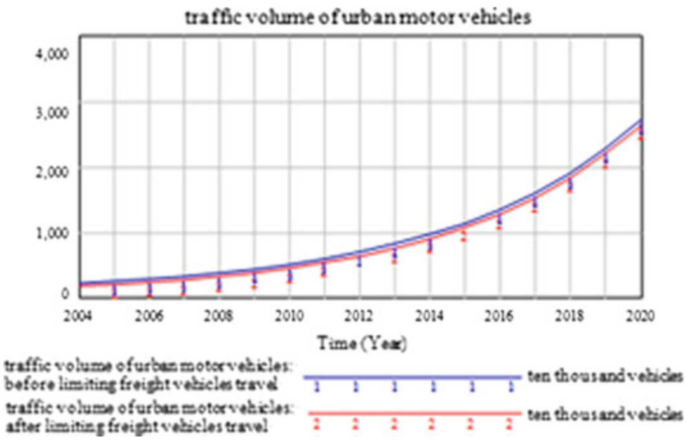

Fig. 32.8 Comparison of traffic volume of urban motor vehicles between before and after the implement of limiting freight vehicles travel policy

Conclusion six: Because of the relatively small amount of freight vehicles, limiting freight vehicles travel policy has little influence on relieving urban traffic jam.Transformed passenger cars to freight vehicles to transport cargos will greatly raise the transport cost and other costs, and will bring a lot of unnecessary waste of fund and recourse. After transforming passenger cars to freight vehicles, the traffic volume of urban motor vehicles is as shown in Fig. 32.9.

Conclusion seven: Because of the appearance of transforming passenger cars to freight vehicles after limiting freight vehicles travel, limiting freight vehicles travel policy don't reduce the traffic volume of urban motor vehicles, but aggravate the traffic jam.Because of the restrictions of limiting freight vehicles travel policy in the city, Beijing introduces urban public truck utilization system to meet the fright demand of citizens. The comparison of traffic volume of urban motor vehicles between before and after the introduction of urban public truck utilization system is as shown in Fig. 32.10.

Conclusion eight: **Urban public truck utilization system can relieve urban traffic jam under the situation that meet the demand of urban logistics**.

Finally, compared implementation effects of various plugging measures is as shown in Fig. 32.11. According to Fig. 32.11, limiting vehicles purchase policy by license plate lottery combined with limiting travel policy is the most effective way to relieve urban traffic jam, but this measure will bring many negative influence; the government

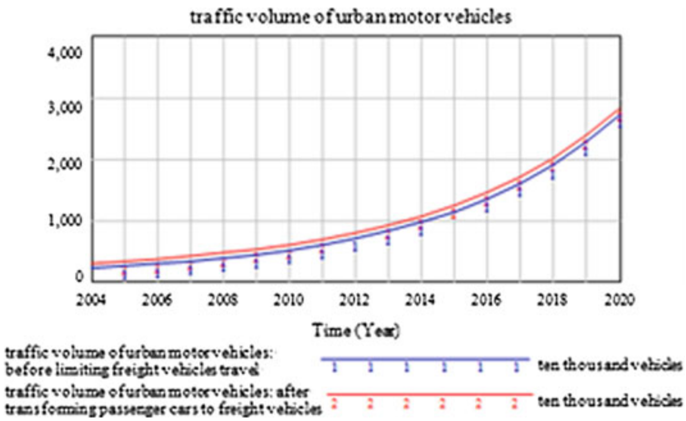

Fig. 32.9 Comparison of traffic volume of urban motor vehicles between before and after transforming passenger cars to freight vehicles

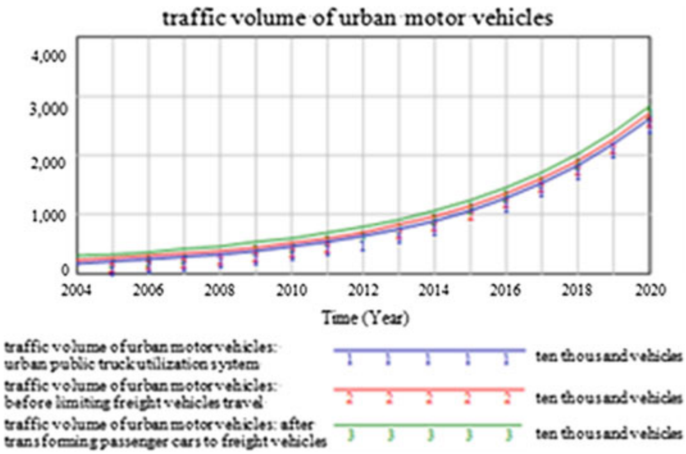

Fig. 32.10 Comparison of traffic volume of urban motor vehicles between before and after the introduction of urban public truck utilization system

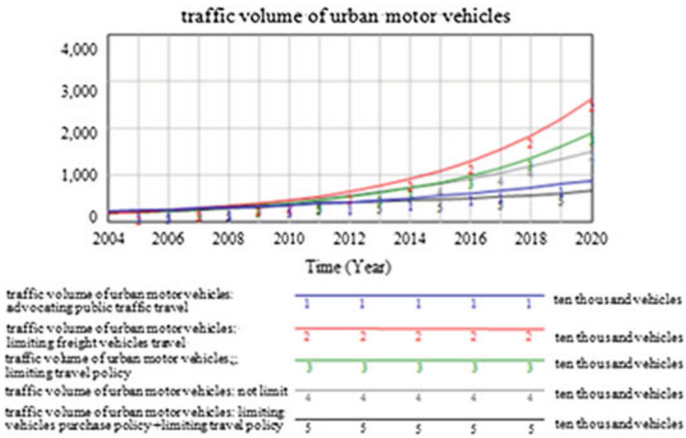

Fig. 32.11 Comparison of implementation effects of various plugging measures

advocating public traffic travel, improving service level of public traffic are effective plugging measures and will not bring other discontent; limiting travel policy by tail number is more significant to relieve urban traffic jam.

32.4 Conclusion

This paper summary the existing measures for the governance of urban traffic jam from the perspective of urban residents travel and urban logistics. On the basis of summarizing the plugging measures as well as considering the actual situation of our country, this paper establishes the system dynamics model of the management of urban traffic jam with the method of system dynamics, and takes Beijing as an example, simulates the effect of the typical plugging measures.

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Chapter 33
The Design and Realization of Urban Mass Information Publishing System

Kai Yan, Li-min Jia, Jie Xu and Jian-yuan Guo

Abstract With the advocating of the low-carbon traffic and transportation concept, more and more urban residents choose urban mass as their main travel mode every day. At the same time, development in urban mass transit impels mass lines to a complicated mass network. Based on the urban mass network, this paper aims to discuss how to design and realize an Urban Mass Information Publishing System to mainly publish passenger flow guidance information including urban mass network state information, passenger flow controlling information, operation situation information of first and last train, emergency information, etc. According to the analysis of system business requirements, the system architecture is divided in three layers: presentation layer, business service layer and data layer. The function architecture is also designed based on the requirement analysis. Then we design the business flow and data organization of the system. Finally a demo system is realized as a case application.

Keywords Information publishing system · Information management system · Urban mass transportation · Intelligent transportation system · Low-carbon transportation

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33.1 Introduction

With advocating of the low-carbon traffic and transportation concept, more and more urban residents choose urban mass as their main travel mode in every day. The influence of the passenger flow aggregations and the emergent events such as fire or equipment fault is getting more serious. To coordinate and unify all lines in the urban mass network and realize the stable operation of the urban mass traffic work, Traffic Control Center (TCC) has been established in many cities. To provide better services for urban residents in their daily travel, the TCC needs to timely publish those information of passenger flow controlling, operation situations of first and last train, emergency events and other activities. This paper aims to discuss how to design and realize an Urban Mass Information Publishing System (UMIPS, IPS for short) base on the urban mass network.

33.2 System Requirement Analysis

As a comprehensive information management system, IPS should not only meet the demand of information publishing works, but also show some management function (Dennis et al. 2006).

The system basic requirements have been collected and filtered out, and divided into aspects as follows:

(A) **All mass network real-time publishment**

For more accurately and timely giving suggestions to all passengers riding or waiting on every train or station, and assigning tasks to all staffs working on every station and train, IPS should publish information covering all mass networks. Establishing a communication network is necessary, which can be realized by Internet or large-scale internal LAN network.

(B) **Comprehensive business publishing**

IPS aims to publish information comprehensively to meet all the business demands as follows: (1) Publishing passenger-flow-control information in high passenger flow period in every day. (2) Publishing adjustment plan of lines, stations and trains in daily operation of the urban mass transit. (3) Publishing suggestions and warnings to all passengers after emergency events happened.

(C) **Diverse publishing ways**

The ways of information publishing should be diverse and selectable, including broadcast, send messages, PIDS display and publish on website. Multiple publishing ways help passengers to receive the suggestions and warnings more quickly and comprehensively.

(D) **Information templates establishment supported by preplan**

For efficiently publishing information, IPS should support establishment and management of information templates base on comprehensive urban mass transit preplans which are established already or establishing by an editor of the system.

(E) **System information management**

To coordinate with other ITS well, IPS should support the maintenance of some basic parameter and data exchange from other systems including congestion parameter, station image and timetable of the mass network. IPS also should support some management function such as user information and authority management, and inquiry of system history operation.

33.3 System Design

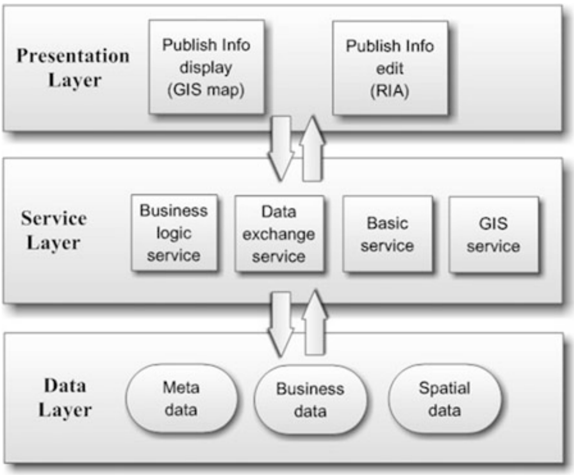
33.3.1 System Architecture

(1) **System Overall Architecture**

Information Publishing System is a three-layer application system which adopts B/S structure mode, including data layer, service layer and presentation layer (Geisler and Quix 2012). The IPS architecture chart is as shown in Fig. 33.1.

Presentation layer is the highest layer of IPS, in which show and collect data except deal with data. It provides the interface for user operation, collect user operation information and submit request to service layer, then shown the disposal result to user according specified demand. System function is realized in this layer by two mode including GIS map and RIA. Geographic information system (GIS) map is an electric map with lots of functions like dynamic display and spatial data

Fig. 33.1 Architecture of the IPS



exchange, etc. Rich internet application (RIA) is a more intuitive, responsive, flexible, and convenient and offline supported Web application.

Service layer is the most important layer of IPS, in which define the rules of how every logic unit can be realized and implementation of the system functions (Horsburgh and Tarboton 2009). (a) Business logic service encapsulates a lot of independent system function unit. Each business logic service corresponds to one specific function, receives presentation layer's request and returns the result. (b) The main work of data exchange service is to exchange the data between presentation layer and the data layer. It provides uniform exchange interface rules and a communication module to obtain and send message in different way. In general, it deals with data flow to be transmitted to front-end application or stored in back-end database. (c) Basic service is composed of minimum function unit that cannot be subdivided. High cohesive and low coupling is the main ability of a basic service application. In addition, every basic service application is realized with emphasis on its reusable ability and interoperation. (d) GIS service is realized on several GIS basic services and exchanges data with other service application. It is used to display the mass network states on an electric map betimes and dispose of some data from the electric map.

The data layer is the bottom of IPS and includes three data types which are metadata, business data and spatial data. All of them can be stored in a relational database or an object-oriented database with several basic data format and extensible markup language (XML) format which one can be simplicity, generality, and usability over the Internet.

(2) **System Function Architecture**

According to the requirement analyses of IPS, its function architecture is divided in four function modules that include publish editor module, publish management module, system maintenance module and GIS dynamic map module (Wang et al. 2010). The function architecture chart is as shown in Fig. 33.2.

A. **The publish editor module** is divided into two parts that include select publish template and select publish tool. The most important function of IPS is to publish guidance information to all passengers in the mass network including passengers in the stations and on the trains. Therefore, a set of complete, clear and normative guidance information template is indispensable. To publish guidance information in different ways, IPS is designed to provide a process which is used to select one or more publish tools after users confirm the content of awaiting publishing information. Such publish tools include broadcast, passenger information system (PIS), website, station screen, enquiry machine and cellphone message.
B. **The publish management module** is responsible for the management of all publishing information templates and a list of published information. The information templates can be a skeleton of a message for publishing. In the templates management module, the main function include build new information template when the user need to construct some new type information,

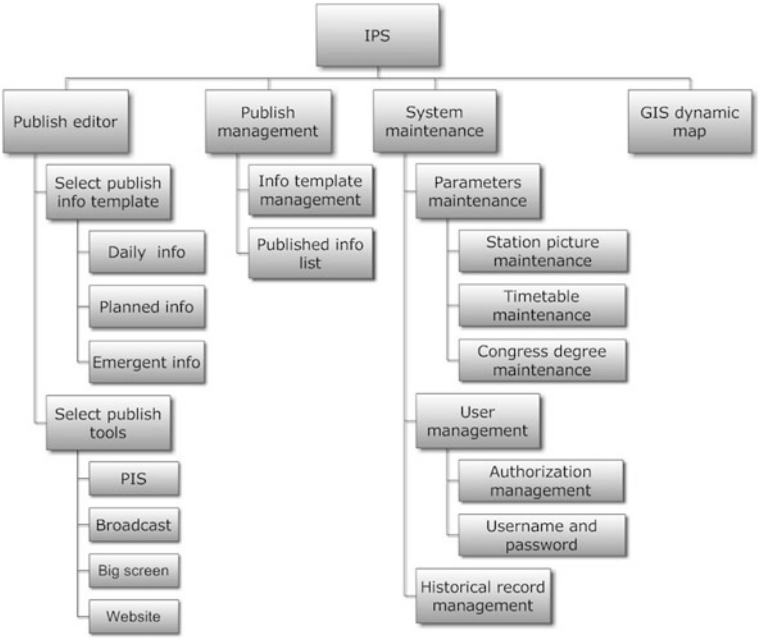


Fig. 33.2 The function architecture chart

delete and modify one or more templates. All operation on every template exchanges data with the central database. All templates can be searched in some relational datasheets of the templates.

C. **System Maintenance module** consists of user management, basic data maintenance and history inquiry. (a) The basic data maintenance function module is divided into three parts. The first is the station picture maintenance. The second part is the train timetable maintenance. The third part is the congestion degree maintenance. (b) The user management function module is responsible for the management and organization of user's information: username and password. (c) The history inquiry function module is realized with a usual history data management tool what is used to record the operating logs.

D. **GIS dynamic map module** is designed to assist all users to browse real-time state of the urban mass network better. This module consist of three sub-function module: (1) map scaling and roaming, such as zoom in, zoom out, etc.; (2) station image viewing; and (3) map rapid positioning, for instance line or station locking and positioning.

33.3.2 Data Organization

According to the system main architecture design, the data organization architecture of IPS is divided into three layers: Metadata, Business data, and Spatial

Table 33.1 Data organization

Layer	Data classification	Datasheet
Metadata	User management information	account_information, user_priority
	Data standard	data_type, storage_rule
Business data	Information templates	daily_info, planned_info, emergent_info
	Station information	station_data, station_map
	Event information	event_data
Spatial data	Mass network operation state	line_state, station_state
	Passenger flow state	pf_state

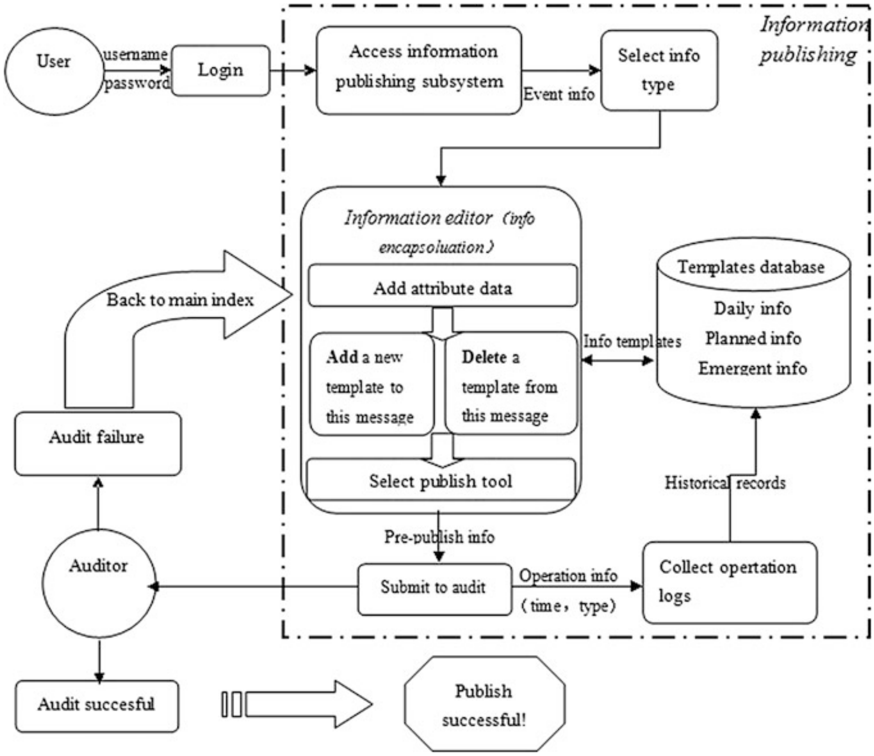


Fig. 33.3 The publishing processing chart

data. As shown in Table 33.1, the first column is Layer as a basic division, second column is Data classification in which column the data basic function type is, third column is Datasheet what show the detailed data form.

33.4 System Realization

33.4.1 Business Flow Realization

As we have detailed in the previous section, the function architecture of IPS is divided into four parts: publish editor module, publish management module, system maintenance module and GIS dynamic map module. There are different data exchanges processing in each module. The design of each processing aims to effectively realize a flexible, interactive and stable business service flow. And we now have a closer look at how the business flow is processed in the IPS. An overview of the publishing processing design in the system is depicted in Fig. 33.3.

The main function of IPS is information publishing, and it is mainly realized in three steps that including user login, information text edit and submit processed information to audit.

Step 1. User login

User who wants to login the system need input their username and password. The username and password are matching every staff that is responsible of the information publishing work.

Step 2. Information text edit

For publishing information, user has to choose the information publishing subsystem to access into an editor interface to find an information templates tree which has summarize text templates in a tree structure and classify the templates with its branches. User needs to select one template branch and input all event attribute data such as begin time, end time and location, finally, a piece of pre-published text message has been generated.

Step 3. Submit processed information to audit

User submit the processed information to audit, then the message that step 2 has generated is sent to the high level auditor. Every time that user submits to audit, IPS can store user's operation information such as submit time, information type, user's username, etc. into the datasheet of historical records. The auditor's operation information also will be stored as historical records.

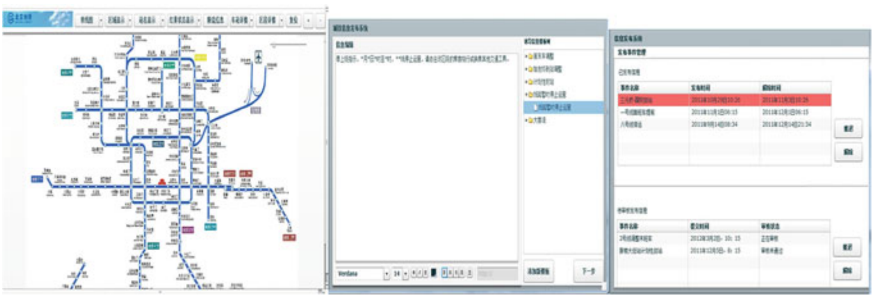


Fig. 33.4 System interface

33.4.2 A UMIPS Based on Beijing Urban Mass Network

To prove the design conception of IPS, we have realized the demo system with the FLEX structure and ArcGIS service base on Beijing urban mass network. To more comprehensively display the function of BMIPS, we developed three operation interfaces as shown in the Fig. 33.4. On the left, it is a screen for watching the whole Beijing urban mass network. The middle screen is the information publishing editor interface. The right part is a screen displaying the information tables about the events state.

33.5 Conclusion

As an assistant system, the IPS tries to meet the need of its users. Therefore, the design of system business process is the major part of the overall design. A flexible, convenient, fast-response and function-complete system can not only help user save more time on daily publishing work, but also help to improve their publishing works.

As a design conception, the analysis and design of IPS is still a continuously improving and innovating process. To solve those detail problems in information publishing also need a large number of researching and exploring works and the system still have much expansion space.

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Chapter 34
Research on Multiple Attribute Decision Making of BRT System Considering Low Carbon Factors

Jia-qing Wu, Rui Song and Li Zheng

Abstract Developing low carbon transportation is the inherent requirement of sustainable development of urban transportation, as well as an effective way to deal with the greenhouse effect. After treating the Bus Rapid Transit (BRT) system as the research object, this paper established an index system of the multiple attribute decision for BRT system by considering low carbon factors, and proposed methods of the BRT system multiple attribute decision making using the fuzzy comprehensive evaluation theory. The case study was conducted on the basis of BRT line 1, line 2 and line 3 in Beijing, which verified the effectiveness of the proposed index system and decision making methods.

Keywords Low carbon · BRT system · Multiple attribute decision making · Evaluation index system

34.1 Introduction

Problems of the transportation energy consumption and greenhouse gas emissions have become one of the major issues that humans have to deal with. "Low carbon transportation" is a transportation development mode with low power consumptions, low pollutions, and low emissions, which is directly on target to reduce the greenhouse gas emissions of transportation tool. As a sustainable urban

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transportation system structure, “Low carbon transportation” can effectively reflect the meaning of the sustainable urban transport system structure.

Recent years, many cities in China have built the BRT system considering the local conditions. Since the first BRT line (South-Centre Corridor BRT1 in Beijing) opened into operation, several cities such as Hangzhou, Changzhou and Jinan built BRT systems one after another. Therefore, the BRT system is becoming increasingly important in the urban low carbon passenger transportation system.

The existing low carbon transportation researches (Romilly 1999; Lia and Head 2009; Deng 2006; Hayashi et al. 2001; Cherrya et al. 2009) mostly focused on the comparison of different transportation modes instead of the BRT system multiple attributes decision making considering low carbon factors. Till now, few researches are found to carry out the case study using various BRT systems. Consequently, this paper aims to study the BRT system multiple attributes decision making by considering low carbon factors.

34.2 Multiple Attribute Decision Making Index System of BRT System Considering Low Carbon Factors

34.2.1 Construction of Index System

Multiple attribute decision is a decision problem that considers a number of sorted indices, according to certain rules, to assess the integrated status of evaluation object from some or more aspects. BRT system is a large comprehensive system including level of service, operational efficiency, economic efficiency and other factors, which should involve up to dozens of indices. The developed evaluation index system is shown in Fig. 34.1, which considers low carbon factors.

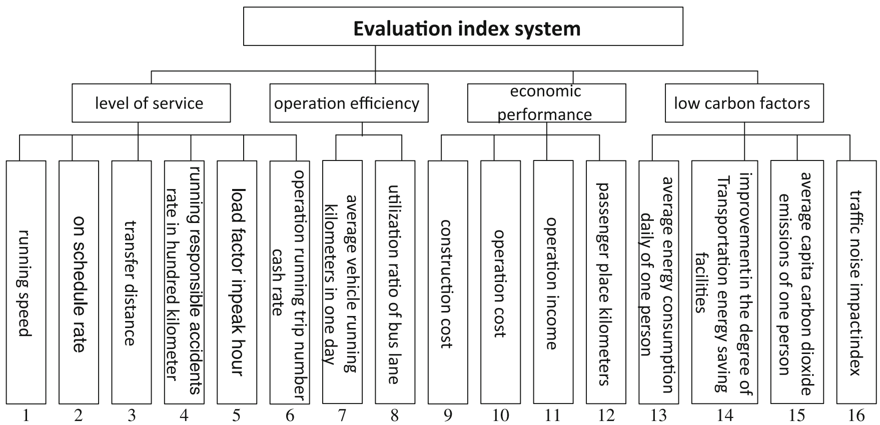

Fig. 34.1 Evaluation index system of BRT system considering low carbon factors

After confirming the index system, the method to solve the problem that each index has different dimension is to classify and determine a standard range, which are divided into four categories, positive index, negative index, segmentation processing by interval index, temporarily don't treatment index. The "positive index" refers the more the actual value the better the index is. The "negative index" refers the smaller the actual value the better the index is.

In order to facilitate the comprehensive evaluation, the index is transferred into the dimensionless form within the range of [0, 1]. For the evaluation index $u_i \in$ u, its domain is set as $d_i = [m_i, M_i]$, while m_i and M_i respectively represent the minimum and maximum values of the evaluation index. Define $r_i = u_i(x_i)$, $i = 1, 2, \ldots, n$, as the dimensionless value of attribute values x_i that the decision-maker evaluate for index u_i, and $r_i \in [0, 1]$. $u_{di}(\bullet)$ is the dimensionless standard function of index u_i which is defined in the domain of d_i. Standardized conversion functions of "positive index" and "inverse index" are respectively expressed as follows:

$$r_i = u_{di}(x_i) = \begin{cases} 1 & (x_i \geq M_i) \\ \frac{x_i - m_i}{M_i - m_i} & (x_i \in d_i) \\ 0 & (x_i \leq m_i) \end{cases} \tag{34.1}$$

$$r_i = u_{di}(x_i) = \begin{cases} 1 & (x_i \leq m_i) \\ \frac{M_i - x_i}{M_i - m_i} & (x_i \in d_i) \\ 0 & (x_i \geq M_i) \end{cases} \tag{34.2}$$

34.2.2 Determination of Index Weights

The index weights are determined using the expert scoring method. Table 34.1 gives the weight value of each index scored by a number of experts based on the comprehensive, integrated, scientific, pragmatic and fair principles, as well as the index category and the value interval.

It can be found that the share of the level of service is largest in the criteria layer, accounting for 39.4 %; and the following one is that of the low carbon factor, accounting for 37.5 %. It demonstrates that the degree of BRT system meeting requirements of passengers and low carbon factors attract the most attentions of public when making an assessment of the level of development of the BRT system.

Table 34.1 Weight value of index (including index sort and interval size)

Index number	Index unit	Index sort	Interval size	Weight value relative to criteria layer	Weight value relative to target layer
	Level of service (X1)				**0.39421**
1	km/h	positive	15–30	0.25091	0.098911231
2	%	positive	0–100	0.22273	0.087802393
3	m	inverse	0–200	0.15727	0.061997407
4	Yuan/100 km	inverse	0–1000	0.11	0.0433631
5	%	inverse	30–100	0.16455	0.064867256
6	%	positive	90–100	0.09454	0.037268613
	Operation efficiency(X2)				**0.10444**
7	km	positive	100–300	0.42727	0.044624079
8	10,000 persons/km	positive	0–10	0.57273	0.059815921
	Economic performance(X3)				**0.12567**
9	10,000 Yuan/km	inverse	1000–3000	0.271362	0.034102063
10	10,000 Yuan	inverse	200–500	0.231362	0.029075263
11	10,000 Yuan	positive	500–3000	0.176824	0.022221472
12	10,000 km	positive	200–400	0.320452	0.040271203
	Low carbon factors(X4)				**0.37568**
13	KJ	inverse	0.8–1.2	0.201362	0.075647676
14	%	positive	0–100	0.331362	0.124486076
15	kg	inverse	5–8	0.236824	0.08897004
16	%	inverse	0–100	0.230452	0.086576207
Total					1.0

34.3 Multiple Attribute Decision Making Method of BRT System Considering Low Carbon Factors

Multiple Attribute Decision Method (MODM) shows particular advantages in dealing with various complex system problems that are difficult to be described using precise mathematical methods, so it has been widely used in many study areas. MODM has two different forms, as follows:

(1) Single-level fuzzy comprehensive evaluation model. Given two finite domains: $U = \{u_1,\ u_2,\ldots,u_n\}$ and $V = \{v_1, v_2,\ldots,v_n\}$, U is the set of all evaluation factors, and V is the set of all reviews grades.

For the ith $i(i = 1, 2,\ldots, n)$ evaluation factor u_i, if its evaluation result is $R_i = [a_1, a_2,\ldots, a_n]$, then the decision matrix for various evaluation factors is defined as R, and the fuzzy relation from U to V is shown in Eq. (34.3).

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \cdots \\ R_m \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{34.3}$$

If the weight of evaluation factors is assigned as $A = \{b_1, b_2, , b_n\}$ (obviously A is a fuzzy subset of the domain, and $0 \le a_i \le 1, \sum_{i=1}^{m} a_i = 1$). Through the fuzzy transformation, a fuzzy subset of the domain can be derived, which is the comprehensive evaluation results $B = A \cdot R = \{b_1, b_2, \ldots, b_n\}$.

(2) Multi-level fuzzy evaluation model. Divide the evaluation factors into several categories according to some property; and then do the comprehensive evaluation for each category; finally, do the high-level comprehensive evaluation for the evaluation results of all kinds of categories. This is the problem of multi-level fuzzy comprehensive evaluation. The model follows these steps:

Step1: The factors set U can be divided into m subsets according to some attribute c, so that they can meet$\begin{cases} \sum_{i=1}^{m} U_i = 1 \\ U_i \cap U_j = \varphi(i \neq j) \end{cases}$. Then the second stage of the evaluation factors $U/c = \{U_1, U_2, \ldots, U_m\}$can be obtained.

In above formula, $U_i = \{u_{ik}\}(i = 1, 2, \ldots, m; k = 1, 2, \ldots, n)$means that U_i subset contains n_k judgment factors.

Step2: n_k judgment factors in each subset U_i can be evaluated according to the single-level comprehensive evaluation model. If the weights allocation of all factors in the U_i is A and its judgment decision-making matrix is R_i, then the comprehensive evaluation result of the ith subset U_i is $B_i = A_i \cdot R_i = \{b_{i1}, b_{i2}, \ldots, b_{in}\}$

Step3: Do the comprehensive assessment to m subsets $U_i = \{i = 1, 2, \ldots, m\}$ in *U/c*, and the evaluation matrix is:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \cdots \\ B_m \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix}$$

If the weight of the subset of various evaluation factors is assigned to A in *U/c*, we can get comprehensive evaluation result $B = A \cdot R$. B is not only the comprehensive evaluation results for *U/c*, but also the comprehensive evaluation results of all the evaluation factors in U. There are two methods to calculate the above calculation of matrix synthesis. The first one is the main factors determination model method and the other one is the ordinary matrix model method.

34.4 Case Study

34.4.1 Case Evaluation

Until June 2012, Beijing has built three BRT lines with the total length of 55 km. Based on the proposed multiple attribute decision making index system and methods, the evaluation results of three BRT lines are illustrated in Table 34.2.

From Table 34.2 we can see, BRT1 line gets the highest score and has the best implementation effect, BRT2 line gets the lowest score and the worst implementation effect. Based on the implementation effect of the BRT1 line, the following part will comparatively analyze the existing problems of BRT2 line and judge the "gain and loss" in construction of the BRT system from different perspectives.

34.4.2 Effect Analysis

Low carbon factors: From Table 34.2, it can be seen that the index values of low carbon factor of the three lines reflect the low carbon effect of BRT system comparing with other traffic modes. But the fact that the traffic noise pollution index is close to the average level of Beijing indicates that the opening of BRT

Table 34.2 Evaluation result of three BRT lines

Index number	South-centre corridor BRT1		Chaoyang road BRT2		Anli road BRT3	
	Operation value	Score	Operation value	Score	Operation value	Score
1	24.4	0.062	17.55	0.0168	21.61	0.0436
2	38.47	0.0338	12.99	0.0114	64.78	0.0569
3	130.0	0.0217	120.0	0.0248	90.0	0.0341
4	414.78	0.0254	299.24	0.0304	931.15	0.003
5	71.13	0.0268	37.0	0.0584	48.07	0.0481
6	94.78	0.0178	94.95	0.0184	100.13	0.0373
7	215.82	0.0258	221.12	0.027	219.42	0.0266
8	6.5	0.0389	3.39	0.0203	4.65	0.0278
9	1801.19	0.0204	1792.56	0.0206	1443.77	0.0265
10	350.78	0.0145	396.61	0.01	386.15	0.011
11	2438.11	0.0172	1130.63	0.0056	915.78	0.0037
12	358.34	0.0319	235.29	0.0071	269.88	0.0141
13	0.98	0.0567	1.01	0.0359	0.99	0.0473
14	70.0	0.0871	75.0	0.0934	80.0	0.0996
15	6.08	0.0569	6.15	0.0549	6.13	0.0555
16	75.0	0.0216	70.0	0.026	75.0	0.0216
Total score		0.5586		0.461		0.5567

system alone cannot effectively reduce noise, it should be implemented together with other measures.

Line planning: BRT2 Line is very close to Jingtong Expressway and Subway Batong line located on its southern side. The general bus lines on Jingtong Expressway are perfect enough, so authors think that both of the two traffic modes mentioned above are more attractive. Therefore, the passengers of BRT2 Line are greatly shunted.

Right-of-way: The lane of BRT1 is nearly closed, and the length of exclusive bus lane is 15 km, occupying 94 % of the total length of the whole line. But the exclusive lane length of BRT2 line is 12.3 km, only occupying 76.8 %, the length of about 3.7 km is not the exclusive lane, and the intersections does not have been channelized. In one word, the ultimate problem of BRT2 Line is the right-of-way, which leads to low speed, more delays and low punctuality rate.

Line combination: Another current problem of BRT2 Line is that it does not deal with the general bus line combination well. When the BRT2 Line just opened, the daily passenger number was only 35,000 persons. After integrating two bus lines, as well as opening several branches, the daily passenger number reached 46,000. If the problems of vehicle type, limited capacity of the platform, and ticket system could be overcome, the daily passenger number would reach more than 80,000.

Transfer: For the three BRT lines, the layout patterns of stops include the central island and the central side turnout. The stops of general bus lines, however, are generally set outside the assistant-road. Therefore, no matter adopting what cohesive mode, the transfer distance is inevitably increased. Quite many passengers of BRT2 line give up BRT because of the long transfer distance. Of course, the “zero distance” transfer between Qianmen and the Subway line 2, as well as the vertical transfer between Muxiyuan Qiao and the Third Ring main road, are worthy of reference.

34.5 Conclusion

BRT is a new direction to promote low carbon life, but how to evaluate it holistically and scientifically is always a big problem puzzling the experts. Considering low carbon factors, this paper established an index system for BRT system multiple attribute decision making based on using the fuzzy comprehensive evaluation theory. The case study was conducted in BRT line 1, 2, 3 of Beijing, which verified the effectiveness of the proposed index system and decision making methods. The result also shows that BRT system has a good influence on low carbon.

However, this paper has not taken the waste of road resources caused by BRT exclusive lanes into consideration, which would lead high carbon emissions since more and more vehicles are gathered on the lanes beyond the BRT lanes. This is also likely to be a useful effort for further research.

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Chapter 35
Research on Time Cost of Urban Congestion in Beijing

Qifu He

Abstract During the past 10 years, with the geometric vehicle population growth and subsequent worse road congestion of Beijing, people have got longer travel time and more uncertainty and the speed of vehicles have got evident decrease. As road traffic efficiency drops, the cost of time delay for people increases. People often neglect time cost, but it plays an indispensable role in economics that you can hardly ignore. The externality caused by traffic congestion significantly affects the city's transportation accessibility and efficiency, ultimately having a negative impact on the sustainable development of society and economy. With the aim to present the externality with the form of currency by quantitative method from the economic point of view, the external costs of congestion are measured by the proposal and accounting of cost of urban congestion based on relatively accurate data. In this thesis, research goals are refined to time cost which is emphasized and analyzed from congestion cost and quantified. Besides, policies and advice for alleviation of road congestion are also provided.

Keywords Externality · Congestion cost · Time cost

35.1 Background

With the development of society and economy, the quickening pace of urbanization and the rapidly growing demand of urban transportation, the problem of traffic congestion becomes increasingly worse in China. Moreover, as the center of

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politics, economy and culture of China, the traffic demand of Beijing increases sharply with the pace of urbanization, modernization and mechanization, resulting in new records of numbers of vehicles. According to statistics of Beijing Traffic Management Bureau, the number of vehicles in Beijing has increased from 2300 in 1949 to 1,000,000 in 1997. However, it only took six years and six months to increase from 1,000,000 cars to 2,000,000 cars. Until February 17th 2012, the number of cars in Beijing amounted to more than 5,000,000. The development of transportation condition in the 12th Five-Year Plan of Beijing Transportation Research Center predicts that it is in 2016 that the number of cars in Beijing will reach 6,000,000 in accordance with the expectation of speed increase in 2011.

Traffic congestion lowers the speed of cars in urban area, increases travel time and the uncertainty and leads to external costs such as the increase of motor fuel consumption, standard contaminants and greenhouse gas emissions etc. But time cost is the most direct external cost, which directly reflects opportunity cost and profound economic meanings.

35.2 Literature Review

From the view of the definition of congestion cost, China is now at the starting stage of research on traffic congestion costs and scholars don't have clear definitions and divisions of congestion costs. Liu (2007) think that costs can be divided into private cost and social cost (See Table 35.1). Private cost refers to the part of traffic costs undertaken directly by individuals in urban transportation, which includes actual payment cost such as vehicle purchase and fuel cost etc., and invisible cost such as time cost and traffic congestion cost (traffic congestion inside cars). Social cost refers to the part of traffic costs undertaken by the society in

Table 35.1 Classification of transportation costs

Item	Classification of costs	Constitution of costs
Private cost	Actual payment cost	Vehicle purchase, fuel cost, parking charges, vehicle maintenance and traffic accidents charges
	Invisible cost	Time cost and traffic congestion cost
Social cost	Environmental pollution cost	Noise pollution cost, air pollution cost and weather change cost
	Traffic accident cost	Health loss, production loss and administration
	Traffic congestion cost	Time cost and other costs
	Urban development cost	Construction cost, urban space occupation cost and urban image decrease cost

urban transportation, such as environmental pollution cost, traffic accident cost, traffic congestion cost (road) and urban development cost.

Jing (2005) believes that urban transportation refers to the third-party influence from urban traffic users on non-traffic vehicle users. Cui (2006) maintain the external costs of urban traffic congestion includes extra trip time, environmental pollution cost caused by traffic congestion and traffic accident cost from the view of individual motors. Qi (2008) notes that travel time cost of residents is the value produced from time consumption and opportunity cost during travel.

From the view of congestion cost estimation and calculation, Cui (2006) puts forward extra time cost $C_{ET} = \bar{l} \times (\frac{1}{v_{q+1}} - \frac{1}{v_q}) \times c_{pt} \times n \times m_w$, ($\bar{l}$ is the average distance of commuter cars, c_{pt} is the value for the unit of time of car users, namely yuan/h; n is annual average times of travel of commuter cars; m_w is the average daily number of commuter cars). Jin (2007) quantifies traffic impedance and constructs toll model of environmental pollution which exceeds standard on the basis of function form of American National Highway Traffic Safety Administration.

Foreign evaluations are similar to those of domestic evaluations and they have a number of evaluation methods, which have been referred in Exteriorization of the Cost of Traffic and Society translated by Yunping etc. At present, countries in US and Western Europe divide the external effect of traffic into three spaces or time to analyze: near or short period, medium period and far or long period. The social cost of urban traffic has a characteristic of extensiveness, complexness and non-linear. Meanwhile, the nature of the effect of urban traffic and society has evident differences. Therefore, foreign evaluations of social cost currently focus on the local effect of urban traffic, namely the social costs from local air pollution, noise and traffic congestion. In recent years, in terms of the complicated relations among the speed of vehicles, time cost and motorization level and the difficulty to collect data, there are two relatively authoritative evaluation models. One is the simple concept model of the external cost of traffic congestion constructed by Maddison, $TC = g \times M = Ma + \frac{Mb}{\alpha - \beta M}$, among which a represents the actual currency cost of unit mileage (fuel cost, daily maintenance of cars and fares etc.), b represents the value of unit time, T represents the time of unit mileage, s represents the average speed of vehicles and M represents the traffic flow. The other is the evaluation model used by Institute of US Texas Traffic in its annual report. The basic assumption of Maddison model is that all the travelers and vehicles share no differences, which means that the unit travel cost and operation cost are identical and the values of unit time are equal. But the evaluation model of external cost of congestion in Institute of Texas maintains that the external cost of passenger traffic and freight should be calculated separately. In that way, it is comparatively easy to operate and understand.

35.3 Accounting of Time Cost

Congestion costs include nine sub-costs (Gao 2007), among which time cost is the most direct one. The travel time people delay has economic value and the method to measure it mainly depends on wage rate in unit time. As a consequence, time costs vary from people of different income during the same period. In terms of people with high wages, the wage per hour is higher than those of low wage in the same travel time. He probably gives more benefit (Bilbao-Ubillos 2008).

The scale of time cost has close relations with the purposes of travel, such as going to work, business trips, leisure time and going to schools etc. Generally, it can be divided into commute, non-commute and school. Different travel purposes have various affects to the value of unit time. In general, the values from commute or the period of business trips are higher than those of non-commute or the period without business trips. Considering different travel purposes and time value from congestion given up by people of various incomes, the evaluation of the cost of time should be in accordance with travel aims and the average income of various levels.

The phenomena of congestion in this study occur in the period of congestion. Firstly, calculate the total cost of time in the period of congestion. Then calculate the extra cost of time according to the percentage of the extra time of one travel to total travel time.

According to the travel volume and one travel time in the period of traffic congestion, the total cost of time can be calculated using of the values of unit time with different vehicles and their relations:

$$\mathrm{C}_{\text{total cost of time}} = \sum_{i=1}^{3}\sum_{j=1}^{3} t_i (C_{ij} \times M_j) \times 365 \tag{35.1}$$

In the equation, $\mathrm{C}_{\text{total cost of time}}$ refers to the total cost of time, t_i refers to one time consumption of various travel methods, C_{ij} refers to the value of unit time of purpose, M_j refers to the daily travel volumes of various purposes, i refers to buses, taxis and cars and j represents three travel methods which are commute, non-commute and school.

The calculation formula of the extra cost of time in the period of congestion is as follows.

$$\mathrm{C}_{time} = \sum_{i=1}^{3} \frac{t_i - t_{ic}}{t_i} \times C_{i\,\text{total cost of time}} \tag{35.2}$$

In the equation, C_{time} cost refers to the total cost of time in the period of congestion, t_i refers to one time consumption of travel in the period of congestion, t_{ic} refers to the distance of one travel in the period of congestion, $C_{i\,\text{total cost of time}}$ refers to the total cost of time with various travel methods in congestion periods, i refers to buses, taxis and cars.

According to the statistics of Beijing Bureau of Statistics, the average income of employees of 2010 in Beijing is up to 48444 yuan, which reflects the average income of employees in national and collective enterprises, joint ventures, solely funded enterprises and private enterprises except the self-employed people.

In accordance with the 51th regulation of Law of The People's Republic of China, in the provided holidays, the employers should pay employees, which means they should pay the employees according to days or hours even in those holidays.

Therefore, the method to calculate the average rate of income of per hour is $x_h = \frac{I_a}{12} \times \frac{1}{D_m \times 8}$. In this equation, x_h refer to the rates of income of per hour, I_a represents the average annual rate of income and D_m refers to the days of monthly income respectively. According to the data of Beijing Bureau of Statistics, the average income of employees of 2010 in Beijing is up to 48444 yuan. In this way, the average rate of income of per hour amounts to 22.9 yuan.

In the *Annual Report of the Development of Traffic of 2011 in Beijing*, the basic travel is the most common purpose of daily travels for people, including commute and school, accounting for 30.02 % of the total travel volume. Other travels include shopping, going to gyms and leisure, visiting relatives and friends and having dinners etc. This thesis mainly focuses on three conditions in weekdays, which are commute, school and other.

Firstly, the income of people with various travel methods in 2010 can be calculated by the influence coefficients of the time cost in 2005 (Table 35.2).

In terms of the effect of the purpose of travel to the time cost, the influence coefficients recommended by the World Bank are as follows.

W = average income of per hour
The cost of per hour for commute = 1.33 W
Time cost of per hour of other non-commute travel = 0.3 W
Time cost of per hour of school = 0.15 W

The value of time of various travel methods and purposes are shown in Table 35.3.

According to *Research on Beijing Comprehensive Transportation Cost*, different modes and purposes of Beijing daily travel volume of 2005 are shown in Table 35.4.

According to Table 35.4, the percentages of three types of vehicles with different travel purposes are shown in Table 35.5.

Table 35.2 Income situations of all travel ways of 2010

	Bus	Taxi	Private car
Influence coefficient of time cost	1	1.35	1.74
Annual per capita income (Yuan)	48444	65399	84292
Per hour per capita income (Yuan)	22.9	30.9	39.84

Note Influence coefficients of time cost are from research on Beijing comprehensive transportation cost

Table 35.3 Time costs of different ways and trip purpose of 2010 (Yuan/h)

	Commute	Non-commute	School
Bus	30.4	6.87	3.43
Taxi	41.1	9.27	4.64
Private car	52.98	11.95	5.97

Table 35.4 Different modes and purposes of Beijing daily travel volume of 2005 (Million people/day)

	Commute	Non-commute	School
Bus (include subway)	351.5	434.2	84.4
Taxi	89.7	110.7	21.5
Other	351.5	434.2	84.4

Table 35.5 Different ways and purposes of Beijing travel daily proportion of 2005

	Commute	Non-commute	School
Bus (include subway)	1	1.24	0.24
Taxi	1	1.23	0.24
Other	1	1.23	0.24

Table 35.6 Different models and purposes of Beijing daily travel volume of 2010 (Million people/day)

	Bus	Taxi	Other
Total daily travel volume	1317	188	882
Business	531.1	76.1	357.1
Non-business	658.5	93.6	439.2
School	127.5	18.3	85.7

In the *Annual Report of the Development of Traffic of 2011 in Beijing*, daily travel volume of various travel methods in 2010 can be found. With Table 35.5, daily travel volume of various models and purposes are shown in Table 35.6.

In this thesis, the calculated cost is the cost of traffic congestion, thus this calculation chooses the period of congestion and all the costs are costs from vehicle congestion in the period of traffic congestion. The periods are set from 7 a.m. to 9:30 a.m. and 4:30 p.m. to 7 p.m. From Fig. 35.2, it can be seen clearly that during the two periods, the traffic volumes reach the peak and those of other periods are quite small, thus not included in congestion periods.

Figure 35.1 shows the rate of travel areas of private cars during congestion periods to the daily areas. By this, the total travel volume of cars during congestion periods can be calculated and so do other travel modes, which are shown in Table 35.7.

The average numbers of the average travel time for peaks in the morning and evening of three types of vehicles are taken as the average travel time of those three types of cars during congestion periods. According to the traffic research, parts of the data are shown in Table 35.8 (except taxis).

Combine different travel figure out all kinds of car travel for the purposes of the ratio of their total trip different travel purposes as shown in table 35.9.

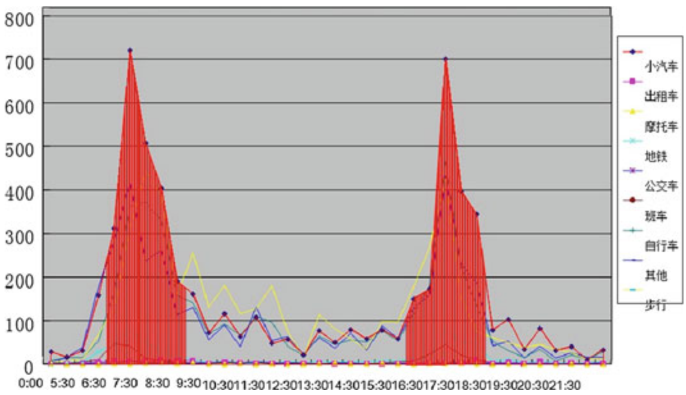

Fig. 35.1 Relationship between travel volume of private cars during congestion periods and total travel volume

Table 35.7 Different modes of Beijing daily travel volume for residents during congestion periods (Million people/day)

	Bus	Taxi	Other
Ratio of travel volume during congestion periods to total daily volume	0.63	0.38	0.69
Total daily travel volume	1317	188	882
Travel volume during congestion periods	829.71	71.44	608.58

Note Total daily travel volume is from Beijing annual report of transportation development of 2011

Table 35.8 Average travel time of vehicles in rush hour on (Min)

Vehicle	2010 rush hour in the morning	2010 rush hour in the evening
Car	36.43	35.78
Subway	68.31	62.72
Bus	54.4	55.41
Bike	23.04	24.87
Walk	12.14	11.34

Note Data from Beijing annual report of transportation development of 2011

Table 35.9 Different modes and purposes of Beijing travel volume for residents during congestion periods of 2010 (Million people/day)

	Total travel volume during congestion periods	Commute	Non-commute	School
Bus	829.71	334.56	411.51	80.29
Taxi	71.44	28.92	35.57	6.94
Other	608.58	246.38	303.05	59.13

Table 35.10 Taxi trip distance during different periods

Trip distance	12 p.m.–7 a.m.	7 a.m.–9 a.m.	9 a.m.–5 p.m.	5 p.m.–7 p.m.	7 p.m.–12 p.m.	All day
Distance (km/car)	10.26	8.23	7.63	8.35	8.89	8.22

Due to the lack of data of taxis in Table 35.9, the travel time of taxis in peak periods is calculated separately. According to the third traffic comprehensive survey in Beijing, the travel distance of one time for taxis of various periods in 2005 can be figured out (details in Table 35.10). Since there is no big change in travel distances of one time, one travel distance of 2005 is regarded as the travel distance of 2010 and is dealt with the speed conditions of road network in peak periods of 2010.

The average travel distance of every time for taxis in peak periods is (8.23 + 8.35)/2 = 8.29 km.

In the beginning period of data preparation, receipts of taxis should be extracted and collected randomly, figuring out the travel speed of taxi in congestion periods reaches 20.63 km/h, thus the travel time of every time in that periods should be 8.29 km/(20.6 km/h) = 24.1 (min).

Furthermore, related survey shows that the rates of bus time, walking time and waiting time amount to 64:36:13, which is shown in Fig. 35.2.

According to the data of traffic survey, one travel time of people by bus in congestion periods is $\frac{54.4+55.41}{2} = 54.9\,(\text{min})$. After subtracting the waiting time and transferring time, the average consumption of time on bus is $\frac{(54.4+55.41)\times 64\,\%}{2} = 35.14\,(\text{min})$. Therefore, the average consumption of time by bus in congestion periods amounts to $\frac{36.43+35.78}{2} = 36.1\,(\text{min})$ (Table 35.11).

1. **Total time cost of three types of vehicles in congestion periods**:

$$C_{\text{itotaltimecostofvehicle}} = t_{\text{ieverytimeconsumption}} \times \sum \left(C_{\text{thevalueofunittime for certainpurposes}} \times M_{\text{travelvolumeofcertainpurposes}}\right)$$

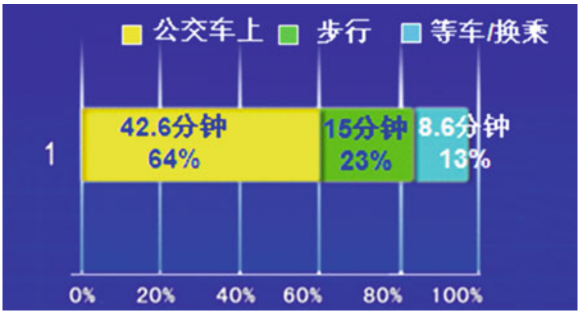

Fig. 35.2 A public transport travel time

Table 35.11 Time consumption and travel distance of three types of cars in congestion periods

	Bus	Taxi	Car
One travel time consumption in congestion periods (min)	35.14	24.1	36.1
One travel distance in congestion periods (km)	11.1	8.29	10.78

a. During the congestion periods in 2010, the time cost of all the residents by buses is:

$$\begin{aligned} C_{\text{totaltimecostofbus}} &= t_{\text{everytimeconsumptionofbus}} \\ &\quad \times \sum (C_{\text{thevalueofunittime for certainpurposes}} \text{travelvolumeofcertainpurposes}) \times 365 \\ &= \frac{35.14}{60} \times (334.56 \times 30.4 + 411.51 \times 6.87 + 80.29 \times 3.43) \times 10^4 \times 365 \\ &= 283.74\,(\text{billion yuan}) \end{aligned}$$

b. During the congestion periods in 2010, the time cost of all the residents by taxis is:

$$\begin{aligned} C_{\text{totaltimecostoftaxi}} &= t_{\text{everytimeconsumptionoftaxi}} \\ &\quad \times \sum (C_{\text{thevalueofunittime for certainpurposes}} \times M_{\text{travelvolumeofcertainpurposes}}) \times 365 \\ &= \frac{24.1}{60} \times (28.92 \times 41.1 + 35.57 \times 9.27 + 6.94 \times 4.64) \times 10^4 \times 365 \\ &= 22.73\,(\text{billion yuan}) \end{aligned}$$

During the congestion periods in 2010, the time cost of all the residents by taxis is:

$$\begin{aligned} C_{\text{totaltimecostofcar}} &= t_{\text{everytimeconsumptionofcar}} \\ &\quad \times \sum (C_{\text{thevalueofunittime for certainpurposes}} \text{travelvolumeofcertainpurposes}) \times 365 \\ &= \frac{36.1}{60} \times (246.38 \times 52.98 + 303.05 \times 11.95 + 59.13 \times 5.97) \times 10^4 \times 365 \\ &= 373.94\,(\text{billion yuan}) \end{aligned}$$

Consequently, the total time cost of residents during congestion periods in 2010 is 68.041 billion yuan (Table 35.12).

By the sampling survey of taxis in Beijing, the average speed of taxis during non-peak periods (6:30 a.m. to 7 a.m. and 9 a.m. to 5 a.m.) is 25.39 km/h. As for the speed of road network of Beijing, when the congestion coefficient reaches four, the average speed is 24.5 km/h. Since the speed in the evaluation system of congestion coefficients includes buses, it is difficult to identify them. Therefore,

Table 35.12 The total time, extra congestion time and total time cost of different ways of travel in 2010 in Beijing during congestion periods

	Bus	Taxi	Car
Total congestion time (ten thousands hours)	177365.7	10473.7	133649.2
Total cost during congestion periods (billion yuan)	283.74	22.73	373.94

this study adopts 25.4 km/h as the critical speed of congestion and flow for taxis and cars.

Due to the lack of travel volume of buses in different periods, the weighted average speed of buses cannot be calculated. Thus, this thesis takes the average speed of critical congestion periods as the critical speed of congestion and flow for buses.

Table 35.13 shows the critical flow speed and congestion speed of buses, taxis and cars in the road network.

The passages above figure out one time consumption and distance of different travel modes for residents during congestion periods. By combining the standard of flow speed, the time difference between congestion travel and flow travel can be calculated and the total cost of extra congestion can be drawn from the proportional relation.

2. **One travel time consumption of flow speed for three types of travel modes**

$$t_{\text{flow speed of bus}} = \frac{11.1}{20.4} \times 60 = 32.6\,(\text{min})$$

$$t_{\text{flow speed of taxi}} = \frac{8.29}{25.4} \times 60 = 19.6\,(\text{min})$$

$$t_{\text{flow speed of car}} = \frac{10.78}{25.4} \times 60 = 25.46\,(\text{min})$$

3. **Total cost of extra congestion time of Beijing vehicles in 2010**

$$C_{\text{itimecostofextracongestion}} = \frac{t_{\text{itimeconsumptionofextracongestion}}}{\text{t}_{\text{itotaltimeconsumptionofcongestion}}} \times C_{\text{totaltimeconsumptionofcongestion}}$$

Table 35.13 Standards of flow speed and congestion speed of Beijing urban road network

	Bus	Taxi	Car
Flow speed (km/h)	20.4	25.4	25.4
Congestion speed (km/h)	18.8	20.6	20.6

$$C_{\text{timecostofextracongestionofbuses}} = \frac{35.14 - 32.6}{35.14} \times 283.74 = 20.51\,(\text{billion yuan})$$

$$C_{\text{timecostofextracongestionoftaxis}} = \frac{24.1 - 19.6}{24.1} \times 22.73 = 4.24\,(\text{billion yuan})$$

$$C_{\text{timecostofextracongestionofcars}} = \frac{36.1 - 25.46}{36.1} \times 373.94 = 110.2\,(\text{billion yuan})$$

Thus, the total cost of extra congestion time of Beijing vehicles in 2010 is:

$$C_{\text{costofextracongestiontimeofBeijing}} = 20.51 + 4.24 + 110.2 = 134.9\,(\text{billion yuan})$$

35.4 Conclusion

In the above analysis, it can be found that the time cost caused by congestion is enormous and that of private cars account for a proportion of the total. Furthermore, it can be judged that a large number of private cars lead to traffic congestion. As a result, the time cost of private cars increases a lot and affects the time cost of taxis and passengers of buses. Consequently, two basic suggestions are offered here.

Firstly, we need to solve the preference of people when they go out and lead them to travel with less emissions of carbon dioxide. We need to change their blind pursuit for private cars, enhance the guidance of modern traffic awareness, improve the concept of traffic consumption, use cars reasonably and moderately, strengthen the awareness of modern traffic safety and drive safely and scientifically.

Secondly, with the characteristic of low carbon, green traffic is the component of urban sustainable traffic system. According to the conditions of traffic congestion in Beijing, great efforts should be made to construct a comprehensive urban traffic system of bus, walk and bike, which is a healthy development mode for the actual circumstance of Beijing. For instance, we can give a plan of traffic system rules for walk and bike, make regulations and rules of example streets and districts for walk and bike in the western part of Zhongguancun and central business districts and gradually promote it. We can also encourage and support the development of public bike systems, set up about 1,000 spots for bike rent, which will make the ratio of travelling bikes in Beijing at about 20 % and make the structure of traffic travel more reasonable. Therefore, the integrity of traffic and land is the technical key of the construction of sustainable traffic system and the government is responsible for making policy structure of the coordination and development of traffic and land.

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Chapter 36
The Development and Application of Transport Energy Consumption and Greenhouse Gas Emission Calculation Software Based on the Beijing Low-Carbon Transport Research

Weiming Shen, Feng Chen and Zijia Wang

Abstract According to the established calculation model for energy consumption and greenhouse gas (GHG) emissions from the Beijing low-carbon transport research, a general calculating software visualizing the whole calculation and providing flexible data input interface was developed. The user can calculate the values of energy consumption and GHG emission of urban road transport and rail transit, and do some scenario analysis through the succinct interface of the software and rich parameters to input. This tool allows the transport agencies to analyze transport policies and evaluate the implication of these policies, the analysis can improve the scientific and rationality of the traffic decision-making and ensure the implementation of green transport goals.

Keywords Transport energy consumption · Greenhouse gas emission · Calculating and predicting · Scenario analysis

36.1 Introduction

Fossil fuels, the global energy supply and greenhouse gas (GHG) emissions have increased rapidly because of the development of industrialization. Global energy crisis and climate change make energy saving receive worldwide consensus. According to the established calculation model for energy consumption and GHG emissions, a general calculating tool visualizing the whole calculation and providing flexible data input interface was developed, which allows the transport

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agencies to analyze transport policies and evaluate the implication of these policies, The analysis can improve the scientific and rationality of the decision and ensure the implementation of green transport goals.

With this software, the user can input the values of parameters included among the urban road transport and urban rail transit, through the calculation of the computer, the energy consumption and GHG values can be obtained. Especially, the user can utilize the energy consumption model formulated and the calculating program developed according to the basic data and traffic policies, the future annual traffic energy policies and trend of traffic energy consumption and GHG emissions be analyzed, and the efficacy of the energy saving policies be predicted. These analyses can provide reference for traffic policy making.

36.2 Basic Framework and Design Goals

The transport energy consumption and GHG emission calculation software is built based on the establishment of Beijing low-carbon transport quantitative model. According to the calculating tool built, the user can calculate the values of energy consumption and GHG emission and do some scenario analysis through the succinct interface of the software and rich parameters to input. The software aims at the visualization of the calculation and analysis procedure, which can help to improve the decision-making more rationally and scientifically, so that to ensure the implementation of green transport. The basic framework of the software is as shown below.

Software could be divided into two parts: calculation and predicting of the energy consumption and GHG emissions and scenario analysis. The calculation and predicting part is composed of three modules: input modules, calculation module and Output module. Calculation module is actually the visualization of calculation model developed above which generates the calculation process with the data input by users, and provides results, Therefore, this module bear little linkage with users. Parameter input module and the result output module are more important to the users.

(1) **Data input module**

Parameter input interface is divided into two parts: urban road parameters input and urban rail transit parameters Input. Urban road traffic includes vehicle amount of different types, VKT of different types, vehicle fuel economy, passenger volume and PKT of different vehicle types, average trip distance and other parameters. The urban rail transit involves line length of different alignment types, numbers of station of different alignment, annual train departure, passenger volume, average trip distance and so on Beijing (2007) . Energy consumption per load per kilometer is user-selectable input parameters. The two parts of parameter input bear a relationship through passenger attribution. The figure below shows the input parameters of public diesel vehicles and parts of the urban rail transit (Fig 36.1).

Fig. 36.1 Input parameters of public diesel vehicles and parts of urban rail transit

(2) **Results Output Module**

The results of the software include the transport energy and greenhouse gas emissions can also be output by the corresponding mode of transport and energy consumption and vehicle emissions inventory, and the form of a chart to show users.

The scenario part includes two main interfaces, the parameter input interface and the result interface, and the latter one is same as the result output module of the calculation part. Entering the interface of Scenario analysis, Firstly the user chooses target year he wants to calculate or predict, and the right parameter table can be chosen to change the corresponding parameter values. If the user cannot know some of the parameter values, the software set them as the default values automatically.

There are 4 scenario situations settled in the software: Reduction of average trip distance and promotion of fuel economy of social car, limitation on purchase of social cars, reduction of energy economy of rail traffic and modes shift of passenger traffic. In the next chapter, the first scenario will be mainly interpreted.

Except for the three modules, there are shortcuts for all the types of calculation and the macro indexes (such as GDP per capita and the number of year) on the left of the interface, so the user can enter the interface which he wants to calculate directly without click in one by one (Fig 36.2).

36.3 Sample Application

There are two examples to show how the software operates: The first one is to calculate the values of Beijing energy consumption and GHG emission in 2009 which are already analyzed by the relevant departments, and this process can be seen as a test of the calculating accuracy of the software. The other is to analyze the scenario “Reduction of average trip distance and promotion of fuel economy of social car”.

Fig. 36.2 Parameter input of scenario analysis

(1) **Calculation of Beijing energy consumption and GHG emission in 2009**

After choosing the urban road transport on the main interface, firstly setting the parameter values of lorry: Freight turnover: 8543719901 t · km Beijing (2010) and the average energy intensity value as the default value, 0.1079 L/(t · km) IEA (2004) and click on the calculate button, the energy consumption value is 921867377L. And do the same procedure in the Public electric vehicle, taxi, public passenger vehicles and road lighting system. In every page there is a energy and GHG result of the corresponding vehicle type.

About the urban rail transit, the parameters are divided into 2 parts. For the metro vehicles, the energy consumption for unit of freight traffic turnover for both underground and ground lines is needed to input. For the metro stations, the average energy consumption for the action and lighting per month for 3 different kinds of stations (underground station with platform screen doors (PSD), underground station without PSD and ground one without PSD), the number of each kind of station and turnover volume for the underground and ground lines should be obtained by the user. However, if the user cannot get any of the parameter value, he can use the default value set in the software which is related to urban rail transit in Beijing. After calculation, the total result of energy consumption and GHG emissions of Beijing in 2009 are 6.50 billion kgce and 42.19 billion kg.

In the urban rail transit part, if the user wants to calculate the energy consumption for unit-load of the new-bulit metro line, the figure below is available and the user just needs to input the corresponding parameter values, and the values of unit-load for every new-bulit lines will be shown in the table and the total energy consumption for metro vehicles are calculated out.

(2) **Scenario analysis**

In the scenario "Reduction of average trip distance and promotion of fuel economy of social car", considering average resident trip distance gradually decreases with the rationalization of urban distribution of Beijing. Because of the increasing of the proportion of Euro V vehicles Wang (2009), the average fuel

Table 36.1 Energy consumption and GHG emissions in scenario of travel distance decrease and fuel economy promotion

Target year	Social car energy consumption (million L)		Social car GHG emissions (ten thousand t)	
	Default value	Value of scenario	Default value	Value of scenario
2015	5761	3904	57.61	39.04
2020	9623	37.80	96.23	37.80

efficiency of Beijing increases from 7.76 L $\times$ 100^{-1} km^{-1} to 7.09 and 6.57 in 2015 and 2020 . The average trip distances of social cars change from 10.78 km to 8 and 5 in 2015 and 2020. Using the default value in inertial model for other parameters, the results are drawn from the software, as shown in table. According to the result, Reduction of average trip distance and promotion of fuel economy of social car can make the values of energy consumption and GHG emission drop by 60 % at most (Table 36.1).

36.4 Conclusion

Various and flexible parameter input, enable the software having relatively strong function and general usage to some degree.

Software can be used to establish transport energy consumption and GHG emissions inventory. The inventory involves energy consumption and GHG emissions from on-road and rail transportation, and different vehicle types. As long as the basic transport data is input, the corresponding energy consumption and emissions inventory could be drawn and presented to the user in the form of chart.

Software can be applied for the scenario analysis of a variety of policies and the implication analysis of energy saving policies. There are many types of input parameters, including parameters of vehicle amount, passenger volume, average trip distance and other factors, so the transport policies or management measures such as control on vehicle purchase, clean fuel technology and promoting the traffic sharing of urban rail transit, which can impact transport energy consumption and GHG emissions in Beijing, could be fully analyzed, and conduct comparative analysis between the different scenarios could be launched.

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Chapter 37
Operational Planning of Electric Bus Considering Battery State of Charge

Qian Qiu, Jun Li and Hongru Yu

Abstract Electric bus has a different energy resource from the traditional one, which makes the traditional bus operating mode unsuitable for the electric one. In consideration of battery state of charge, a single depot and single route vehicle scheduling model of electric bus is built with route and charging time constraints. A case study of Dongguan Songshan Lake National High-tech Industrial Development Zone is presented: Electric bus is selected as operational vehicle, an operational scheme of electric bus is proposed based on field testing data and operational model by Higer KLQ6702EV electric bus.

Keywords Electric bus · Operational planning · Battery state of charge · Vehicle scheduling model

37.1 Introduction

The optimal operation of electric vehicle is a new challenge in the developing area of electric vehicles due to the characteristics of electric vehicles, the short driving range and the long charging time. In 1992, a testing base of European electric vehicle was built in Rugen island of Germany, in which a four-year operating test for 62 cars from Big-four Company was carried out (Heber 1997). In 2002, a project named Clean Commute was implemented in New York, America, who applied more than a thousand electric vehicles for shuttling between the urban area

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(Francfort 2004). The application of electric vehicle have are markable progress after building the national electric vehicle testing base in Nan'ao, Shantou, China, in 1998 (Liu 2008). The government started the project named "Ten Cities, Thousand Cars" in 2008. Consequently, It's meaningful to build a operating mode for green-bus-network with electric buses, not only it can spread a healthy travel concept and increase the conveniences for residents, but also it can accumulate the experience for further application and promotion (Wang and Gong 2012).

37.2 Operational Planning of Electric Bus

A small number of electric buses operate with the single line when electric bus is in the demonstration operation stage. However electric bus has a different energy resource from the traditional one, which makes the traditional bus operating mode unsuitable for the electric one (Xu and Yu 2009), and a special operation mode on the basis of battery constraints is required for the electric bus. Electric bus vehicle scheduling model of single line with the timetable of operation is given. The timetable of operation fixed, vehicle scheduling model of electric bus with the single line is built considering battery state of charge in this article.

37.2.1 Battery State of Charge

In the process of solving vehicle scheduling problem, it's necessary to consider the State of Charge (SoC) of battery calculation, which is a ratio of battery remaining power against full charged capacity (Shi and Jiang 2010). As Fig. 37.1 showed, the EMF of battery is changing smoothly when SoC is between C_n to C_m, which is the most appropriate operation interval for the electric bus, in other words, the electric bus has a low performance when the SoC is under C_n or over C_m and it will be an important constrain for actual practice.

37.2.2 Charging Strategy

The operation of electric buses needs serving stations for charging and maintenance when they're in terminal parking lot (Teng 2009; Han and Jiang 2011). In order to promote the operational sustainability of electric bus, taking a new charging strategy into action named operating-charging-operating is reasonable. Firstly, the electric bus operates for a period basing on the timetable; secondly it comes back to the station for a fast charge; then it operates again according to the

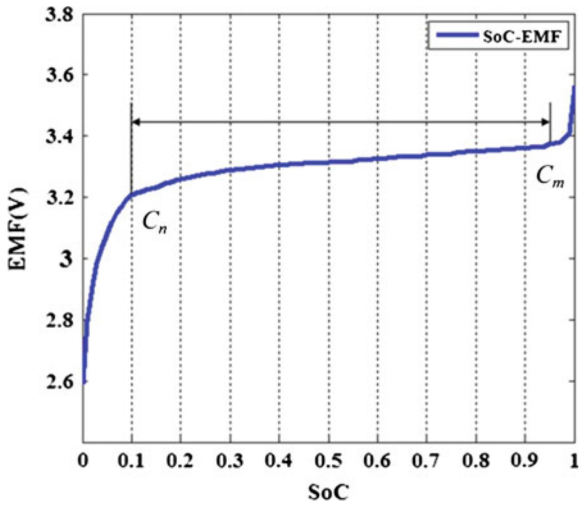

Fig. 37.1 SoC-EMF curve of battery (20 °C)

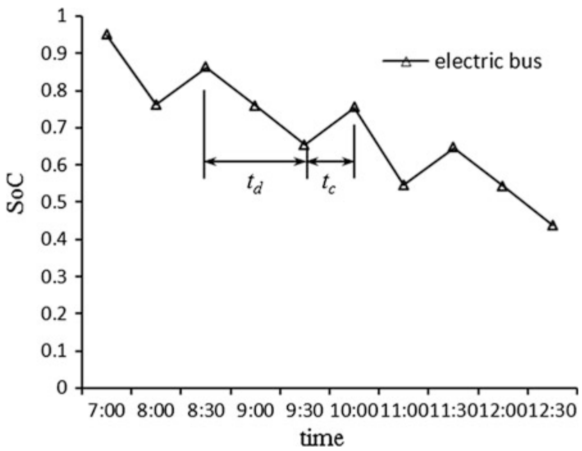

Fig. 37.2 SoC of electric busover operational time

schedule after the fast charge. Once the charging strategy of operating-charging-operating is carried out, SoC of electric bus would be changed over operational time showed as Fig. 37.2, where t_d is discharging time of battery and t_c is charging time of battery.

37.2.3 Vehicle Scheduling Model

The study of bus operating and planning with electric bus can start with a single depot and single route vehicle scheduling problem with route and charging time constraints. The vehicle scheduling model is based on followed assumption:

(1) the style of electric bus is same,
(2) the average round-trip time T_r is invariable,
(3) the average round-trip consumption of the battery power C_r is invariable,
(4) there are enough charging equipments to serve the operational electric bus with n_cC charge in the charging station.

Let N be the fleet size of electric buses with a single route, related to F that defined as the sum of the departure trips, which can be calculated if the timetable is fixed. The vehicle scheduling model of electric bus with a single route is aiming to solve the problem about the minimum fleet size of electric buses when the timetable is fixed, that is to promote the maximum trips of a electric bus according to the charging strategy which can meet the service of the fixed timetable. Using variable f defined as the maximum trips of electric bus with the fixed timetable, the vehicle scheduling model of electric bus with a single route can be formulated as follows:

$$\min N = \frac{F}{f} \tag{37.1}$$

$$C_m + fC_r + n_c T_c \geq C_n \tag{37.2}$$

$$C_m + fC_r + n_c T_c \leq C_m \tag{37.3}$$

$$T_d + T_c \leq T \tag{37.4}$$

$$T_d = fT_r \tag{37.5}$$

Equation (37.1) is the objective function, Eqs. (37.2) and (37.3) assure that SoC of a electric bus is in the working range each trip, and Eq. (37.4) define a bus operational time T where T_d is the sum of t_d, T_c is the sum of t_c.

37.3 Vehicle Route Test

The Entertainment and Food Special Line (EFSL), which is located in Dongguan Songshan Lake National High-tech Industrial Development Zone, is used as test operational line. As Fig. 37.3 showed, EFSL is connecting the industrial, commercial and education areas, in order to increasing the accessibility of each area. EFSL starts from A towards J and returns along the same path to A as the terminal of the bus line. The single-way distance of the line is 12 km and the round-trip is 24 km.

Higer KLQ6702EV is chosen as the operation bus of EFSL, major parameters are showed in Table 37.1, and the results showed in Table 37.2 are testing parameters and running indicators on EFSL according to the test mode without charging.

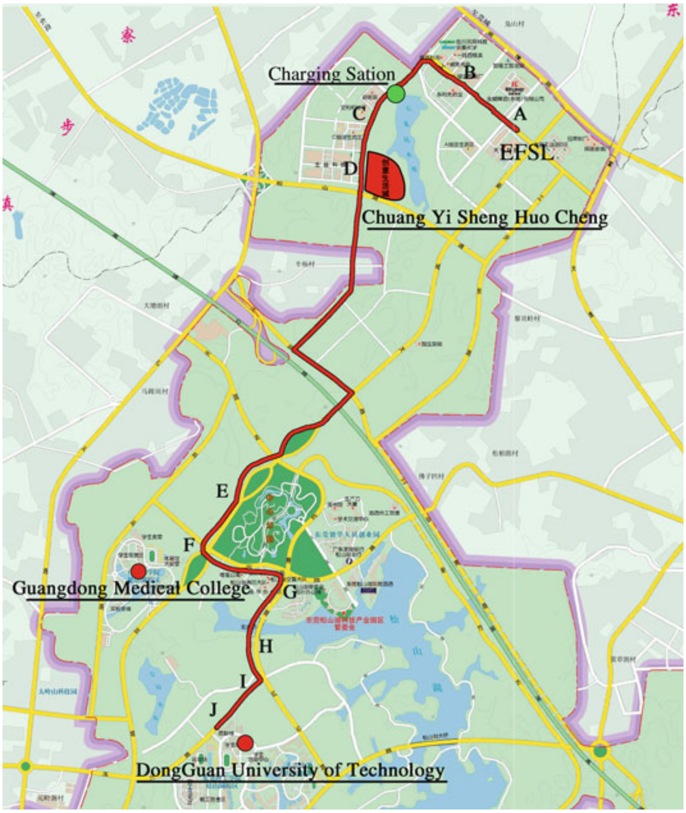

Fig. 37.3 Entertainment and food special line

Table 37.1 Major parameters of higer KLQ6702EV electric bus

Size (mm)	Curb weight	Capacity	Max speed	Battery pack
7020 × 2040 × 2790	6000 kg	13 person	90 km/h	336 V/250 Ah

Table 37.2 Test result of higer KLQ6702EV electric bus

Round-trips	Distance	SoC	AVS	Energyconsumption
4	98 km	95–10 %	26.3 km/h	0.65 kWh/km

37.4 Scheme of Operational Planning

The operational time of the EFSL is 7:00–22:00. The buses departs every hour and reducing the departure interval to 30 min at traffic peaks, as shown in Table 37.3.

Fixed timetable given, the operational time of electric bus T is 16 h, and the sum departure trips F are 19 trips. The battery of electric bus has a capacity of

Table 37.3 Fixed timetable of EFSL

7:00	10:00	13:00	17:00	20:00
8:00	11:00	14:00	18:00	21:00
8:30	11:30	15:00	18:30	22:00
9:00	12:00	16:00	19:00	–

Table 37.4 Process of vehicle-chain construction

Number	Vehicle-chain construction
1	1 → charge → 3 → charge → 5 → charge → 7 → charge → 9 → charge→ 11 → charge → 13 → charge → 15 → charge → 17 → charge → 19
2	2 → charge → 4 → charge → 6 → charge → 8 → charge → 10 → charge→ 12 → charge → 14 → charge → 16 → charge → 18

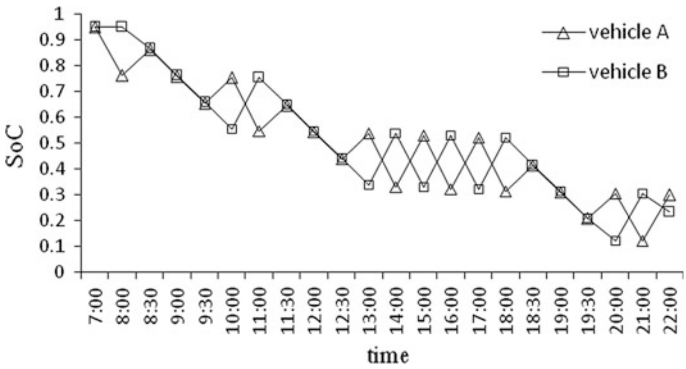

Fig. 37.4 Appraisal curve of real-time SoC of electric bus

75 kWin EFSL, and its working range is from $C_n = 10\,\%$ to $C_m = 95\,\%$ by test, which charge at the rate of 0.2 C in the charging station. It's based on the test data of Higer KLQ6702EV electric bus that T_r is 0.91 h, C_r is 15.6 kWh/km. According to Eqs. (37.2), (37.4), and (37.5), the result is $f \leq 10.3$ trips, so the minimum fleet size of electric bus N are 2 vehicles by Eq. (37.1). The vehicle-chain of electric bus in EFSL is constructed showed in Table 37.4.

According to the data and operational vehicle-chain described above, the appraisal curve of real-time SoC is calculated and shown in the Fig. 37.4, which indicates that the constraints of route and charging time could be fulfilled by the vehicle schedule, that is, the vehicle scheduling model of electric bus with a single route is effective.

37.5 Conclusions

Considering the battery state of charge, a model is built to solve a single depot and single route vehicle scheduling problem with route and charging time constraints. In the case study of Dongguan Songshan Lake National High-tech Industrial Development Zone, there is an effective operational Planning scheme of electric bus based on the vehicle scheduling model. However it hasn't been taken into account that the number of charging is finite for a battery, which will be considered in the further research aimming at lengthenning the battery life and reducing the operational costs of electric bus.

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Chapter 38
Scheme Research of Urban Vehicle Restriction Measures According to Synthesis Criterion

Long Chen, Ming-jiang Shen and Xing-yi Zhu

Abstract Transportation demand management is an effective way to realize urban low-carbon transport. The urban vehicle restriction is one of the modes of transportation demand management. However, why, when, and how to start the vehicle restriction are the problems the traffic administrators will meet with. Therefore, in this paper, three criterions are presented, and then are verified by the case of vehicle restriction schemes adopted in Hangzhou to show the significance and effectiveness.

Keywords Vehicle restriction · Synthesis criterion · Transportation demand management

38.1 Introduction

The vehicle restriction is one of the modes of transportation demand management (TDM). Compared with the district congestion charge mode mature adopted in England, Singapore, and other developed countries, the district vehicle restriction

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is a method quite suitable to resolve traffic problems in China, where the quantity of vehicles is rapidly increasing, however, the transportation manage measurements still exist many limitations (Cynthia et al. 2010).

The district vehicle restriction scheme has been carried out in San Diego, Bogota, Beijing, etc. In china, this scheme is developed from the countrywide activity of "No vehicle day", which obtained public praise. Then, different categories and scope of vehicle restriction schemes were adopted accompany with the important pageants, such as Olympic Games in Beijing (Cynthia et al. 2010; Mahendra 2008) Asian Games in Guangzhou, the World University Student Summer Sports Games in Shenzhen. After these three successful attempts, the regular district vehicle restriction policy was unveiled in Beijing in Oct. 2008, which implemented by three stages. From then on, Nanchang, Lanzhou, and other cities in China started to adopt this scheme.

The regular vehicle restriction policy is an intrepidity and effective attempt of TDM, however, it will seriously affect all the citizen's daily life. Therefore, the two questions, namely, how to accurately judge whether the vehicle restriction policy is the best choice to resolve the urban transportation problem, and which kind of vehicle restriction schemes are more suitable to the city's characteristic, are the principal problems the traffic administrators will meet with during the decision-making.

In this paper, combined with the research experience of urban vehicle restriction policy in Hangzhou, three criterions, namely, starting criterion, causation criterion, choice criterion, are suggested to improve the design of vehicle restriction schemes. Finally, these three judging criterions are used and verified by the implement of vehicle restriction schemes in Hangzhou on Oct. 2011.

38.2 Starting Criterion

The objective of vehicle restriction is car, and the direct intention of restriction is to control such rapid increase of the quantity of cars as well as to decrease the trip frequency, therefore, to change the develop mode of motorization in the future. Hence, the thousand people car-occupancy's rate (P) is used as the starting threshold. Since by using P as the division criterion of the develop stages of the quantity of city's cars, the develop stages can be separated into the following three stages (Li 2006): primary stage ($P = 0$–40 cars per thousand people); intermediate stage ($P = 40$–200 cars per thousand people); mature stage ($P > 200$ cars per thousand people);

The increasing trend curves of P in different developed countries are plotted in Fig. 38.1. It is shown that the measures have been taken in order to relieve the increasing trend after the value of P comes into the mature stage, such as $P = 357$ cars per thousand people for France, $P = 213$ cars per thousand people for England, and $P = 202$ cars per thousand people for Japan. Take England as an example, in 1970, when the value of P in London comes into mature stage

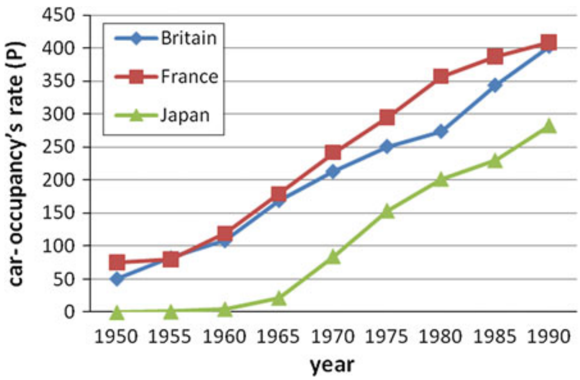

Fig. 38.1 Thousand people posse's rate curves for the developed countries

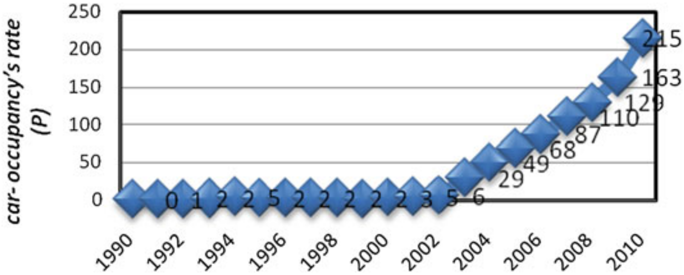

Fig. 38.2 Thousand people car-occupancy's rate curves for Hangzhou

($P = 213$ cars per thousand people), the congestion charge measurement (charged two dollars for each vehicle driving into city center) was adopted and gained great successful.

As for Hangzhou, from 1990 to 2010, the value of P increases rapidly (see Fig. 38.2). In 2010, the value of P in the main city zone reaches to 215 cars per thousand people, which means Hangzhou has already goes into the mature stage. Therefore, according to the starting criterion, Hangzhou city has been provided with the starting reason to implement the vehicle restriction policy.

38.3 Causation Criterion

The main reason for serious traffic congestion in China is that the capacity of road network can not satisfy the demand of increase of motor vehicles. Recently, with the increasingly strained resource of urban land and the basic formation of city road network, the sustainability of increase of capacity of road network is decreasing rapidly. Under this background, the main reason to choose the vehicle restriction policy is that through this measure we can effective prevent the demand of too fast increase of motor vehicles. Therefore, we choose the degree of space–time saturation (S_{at}) as the causation criterion. When the value of S_{at} is larger than 1.05, the vehicle restriction measures can be considered to be adopted.

The degree of space–time saturation can be defined as the ratio of total trip volume of motor vehicles in peak hour (D_n) with the actual capacity of vehicle road network (C_{apr}) (Chen 2002), namely,

$$S_{at} = \frac{D_n}{C_{apr}} \tag{38.1}$$

where D_n can be calculated by

$$D_n = \frac{Q_h s_h + Q_c \mathrm{s}_c + Q_b \mathrm{s}_b + Q_t \mathrm{s}_t}{(1 - \mathrm{s}_w)} \tag{38.2}$$

in which Q_h, Q_c, Q_b, and Q_t are the after-convert number of freight carriers, taxis, buses, and the other vehicles, respectively, in the observation district on hand; s_h, s_c, s_b, and s_t are the trip proportion of freight carriers, taxis, buses, and the other vehicles during the peak hour, respectively,; s_w is the proportion of the non-local vehicles, which is as one part of the traffic flow.

The actual capacity of vehicle road network (C_{apr}) can be calculated according to the space–time consumption method, which is based on a certain level of service. The formulation of C_{apr} is given as follows:

$$\begin{aligned} C_{apr} &= \\ &= \frac{\sum_{i=1}^{4} (l_i \times \eta_{1i} \times \eta_{2i} \times \eta_{3i}) \times (1 - S_w) \times \alpha \times c}{l_p \times s_t} - (\frac{v_t}{l_p \times s_c} - 1) \times Q_C \\ &\quad - (\frac{k_b \times v_b \times s_\mathrm{b}}{} - \mathrm{s_b}) \times Q_b \end{aligned} \tag{38.3}$$

where l_p is average trip distance for vehicles; l_i is the equivalent length for the i-th level road, in which the road level includes expressway, main road, secondary road, and collector road; η_{1i} is the coefficient of effective length for all levels road; η_{2i} is the utilization factor of junction for all levels road; η_{3i} is the number of lanes for all levels road; α is the coefficient of the level of service for total road network; c is the travel traffic in a single lane (is equal to the road section capacity).

Here, we take Hangzhou city as an example. Firstly, we set down the research area considered to carry out the vehicle restriction policy. Then, According to the observation data of vehicle flow, all vehicles' trip coefficients in Eqs. (38.2) (38.3) can be obtained. The coefficient of the level of service for total road network is 0.75–0.8. Finally, according to the Eq. (38.1), the degree of space–time saturation in peak hour of the research area is 1.08, which is large than the causation threshold. Hence, it can be concluded that under the present traffic network conditions, the research area in Hangzhou already has satisfied the causation criterion to adopt the vehicle restriction policy. However, the degree of space–time saturation in peace hour of the research area is 0.95, which is less than the causation threshold. Therefore, the final decision of vehicle restricted only in peak hours was made. Besides, stage estimate is needed during the implement of the vehicle restriction, especially when Railway No.1 is put into operation.

38.4 Option Criterion

During the design of vehicle restriction schemes, three important variables are needed to be opted for, they are time, range, and type (namely, the type of vehicle to be restricted). The diverted traffic volume is a parameter closely related to the variables of time, range, and type. Besides, it is also a determinate parameter for judging the effect of vehicle restriction and judging if the other supporting system is perfect enough. The estimate of the diverted traffic volume is able to offer the basis for decision-making of the selection of the design schemes. Therefore, the diverted traffic volume is regarded as the option threshold for these three variables.

Here, we still take Hangzhou city as an example. Three factors are considered as follows.

(1) Firstly, the public transportation includes railway and bus. However, the railway in Hangzhou is still in construction. Therefore, the affordable diverted traffic volume of buses can be regarded as the threshold in the public transportation level (Chen et al. 2006).

The restricted area is involved 387 bus lines, which is 63.8 % of the total lines, and is involved 3476 buses, which is 46.7 % of the total amount. The passenger flow volume is 280.67 million per day during the peak load shifting period, and the passenger flow volume is 119.73 million per day during the morning and evening peak hour period. The average load factor of bus line during the morning and evening peak hour period is 90–92 %. Therefore, based on the actual traffic conditions in Hangzhou, a more conservative scheme is adopted, namely, the vehicles are restricted according to the tail number rather than the odd or even number, and the vehicles are restricted during the peak hour rather than all day around.

Based on the above measures, the diverted traffic volume will reach to 12–15 million trips. Referenced by the data from the “No vehicle day” over the year, the average convey velocity of bus in the restricted area will increase from 12.5 to 17.61 km/h, that is to say the velocity would be increase 40.88 %. Therefore, if we only intend to increase the average convey velocity of bus by 8–10 %, we can increase the turnover rate of bus. Then, the diverted traffic volume can reach to 8–10 million trips correspondingly. According to the above idea, the exclusive bus lane, whose length reaches to 60 km, was set up, and 170 buses, whose body length is 12 m, were added before the implement of vehicle restriction measures, which satisfy the bus diverted traffic volume.

(2) Secondly, because of the large amount of the ancient architectures, the resource of parking berth in the old city zone of Hangzhou is quite shortage. Therefore, the affordable diverted traffic volume of static parking berth can be regarded as the threshold in the static transportation level.

If the static parking berth cannot satisfy the requirement of the diverted traffic volume, the phenomena of no place to park and no space to move will occur, which will significantly affect the effect of the vehicle restriction measures. Therefore, in Hangzhou, the restricted area does not include the old city zone. And more parking berths are added. Finally, the number of the parking berth in the restricted area is 150246, including 31536 public parking berths inside road and 118710 parking berths outside road. Considering that the vehicles are restricted only during the peak hour, the requirements of "park and ride" or "park and wait" will occur. Besides, the temporary public parking berths and the corresponding guidance sign will set up. (Table 38.1).

(3) Finally, Hangzhou is the provincial capital of Zhejiang, there are 134 provincial administration units in the restricted area in Hangzhou. Besides, it is also a famous tourist city, including the most famous scenic spots, such as West Lake, canal, Xixi wetland, etc. Hence, the number of nonlocal vehicles is huge. Therefore, the affordable diverted traffic volume of nonlocal cars can be regarded as the threshold in the function level (Xiao (2008)).

Here, we take Raocheng Highway entrance as an example to analysis the diverted traffic volume of nonlocal cars in Hangzhou. Figure 38.3 presents the distribution chart of the directions and numbers of nonlocal cars driving into Hangzhou during the peak load shifting period. The observation time is morning peak hour (from 7 am to 8:30 am) and evening peak hour (from 17 am to 18:30 am). The numbers marked in the figure is the nonlocal cars number driving in and out of the interchange entrance. Figure 38.4 gives the comparison of the numbers of nonlocal cars and total cars driving in and out of different interchanges. Figure 38.5 plots the proportion of nonlocal cars number to total cars number driving

Table 38.1 Present status of parking berths in Hangzhou city

District	Total number	Number of parking berths (auxiliary construction)		Number of public parking berths (inside road)		Number of public parking berths (outside road)	
		Number	Percentage of total (%)	Number	Percentage of total (%)	Number	Percentage of total (%)
Shangcheng	41529	30461	73.3	9573	23.1	1495	3.6
Xiacheng	38580	27673	71.7	10194	26.4	713	1.8
Xihu	80134	59438	74.2	17537	21.9	3159	3.9
Jianggan	39913	33352	83.6	6423	16.1	138	0.3
Gongshu	33099	25030	75.6	7999	24.2	70	0.2
Total	233255	175954	75.4	51726	22.2	5575	2.4

*Data are from special planning book of parking facility in Hangzhou city

Fig. 38.3 Distribution chart of nonlocal cars driving into Hangzhou during the peak load shifting period

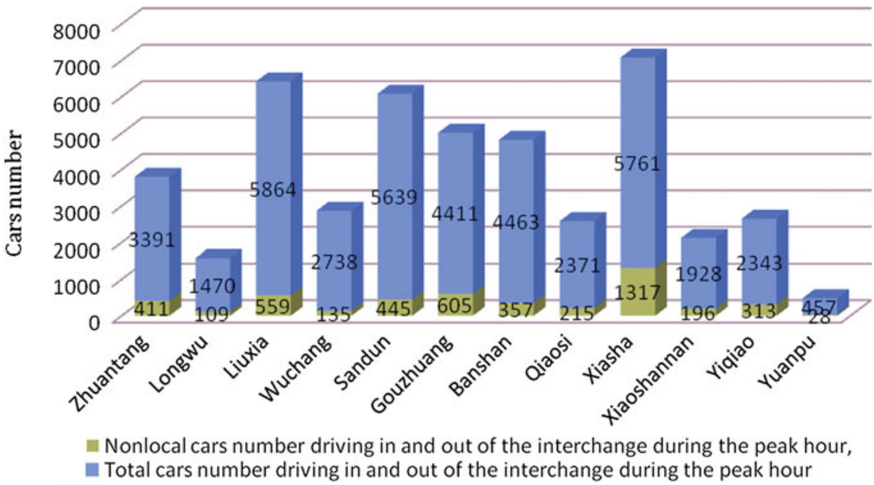

Fig. 38.4 Nonlocal cars number and total cars number in interchange peak

in and out of the interchange of Raocheng Highway entrance during the morning and evening peak hours in the work day. It can be seen from these three figures that the districts most affected by the nonlocal vehicles are Gouzhuang, Sandun, Wuchang, Liuxia, and Banshan. Specially, the entrances in Liuxia and Gouzhuang are quite close to the vehicle restricted area. Therefore, the detour scheme is

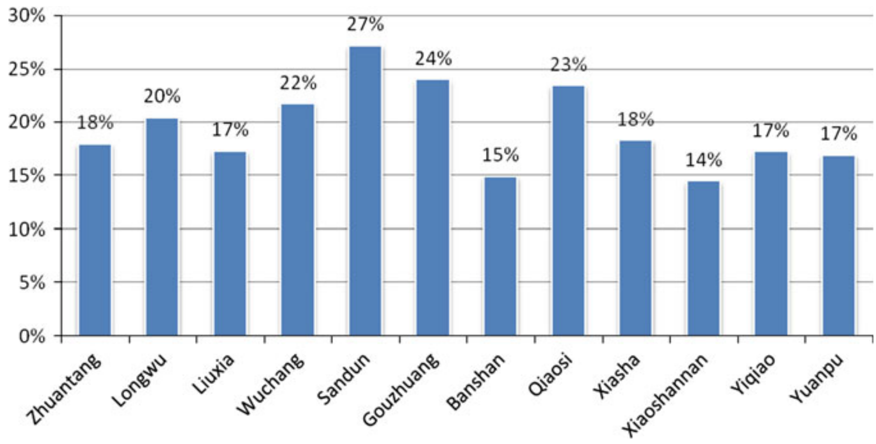

Fig. 38.5 Proportion of nonlocal cars number to total cars number in the interchange entrance during the morning and evening peak hours in the work day

suggested and the places for "park and ride" should be set up during the design of the scheme of vehicle restriction measures in Hangzhou.

38.5 Conclusions

In this paper, the synthetic criterions are put forward, which include starting criterion, causation criterion, and operation criterion. Then, these criterions are used and verified. Actually, the proposals of these three synthetic criterions are the significant supports to make plans of the vehicle restriction measures. In Oct. 2011, the vehicle restriction measures were started and were implemented during the peak load shifting period. After one month, according to the statistics, the average trip velocity during the morning and evening peak hours increases 21.6 %. Meanwhile, the trip is orderly, and the citizens show their support to the vehicle restriction measures. Furthermore, more and more citizens begin to trip during non-peak hours and are willing to park and ride, which helps to realize the demand management of Hangzhou's transportation.

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Chapter 39
The Research of Low-Carbon Transportation Management System

Wen-shuai Guo and Chao-he Rong

Abstract Energy constraints and climate change are being more and more concerned. It is the objective requirement of following the world trend to develop the low-carbon economy vigorously. As the transportation industry is an important section of energy-saving, the low-carbonization of it is inevitable. However, resource-wasting still exists in the construction of traffic infrastructure at present in China. The irrationality of transportation structure results in inefficient use of resources, which opposite to the idea of low-carbon transportation. These problems caused by the discordance between the traffic management system and traffic development limit the advance of low-carbon transportation. This paper argues that it is necessary to build integrated transportation management system to realize the advance of low-carbon transportation, and also put forward ideas and specific suggestions on the establishment of integrated transportation management system.

Keywords Low-Carbon transportation · Integrated transportation · Management system

39.1 Introduction

39.1.1 The Connotation and Necessity of Low-Carbon Transportation

Low-carbon transportation is a main component of energy-saving economy. It is a mode of transportation development which is characterized by high-efficiency, low-energy, low-pollution, and low-emission. Its core lies in the realization of

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shifting the mode of transportation development from an extensive way to an intensive one, the overall arrangement of transportation infrastructure construction, the improvement of transportation structure, and the advancement of energy efficiency.

Energy is the foundation of the development of our national economy, and the environment is one of the necessary conditions of sustainable development of the society. On one hand, as a major energy consumption, transportation industry consumes one third of the world energy, and more than half of the oil in the world was put into use of transportation. In recent years, China's energy consumption of transportation industry is with an average annual growth at the rate of more than 10 %, which accounts for 8 % or so in the total energy consumption. On the other hand, a lot of traffic energy consumption caused severe environmental pollution.

39.1.2 The Existing Problem of Low-Efficiency of Energy Usage and Resource-Wasting Phenomenon in the Transportation Filed

39.1.2.1 The low-Energy Efficiency Caused by Unreasonable Transportation Structure

In the domestic and foreign material, aviation has the highest energy consumption, highway is the second and the third is railway, waters has the lowest energy consumption. However, the development of railway and inland waters transportation in China are relatively slow. The imbalanced development of each mode of transportation results in the unreasonable transportation phenomenon, such as the expensive long-distance transportation of bulk goods. This kind of problem is serious in coal and ore area and other area of large items. In some of the important coal transportation, the capacity of railway transportation is in severe shortage. The ability of main railway lines is very limited, which causes that some main highways assume a lot of coal transportation tasks. Because of the poor construction of the inland river, it was left to the road to take over much low value-added coal, ore, chemical fertilizer, grain and other commodities in the long distance transportation in some parts of the channel along. However, the excessive use of road transportation is bound to bring huge uneconomic energy consumption and large amounts of carbon emissions.

39.1.2.2 The Lack of Overall Plan of Transportation Infrastructure Results in Waste of Resources

Some parts of important transportation area in China have highway, railway, and the inter-city rail lines densely, where lack of overall arrangement of specific position of the line, and technical standards. Thus, to some extent, it led to the waste of resources. A typical example is that the Jingjin channel which has three expressways, 2 first class roads, and 2 high speed railways, 1 common railway with 3 branches. These roads are basically parallel. It is hard to get effective use of the land between them. The urbanization will be affected. Meanwhile, there still exists the problem of surplus of transportation capacity.

On the use of resources of the river-crossing channel in China remains the same problem, i.e. lack of overall arrangement. At present, there are a total of 86 blocks of bridges (excluding Yangtze River Tunnel) across the Yangtze River from Shanghai to Yibin, in which only seven bridges can be used both by cars and trains. In addition, there are the Hangzhou Bay Bridge, Zhoushan Islands Bridge, and most of these river-crossing bridges are highway bridges. Along with the rapid growth of railway network construction, the river-crossing channel resources will be more deficient.

39.2 The Systematic Reason that Restricts the Development of Low-Carbon Transportation

Low-carbon transportation requires the cohesion among every part of the system. This is mainly a multi-modal transportation style, and it requires the coordinated state between transportation system and its external environment. This mainly refers to the state of coordinated and sustainable development between transportation and land exploitation, environmental protection and energy usage. However, in the condition of the present level of productivity force of transportation section, the existing management system has not been able to well adapt to the condition of productivity force, and has begun to restrict its development, which mainly displays in that low carbon traffic demand to the development of energy conservation and environmental protection mode of transportation, however, the traditional system make the railway and water transportation become a shortcoming of transportation system. Urbanization and urban agglomeration required efficient urban transportation, especially urban rail traffic with the characteristics of low carbon and environmental protection. But in the traditional system the examination and approval for urban rail traffic is always after when people bought cars. Resources and environment restriction require that transportation industry would change the development mode, but preempted resources, waste resources and the destruction of the environment always characterize the traditional system.

Rectifying the systematic reason, it mainly includes the division among different transportation managements, the lack of cooperation and coordination mechanism among high efficient departments, and the lag of legal systematic construction and social governance. In a nutshell, there hasn‘t been set up an integrated transportation management system. If we do not adjust current transportation management system promptly, there would be less and less harmony between the transportation system and the environment. This will not only cause bigger resistance but destruction to the development of the integrated transportation. What‘s more, because the transport construction has the characteristics of path dependence, it will bring greater cost to the transportation industry and systematic reform in the future. For example it can lead to huge waste of resources and even damage, excessive emissions, the deterioration of the environment, inefficient transportation and so on (Rong 2005).

39.3 Reference from the Experience of Foreign Transportation Management System

Taking the international experience for reference, during the speeding up stage of industrialization, urbanization and transportation, it is an important time to reconstruct the transportation infrastructure and basic structure. To construct a high efficient, comprehensive and sustainable development mode of integrated transportation, all sorts of technologies, policies, plans, legal systems should jointly work together. Thus, we will get better results. Each mode of transportation has the support of inherent advantages and interest group, and they develop according to their respective system. It may not get favorable results for the overall efficiency of integrated transportation and the whole social economy, if the plan, construction and operation of integrated transport hub was ignored. However, the influence of transportation facilities and transportation structure would last long and become difficult to adjust to some extent. From this point of view, the establishment of integrated transportation management system should be realized the sooner the better in the condition that every mode of transportation have got development to some degree (Rong 2008).

On the construction of integrated transportation management system, the developed countries already have some very good researches. According to the research of Dominic Stead, since a lot of transportation policies cross various departments, different departments need cooperate with each other during the drafting. During the lateral management of the department policies, according to the close degree of various departments‘ cooperation these policies can be divided into: Policy cooperation, which contains dialogues and informative communication among various departments, and Policy coordination, which refers to further transparency on the basis of policy cooperation among various departments, and avoiding the conflict of policies through the coordination of interest between each other, as well as Policy integration, which means joint work and unifying the goal to formulate policy on the basis of policy cooperation and coordination (Dominic Stead 2008). At present most countries in the world, choose the integrated transportation management system to rule over all kinds of transportation, even including the management of land development, urban construction, which are closely tied to transportation development, so as to improve the degree of integration on policy formulation and implementation.

In practice, among the 126 countries in the world that establish railways, there are 119 that had implement the integrated transportation management system, including 40 countries which established the integrated transportation departments ruling over all kinds of transportation (such as the Department of Transportation), while, the rest of 79 countries established more comprehensive management department including integrated transportation management system. Such as Department for Transport in England, Ministry of Land, Infrastructure, Transport and Tourism in Japan and so on (review and enlightenment on the strategy of Foreign integrated transportation development 2011; Wang and Yang 2008; U.S.department of transportation 2012; Japan website traffic department of transportation 2012).

39.4 The Construction of Integrated Transportation Management System

Through the analysis of the management systematic problems restricting low carbon traffic development in China at present, and using the successful experience of the developed countries on the management system reform for reference, this paper argues that transportation management system reform in China should abide by the following directions.

39.4.1 Take the Opportunity to Complete the Super-Ministries Reform of Transportation

Realizing integrated transportation must be guaranteed by organizations and systems, the establishment of the integrated transportation authority, to a great extent, is the prerequisite condition to form integrated transportation system in China and be put into positive operation as soon as possible. At present the separation of government and enterprise on roads, water transportation and civil aviation has already achieved. The conditions of establishing the super-ministry of transportation is mature. While the main obstacle is that the separation of government and enterprise on railway has not been achieved in China. We should separate the function of governance from the Ministry of Railways, and merger it into the super-ministry of transportation. The further reform and reorganization of the railway industry can be researched and realized in the framework of the super-ministry of transportation.

After the establishment of the super-ministry of transportation, we should set up professional bureaus like: Railway Bureaus, civil aviation Bureaus, Highway

Bureaus and Shipping Bureaus. After straighten out the set-up of organizations in super-ministry of transportation, we should classify, integrate and comb the various departments in it. It is the formulation of laws and regulations, policies, plans, as well as constructive and administrative construction.

39.4.2 To Set Up Efficient Cooperation and Coordination Mechanism Between Different Departments

Integrated transportation of administrative management involves the various aspects of the social and economic life, besides the relationship among a few transportation industries, it also involves many other administrative departments. Even if the Ministry of Transport covered all the administrative managements of transportation industry, there will still exist overlapping responsibilities between this department and others, which mainly includes but not be limited to: The balance of transportation plan and national economic and social development plan with the National Development and Reform Commission, and the examination and approval of transportation infrastructure constructive project, and the management and coordination of relevant freight rate or the charge, as well as the plan and management on urban road, subway, and rail transportation with the City Construction Department; the coordination of overall urban planning and integrated transportation system planning of city with Ministry of Housing and Urban–Rural Development; the coordination of land development, utilization planning, examination and approval and regulatory, with the Ministry of Land and Resources; the coordination of the energy supply, the energy conservation, the environmental protection areas, with the National Energy and Environmental Protection Departments.

In recent years, there are some affairs such as the governance of overload vehicles on highway transportation and the promotion of the development of the logistics industry, have connected more than ten ministries to cooperate with each other. This proved that the requirements of coordination in terms with transportation is obvious. To some extent, it is apparently not enough just to merge a few transportation industry management departments in order to solve all problems. Some countries continued to implement the super-ministry management in a greater scope after realizing the super-ministry of transportation, to further integrate various administrative institutions and resources. This done really has its immanent rationalization, which can improve the administrative efficiency to a certain extent. However, there is no country which is likely to integrate all administrative affairs related to transportation into one government department. No matter how large the integrated transportation department is, the cooperation and coordination among different departments in necessary fields is inevitable.

Recently the reform of integrated transportation management system in China can only be limited to a few direct transportation management departments. We should gradually create conditions for further integration. Therefore we must make great efforts to establish efficient cooperation and coordination mechanism between different departments. For example, we should establish related mechanism based on information sharing and policy-making dialogues among Ministry of Transport, Ministry of Housing and Urban–Rural Development, Ministry of Land and Resources and Ministry of Environmental Protection. We can also organize joint working group or hold up conference among Ministries, and establish inter-departmental training mechanism for civil servants so as to avoid the shortcomings such as confusion about responsibilities, non-uniform goals and so on. This can also help to overcome the barriers of lacking knowledge of such aspects as law, organization, financial and engineering technology. In a word, we must ensure the system and mechanism to conform to the important policies, laws and regulations, strategic planning, rules and standards of integrated transportation in order to meet the requirements of comprehensiveness, continuity and collaboration.

39.4.3 Strengthen the Construction of Legal System, Promote Responsible Administration, Introducing Social Management

The super-ministry reform is related to the innovation of governmental system and mechanism as well as the readjustment of the power interests. Because of the influence of the planned economy and the department legislation, in China, to a quite extent, there exist different sets of legal systems in different departments. After the super-ministry reform, there may be some problems in the aspect of relevant law enforcers, litigation jurisdiction and legal application. So we should strengthen the construction of the relevant laws and regulations system and promote the administrative organization setting, function orientation as well as the legalization operation mechanism in order to solve the problem of overlapping functions, decentralizing functions, confusion of responsibilities, and shuffles over responsibilities in the government affairs from a system point of view.

After integrating the different modes of transportation management organization, the super-ministries reform of transportation realized the different modes of transportation management, which objectively caused the problem of the construction of power. We also need to build supervision mechanism to match the degree of power centralization, and to realize reasonable power restriction. Generally speaking, the division of interests is up to the policies, the realization of interests is up to execution, and the rectification of interests is up to supervision. Under the current transportation management system, the configuration of decision-making power, executive power, and supervision power of relevant departments are not reasonable, which results in department interests override the public interests. This leads to the deformation and distort of public policies, such as unreasonable transportation structure, lack of comprehensive utilization of the resources, inconvenient transportation of both passengers and goods, and even causes power departmentalization, departmental benefits, the interest collectivization. Therefore, we should strive to promote scientific decision democratization, executive specialization, supervision independence, and explore the mechanism in which decision-making power, executive power, and supervision mutually restrict and coordinate.

The premise of effective super-ministry system is "limited government". In the transportation administrative area, we must also change the main concern from the previous "effective administration" to the "responsible administration". That is, from excessive one-sided emphasis on concentrating resources to accomplish large undertakings, i.e. the so-called "efficient", to the equivalence of administrative responsibilities and power. What's more, through the administration according to law, restrict accountability and the supervision of the general public to achieve the constraints of government power. We should make the formulation and implementation of our integrated transportation policy can reflect the public interest, as well as show normativity and operability, and avoid the dislocation of government, which could cause the problem of "department with too much power", "power benefit" and even "benefit legalization" situation. It's very significant to bring public policy program and social management in this mechanism.

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Chapter 40
Urban Low-Carbon Transport System

Peng Xing and Tianjun Hu

Abstract Establishment of urban low-carbon transportation system is the main means to achieve urban low-carbon transport. Learn from the advanced experience of foreign countries, the construction of urban low-carbon transport system mainly consists of the layout of urban traffic, the public transport system construction, the main optimization of the traveling population, the development of the transport of low-carbon technologies and the improvement of traffic management policies. As to how to realize low-carbon transport, this paper first analyzes the energy consumption and carbon emissions; then it illustrates the concept and connotation of low-carbon transport; then it raises the above five aspects of the construction of urban low-carbon transport system. Finally, based on china national conditions, the paper proposes some suggestions for establishing green transportation system characterized by low-carbon and promoting sustainable urban development.

Keywords Urban traffic · Energy consumption · Carbon emissions · Low-carbon transport system

40.1 Introduction

Urban transportation is an important carrier for carrying urban development, but also an important source of energy consumption and CO_2 emissions. With the rapid process of urbanization and motorization, urban traffic has been rapid development. As a result, the problems of traffic jams, environmental pollution and

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energy consumption have become increasingly prominent. Transport development should be coordinated with economic and environment is a worldwide consensus.

In recent years, many concepts and theories of urban low-carbon transportation have been proposed, and some strategies have been applied to the practice process. Our new research topic is mainly to clarify the relationship between them, and establish a scientific, reasonable, comprehensive urban low-carbon transport system to promote the sustainable development of cities.

40.2 Energy Consumption and Carbon Emissions

40.2.1 Energy Consumption

With the rapid growth of urban population and the rapid expansion of urban space, a large number of residents travel and the flow of goods have led to the rapid increase of energy consumption in urban traffic.

As shown in Table 40.1 Zhang et al. (2011), energy consumption of China's urban transportation is increasing rapidly every year. Energy consumption (per person per kilometer or energy consumption of per ton -kilometer) is different for different modes of transport. The energy consumption of the bus as a benchmark, the energy consumption of bicycle, bus rapid transit, streetcars, light rail, subway, trolley buses, motorcycles, cars are 0,0.3,0.4,0.5,0.8,5.6,8.1.Therefore,in the various transport modes, energy consumption per unit the biggest is cars, the smallest is public transport such as light rail, subway, tram, bus, and so on.

40.2.2 Carbon Emissions

Carbon intensity is defined to carbon dioxide emissions per unit of GNP growth. This indicator is used to measure the relationship between a country's economic growth and carbon emissions growth. If a country has a growing economic, while carbon dioxide emissions per unit of GNP are declining, it indicates that the country has a low-carbon development model. The carbon intensity of the transport is usually expressed as the carbon dioxide emissions from energy consumption of person km.

Table 40.1 2004–2009, China's urban transportation energy consumption (million tons of coal)

	2004	2005	2006	2007	2008	2009
Gasoline	2191	2717	2908	3205	3646	4177
Diesel fuel	2641	3297	4096	4857	5779	6645

Table 40.2 2004–2009 urban transport CO_2 emissions (Unit: million tons)

	2004	2005	2006	2007	2008	2009
CO_2 emissions	1.06	1.28	1.46	1.65	1.83	2.14

Table 40.3 Carbon intensity of several modes of transportation

Way to travel	Rail transport	Bus	Cars	Electric cars	Bicycle	Walk
Carbon emissions kg/person km	0.049	0.075	0.135	0.017	0	0

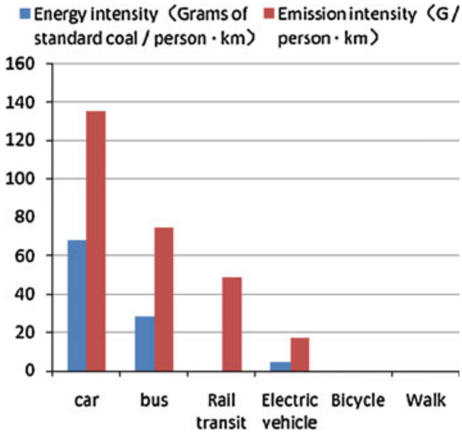

Fig. 40.1 Different modes of transportation carbon emissions intensity comparison

Table 40.2 shows that the city's carbon dioxide emissions present the trend of rapid growth during these years. As shown in Table 40.3, the carbon emissions have a significant difference for different modes of transportation. If we want to reduce CO_2 emissions, we must choose low-emissions transports, reduce the use of high-emission vehicles, and provide a reasonable urban transport system (Fig. 40.1).

40.3 Low-Carbon Transport

40.3.1 The Origin of the Low-Carbon Transport

Low-carbon transport is actually an important integral part of a low-carbon economy. "Low-carbon economy" first appeared on Energy White Paper published by the British Government in the 2003 for our energy future: Creating a low-carbon economy". Low-carbon economy is to reduce greenhouse gas emissions as a starting point, bases on low-carbon energy systems, low-carbon technologies systems and low-carbon industrial structure to adapt to climate change, and build an ecological civilization economic model as the main content.

The construction of low-carbon transport system is an important part of energy conservation and low-carbon economy, the strategic plan of the national response to climate warming, the inherent requirements of the changing patterns of development of urban transport. An important part of building a low-carbon city is exploring more efficient, more energy, more low-carbon and cleaner transportation modes, promoting green travel, creating low-carbon transport.

40.3.2 The Connotation of Low-Carbon Transport

Low-carbon transport is a new concept of sustainable development and practical goals. We have basically reached a consensus on the low-carbon development, but because of the different national positions and stages of development, it leads to different metrics. There is no a clear and unified concept in the low-carbon transport, it can be summarized as: In the context of a growing awareness of climate change and its serious impact on the survival of mankind, for the purpose of energy saving, in order to achieve the environmental, social, economic sustainable development, by using the system adjustment and technological innovation and other means, we can achieve transport way efficiency to enhance, the transport structure optimization, the effective regulation of traffic demand, transportation organization and management innovation for ultimately achieving the full cycle of the whole industry chain of low-carbon development, promoting the transition of low-carbon social and economic development Yu et al. (2011).

40.4 Urban Low-Carbon Transport System

The core of the low-carbon transport is to use different means to reduce energy consumption and reduce carbon emissions from transport travel. In order to achieve the sustainable development of urban transport, it is necessary to establish the urban low-carbon transport system. From a macro, urban low-carbon transport system includes the layout of urban transport, public transport-based system construction, the optimization of the travel groups, low-carbon technology development and the improvement of traffic management policies (Fig. 40.2). These five respects can realize the traffic congestion minimum, traffic demand minimum, motor vehicles use minimum, motor vehicles lowest carbon emissions, inefficient transportation minimum, so as to achieve the goal of traffic emission minimum.

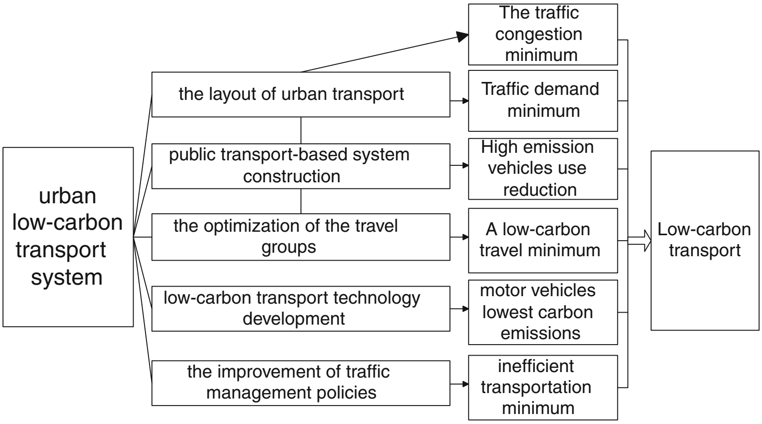

Fig. 40.2 Urban low-carbon transport system Wang (2011)

40.4.1 The Layout of Urban Transport

The layout of urban space and urban transport modes are mutually reinforcing. Multi-center layout is the basis of the urban space for the low-carbon transport. The spatial structure of the multi-center is the best form, which can coordinate the aggregation efficiency and transport costs for big cities. The spatial structure of the multi-center can reduce traffic demand and balance distribution of traffic. We can use the rail transit which is the high transport capacity connecting the centers; within the centers, we mainly use the public transport, private transport as an auxiliary; it not only can reduce the traffic total, but also reduce traffic congestion, thereby greatly reducing carbon emissions.

Consider land use and transportation planning. Build a balanced distribution of traffic demand compact and networking of urban spatial form, mixed development of high-density of land use and public transport to reduce travel distances and car use, and reduce the traffic demand from the source.

40.4.2 Public Transport-Based System Construction

In a variety of urban transportation system, the carbon emission of the system which is based on urban public transport is far less than car-based transport system. Among them, the rail transit public transport system is the lowest carbon emissions.

We must vigorously develop intelligent traffic information systems to provide transport options, the path to guide, transfer, real-time traffic and other traffic travel information services for the traveler. Transport services efficiency improvement can significantly reduce carbon emissions.

40.4.3 The Optimization of the Travel Groups

Implement bus priority strategy and change resident travel mode. Improve the operating environment for public transport and slow traffic, enhance passenger transport hub functions and transfer facilities, and improve related safeguards to enhance public transport attractiveness and level of service in order to guide the public shift to low carbon modes of transportation.

We should enhance residents' knowledge of low-carbon trip and sense of responsibility to promote and encourage the people to support low-carbon travel.

40.4.4 Low-Carbon Transport Technology Development

The low-carbon of transport depends on the development and popularization of low-carbon technologies. The increasing of the low-carbon motorized transport and non-motorized transport is a strong guarantee for the construction of low-carbon transport system. Transportation technologies need to complete the dual task of energy saving and low-carbon in China. We should try to catch up with the technical level of developed countries, while we enter to the new low-carbon technology field.

Low-carbon technologies of motorized transport mainly refers to the utilization of new energy technologies, In addition to using alternative energy or alternative fuels and develop new energy vehicles, we can develop lightweight materials to reduce motor vehicle weight in order to reduce fuel consumption and emissions. Non-motorized transport is carbon-free, so it should be strongly innovation and upgrading. With the development of low-carbon transport technologies, non-motorized transport has been put on the agenda to improve the performance of the bicycle and other non-motorized transport, comfort and safety, so that the bike fit and attract more people to use. Of course, we can also look for other ways, liking the invention of better non-motorized transport.

40.4.5 The Improvement of Traffic Management Policies

Traffic areas are conducing management and innovation by freight logistics, intelligent transportation, information systems, and efficient work to improve the transport organization, management and service level, thus we can achieve intensive use of transport resources, reduce energy consumption and greenhouse gas emissions, and implement low-carbon transport.

The traffic order is a guarantee of the urban traffic. The traffic rules are essential to traffic order. Traffic management is the basic way to maintain traffic order. Traffic management in urban low-carbon transport system is necessary to maintain traffic order, also to supervise the transportation low carbonization. Good traffic order can reduce congestion and emissions; eliminating the motor vehicle on the road is the guarantee for low-carbon transport.

The construction of traffic management should comply with the requirements of the low-carbon transport. We can build from the following three areas Yu and Wei (2011). First, build the low-carbon transportation laws and regulations system. We can prohibit effectively the acts which isn't meeting the requirements of the low-carbon based on legal. Second, establish the intelligent traffic management system. Intelligent traffic management system is the integrated use of advanced information technology, electronic technology and computer processing technology to the traffic management system, in order to establish a real-time, accurate and efficient, all-round playing a role in traffic management systems. It is internationally recognized as the best way to solve urban traffic congestion, improve operational efficiency, improve traffic safety, etc. For example, it can make the road capacity increased by two to three times; vehicles traveling on intelligent road, the number of stops can be reduced by 30 %, the parking time is reduced by 13–45 %; traffic accidents can be greatly reduced. The last one, strengthen motor vehicle emissions inspection management. The arbitrary use of the vehicles of non-standard emissions will inevitably lead to low-carbon transport lost by the wayside, so we must vigorously develop and improve motor vehicle emissions testing technologies and management methods. We can prohibit the non-standard emission vehicles on the road at any time, and ensure that all the motor vehicle on the road reach the low-carbon criteria.

40.5 Conclusion

Low carbon development is an important strategic measure which can achieve economic development to shift from the traditional extensive economy to intensive economic. The city as a center of human production and life plays an important role in the economic and social development. Urbanization is a low carbon way that the human society pursues material and spiritual civilization. High-carbon urbanization development model is not desirable; low-carbon urbanization is the inevitable choice.

Low carbon transport system and the construction of low-carbon cities interact and complement each other. Development of low-carbon economy must conduct the city's low-carbon construction. Low-carbon transport system as an important part of the urban construction is essential in the urban modernization. Low-carbon transport system can reduce environmental pollution and carbon emissions Liu and Wei (2011). It can effectively alleviate the traffic pressure on urban centers and change people's lifestyle and urban development model. It will surely promote the city to develop low-carbon economy, promote low-carbon life, so as to promote the city's low-carbon transition, and promote the sustainable development of cities.

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Chapter 41
Study on the Control of AC Dynamometer System for Hybrid Electrical Vehicle Test Bench

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Abstract This paper evaluate the testing bench of AC dynamometer system, the induction machine can run in electro motion and generate electricity status under speed and torque control by direct torque control (DTC). It develops the AC dynamometer system controller based on PXI, and study on the AC dynamometer steady-state control strategy under the rapid prototype method in LabVIEW RT software. It effectively enable to n/P, M/P, n/M and M/n control mode, get ideal control quality by adjusting the PID control parameter, each control mode charge smoothness. Experimental results show that the controller is excellent, and the control performances for engine testing completely satisfied the demand of quality control. It provides the basis for further study on dynamic control of AC dynamometer.

Keywords AC Dynamometer · Control strategy · Hybrid electrical vehicle

41.1 Introduction

Dynamometer is a key equipment in motor performance test platform, mechanical transmission test bench and engine test-bed etc. Alternating current dynamometer use three-phase alternating current engine as load equipment, converter affords

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drive power of variable frequency for asynchronous motor as well as accurately control the rotation speed and torque. Compared with other dynamometer technology, alternating current dynamometer has many characteristics such as easily control power, high control accuracy of torque and rotation speed, short dynamic response time, flexibility and variety of the structure, high efficiency energy saving and high reliability. In the application of engine bench or motor test, target motor's torque and rotational speed which are main control objects and measurement parameters of alternating current dynamometer system. In this paper the control of target motor system adopts direct torque control technology.

41.2 Direct Torque Control

Direct torque control compare set torque value with actual torque of motor, through a simple hysteresis control to get control signal of torque. Then combining stator flux control signals, and choosing a suitable stator voltage space vector. Thus making asynchronous motor's electromagnetic torque quickly tracks the set torque to realize direct torque control. During the process of controlling torque, it also achieve flux control to make sure that stator flux change in a error prescribed scope. The whole control system includes flux control and torque control (Gao 2005; Takahashi and Ohmori 1989).

41.2.1 Flux Control

The foremost task of direct torque control is to accurately obtain stator flux, because during the process of control, comparing actual amplitude of flux with the set value of flux to get flux control signal, then the state of inverter switch is confirmed based on flux location. At the same time, electromagnetic torque is obtained according to calculating flux and stator currents. From the above whether flux is good or not which surely affect whole properties of control system.

U-I Model of stator flux can be expressed as

$$\psi_s = \int (u_s - i_s R_s) dt \tag{41.1}$$

This model is simple, which is only used stator resistance of motor parameter, It can be calculated the value of stator flux through stator's current and voltage from sensor sampling. But when the rotational speed is much lower, voltage drops from stator resistor (Rs) is occupied a large part which will affect the observer exactitude of flux, so this model is used in high speed.

In low speed, it makes U-I model has large error in flux observer due to the influence of the stator resistance. In order to make sure that flux observer is accurate, we adopt stator currents and rotor speed of flux observer model which is I–N model.

According to the equation

$$\psi_s = \frac{1}{1+\frac{L_\sigma}{L}}(i_s L_\sigma + \psi_r) \tag{41.2}$$

$$\frac{d}{dt}\psi_r = \frac{R_r}{L_\sigma}(\psi_s - \psi_r) + j\omega\psi_r \tag{41.3}$$

$$\psi_s = \psi_{s\alpha} + j\psi_{s\beta} \tag{41.4}$$

$$\psi_r = \psi_{r\alpha} + j\psi_{r\beta} \tag{41.5}$$

$$i_s = i_{s\alpha} + j i_{s\beta} \tag{41.6}$$

We could get,

$$\begin{cases} \psi_{s\alpha} = \dfrac{1}{1+\frac{L_\sigma}{L}}(i_{s\alpha} L_\sigma + \psi_{r\alpha}) \\ \dfrac{d}{dt}\psi_{r\alpha} = \dfrac{R_r}{L_\sigma}(\psi_{s\alpha} - \psi_{r\alpha}) - \omega_r\psi_{r\beta} \end{cases} \tag{41.7}$$

$$\begin{cases} \psi_{s\beta} = \dfrac{1}{1+\frac{L_\sigma}{L}}\left(i_{s\beta} L_\sigma + \psi_{r\beta}\right) \\ \dfrac{d}{dt}\psi_{r\beta} = \dfrac{R_r}{L_\sigma}\left(\psi_{s\beta} - \psi_{r\beta}\right) - \omega_r\psi_{r\alpha} \end{cases} \tag{41.8}$$

Rotor resistance (Rr) inductance (L_σ) and rotational speed are used during the process of calculation in this model. In high speed, measurement error of rotational speed will bring certain effects to the model, so it has high precision in low speed. Therefore, we may combine two flux observers, adopting I–N model in low speed, but taking U-I model in high speed.

41.2.2 Torque Control

According to motor mathematical mode, electromagnetic torque

$$T_e = \frac{3}{2}P_n(\psi_s \otimes i_s) \tag{41.9}$$

derivation to both sides, and at the same time multiplied by L_σ, get

$$L_\sigma \frac{d}{dt}T_e = \frac{3}{2}P_n L_\sigma\left(\frac{d}{dt}\psi_s \otimes i_s + \psi_s \otimes \frac{d}{dt}i_s\right). \tag{41.10}$$

and

$$L_{\sigma}\frac{d}{dt}i_{s}=\frac{L+L_{\sigma}}{L}\frac{d}{dt}\psi_{s}-\frac{d}{dt}\psi_{r}\ . \tag{41.11}$$

though the deduce get

$$L_{\sigma}\frac{d}{dt}T_{e}=\frac{3}{2}P_{n}\psi_{r}\otimes u_{s}-\left[\left(1+\frac{L_{\sigma}}{L}\right)R_{s}+R_{r}\right]T_{e}-\frac{3}{2}P_{n}\omega\psi_{s}\psi_{r}\ . \tag{41.12}$$

It can be seen in a control cycle of delta t, stator flux $\psi_s$and rotor flux ψ_r's change is very small. The main factor is u_s that affect instant torque change, once u_s has apparent change in a cycle which will induce motor's torque to produce rapid change. It will realize a high- performance control of torque through improve DC voltage U_d and shorten the control cycle time under inverter promised condition.

By formula (41.12) we can see that $\psi_r$and u_s are cross product relationship. The response of torque is fastest when they are perpendicularity, but the relationship between stator voltage vector and rotor flux linkage is not easy to know, approximate using stator flux to express the rotor flux, namely $\psi_r \approx \psi_s$. Formula (41.12) expressed as:

$$L_{\sigma}\frac{d}{dt}T_{e}\approx\frac{3}{2}P_{n}(\psi_{r}\otimes u_{s})-\left[\left(1+\frac{L_{\sigma}}{L}\right)R_{s}+R_{r}\right]T_{e}-\frac{3}{2}P_{n}\omega\psi_{s}^{2}. \tag{41.13}$$

By formula (41.13) we can see, choosing a voltage vector vertical with the current stator flux linkage in direct torque control, it can get the maximum torque response, but inverter offers alternative voltage vector is limited, only voltage vector's direction similar to vertical could be choose to get high torque.

From above analysis, when voltage vector applied in advance of the stator flux, the change rate of torque is above zero ($dT_e/dt > 0$), electromagnetic torque increase. When voltage vector applied behind of the stator flux, the change rate of torque is below zero ($dT_e/dt < 0$), and electromagnetic torque reduction. This feature can be use to control torque.

In physical concept, electromagnetic torque is decided by cross product between the stator flux and rotor flux, written as:

$$T_{e}=\frac{1}{L_{\sigma}}\frac{3}{2}P_{n}(\psi_{r}\otimes u_{s})=\frac{1}{L_{\sigma}}\frac{3}{2_{n}}P_{n}|\psi_{r}|*|\psi_{s}|\sin\theta. \tag{41.14}$$

From formula (41.14) we can see that in direct torque control, keeping the stator flux changeless, but rotor flux's amplitude is decided by load. Change stator flux angleθ to alter electromagnetic torque. The rotation speed of rotor flux changes slowly, it is mainly through the control of stator flux's rotating speed to realize torque control during control process.

41.3 Control Effect

This paper builds alternating dynamometer system which include motor control integration, energy processing system, throttle actuator control integration, rotation speed and torque measurement devices, and hardware real-time controller etc. The whole control system belongs to complex, large inertia, time-variant nonlinear system, accurate mathematical model is difficult to establish (Sandholdt et al. 1996; Bunker et al. 1997; Diana 1998). Therefore each control loop controller is adopted control strategy based on PID controller.

In the test bench, the rated power of Toyota 8A engine is 63 kW, highest rotating speed is 6,000 r/min, and maximum torque in 5,200 r/min is 110 Nm. A serial of experiments of n/M mode are schemed out, and test results are given.

The rotating speed step and torque curves of n/M mode are shown in Fig. 41.1. The torque keeps in 40 N·m during the process of rotating speed from 2,000 r/min step to 2,500 r/min. The analysis reveals that the whole process of adjustment is quickly and stabilization, rotating speed without overshooting, and the adjusted time is about 3 s. At the beginning of the process, for the AC dynamometer control speed is faster, the torque decreases first and then steadily rising. The whole transition process approximately 5 s then the system reaches steady state.

The torque step from 40 to 60 N·m curves of n/M mode are shown in Fig. 41.2. The rotating speed is 2,500 r/min and torque step from 40 N·m to 60 N·m. It can be concluded that the whole transition process approximately 3 s, the torque curve is smoothly and less fluctuation. The rotating speed fluctuate 1 r/min during the throttle begin to change, and the subsequent speed fluctuations are in scope of ±1 r/min.

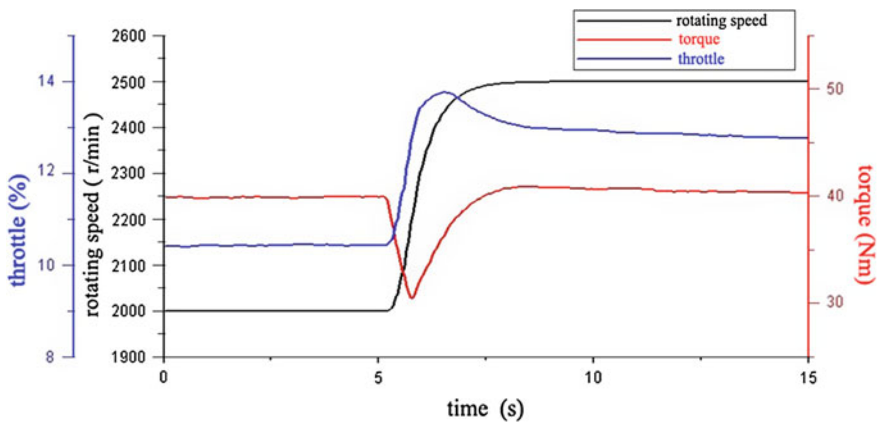

Fig. 41.1 n/M mode rotating speed step curve

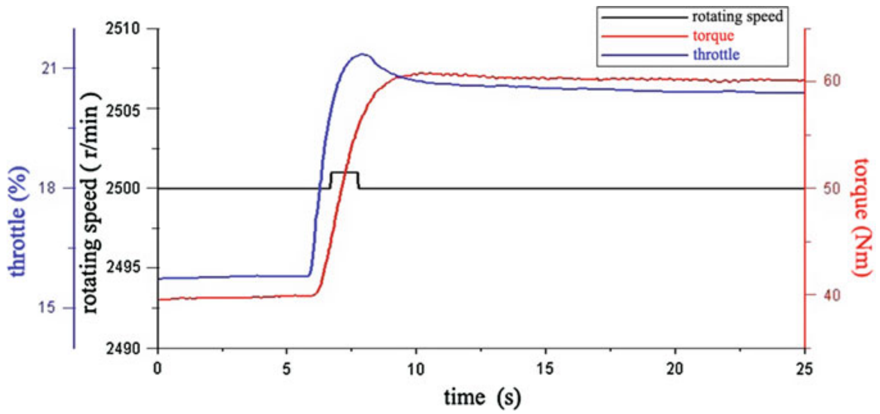

Fig. 41.2 n/M mode torque from 40 to 60 N · m step curve

41.4 Conclusions

AC dynamometer system controller development experiment platform is based on PXI. It adopts rapid prototype method to study steady control algorithm for AC dynamometer in LabVIEW RT, which the n/P, M/P, n/M and M/n four control modes, Through test adjusting that control parameters achieve an ideal control quality, various states switch smoothly, an ideal control effect of system steady control, which is satisfied and realized the requirements of measurement and control system for engine experiment bed.

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Chapter 42
Low-Carbon Transport System by Bicycle, in Malmö, Sweden

Yingdong Hu and Xiaobei Li

Abstract Low-carbon transportation is the trend of development of the sustainable urban transport. With the features as lightweight, flexible, environmentally friendly, and comfortable, bicycle transport has become an important part of the urban low-carbon transport. The article describes the background of low-carbon transportation in Malmö, Sweden, analyzes the status and strategies taken for bicycle travel and proposes problems to be solved and solutions.

Keywords Malmö · Low-carbon transportation · Bicycle travel

42.1 The Background of the Low-Carbon Transportation Development in Malmö

Malmö is Sweden's third largest city. In recent years, Malmö is in economic transition—transforming from traditional and declined shipbuilding and textile industry to new high-tech information industry and biotechnology industry. How to shape a city image of cultural and environmental sustainability in the post-industrial period is the strategic objective of Malmö. To create an ecological livable urban environment, Malmö has made groundbreaking contributions to the combination of old city reconstruction, urbanization process and sustainable development. The

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project of "City of Tomorrow—Bo01" has achieved the goal of more than 1000 residential units 100 % relying on renewable energy and self-sufficiency.

Low-carbon transport refers to the low power, low emission and low pollution modes of transport, which is the trend of development of the sustainable urban transport. With features of lightweight, flexible, environmentally friendly, comfortable, bicycle transport has become a zero-energy green way to travel. And encouraging non-motor vehicle travel has a positive effect on the reduction of urban transportation energy consumption. Within the range of 5 km, bicycle travel is generally no more than 20 min, and its travel cost is about one twentieth of the car. Compared to walking, it is of higher speed and a wide range of travel. The development model of public bicycle system in Malmö has provided the ideas for solving the problem of urban traffic, reducing impact on the climate and environment and establishing low-carbon transport system and livable city.

42.2 The Status of Bicycle Travel in Malmö

Malmö has mild seasonal climate and flat terrain, one of the most suitable cities for bicycle travel. Bicycle travel accounts for about 25 % of the total travel. The municipal government has committed to improve the driving conditions of bicycles and gradually built a bicycle path network covering the entire urban area. At present, Malmö has about 2100 km sidewalks, 420 km bike paths and 1125 km motor vehicle lanes. There are obvious bicycle paths on urban main roads, the city has many free bicycle parking, and bicycles and public transport achieve seamless. During 8 years from 2002 to 2010, the number of citizens using public transport has increased by 30 %. And 40 % of 280,000 urban citizens choose to ride bicycles to school or work. As shown in Fig. 42.1, with city center square (Stortorget) in Malmö and Central Station and other public facilities in the center, cycling within 5 min can cover the center city in Malmö and within 30 min, the whole urban area of Malmö.

42.3 Strategies Taken for Bicycle Travel in Malmö

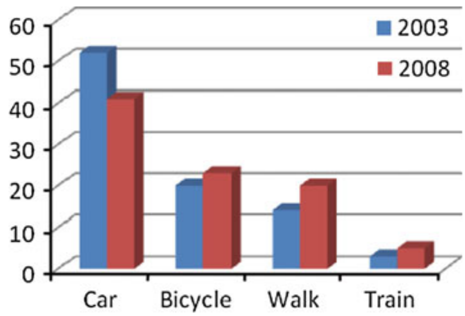
42.3.1 Transport Policy

In order to create a better transport, Malmö has developed a series of programs, objectives and plans.[1] The programs have laid the foundation for further enhancing the status of citizen cycling and walking and made the two travelling ways more attractive.

[1] Including "Overall planning in 2000", "Environmental programs and transportation policy of Malmö in 2003–2008", "Traffic environment in 2005–2009" and its new bicycle travel program and the first walking program.

Fig. 42.1 Bicycle paths coverage and travel radius in Malmö, the *red road* is 420 km bicycle path. (*Source* Organized and drawn according to the information, CykelkartaMalmö 2009 slutversion (Malmo bicycle map in 2009—http://www.malmo.se/)

Fig. 42.2 Contrast of the proportion of travel volumes in different travel ways in 2003 and 2008 in Malmö. (*Source* Self-drawn)



(1) **The survey of travel habits**. Malmö conducts a large-scale survey of travel habits every 5 years and most recently in 2008. As the data shows, in the premise of per capita travels in 2008 and 2003 basically the same, the proportion of a short-distance travel by car has decreased and the proportion of walking, cycling travel and a long-distance travel by train has increased[2] (Fig. 42.2).

[2] Organized and drawn according to the relevant data of "Improving Malmo's traffic environment" (http://www.malmo.se/).

(2) **Travel guidelines**. The pedestrian can receive a free map indicating all bicycle paths from City Hall and the Tourist Information Office. The map updates every 2 years to label the newly constructed bicycle paths. Besides, the website of Skånetrafiken (Transportation network in Skane) provides online bicycle trip planning assistant to check the best route for cycling trips in Malmö conveniently.

42.3.2 The Set of Bicycle (Dedicated) Paths

There are two bicycle paths. One is a dedicated lane of independently set without the interference of motor vehicles and traffic lights, and the other is a side-by-side arrangement with the motor vehicle lanes. In order to ensure the safety of the rider, most of bicycle paths are located between the sidewalk and street parking area. So there is protection and buffering of the parking vehicles between riders and fast moving car flow. Besides, there are dedicated signal lights on bicycle paths, which give bicycles the same status as motor vehicles.

In order to improve the conditions of bicycle travel, Malmö has taken a series of improvements on bicycle paths. Firstly, bicycle paths pass through urban residential areas, railway stations, subway exits and other important urban public areas, combined with the riverbank, beach, public green, squares and other open space to form scenic humanized walking and bicycle paths. Secondly, to carry out alterations to the road in the central areas of the city, turn part roadways of originally bi-directional four-lane into bi-directional two-lane and reduce the width of roadways to increase or widen bicycle paths and sidewalks (Fig. 42.3). Thirdly, reduce the scale of motor vehicle parking and encourage public and bicycle travel.

Fig. 42.3 Bicycle paths combined with seaside landscape, located in Bo01 residential district in Malmö, east coast of the Öresund (*Source* Self-shot)

42.3.3 The Design of Bicycle Paths and Bicycle Parking Space

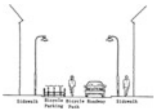
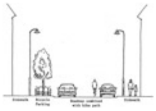
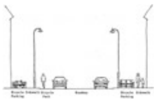
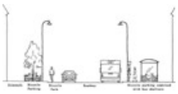
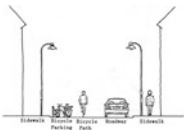
(1) **The relation between bicycle paths, parking space and roadways**

In theory, addition of bicycle lanes in the limited street space is bound to compress the motor vehicle lanes and brings the risk of traffic jams. But the setting of bicycle paths will help improve traffic efficiency and occupy a smaller area of the road to meet the travel needs of large groups of people. So it is very important to layout bicycle paths reasonably and deal with the relationship between parking space and roadway. The following chart (Table 42.1) reflects the settings of different situations between bicycle parking areas, roadways and sidewalks.

(2) **The design of bicycle racks**

Malmö currently has about 45,000 bicycle racks. Freely parked bicycles may cause troubles to pedestrians, vehicles, the blind and other disabled. Therefore,

Table 42.1 The settings of bicycle parking and the roadway and sidewalk

Traffic	Width of the street	Width of sidewalks	Characteristics	Icon
Heavy	Narrow	Narrow	Bicycle parking parallel to the road, combined with car parking. The width of bicycle parking is 2.0 m, bicycle paths and roadways are separated	
	Wide	Narrow	Bicycle parking parallel to the road, combined with green. Bicycle paths and roadways are mixed	
	Wide	Wide	Bicycle parking is combined with roadways: 1. have an angle of not less than 45° with building facades; 2. parallel to the road	
			Bicycle parking is combined with sidewalks: 1. Vertical to the road, combined with green; 2. Vertical to the road, combined with bus shelters and the distance between is no less than 1.5 m	
Light	Narrow	Narrow	The angle between bicycle parking and the road edge is not less than 45°. The width of bicycle parking is 1.5 m	

This table is organized and drawn according to the information and research data, Cykelparkeringshandbok for Malmö (Bicycle Parking Guide in Malmö—http://www.malmo.se/

Fig. 42.4 Bicycle parking areas on one side of the bus station, Malmö Central Station (*Source* Self-shot)

encourage people to use bicycle racks as many as possible. Bicycles in sur-

Fig. 42.5 The design of new bicycle rack (*Source* The official website of Malmö—http://www.malmo.se/)

rounding areas of Malmö Central Station must be parked on bicycle racks to keep the pavement clean (Fig. 42.4). If incorrectly parked, they will be towed away.

Figure 42.5 is the design of Malmö's new bicycle rack. The color is striking orange and the overall appears like the car outline, in order to trigger people's reflection: choose 2 cars or 20 bicycles? This is a new symbol of proposing the sustainable development of urban bicycles.

(3) **The design of indoor bicycle parking**

Near public areas such as city squares, railway stations and subway stations, it is often necessary to set the indoor bicycle parking to meet transfer needs of the public.

Fig. 42.6 The transfer between bicycles and public transport (*Source* Drawn based on existing information, CykelP(Bicycle parking——http://www.malmo.se/)

42.3.4 The Connection and Transfer Between Bicycles and the Public Transport

Another key to popularize bicycles is whether the use of bicycles achieves convenient transfer with other public transport. The general practice is to set up the bicycle parking on the side of the road near the train station or subway station entrances and exits and have good convergence with the train station (Fig. 42.6). Only near Malmö Central Station, there are about 3,000 people parking bicycles every day.

The Three-dimensional bicycle garage near Västra station in Lund adopts double-layer trailers. The area of approximately 200 m^2 in two floors can accommodate about 460 bicycles, average 0.434 m^2/vehicle, much lower than domestic standards for cars 1.5–1.8 m^2 (Fig. 42.7).

42.3.5 Innovative Technology Solutions

In order to make travel by bicycle faster, safer and more comfortable, Malmö has tried to set up a variety of facilities of more innovative sense.[3]

[3] Organized according to relevant information of "Improving Malmo's traffic environment" (http://www.malmo.se/).

Fig. 42.7 Bicycle garage near Västra station (*Source* The official website of Malmö http://www.malmo.se/)

(1) **Bicycle counting license recording cycling number**. Malmö has equipped with "bicycle counting license" at Kaptensgatan and Södervärn to record the number of passing bicycles. Values indicate the current situation of bicycle riding, which make cycling traveler have the sense of pride on contributing to urban low carbon transport (Fig. 42.8).

(2) **Bicycle first**. Radar sensors have been installed in nearly thirty intersections to detect bicycles passing. The traffic signal will automatically transform into green when bicycles pass. This can ensure the smooth bicycle travel.

(3) **Bicycle service station**. Malmö has placed the inflatable pump at six locations (Kaptensgatan, Södervärn, Värnhem, GamlaIdrottsplatsen, Hovrätten and Erikslust), which is convenient for bicycle inflation (also applies to baby carriages and wheelchairs). Three pump stations are equipped with simple vehicle maintenance tools to be small service stations.

(4) **Other facilities**. In addition to the above measures, Malmö has also installed railings at the traffic lights for cyclists to rely and eliminate the trouble of on and off bicycles, placed several large mirrors at intersections of narrow perspective to make it convenient for people to see road conditions at corners. Besides, try to set up a variety of lighting facilities to improve the visibility of the night along the road.

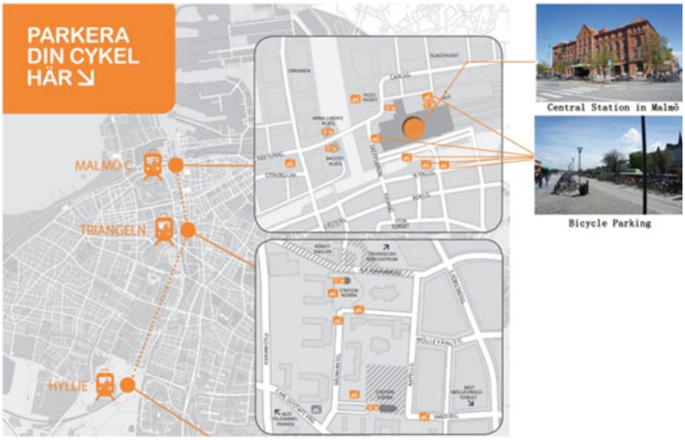


Fig. 42.8 Bicycle counting license (*Source* The official website of Malmö—http://www.malmo.se/)

42.3.6 Promotion to the Public

In addition to rehabilitation measures on the transport policy and hardware facilities, the propaganda work to guide the public to participate can not be ignored. The most successful one is “travel not by bicycle within 5 km is shameful”. Through campaigns close to the life, the use of private cars in Malmö has decreased by about 10 % in 10 years.

42.4 Conclusion

Although Malmö has achieved certain results on the bicycle low-carbon travel, still need to make efforts in the following areas:

(1) **Improve the bicycle path network**

In the past 5 years in Malmö, among citizens riding bicycles, 105 people out of an average of 420 will hurt.[4] This may be due to the set of some bike lanes is not coherent, lacking the necessary isolation between bike lanes and motor vehicle lanes, which have increased traffic accident risks. At this point, the experience of bicycle lanes setting in Copenhagen is worth learning. Bicycle lanes and driveways, sidewalks are clearly differentiated in elevation, clear at a glance and without disturbing each other.

[4] Cykelkarta Malmo 2009 slutversion (Malmo bicycle map in 2009——http://www.malmo.se/).

(2) **Realize seamless between bicycles and other travel modes**

As a green transport, bicycles should be combined with other public travel modes, forming the green travel pattern of bicycles and public transport (B + R), to better achieve short distance travel advantages of bicycles. Only by reaching the integration between transfer and convergence on space and time, realizing seamless and zero transfer, the radiation range of the bicycle traffic can be extended and realize in the end the sustainable development of low carbon transport.

Acknowledgments This research is supported by National Natural Science Foundation of China (51178038); longitudinal research projects funded projects of Beijing Jiaotong University (2011JBM180, 2010RC030, 2012JBM120).

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Chapter 43
A Study on Low-Carbon Transportation Strategy Based on Urban Complex: Taking Shenzhen and Hong Kong as Examples

Yezi Dai

Abstract Public transportation is an important way to realize the mode of urban low-carbon transportation. Reasonable design and planning of urban complex will effectively organize as well as integrate regional public transportation. And it could also achieve low-carbon travel of urban residents on the premise of comfortableness and convenience. The article took cities of Shenzhen and HongKong as examples, and discussed planning and design of urban complex oriented by low-carbon transportation.

Keywords Urban complex · Low-carbon transportation · Shenzhen · Hong Kong · Multidimensional transportation hub · Regional walking system

43.1 Introduction

From a worldwide perspective, transportation mode based on traditional fuels is one of the main areas that emitting greenhouse gas. To alleviate the trend of global warming low-carbon transportation mode which aims to reduce carbon emissions is definitely imperative. In general, there are several ways to achieve this: improving the carbon emissions performance of transports, optimizing the way of travel and the model traffic management. Optimizing the way of travel means reducing use of private cars by promoting public transportation so as to achieve the goal of low-carbon transportation. The essay will take this as a starting point to

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inquiry into planning and design of urban low-carbon transportation mode which take urban complex as the core.

Urban complex is a kind of building or building complex composed by two or more space with different functions. It is now one of the effective measures to handle increasingly lack of land resources in cities. And it also becomes an important linkage of urban public transport network for its characteristic of collecting and distributing a large number of people and its countless ties with urban space and urban functions. Reasonable layout and design of urban complex will be able to improve use efficiency of public transportation and relieve urban traffic pressure. As economically developed SAR cities, Shenzhen and Hong Kong enjoy high level of municipal construction, favorable conditions of road infrastructure and convenient public transportation. However, as immigrant cities, they inevitably encounter extremely high population density and relatively scarce available land resources for construction. In view of this, using land efficiently through urban complex and integrating surrounding public transport resources by means of planning or architectural design become important ways for the two areas to promote green travel and develop low-carbon transportation.

43.1.1 Combining with Subway Stations

The aim of multidimensional comprehensive development of urban complex is to obtain the maximum economic efficiency with the least urban land. However, comprehensive development only considered from the perspective of commercial area without matchable traffic conditions and urban facilities also contraries to the original intention of sustainable development. As its rich commercial and recreational functions which bring about public and open character embracing different ages and industries will unavoidably gather lots of people and vehicles. Absence of efficient transport modes and convenient diverting mechanism will definitely further increase the regional traffic burden and affect normal use and benefits of the complex. But one of the important solutions for low-carbon transportation is to encourage efficient and fast public transportation. Consequently, high-frequently distributing of urban complex has an inner connection with high-efficiently diverting of public transportation.

Currently, the most common public transports include conventional ground bus and capacious rail transit (subway). Subway is second to none in terms of transportation efficiency, safety and comfort. Its characteristics of gathering sustainable and stable crowd and a series of deeper transforms aroused by which in underground space development and urban business model further agree with the spatial characteristics of complex. Therefore, combination of urban complex and subway stations embody the priori necessity. Underground commercial space link up with subway station and the connection become the gateway and transfer space of subway station. The business and transport functions of complex integrate into urban public transportation and it not only achieve the goal of saving land and investment but also make complex an indispensable part in the urban space system. In Shenzhen Special Economic Zone, most of commercial complexes link directly with subway stations through underground passages. (Figure 43.1) In fact, development and site selection of the complexes matched with planning and construction of urban subways from the very beginning. In Hong Kong, the MTR Corporation even led or participated in exploitation of several shopping malls along subways. Linkage development between subway construction and shopping centers has maximized utilization of public transports, brought great convenience to people's life, saved investment cost and realized maximization of economic and social benefits.

43.1.2 Setting Up Multidimensional Transportation Hub

When combining complex with subway stations, we can not ignore the important role of traditional ground transportation at the same time which is irreplaceable in popularity and coverage. So setting up public transport hubs such as bus starting stations, subway stations, and intercity terminals on or under the ground of complex buildings is benefit for overcoming traffic bottlenecks between bus stations and public place, reducing traffic pressure of street, and diverting flow quickly. Based on statistics about number of average daily passengers made by Hong Kong Transport Department in September, 2011, subway passengers accounted 39.7 % of all public transport passengers while bus passengers reached 50.7 %.(http://www.td.gov.hk/filemanager/en/content_4494/chart27.pdf) It can

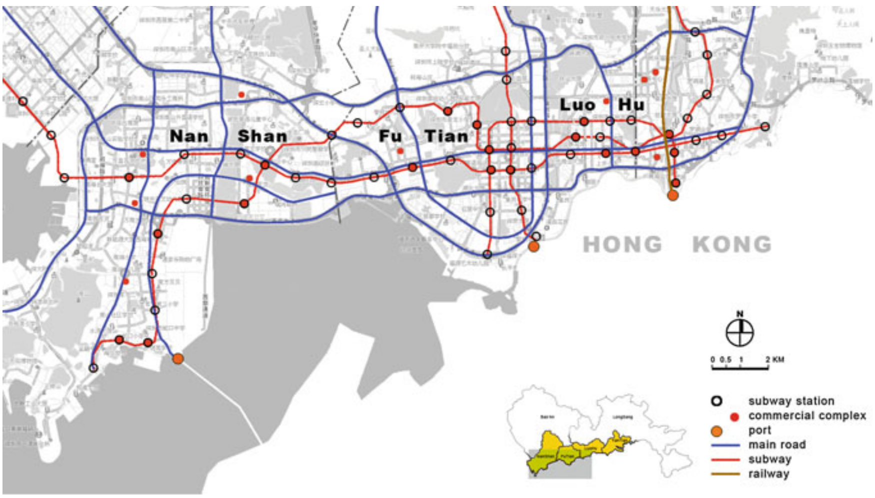

Fig. 43.1 The location of main ShenZhen commercial complexes and their relation to the subway station

clearly be seen that bus which combines with bus transfer stations or terminus is still an important supplementary for subway. The integration becomes a major feature for Hong Kong urban complex in terms of fully use of public transport. And buses successfully bind with subway stations and bus stops. Complex has become intersection of flow ground and underground and inadvertently appeared as transfer station for a variety of transports. These bus stations are often located on the ground floor of shopping centers and passengers will be able to enter directly into shopping malls as soon as getting off buses. It is convenient and fast and people can avoid inconveniences from sun and rain.

Taking Elements as an example, it is a super large urban complex consisted by business, houses, offices and hotels. And the three-floor shopping mall constitutes the main body of the complex podium. As it is located in the "bridgehead position" where Kowloon Peninsula links with Hong Kong Island, the complex becomes a traffic artery converging a number of important public transport routes including MTR Tung Chung Line, Airport Express Kowloon Station, Shenzhen Airport Express Bus, West Kowloon Underground Terminus of Guangzhou-Shenzhen-Hong Kong Express Rail link. (Figure 43.2) The ground floor and basement of the shopping center collect lots of transport routes and terminus of bus lines, (Fig. 43.3) and its first floor becomes a shared lobby for the shopping center and these transportation lines. Commercial space and transportation hubs are in perfect harmony. Broad perspective, good lighting and clear identity maximized the public character of space. Large numbers of people gathered here frequently

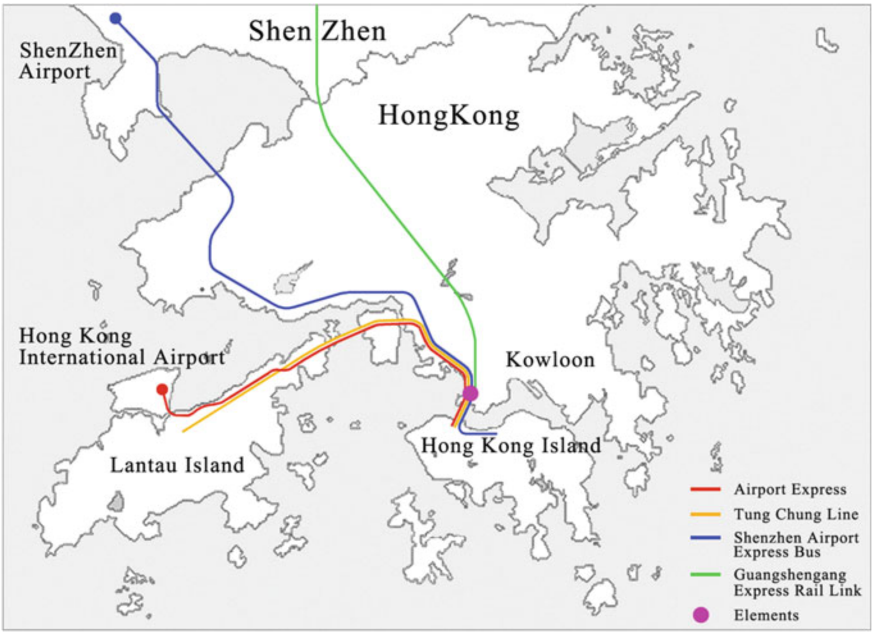

Fig. 43.2 The location of Elements in public

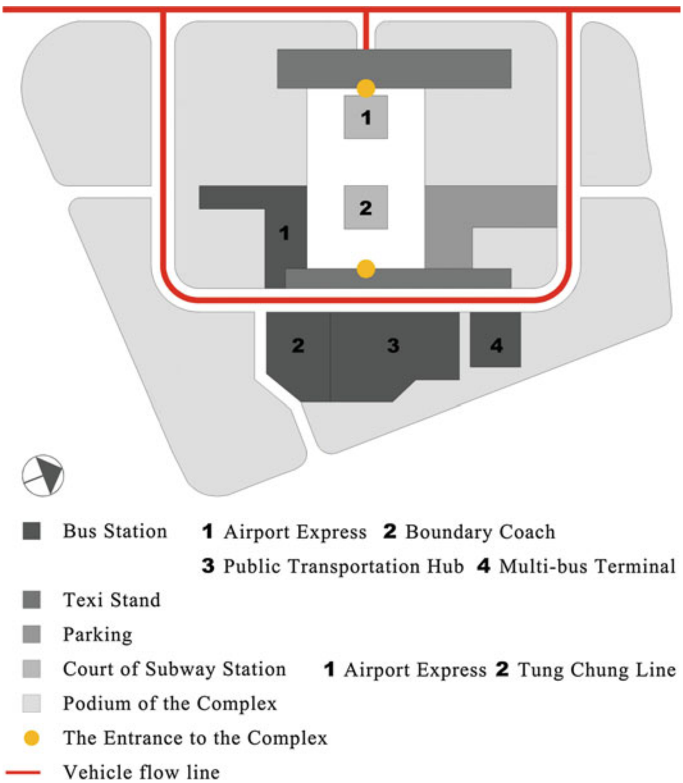

Fig. 43.3 Functional analysis on transportation the ground floor of Elements

and passed through quickly. Commercial space provides a platform of buffering and conversion for urban public transportation system here, and high transport accessibility, in turn, promotes appreciation of real estate and commercial benefits.

43.1.3 Organizing Regional Walking System

Low-carbon transportation mode also includes planning of urban public walking system. Streets are narrow and ground transports are busy in Luohu and Futian district of Shenzhen, then separating people from vehicles becomes a basic solution in solving issues of urban low-carbon transportation and integration of urban architecture.

Central Walk, for example, located on the central axis green belt of CBD of Futian district in Shenzhen is a business complex integrating shopping, entertainment and dining. Its roof, a part of green pedestrian system penetrating the whole CBD from north to south, connects with the north public green space and

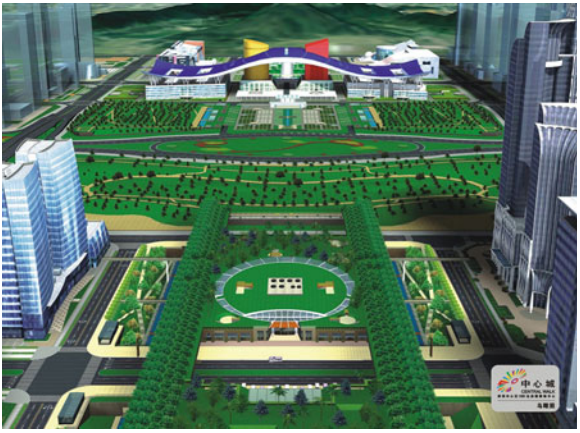

Fig. 43.4 Central Walk on the central axis green belt of ShenZhen CBD Commercial Area

the roof green space of the south under-construction business complex through overpass. Meanwhile, the west and east municipal green land has been sunk to solve the lighting problem of the shopping center's basement, and the space composition of the complex has been extended to the south building. Therefore, a multi-layered multidimensional green space has been formed surrounding the complex. It is extremely distinguishing as it is not only self-contained but also runs through the walking system in the whole area. (Figure 43.4) The other kind of walking system opposite to the aforementioned is a typical renewed old business district. Taking South Renmin business district of Shenzhen as an example, relying on the favorable location of the Luohu port, it once was the central and symbolical area of Shenzhen. As Hong Kong and Shenzhen port moved to west and the surrounding business districts sprung up, business of the area declined gradually these years. Thus, a renovation program of South Renmin business district which is dominated by government and actively joined by the developers came up. The main outcome of the program is the pedestrian overpass which connects the LuoHu Port and the Dongmen business district connects the lined main commercial complexes. (Figure 43.5) The difference compared to the former one is that this channel is much more pleasant and the space is more lively and familiar as it is located in an old business district with relatively cramped space and freer layout, moreover, most of the sections are located within the commercial space.

43.2 Summary

With continuous development of China's economic construction and unceasing advance of urbanization, conflict between urban development and environmental protection has become increasingly prominent. Expression in urban transportation is the contradiction between the significant increase of private cars and travel efficiency and urban environment. Maximizing the use of public transports by

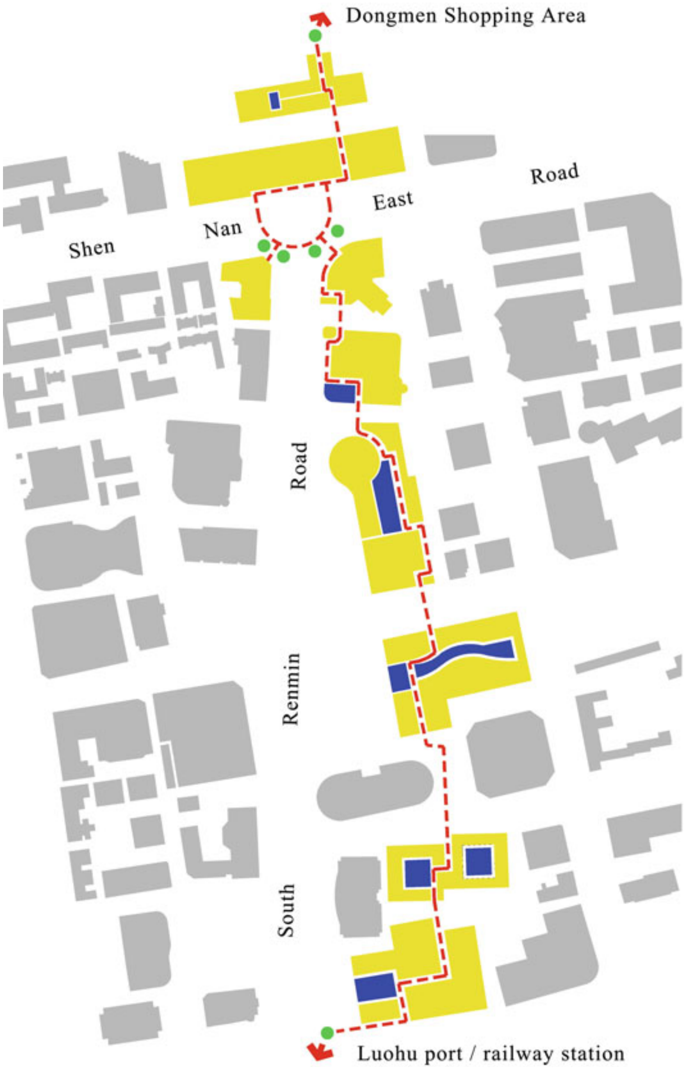

Fig. 43.5 The pedestrian overpass system of South Renmin

adroitly guiding action according to circumstances, meeting low-carbon development trends of future urban transportation and satisfying humane, comfortable and convenient travel requirements of public are not only the subjects placed in front of city governors, but also social responsibilities which the real estate developers should assume. Both Shenzhen and Hong Kong are economically developed areas, they enjoy some valuable experiences in building urban complexes based on low-carbon transport modes. And they should be able to provide us with lots of useful inspiration and reference.

Chapter 44
Study on Data Storage Particle Size Optimization of Traffic Information Database for Floating Car Systems Based on Minimum Description Length Principle

Rui Zhao, Enjian Yao, Xin Li, Yuanyuan Song and Ting Zuo

Abstract Particle size partition plays a key role in the optimization of historical database precision and data storage space. When establishing the historical database of traffic information for floating car systems, proper size of data storage particle can optimize data precision and storage space simultaneously and gives minimum comprehensive cost. This paper proposes a data storage particle size optimization model, which tries to balance data precision as well as data storage space for floating car systems. Furthermore, the proposed data storage particle size optimization model is executed in Beijing case study. The results show that the data storage particle size is 35 min at night while 10 min in the day under the given constraints of minimum cost of data precision and storage space, which is consistent with the real traffic condition and application requirement.

Keywords Floating car · Traffic information · Particle size optimization · Data precision · Data storage space

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44.1 Introduction

Due to rapid urbanization and ever-increasing number of vehicles, the problems with urban traffic, such as traffic congestion, environmental pollution, and energy shortage, are getting worse. Faced with these problems, many countries have focused on the application of Intelligent Transportation Systems (ITS) technologies. Floating car system, a new kind of ITS technology, has been proposed to collect traffic information. Compared with traditional traffic information acquisition systems, the lack of floating car data (FCD) may lead to an incomplete historical database when using fixed time granularities. Moreover, insufficient floating car data sample cannot guarantee data reliability. Too large or too small size of data storage particle cannot give the optimal data precision and storage costs at the same time. Therefore, proper data storage particle size plays a key role in establishing a precise and reliable FCD historical database with cost-effective storage space.

Although extensive research has been undertaken in developing ITS strategies and floating car systems, few articles have been devoted to study data storage particle size optimization of floating car historical database. Sun et al. (2011) proposes particle size monitoring for power consumption statistics of telecommunications industry based on fuzzy analytical hierarchy process (FAHP) and evaluation hierarchy. Yang et al. (2008) introduces a method of the dual granularity's degree, which can provide data of different granularity's degree with respect to dynamic requirements. Lv and Che (2009) analyzes the granularity model of data warehouse and puts forward a data granularity partition of banks considering acceptable minimum data storage particle size and the amount of stored data. Zhong (2004) investigates the granularity design from the following four aspects: requirements, data modeling, dimensions and time granularity. The paper concludes the principles of granularity design that the data granularity of the data warehouse must be altered with the changing of the requirements.

As demonstrated, most recent research focuses on physical storage of computer media. However, few articles have explored the data storage particle size optimization of historical link-based traffic information database for floating car systems when taking into consideration the FCD characteristics. Based on minimum description length (MDL) principle, this paper proposes a data storage particle size optimization model, which tries to balance data precision with data storage space for floating car systems. Meanwhile, a case study in Beijing is introduced and optimal particle size partition is given.

The remaining part of this paper is organized as follows: Sect. 44.2 introduces the concept and optimization of particle size for floating car traffic information. In Sect. 44.3, particle size optimization model based on the MDL principle is proposed. Based on the data collected in Beijing, the optimal particle sizes for different periods are recommended in Sect. 44.4, and the conclusions are given in Sect. 44.5.

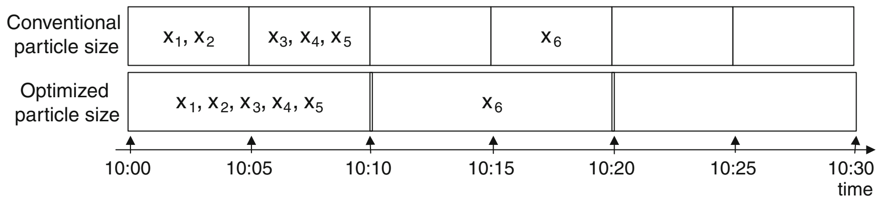

Fig. 44.1 Data storage particle size

44.2 Concept and Optimization of Particle Size for Floating Car Traffic Information

The storage particle size of floating car traffic information describes the length of time interval that information storage unit crosses. Figure 44.1 shows the concept of the conventional storage particle size and the optimized storage particle size of information. Usually, in floating car systems, the storage particle size for a road link is 5 min. After optimization, the storage particle size differentiates with the conventional particle size, e.g. 10 min shown in Fig. 44.1.

The storage space of floating car traffic information is the space needed for saving floating car traffic data in all time intervals during a day. For different particle sizes, any single storage unit occupies the same space of physical medium though crossing different length of time interval (Fig. 44.1 shows as an example). Thence, more storage units need for a road link by a smaller time particle size; in contrast, less storage units can meet the requirement for data storages in all time intervals by a larger time particle size, which saves storage space.

As a consideration of data precision, the storage particle size cannot be too large, while a large storage particle size leads to large differences in data samples and diminishes in reliability of traffic information in storage units for lacking enough data sample. In practical, even though smaller storage particle size improves the precision of data sample in storage unit, the storage space expands accordingly. Therefore, the storage particle size for data as a key factor related to the precision of history database and the optimization of storage space is of theoretical and practical significance.

44.3 Storage Particle Size Optimization Model of Floating Car Data

The FCD storage particle size optimization model is based on the Minimum Description Length (MDL) principle. The fundamental idea behind the MDL principle is that any regularity in a given set of data can be used to compress the data, i.e. to describe it using fewer symbols than the number of symbols needed to describe the data literally. This principle was put forward by (Jorma 1978) in1978 when he researched on generic coding. Its basic principle is that for a given set of instance data, in order to save the storage space, generally a certain model is adopted to conduct the compression coding and then the compressed data is saved. At the same time, the model is also kept to recover the instance data accurately in the future. So the total stored data length is the sum of compressed data length and model length, which is called total description length. MDL Principle aims at choosing the model that has the minimum total description length.

MDL follows the Occam's razor principle that unnecessarily complex models should not be preferred to simpler ones (Zhang and Mühlenbein 1993). Its essence is choosing the most appropriate particle size for describing objects, in order to achieve an optimal trade-off between model complexity and fitness of the data. It provides a quantitative measure to describe model conciseness: the total description length of data consists of two parts: the model coding length and the data coding length (Jiang et al. 2011; Vitanyi and Li 2000). The expression of coding cost is as follows:

$$Cost(Model, Data) = Cost(Data|Model) + Cost(Model). \tag{44.1}$$

Where,

Cost (*Model, Data*)	Total coding cost;
Cost (*Data* |*Model*)	Cost of the data coding;
Cost (*Model*)	Cost of the model coding

Back to the storage particle size optimization problem of FCD, if less data storage space (i.e., with larger particle size) is required, the price in data precision will be paid. Therefore, with reference of this idea mentioned above, the following model is adopted to optimize the data storage particle size.

$$\min\left(\sum_j \frac{1}{2} N_j \log S_j^2 + \frac{1}{2} J \log N\right) \tag{44.2}$$

where,

- S_j^2 data sample variance of each storage unit under the condition of time interval number as j;
- N_j data sample number of each storage unit under the condition of time interval number as j;
- J time interval number;
- N the total number of data samples

The term on the left side of plus stands for error term, and it reflects the ability of the compressed data to recover its original status, i.e., the ability of the storage numerical values in corresponding particle size can represent the original sample numerical values, or the price paid in the data precision under the corresponding particle size. The term on the right side of plus stands for the complexity term of the model, and it reflects the storage size to store information. The formula seeks

Fig. 44.2 Data source

for an optimal particle size to balance the error term and the complexity term and achieve the minimum comprehensive cost.

44.4 Case Study

Experimental data is from Beijing floating system on 15th August 2010 with 14920063 pieces of floating car data included. The road network in Beijing contains 122848 road links. The research area is surrounded by the blue rectangle in Fig. 44.2, and 11440756 pieces of floating data, which is about 77.68 % of the whole data in the floating system, are collected in the area. The experiment is analyzed based on the data on road link No. 59566202171.

Figure 44.3 shows the variation of standard deviation and speed under different time periods of the experimental day. There are 288 time intervals of a day and number of time interval 0 stands for 00:00 while number of time interval 288 stands for 24:00. It can be observed that the standard deviation centralizes in the value of ten during the night, and it fluctuates around the value of five after 108 time intervals (i.e., 9:00 during the day). The values of the speed also indicate different tendencies of the whole day and the two turning points are shown as 9:00 and 23:00 in the Fig. 44.3. There are obvious difference between the nightly

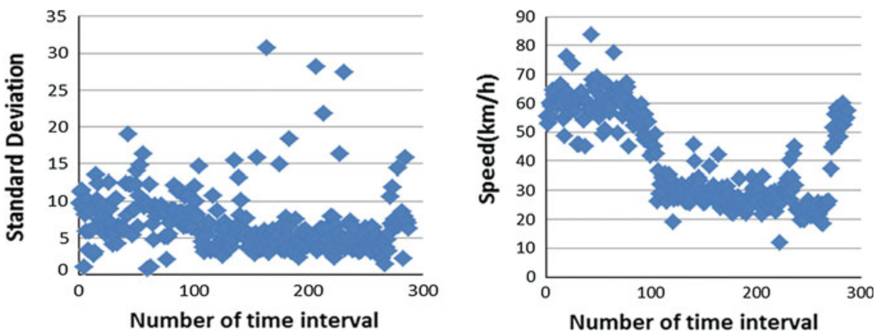

Fig. 44.3 Standard deviation and speed under different time periods of a day

Table 44.1 The MDL Principle based optimization results for daytime period

Particle size (min)	Number of time intervals	Total sample size	Error term	Complexity term	Error term + complexity term
5	168	1851	1324	274	1598
10	84	1851	1424	137	min★1561
15	56	1851	1483	91	1574
20	42	1851	1537	68	1605
25	34	1851	1586	55	1641
30	28	1851	1567	45	1612
35	24	1851	1602	39	1641
40	21	1851	1556	34	1590
45	18	1851	1566	29	1595
50	17	1851	1657	27	1684
55	15	1851	1639	24	1663
60	14	1851	1652	22	1674

periods and daytime periods. Therefore, for the sample link, the storage particle size is optimized based on different time periods, i.e., daytime (9:00–23:00) and night (0:00–9:00).

The calculation results with the FCD on road link No.59566202171 during daytime (9:00–23:00) and night (0:00–9:00) according to the Eq. (44.2) are as follows:

From Tables 44.1 and 44.2, it is obvious that: with the increasing of particle size, the number of time intervals decreases, meanwhile the complexity term also diminishes so the cost to save the model is lower. However, as complexity terms become smaller, error terms referring to the cost of precision for compressing data into a storage unit are larger. For a comprehensive consideration of complexity

Table44.2 The MDL Principle based optimization results for night period

Particle size (min)	Number of time intervals	Total sample size	Error term	Complexity term	Error term + complexity term
5	120	606	576	166	742
10	60	606	577	83	660
15	40	606	585	55	640
20	30	606	595	41	636
25	24	606	597	33	630
30	20	606	602	27	629
35	17	606	581	23	min★604
40	15	606	662	20	682
45	13	606	669	18	687
50	12	606	601	16	617
55	11	606	616	15	631
60	10	606	612	13	625

terms and error terms, the minimum value of the sum of the two terms leads to the balance between the costs. According to the calculation results, the particle size is 10 min when the value of complexity term and error term is the minimum during the daytime, and during the night, particle size is 35 min. Therefore, it can be concluded that the total cost is minimum when particle size is 10 min during daytime and 35 min during night.

44.5 Conclusion

In this paper, a data storage particle size optimization model is proposed to optimize data precision, storage space, and comprehensive cost. Moreover, a dataset of Beijing is examined and analyzed, and the optimal data storage particle size (35 min at night while 10 min in the day) is recommended.

Acknowledgments This research is supported by National 973 Program of China (No. 2012CB725403) and National Key Technology R&D Program (No. 2011BAG01B01).

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Chapter 45
Design of Double Green Waves Scheme for Arterial Coordination Control

Chengkun Liu, Qin Yong, Haijian Li, Yichao Liang, Yalong Zhao and Honghui Dong

Abstract Urban traffic congestion is increasing seriously, the arterial coordination control is an effective way to improve the smooth of arterial road. This paper designs an arterial double green waves coordination control method, which divides the arterial road into two coordination control sections bases on traffic flow, and redistributes the traffic flow in time and space according to phase offsets cooperative setting. This method can make traffic flow run smoothly on arterial road and improve the traffic condition of arterial road. Taking Ronghua Road in Beijing as an example, this paper simulates and analyzes the arterial double green waves coordination control scheme based on the microscopic traffic simulation software VISSIM. The results show that after optimizing, the traffic delay of the arterial road is decreased, and queue spillover phenomenon is improved obviously.

Keywords Traffic engineering · Arterial coordination control · Double green waves · VISSIM simulation

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45.1 Introduction

Traffic smooth of arterial road will affect the service quality of the entire urban road transport system greatly. Arterial coordinated control is an effective method to improve the traffic operation conditions of arterial road at present. So it is significant to improve the traffic running condition of arterial roads (Zhen-wen 2003). Domestic and foreign scholars have done a vast amount of research (Bing 2005). These researches take intersections as an interconnected system to study with, but ignore the influence that different section traffic flow has on the whole arterial road, and the queue spillover phenomenon will occur in the section which has more traffic flow finally.

45.2 Arterial Double Green Waves Coordination Control

This paper designs an arterial double green waves coordination control method according to different sections has different traffic flow. The arterial traffic flow is divided into two sections which adopt arterial coordinated control. And the connected intersection of two sections is named intercepted intersection. Through phase offset setting, traffic flow in the section which has less traffic volume will enter the section which has more traffic volume after staying at the intercepted intersection for some time. Then the traffic volume distribution of arterial road is relative balance and the traffic pressure of the section which has more traffic volume is alleviated.

45.3 Design Process of Double Green Waves Scheme

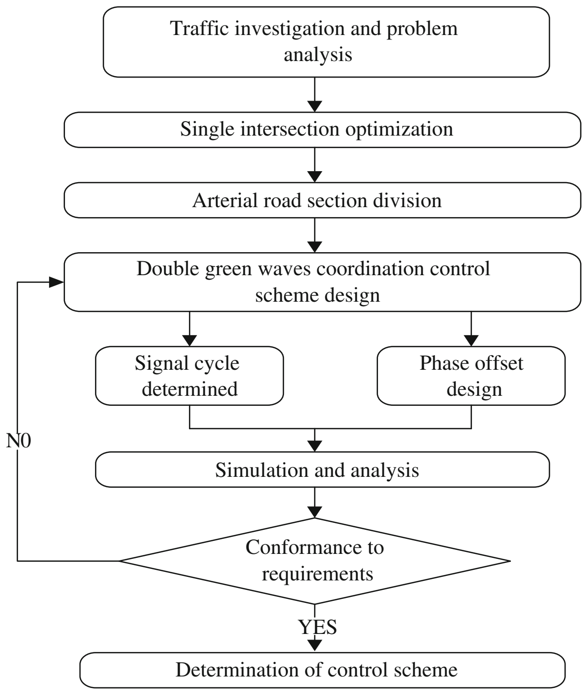
This paper divides design and simulation process of double green waves coordination control scheme into five parts: traffic investigation and problem analysis, single intersection optimization, arterial road section division, double green waves coordination control scheme design, simulation analysis. The process of control scheme design is shown in Fig. 45.1.

45.4 Signal Cycle and Phase Offset Design of Double Waves Scheme

45.4.1 Signal Cycle

In this control system, in order to let the intersections of the arterial road cooperate with each other, signal cycle length of every intersection must be the same (Zhang 2009). So the longest cycle length of signal intersection should be chose as the common signal cycle of this system. The common signal cycle is defined as

Fig. 45.1 Design and simulation process of double green waves control scheme



$$C = \max\{C_1, C_2, \cdots, C_n\} \tag{45.1}$$

Where C denotes the common signal cycle of arterial double green waves coordination control scheme, C_n is the signal cycle of intersection n.

45.4.2 Phase Offset

Phase offset should be set based on the distance of intersections and vehicle running speed.. It denoted byϕ, the calculation formula is given by

$$\phi = \frac{L_{a+i+1} - L_{a+i}}{V} - nC \tag{45.2}$$

where L_{a+i} is the distance from the intersection$i$to the benchmark intersection a,Vstands for is permissible speed, n is positive integer.

In this control system, the benchmark intersection of the green wave system before intercepted intersection is the first intersection. The benchmark intersection of the other green wave system is the intercepted intersection.

45.5 Example Analysis

This paper takes nine adjacent intersections of Ronghua Road in Beijing as example. To facilitate the narrative, the intersections from south to north are named J079–J087.

45.5.1 Traffic Investigation and Problem Analysis

The south and north entrances of J079–J086 intersections have four lanes, and the J087 have five lanes. But the west and east entrances of the nine intersections have few lanes. This paper analyzes the traffic flow on Monday, Tuesday, Friday and Saturday, and selects the evening peak hour 17:15–18:15 on Monday as the study hour. The traffic volume in every entrance of J079–J087 intersections is shown as Fig. 45.2.

All the nine adjacent intersections adopt three phases signal control scheme and use the same signal cycle (164 s). The amber time of all phases is 4 s. The all-red time of south and north straight phase and south and north left turn phase is 2 s, but this time of west and east phase is 4 s. The current signal timing schemes of nine adjacent intersections are shown as Table 45.1.

45.5.2 Scheme Design of Double Green Waves Scheme

Traffic flow from south to north is cumulative, and the distance between adjacent intersections is about 400 meters, so one-way green wave can be set up. The cycle length of arterial double green waves coordination control is 164 s.

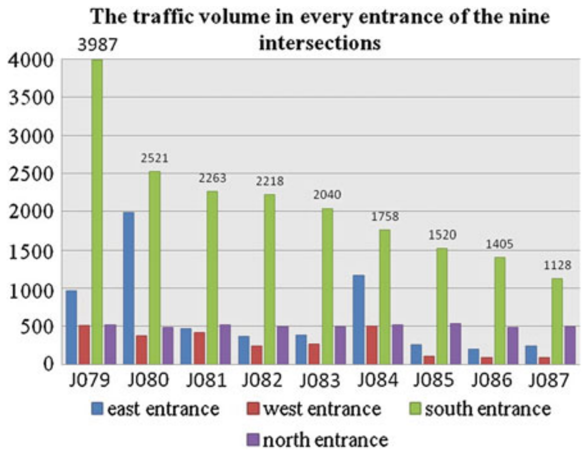


Fig. 45.2 Traffic volume of Ronghua Road adjacent intersections

Table 45.1 Current signal timing of Ronghua Road adjacent intersections

Intersection	South and north straight(s)	South and north left turn(s)	West and east(s)	Offset(s)	Adjacent intersections distance(m)
J079	100	14	30	117	0
J080	80	19	45	78	398
J081	74	14	56	41	402
J082	85	19	40	4	383
J083	80	14	45	131	431
J084	80	19	45	93	420
J085	90	14	40	62	418
J086	90	14	40	31	414
J087	90	14	40	0	445

The traffic data show that traffic flow of Ronghua Road is increasing from south to north, and traffic flow of south intersections are less, but the queue in south entrance of the J079, J080 two north intersections extend to the next intersection, there exists queue spillover phenomenon in these two intersections

The south to north traffic flow of J087, J086 and J085 intersections is less. In order to decrease the queue spillover phenomenon in J079 and J080 intersections, this paper chooses J084 as the intercepted intersection.

The first coordination control section chooses J087 intersection as the benchmark intersection. And the offset of J087, J086 and J085 intersections are set. Then the offset between J084 and J085 intersections is adjusted so that the traffic flow which runs smoothly meet red light at J084 intersection and the pile up effect is formed.

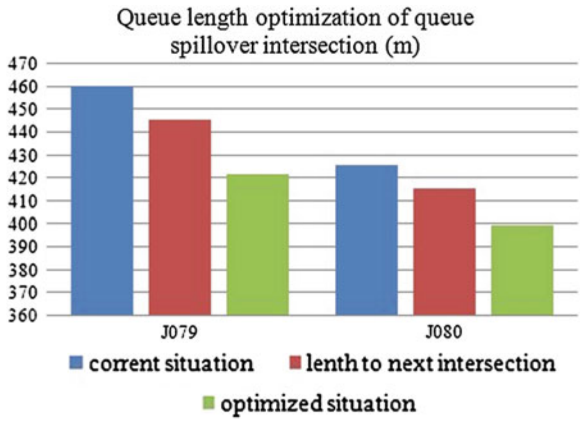
The second coordination control section chooses J084 as the benchmark intersection. And then set the offsets of J084, J083, J082, J081, J080 and J079 intersections. The signal timing of this scheme is shown as Table 45.2.

Table 45.2 Signal timing of arterial double green waves scheme

Intersection	South and north straight(s)	South straight and left turn(s)	South and north left turn(s)	West and east(s)	Offset(s)	Adjacent intersections distance(m)
J079	100	0	14	30	121	0
J080	80	4	15	45	91	398
J081	74	4	10	56	67	402
J082	85	0	19	40	40	383
J083	80	0	19	45	13	431
J084	80	4	15	45	150	420
J085	90	0	14	40	54	418
J086	90	0	14	40	27	414
J087	90	0	14	40	0	445

Fig. 45.3 Simulation testing process

Fig. 45.4 South entrance queue length optimization of queue spillover intersections



45.5.3 Simulation Evaluation

This paper adopts VISSIM to simulate the optimization scheme. VISSIM is capable to analysis the urban traffic operation under various traffic conditions. It is an effective tool for evaluating traffic engineering design and traffic organization optimization schemes (Chun-ying 2005; VISSIM 2006).

Establishing current model and double green waves scheme of the Ronghua Road based on fundamental data, input the traffic volume, signal timing scheme, traffic operation parameters, etc. The simulation testing process is shown in Fig. 45.3.

The simulation results are illustrated in Figs. 45.4 and 45.5.

The result shows that, the arterial double green waves coordination control scheme has some influence to improve the traffic quality. The south entrance queue length of J079, J080 intersections are decreased. The queue length of J079 intersection is improved 8.48 %, the queue length of J080 intersection is improved 6.12 %. The queue spillover phenomenon is improved. The delays of all the intersections in the arterial double green waves coordination control system are decreased except the J084 intersection.

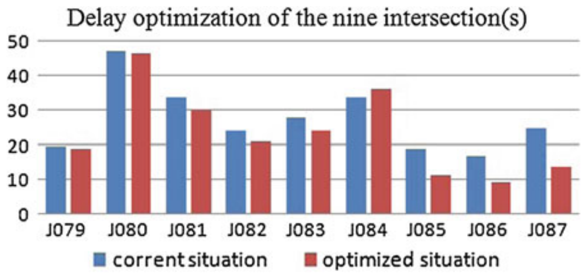


Fig. 45.5 The south to north traffic delay optimization of Ronghua Road adjacent intersections

45.6 Summary

Arterial road coordination control scheme is an effective method to improve traffic operation condition and alleviate traffic pressure. Aiming at the distribution of traffic flow is uneven and some intersections queue spillover. This paper designs a kind of arterial road double green waves coordination control scheme, and describes the design method and simulation process in detailed. Taking Ronghua road as an instance, a scheme is designed, adopting VISSIM microscopic simulation software to simulate and analyze current situation and double green waves scheme, the results show that the method has practical value. This work is supported by "the Fundamental Research Funds for the Central Universities" (2012YJS059), the National 863 Program (GrantNo.2006AA11Z231) and the National Natural Science Foundation of China (Grant No. 61104164).

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Chapter 46
An Evaluation Indicator System of Low-Carbon Transport for Beijing

Siyuan Zhu and Xuemei Li

Abstract Establishing an indicator system is an effective way to find out the exited problems in development low-carbon transport. In this paper, we have analyzed the related principles and established the system of evaluation based on data dependency and principal components analysis (PCA). This system is composed by 23 indicators, taking the core of sustainable development. Based on the index system and weights of index, the paper gives an evaluated level of low-carbon transport in Beijing from 2006 to 2010. The conclusion is that Beijing's low-carbon transport development level is increasing continuously. Some positive results were achieved form public infrastructure construction, improving ecological environment and upgrading the industrial structure. But there are still some shortcomings, such as decline in bicycle riding, traffic jams and insufficient investment in assets, which reduce the overall level of the low-carbon transport.

Keywords Low-carbon transport · Principal components analysis (PCA) · Evaluation indicator system · Urban transportation

46.1 Introduction

As a major source of carbon emissions, transportation becomes an important field in international greenhouse gas emission reduction and climate change mitigation. Establishing an indicator system is an effective way to find out the exited problems in development low-carbon transport.

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The existing research in low-carbon transport evaluation system, mainly concentrated in two parts. One is the index selection, and the other is the construction of the indicator system. Peris Mora et al. (2005) present when choose indicators need to meet the following two points: (1) Simple. The number of indicators and the method of calculation should be simplified as much as possible. (2) Goal-oriented. Correlation between indicators and the goal must be obvious, so that indicators can reflect the target's changes sensitively.

In the major application of statistical method, one is the Principal Component Analysis. From many observation variable original data to carry out comprehensive information and most independent several factors to explain the original data variables, make multidimensional variable dimensional reduction, thus simplifying the data structure. Another is Analytic Hierarchy Process (Saaty 1990). Comparing between every two factors have done and get the sort order by weightiness of all factors. With the development of artificial intelligence, scholars established new multi-criteria decision analysis method, such as Fuzzy AHP, Fuzzy Comprehensive Assessment (Lu et al. 1999). Anjali Awasthi (2011) uses Dempster-Shafer Theory, processed uncertain data and combined with AHP method to establish the evaluation indicator system of sustainable transportation development.

Together with a number of domestic and foreign literatures researches, foreigners have more empirical researches in different angles. But considering the data statistics and policies are different, foreign existing system can't completely suitable for urban traffic evaluation in china. In contrast, the domestic research is still in the starting period. Focus more on low-carbon traffic definition, system framework and policies. Given theoretical research and policy advice, be short of empirical research.

46.2 Methodology

46.2.1 Selection of Indicators

The selection of evaluation indicators is a repeated the experiment process, combing subjective experience and data analysis. The various steps are explained as follows.

(1) Initially draft of indicators

According to the existing research results and related system, we reference the form and principle of establish an evaluation system and find the widespread use of key indicator. Reference source mainly come from government agencies report and the periodical literature in both domestic and foreign, such as Herb Castillo (2010) and Nicolas Moussiopoulos (2010).

(2) Selection of indicators

Data collect. Find the above reference data in "Beijing statistical yearbook", "China's environmental statistics yearbook", "Chinese urban statistical yearbook" and "the Beijing transportation development of the annual report" from 2001 to 2010. According to the properties divided into three categories: urban traffic, social economic and environmental energy.

Adjust the negative indicators. For criteria having negative impact, use reciprocal value to determine score. And then, make them available by data's standardization.

Remove uncorrelated and repeated indicators. In SPSS, we use Pearson correlation analysis to remove uncorrelated and repeated indicators in order to reduce index number, simplify the calculation amount. At the same time, select the indicators more objectively through the data analysis.

(3) The main indicators of the evaluation system

Through the selecting of relevance, establish a complete low-carbon transport evaluation indicator system, such as Table 46.1.

46.2.2 Quantification and Weighting

"The Principal component analysis" (PCA) basically eliminates the subjective judgment and be used in practice widely. So this paper uses it for quantification and weighting those indicators. PCA weights data by combining original variables into linear combinations that explain as much variation as possible. Mainly includes the following four steps:

(1) Calculating correlation coefficient matrix

Using standardized data calculate correlation matrix R, $R = \begin{bmatrix} r_{11} & \cdots & r_{1p} \\ \vdots & \ddots & \vdots \\ r_{p1} & \cdots & r_{pp} \end{bmatrix}$

Dim r_{ij} as Correlation Coefficient between x_i and x_j.

$$r_{ij} = \frac{\sum_{k=1}^{n} (X_{ki} - \overline{X}_i)\left(X_{kj} - \overline{X}_j\right)}{\sqrt{\sum_{k=1}^{n} (X_{ki} - \overline{X}_i)}\sqrt{\sum_{k=1}^{n} (X_{kj} - \overline{X}_j)}} \qquad (i, j = 1, 2, \ldots, p)$$

(2) Calculating Eigenvalue and variance contribution

Solve equation, $|R - \lambda E| = 0$ and Calculate correlation matrix R's eigen value named λ, if $\lambda_1 \succcurlyeq \lambda_2 \succcurlyeq \ldots \lambda_n \succcurlyeq 0$ and then according to the factor accumulative total variance contribution over 85 to determine the number of main component.

Table 46.1 The main indicators of the evaluation system

Target layer	Rule layer	Indicator layer	Number	Property
Low carbon traffic development	Urban transportation	Private car growth	X1	–
		Number of the public transport vehicle operation in the end of year	X2	+
		Highway miles	X3	–
		Road area	X4	+
		Total length of public transport operating routes	X5	+
		Highway passenger quantity	X6	+
		Public transport passenger quantity	X7	+
		Taxi passenger quantity	X8	+
		Travel options-Bicycle	X9	+
		Travel options-Car	X10	–
		Travel options-Public transportation	X11	+
		Congestion conditions in workdays	X12	–
		The traffic accident happened several	X13	–
	Environment and Energy	Per capita green area	X14	+
		Air quality	X15	+
		Qualified rate of emission testing throughout the year	X16	+
		Ten thousand yuan in GDP energy consumption	X17	–
		Ten thousand yuan in GDP coal oil accounts for the proportion of total energy consumption	X18	–
	Social economy	Permanent population density	X19	–
		Per capita in GDP	X20	+
		Disposable income	X21	+
		Fixed assets investment in traffic	X22	+
		Financial expenditure in environmental protection	X23	+

(3) Determine the principal components number and the economic significance

To explain economic meaning of those components, key indicators attributes that had great impact weight are used. If the loads on 23 indicators on one of components are not far from each other, then rotate factors to make the principal components can be explained. This paper chooses the method of varimax orthogonal rotation to rotate factors.

(4) Calculation of main component scores and total points

We can calculation the score of main component by computing the Main component scores coefficient matrix. And then uses each of the principal component eigenvalue as root weight, to weighted summary for each main ingredient. Finally, we get the total score for evaluation.

Table 46.2 Eigenvalue and variance contribution

	Initial Eigenvalues			Extraction squares of the load			Rotating squares of the load		
	T	V	A	T	V	A	T	V	A
1	19.77	85.96	85.96	19.77	85.96	85.96	10.13	44.05	44.05
2	2.22	9.65	95.61	2.22	9.652	95.61	8.81	38.32	82.36
3	1.01	4.39	100.0	1.01	4.393	100.0	4.057	17.64	100.0

T total, *V* variance %, *A* accumulated %

46.3 An Application on Beijing

According to the establishment of the above evaluation system, we evaluate low-carbon development level in Beijing nearly 5 years by using the data from "Beijing statistical yearbook" and "the Beijing transportation development of the annual report" from 2006 to 2010.

46.3.1 Results

First of all, calculating correlation coefficient matrix, and the results show that there was significant correlation between 23 indicators. So the conditions of using PCA are satisfaction. Then, calculate the eigenvalue and variance contribution. From the Table 46.2, it is known that the first, second and third composition of the eigenvalue greater than 1, and three of main components of contribution rate is up to 100 %, which retain the original indicators all information, explain the three main ingredients can cover the whole indicators information.

Select the first three principal components, and calculates the corresponding main component of the correlation coefficient. Then rotate factor, the main components have explicable.

The first PC reflects the urban transportation condition, including city infrastructure, transportation passenger travel choice and road way, crowded degree, etc. The second PC reflects the city environment and economic development, including the environmental quality, and energy consumption, economic development level, etc. The third PC elements less, added that the urban traffic development, including: Qualified rate of Emission testing throughout the year and fixed assets investment in traffic.

Named three PC as f_1, f_2, f_3, scores as f, with each of the principal component eigenvalue for the root weight. Name three eigenvalues as λ_1, λ_2, λ_3. Use the equation is said for:

$$f = \frac{\lambda_1}{\lambda_1 + \lambda_2 + \lambda_3} f_1 + \frac{\lambda_2}{\lambda_1 + \lambda_2 + \lambda_3} f_2 + \frac{\lambda_3}{\lambda_1 + \lambda_2 + \lambda_3} f_3$$

Will the data of Beijing 2006–2010 are generation into the above formula, get all the main component scores and total score such as Table 46.3.

Table 46.3 Main component scores and total score

Years	f_1	f_2	f_3	f
2006	0.265	0.060	−0.779	−0.001
2007	0.398	0.087	−0.436	0.130
2008	0.491	0.939	−1.081	0.379
2009	−0.051	1.077	0.472	0.472
2010	0.317	1.727	−0.788	0.654

46.3.2 Analysis

(1) Total score analysis

Based on the above calculations of the Beijing low-carbon transportation development total score, it is easy to see in the 5 years, Beijing's low-carbon traffic comprehensive evaluation scores have been tend to growth, explained this 5 years Beijing has achieve the goal of low-carbon traffic benign development. From the absolute number of the growth, from 2006 to 2008, comprehensive score turned from negative to positive. The growth become moderated after 2008, but still maintained a good momentum.

(2) Prin1 analysis

First principal component scores is not very high, experienced three years growth until 2009. After the Olympic Games in 2008, directly investment in low-carbon traffic has been cut back. We analyze the reasons from both positive and negative aspects below.

First, the causes of positive factors promote the growth. One is increasing number of urban transportation infrastructure construction. From 2006 to 2010, Beijing's highway mileage and road area are continuing to increase, alleviate the pressure of too much motor vehicle, and improve travel road conditions. Another is the development of public transport. The number of public transport, operating routes, the passenger in the total length are increasing year by year, dense urban public transportation network, promote residents travel choice public transportation, and promote the development of the low-carbon traffic.

Negative reasons are following two points:

(a) Proportion of bicycle travel has dropped year after year.

Bicycle travel is a kind of convenient and health way to go out, which is no pollution and saving energy. The promotion of bicycle play an important role in develops low-carbon traffic. However, bicycle travel declined year by year in Beijing from 30 % in 2006 to 16.4 % in 2010. Cause this result both subjective and objective. Subjective reason is that low-carbon travel consciousness among residents is not strong enough. As the city economic development and living standards improving, vehicle travel becomes more popular. Even bicycling and walking are considered a symbol of the backward. The objective reason is the rapid expansion of car serious encroach the bicycle road space, making the bicycle travel environment worsening and security danger has also increased.

(b) Traffic congestion increased carbon emissions

Traffic congestion and carbon emissions are closely linked; the serious traffic congestion will greatly increase the energy consumption and exhaust emissions. However, from the data of “Congestion conditions in workdays”, Beijing is in moderate congestion permanently. This situation become well in 2008, but the momentary relief was followed by a growing trend. This is a big obstacle in the process of low-carbon transport.

(3) Prin2 analysis

The second principal component is the only one maintains the upward trend of score among the three PC. For a number of reasons list below: (a) Economic development. Beijing has maintained a fast speed of economic growth. By adjusting industrial structure and developing the third industry, the per GDP and finance income increase year after year steadily, tremendously support the development of low-carbon transport. (b) Environmental improvement. In the environment, Beijing’s air quality is continuous improvement and financial expenditure is increasing year by year. (c) Energy efficiency improving. Greenhouse gas main composition is carbon dioxide, carbon dioxide emissions mainly from fossil fuel burning and cement, lime, steel and other industrial production process. Beijing made a notable achievement in energy saving and emission reduction. Coal and oil accounts for the share of energy consumption decline every year and promotion in the new energy reduce gas emissions directly.

(4) Prin3 analysis

There is a large fluctuation in the third principal component score. Prin3 mainly explained qualified rate of emission testing throughout the year and fixed assets investment in traffic. Because of the two indexes ascension obviously, the score increase a lot in 2009. One of the reason of the promotion is a construction in several routes needs a mass of investment. Another is abolishment of consists car, vehicle exhaust emission condition has improved since 2009.

In addition, from the detail in Beijing’s fixed assets investment we can find that investment is mainly used for highway construction more than hub stations. The results show that the public transport services don’t get enough attention. Because the high demand of travel, the existing public travel density nets can’t meet the demand. And become one reason to evoke the families to buy private cars.

46.4 Conclusions

In this paper, we have analyzed the related principles and established the system of evaluation based on data dependency and Principal components analysis (PCA). This system is composed by 23 indicators, taking the core of sustainable development. Based on the index system and weights of index, the paper gives an evaluated level of low-carbon transport in Beijing from 2006 to 2010. The evaluation process accord with theoretical requirements, the output of the results can be confirmed by specific data and used for further analysis. The data of indicators are from government institutions, available and powerful. This paper presented general methods and calculating, they have general application ranges.

The conclusion is that Beijing's low-carbon transport development level is increasing continuously. Some positive results were achieved form public infrastructure construction, improving ecological environment and upgrading the industrial structure However, there are still some shortcomings we found by this evaluation: proportion falls on bicycle travel; traffic congestion; incorrect structure of traffic assets investment.

The current work evaluates only consider the objective factors. Limit in available data from the government institutions which can't fully reflect the low-carbon development. Future work will involve assessment of people's subjective factors and the indicators have yet to be further improved.

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Chapter 47
Design and Implementation of Regional Traffic Information Disseminating System Based on ZigBee and GPRS

Weiran Li, Wei Guan, Jun Bi and Dongfusheng Liu

Abstract In order to help drivers get traffic information more easily and accurately, a new regional traffic information disseminating system based on ZigBee and GPRS is introduced in this paper. The system consists of two main components: an Information Sending Device (ISD) fixed on the roadside which sends traffic information as well as an Information Receiving Device (IRD) equipped in vehicles which receives traffic information. Real-time traffic information is sent to ISDs through GPRS network by traffic information management center. Then ISD disseminates the information timely and accurately to IRDs through ZigBee network. At last the traffic information is broadcasted vocally to drivers using Text To Speech (TTS) technology by IRD. The hardware structure and software design are presented respectively. The system is tested in Chegongzhuang Street, Beijing. The test results show that the system works well and drivers can obtain traffic information accurately and timely.

Keywords Traffic information dissemination · GPRS · ZigBee · Text to speech (TTS)

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47.1 Introduction

The critical point of a traffic information disseminating system is to transmit traffic information to drivers clearly and timely, which plays an important role in Intelligent Transportation System (ITS). Xiao et al. (2008) proposed a scheme which uses the existing radio equipment to disseminate traffic information. This method fails to consider the fact that the traffic information disseminated by FM doesn't work when the location of traffic information and the location of drivers are not the same; Qin et al. (2006) put forward a new traffic information disseminating system by the Internet. But it is hard for drivers to get the traffic information on the Internet; Shahjahan et al. (2008) introduced a new idea that disseminating traffic information via Short Message Service (SMS). In this scheme, drivers must send a SMS to SMS server, which is not convenient for drivers. Guan et al. (2008) proposed a novel method of disseminating traffic information via Variable Message Signs (VMS). This method does work well to some degree in guiding traffic flow. But when there are obstructs, for example a big bus, in front of the vehicle, the diver cannot see the information in VMS clearly and timely. What's more, the information displayed in VMS is a little simpler. Actually, there are various road conditions, the VMS, however can only show three road conditions, i.e. free, light congestion and severe congestion by three colors, i.e. green, yellow and red, respectively. So it is hard to judge road states that are between two colors.

In this paper, we design a new traffic information disseminating system based on ZigBee, (Bilgin and Gungor 2012) and GPRS (Ghribi and Logrippo 2000), (Ionel et al. 2012). The system is made up of two main components: an Information Sending Device (ISD) fixed on the roadside which sends traffic information as well as an Information Receiving Device (IRD) attached to vehicles which receives traffic information. Real-time traffic information is sent to ISDs through GPRS network by traffic information management center. Then ISD disseminates the information timely and accurately to IRDs through ZigBee network. At last the traffic information is broadcasted vocally to drivers using Text To Speech (TTS) technology by IRD.

47.2 Overall System Configuration

The overall configuration of the traffic information disseminating system is shown in Fig. 47.1. The traffic information management center is charged of traffic information collecting, processing and producing dynamic traffic guidance information. Then, according to the information's destination, the center transmits the information to the specific ISDs through GPRS network. Finally, the ISDs broadcast the traffic information to vehicles by ZigBee network. The ZigBee module in ISD is a coordinator node of ZigBee network and in IRD is an end node.

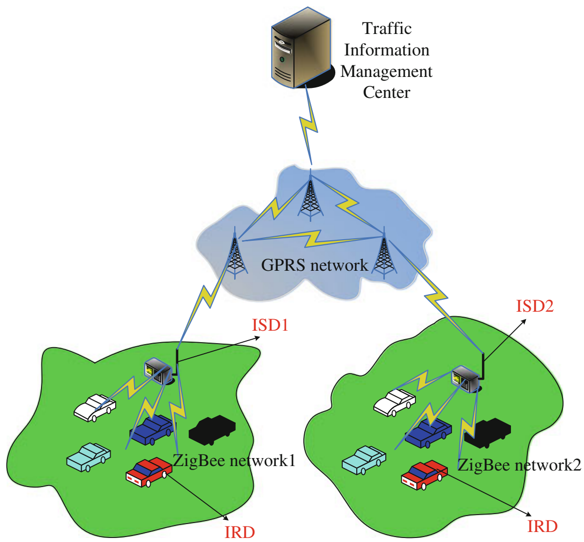

Fig. 47.1 Overall system configuration

47.3 Hardware Design

47.3.1 Hardware Design of ISD

The hardware structure of ISD is shown in Fig. 47.2.The Cirrus Logic' EP9312 is chosen as the MCU, which has many interfaces that can be connected with peripheral devices. Serial port1 connects with GPRS module; serial port2 connects with ZigBee module; storage connects with MCU via SPI bus.

47.3.2 Hardware Design of IRD

The hardware structure of IRD is shown in Fig. 47.3. The IRD is attached to the vehicle, so it should be designed compactly. We choose winbond' W77E58 as MCU, which has two full duplex serial ports and is compatible with MCS-51 instruction set. Serial port0 connects with ZigBee module and serial port1 connects with TTS module.

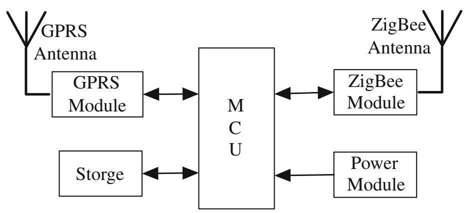

Fig. 47.2 Hardware architecture of ISD

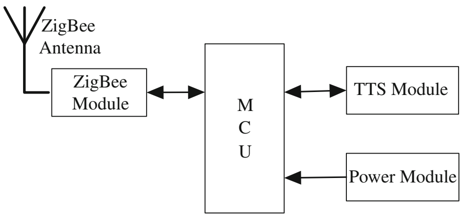

Fig. 47.3 Hardware architecture of IRD

47.4 Software Design

47.4.1 Software Design of ISD

The WinCE5.0 is selected as MCU's embedded operation system and use Embedded Visual C++4.0+SP4 as the developing environment. The multi-thread technology is used to realize the three modules' functions. The main program flow chart of the system is shown in Fig. 47.4.

GPRS module which connects ISD and upper server plays an important role in the system. At first, we need initialize the module, including setting the serial port parameters. By sending a serial of AT instructions and checking the responses, the MCU can control GPRS module to have a connection of TCP/IP with the upper server. We create two threads: m_hReadThread and m_hWriteThread. The m_hReadThread is used to read data from serial port and the m_hWriteThread is used to write data to serial port. Because GPRS wireless network is not absolutely stable, we propose a heartbeat mechanism to guarantee the connection between ISD and server is always reliable. The protocol format of heartbeat data is shown in Table 47.1. The ISD sends heartbeat data every 3 s and the server sends a packet of answer data once receiving heartbeat data. The protocol format of answer data is shown in Table 47.2. If the ISD doesn't receive answer data three times continuously, the ISD will rebuild a connection with the server. And if the ISD doesn't receive answer data after rebuilding two times continuously, the ISD will restart GPRS module. Furthermore, if the ISD doesn't receive answer data after restarting the module two times continuously, the ISD will restart the system.

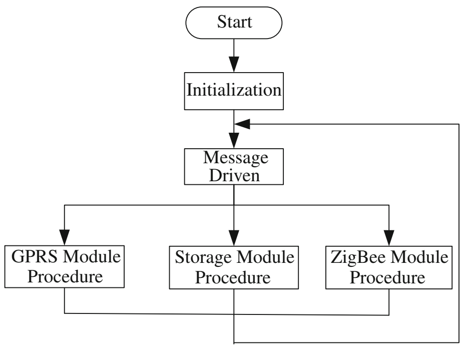

Fig. 47.4 The Main Program Flow Chart of System

Table 47.1 Heartbeat data protocol format

$	S	ID	yy-mm-dd	hh-mm-ss	"heb"	"0"	BCC

Table 47.2 Answer data protocol format of heartbeat

*	r	ID	yy-mm-dd	hh-mm-ss	"heb"	"0"	BCC

Table 47.3 Request data protocol format

&	S	"net"	"0"	BCC

Table 47.4 Traffic information data protocol format

$	S	"guide"	Data length	ID number	Content	BCC

The Block Check Character (BCC) is used as the data check. The function is CString MakeCheckSum (CString strData).

ZigBee module fixed to ISD is a center node of ZigBee network, and fixed in IRD is an end node of network. When the end node enters ZigBee network, it will send a packet of request data to the center node. The request data protocol format is shown in Table 47.3. Once the center node receives the request data, the ISD will broadcast the latest traffic information. The traffic information data protocol format is shown in Table 47.4. ID number is added in format, aiming to let ISDs decide whether to receive the traffic information or not. If a ISD has received a certain traffic information already, it should not receive it again.

To ensure every IRD in ZigBee network can receive a certain traffic information once, a timer is used to deal with this problem. When expire a timer, the ISD will broadcast the latest information again. The program flow chart of ZigBee module' receiving and sending information is shown in Fig. 47.5.

47.4.2 Software Design of IRD

The KEIL C51 is used as the developing environment of Winbond' MCU. The main program flow chart is shown in Fig. 47.6. When detecting ZigBee signal, the IRD will be driven by external interrupt. Then it will send a packet of request data to ISD. Having connected with the ISD, the IRD is just waiting for the interrupt from serial port0. When the interrupt is triggered, MCU will read out the data from buffer to TTS module. And TTS module synthesizes the data to speech. At last, the vocal traffic information is broadcasted to drivers. The function of speech synthesis is bool Send2TTS(char *buf, unsigned char len) of which buf is the pointer to character string to be synthesized and len is the length of character string.

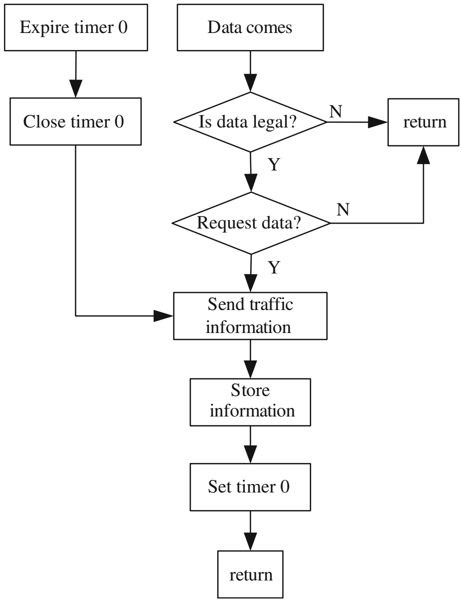

Fig. 47.5 The program flow chart of ZigBee module

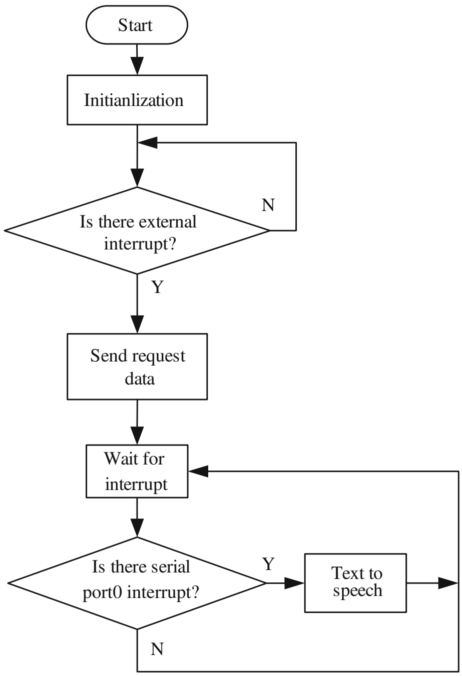

Fig. 47.6 The main program flow chart of IRD

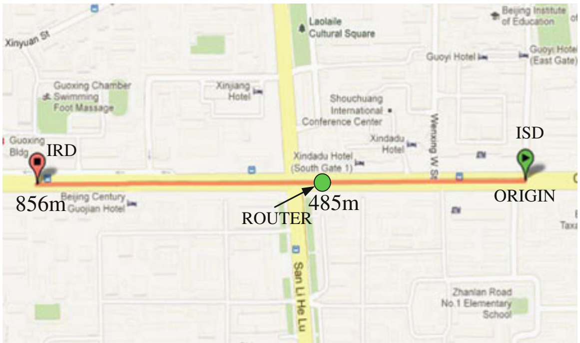

Fig. 47.7 The result map of distance test

47.5 System Test

To verify the feasibility of the system, we carry out system test in Che-GongZhuang Street, Beijing:

Step 1: Open the server in traffic information management center, and set it to send a packet of data every 1 s.

Step 2: The ISD fixed on the roadside is shown in Fig. 47.7, which is the center node of ZigBee network. Once the ISD receives the data from upper server, it will transfer it to vehicles immediately through ZigBee network.

Step 3: The IRD attached to vehicles is used to receive the traffic information from an ISD.

When the ZigBee router, as is shown in Fig. 47.7, is not added, the IRD cannot receive the data by a distance of about 485 m to ORIGIN. When the ZigBee router is added, the distance lengthens to 856 m. At present, the mean speed of vehicle on urban road is 50 km/h, so the time from vehicle receiving the traffic information to reaching the center node is approximately 62 s. It is enough for drivers to choose their routes.

47.6 Conclusions

In this paper, we apply GPRS wireless communication technology and ZigBee wireless network technology to ITS and propose a novel traffic information disseminating system. We designed and implemented two kinds of hardware components, ISD and IRD. The hardware structure and software design of two devices are given respectively. At last, system test was carried out in Chegongzhuang Street, Beijing. The test results show that this scheme we proposed is feasible and practical. Drivers can obtain traffic information accurately and timely and can also have enough time to make the decision of road selection.

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Chapter 48
Studying Electric Vehicle Batteries Consumption with Agent Based Modeling

Jinjin Fu and Xiaochun Lu

Abstract To develop electric vehicle is an approach to increasing the competition of electric vehicles industry, safeguarding energy security and boosting low carbon economy. It is well known that batteries can cause environment problem. Several problems must be solved before electric vehicle technology is applied in large scale. One of the problems is how many batteries should be equipped to meet the demand of certain electric vehicles. In this paper, we have built a batteries consumption model of electric vehicles based on agent. Simulation result shows that the optimum ratio of electric vehicles and lead-acid batteries is 1:2.93 and the optimum ratio of electric vehicles and lithium batteries is 1:1.36 as well. If electric vehicles are equipped with lithium batteries instead of lead-acid batteries, 53.4 % of batteries will be reduced.

Keywords Electric vehicles · Batteries · Environmental protection · Agent Based Modeling

48.1 Introduction

Environmental requirements and rising oil prices make electric vehicles become the new hotspot of vernicle development, because of its advantages of pollution-free, high energy efficiency and energy diversification. Increasingly more countries

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make corresponding development plans for electric vehicles. “The development plan of energy-saving and new energy vehicles industry (2012–2020)” issued by the State Council and other standards make the development of electric vehicles irresistible. However, the current refurbished rate of battery in China is 85 %, which is far lower than the percent of 95 % in the developed countries (XuejiaoYan and Xiang Li 2007). Whether the development of electric vehicles will have the disastrous impact on the recycling of the used batteries in China and what the proper production of batteries is the most friendly to the environment are taken into account, which will receive detailed analysis below.

48.2 Literature Review

For the moment, there is very little research on used batteries of electric vehicles. Research on the batteries of electric vehicles mainly has following several aspects.

The author (Chau et al. 2011) described a new adaptive neuro-fuzzy inference system (ANFIS) model to estimate accurately the battery residual capacity (BRC) of the lithium-ion (Li-ion) battery.

Simulation of the performance of the PHEV throughout its battery lifetime (EricWooda 2011) shows that battery replacement will be neither economically incentivized nor necessary to maintain performance in PHEVs. The results have important implications for techno-economic evaluations of PHEVs which have treated battery replacement and its costs with inconsistency.

For all batteries, it remains a challenge to simultaneously meet requirements on specific energy, specific power, efficiency, cycle life, lifetime, safety and costs in the medium or even long term. Only lithium-ion batteries could possibly attain all conditions in the medium term.(Sarah J. Gerssen-Gondelach, André P.C. Faaij 2012).

48.3 Model Establishment

There are two aspects in the study, the batteries and the electric vehicles. Several batteries need to be replaced before the end of vehicle life. The uncertainty of battery life and electric vehicle life make the model more complex, it is suitable to use the agent-based model. Specific conceptual model is shown in Fig. 48.1.

48.3.1 Introduction of Any Logic Simulation Platform

The platform used in the experiments is AnyLogic 6.7.1 University. The programming language is Java. AnyLogic is the modeling and simulation tools which was introduced by the XJ Technologies. Its application areas include: control

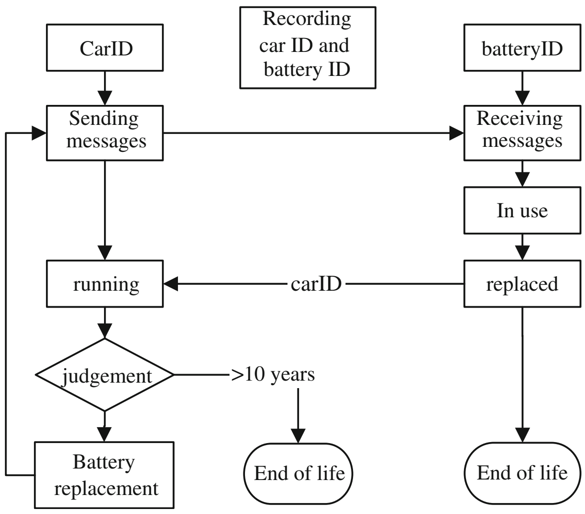

Fig. 48.1 A conceptual model of the usage process of an electric vehicle and battery

systems, traffic, dynamic systems, manufacturing, supply chain and logistics sector and so on.

State transition model of electric vehicles is shown in Fig. 48.2 and State transition model of batteries is shown in Fig. 48.3.

In Fig. 48.2, X_n stands for the state of the electric vehicle, $X_n \in \{1, 2, 3\}$. $X_n = 1$ means the electric vehicles are in the car factory, the electric vehicles are being produced. $X_n = 2$ means electric vehicles are in the state of being in use, the state of the electric vehicle is divided into the state of driving and the state of replacing the battery. $X_n = 3$ means electric vehicles are in the state of being scrapped, that is to say the electric vehicles come to the end of its life. xt_{12} stands for the time of transferring from X_1 to X_2. In the model, we set xt_{12} obeying the exponential distribution with $\lambda = 1/12, xt_{12} \sim$ Exponential (1/12). xt_{23} stand for the time of transferring from X_2 to X_3.

In Fig. 48.3, Y_n stand for the state of the batteries, $Y_n \in \{1, 2, 3\}$. $Y_n = 1$ means the batteries are in the state of waiting, it means it is an unused new battery.

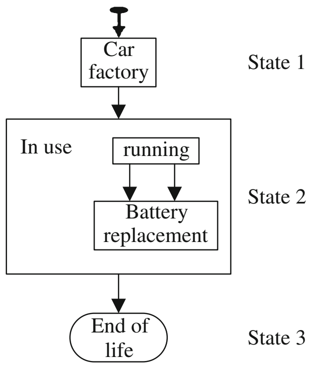

Fig. 48.2 State transition model of electric vehicles

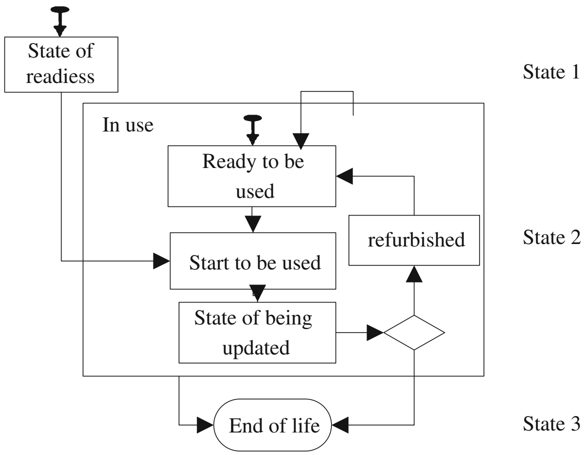

Fig. 48.3 State transition model of batteries

$Y_n = 2$ means the batteries are in use, it is a composite state, including all state changes in Fig. 48.2. $Y_n = 3$ means the batteries have been refurbished more than three times, or be discarded instead of being refurbished.

In the model, it must meet the following conditions before transferring from state $Y_2$to state Y_3:

$$\begin{cases} \text{if } r|3 \quad r \text{ stand for refurbished times of the battery}, r = 0, 1, 2, 3; \\ \text{Transition probability } p_{23} = 0.15 \quad P_{23} = P(Y_n = 3|Yn = 2) \sim \text{Binomial}(1, 0, 15) \end{cases}$$

48.3.2 *Simulation Experiment*

The most widely used secondary batteries with the most mature technology are the lead-acid batteries (LA), its production account for about 90 % of all the secondary batteries (Jianqiang Li 2011). Frequent "excessive blood lead" events occurred in recent years triggered a heavy hit to the lead-acid battery industry leaded by the Department of environmental protection. The lead-acid battery production has reduced, which make the lithium batteries have broad development prospect. In this paper, we set both lead-acid batteries and lithium batteries for example.

The existing literature data shows that the average life expectancy of lead-acid batteries is about 2 years (Hui Wang 2009). The average life of the electric vehicles is about 15 years. The life of the lithium battery is probably about 6 years (Mingjing Nie 2011). Domestic sales of electric vehicles in 2011 are 10,000. Table (48.1.)

48.3.3 Analysis of Simulation Results

For the life of Lithium batteries and Lead-acid batteries varies, the least batteries needed to keep electric vehicles running can be got. At the same time, the number of batteries used in electric vehicles and the number of scraped batteries can be used to study the regulation how electric vehicles consumed batteries.

48.3.3.1 Analysis of Simulation Experiment 1-Lead-Acid Battery

Through modifying the total number of lead-acid batteries, we found that the total number of lead-acid batteries is at least 29,300 to ensure the model running. Therefore, in this paper, there will be 29,300 lead-acid batteries as the basic population parameter of the model. The total number of batteries will increase by 20 and 50 % on this basis to comparatively analyze the battery consumption and scrapped batteries.

1. The number of the batteries is 29,300 in the environment

Under this condition, the curve of the number of total battery consumption, the ones in use and scrapped batteries can be shown in Fig. 48.4.

Battery life and car life are randomly distributed. In order to eliminate the uncertainty, this paper carries out 50 times simulations and make the analysis about them, the results obtained is shown in Table 48.2. M stand for the number of electric vehicles, N stand for the number of batteries production, N_1 stand for the number of battery consumption, N_2 stand for the number of battery used once, and N_3 stand for the number of batteries used twice, N_4 stand for number of scrapped batteries.

2. Comprehensive analysis

There is a comprehensive analysis of the three experiment data to study the impact of changes in battery production and get the data in Table 48.3.

The ratio of electric vehicles and the lead-acid batteries is 1:2.93.Take the change of N_3: N into account, when the 50 % increase in battery production N, and N_3: N will decrease from 0.81 to 0.54 with a change of 27 %, it is moderately sensitive with the sensitivity coefficient of 54 %.

Table 48.1 Parameter settings

Parameter	Value (lead-acid battery)	Value (lithiumbattery)
Number of electric vehicles	10,000	10,000
The life of the electric vehicle	T(13,15,17)	T(13,15,17)
Useful life of Lead-acid batteries for one time	T(1,2,3)	T(5,6,7)
The refurbished rate of used batteries	85 %	85 %

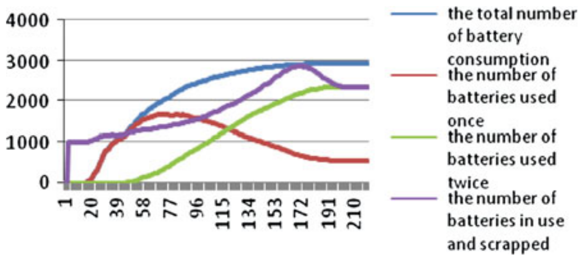

Fig. 48.4 The simulation curve of battery consumption

Table 48.2 Analysis of simulation results

Variable	Battery consumption (N_1)	Batteries used once (N_2)	Batteries used more than once (N_3)	The craped batteries (N_4)
Mean of the Samples	29,183	5,643	23,540	23,275
Sample standard deviation	34.30	141.10	142.18	339.01
Sample average error	4.85	19.96	20.11	47.94
t value	2.01	2.01	2.01	2.01
Confidence interval	9.75	40.10	40.41	96.35

Note: Simulation times is 50, confidence level is 95 %

Table 48.3 Comprehensive analysis of changes in battery production

Lead-acid battery production (N)	M:N	N1:N	N2:N	N3:N	N4:N
N = 29,300 (+0)	1:2.93	1.00	0.19	0.81	0.80
N = 35,160 (+20 %)	1:3.516	0.97	0.31	0.69	0.56
N = 43,950 (+50 %)	1:4.395	0.90	0.46	0.54	0.40

48.3.3.2 Analysis of Simulation Experiment 2-Lithium Battery

In the same way with the simulation experiment 1, there is a comprehensive analysis and we get the data in Table 48.4.

We can see that the most environmentally friendly ratio of electric cars and lithium battery is 1:1.36. Take the change of N3: N into account, when the 50 % increase in battery production N, and N3: N will decrease from 0.48 to 0.18 with a change of 30 %, it is moderately sensitive with the sensitivity coefficient of 60 %.

48.3.3.3 Realistic Effects

"The development plan of energy-saving and new energy automotive industry (2012–2020)" defines the development target of the new energy vehicles: To 2020, the cumulative production is over 5 million. The number of batteries 5 million electric vehicles consume is shown in Table 48.5.

Table 48.4 Comprehensive analysis of changes in battery production

Lead-acid battery production (N)	M:N	N_1:N	N_2:N	N_3:N	N_4:N
N = 13,500 (+0)	1:1.36	1.00	0.52	0.48	0.22
N = 16,320 (+20 %)	1:1.63	0.95	0.70	0.30	0.20
N = 20,400 (+50 %)	1:1.2.04	0.83	0.82	0.18	0.18

Table 48.5 The battery consumption of 5 million electric vehicles (unit:10,000)

	Battery consumption (N_1)	Batteries used once (N_2)	Batteries used more than twice (N_3)	The craped batteries (N_4)
Lead-acid battery	1459.64	284.15	1179.03	1168.57
Lithium battery	678.08	356.22	322.46	152.08

48.4 Conclusions

In this paper, we get the ratio of electric vehicles and lead-acid batteries is 1:2.93 and the ratio of electric vehicles and lithium batteries 1:1.36. The two scale factors have the practical significance for battery production planning. We get the following conclusions:

1. The battery production affects the total number of scrapped batteries

It can be seen from Tables 48.4 and 48.5, with the increase of battery production, the total number of battery consumption and the number of the scrapped batteries will increase. This is due to that some batteries were directly abandoned before they are fully refurbished, which is unfavorable to our environmental policy. Therefore, it is important to determine the production of the batteries according to the number of electric vehicles on the market and make plans for producing batteries.

2. The lithium battery is more environmentally friendly than lead-acid battery

If in China the cumulative production of electric vehicles in 2020 is five million, lead-acid batteries will reach 14.6 million, the lithium battery production is to reach 6.8 million, which apparently has 53.4 % reduction compared with lead-acid batteries. The ratio of the number of scrapped batteries and the number of lithium battery consumption is 0.22, which is much smaller compared with 0.80 of lead-acid batteries. However, the lithium battery technology is not mature and the price of lithium batteries is relatively higher than lead-acid batteries. Therefore, making more effort to the lithium battery research is very important to the significant popularity of electric vehicles and our energy-saving environmental protection.

3. In the present model, some data cannot be obtained temporarily were not considered due to the emerging area of electric vehicle,which needs more study.

(1) The distribution function of the life of electric vehicles and battery life need to be studied, which is assumed to obey the triangular distribution here.
(2) The annual production of electric vehicles is a dynamic process of change, which cannot be reflected in the agent-based model, how to overcome this problem of agent-based model in combination with other methods needs further study.
(3) In this paper, in order to simplify the calculation, battery in each electric vehicles is set to one, how to calculate the batteries in an electric vernicle in a more scientific and rational way needs further analysis.

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1. Project supported by Beijing Education Commission: An optimization research on Beijing Railway Station and urban transit system by simulation.
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Chapter 49
Low-Carbon Scenario Analysis on Urban Transport of a Metropolitan of China in 2020

Xiaofei Chen and Zijia Wang

Abstract This article discussed possible ways of implementing effective energy conservation and GHG emission reduction measures by providing: the forecasts of mid-to-long term city-wide carbon emission rate; and the analysis of potential low-carbon transport solutions. According to the characteristics of the transport system in a metropolitan in China, the comprehensive carbon emission calculation model established in this article includes road traffic and urban rail transit. Existing data were utilized with regression analysis to project the prospective traffic data in the baseline scenario at the target year of 2020 to calculate the emission amount. Four low-carbon scenarios were set in accordance with the goal of "low carbon transportation, green trip", and the effectiveness of each low-carbon scenario was evaluated by comparing them with the baseline scenario in terms of the respective GHG emission rate. The mode switching that increases the ridership of urban rail transit turned out to be the most effective outcome.

Keywords Low carbon transport · Carbon emission · Scenario analysis · Forecasting · Energy conservation and emission reduction

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49.1 Introduction

In China, the negative environmental consequences caused by GHG emissions from transport sector in metropolitan regions grow rapidly along with continuous urbanization process. At the stage of high-speed economic development, the household consumption level in a metropolitan in China rises quickly, resulting in dramatic increase in overall urban residential trips, which in return, increase the carbon emission rate in urban passenger traffic. In fact, the total GHG emissions volume stays at a very high level, despite the recent achievements from traffic and purchase restrictions imposed upon household automobile and actions that encourages the development of rail transportation. Setting up baseline and relevant policy-supported low-carbon scenarios to forecast total GHG emissions from transport industry in this metropolitan and evaluating the effectiveness of implementing certain energy conservation and emission reduction policies such as "public transit priority" are of great significance to this metropolitan and also China for coming up with a successful strategy to control the GHG emissions and to assume its commitment to international emission reduction obligations.

49.2 GHG Emissions Calculation Model of Transport Section of the Metropolitan

Firstly, the calculation model for each fuel category of urban transport was formulated to obtain the overall energy consumption. In accordance with the terminal consumption of each energy resource, the calculation method was established as follows.

For diesel fuel:

$$E_{diesel} = Q_f e_f + N_{d-bus} S_{d-bus} e_{d-bus} \tag{49.1}$$

where E_{diesel} refers to consumption of diesel fuel, Q_f for ton kilometre travelled per year (ton·km), e_f for fuel economy (L/(ton·km)) (Jia et al. 2009), N_{d-bus}, S_{d-bus}, e_{d-bus} for vehicle population, kilometres travelled per year (km), and fuel economy (L/km) of diesel buses, respectively.

For gasoline:

$$E_{gasoline} = \sum_{i=1}^{3} (N_i S_i e_i) \tag{49.2}$$

where $E_{gasoline}$ refers to gasoline consumption, i for relevant vehicle category, including taxis, private cars and cars owned by enterprises and public institutions, N_i for vehicle population of vehicle category i, S_i for km travelled per year of vehicle category i, e_i for fuel economy of vehicle category i (L/km).

For compressed natural gas:

$$E_{gas} = N_{g-bus} S_{g-bus} e_{g-bus} \tag{49.3}$$

where $N_{g-bus}, S_{g-bus}, e_{g-bus}$ refers to vehicle the population, kilometre travelled per year (km), and fuel economy (kg/km) of compressed natural gas driven buses, respectively.

While for electricity consumption:

$$E_e = N_{e-bus} S_{e-bus} e_{e-bus} + E_{illu} + \sum_{j=1}^{n} E_{j-vehicle} + \sum_{j=1}^{n} \sum_{k=1}^{n} E_{jk-station} \tag{49.4}$$

where $N_{e-bus}, S_{e-bus}, e_{e-bus}$ denotes the vehicle population, kilometre travelled per year (km), and fuel economy (kg/km) of electricity-based buses, respectively; E_{illu} for electricity consumed by road illumination system, which is recorded by power department, and $E_{j-vehicle}, E_{jk-station}$ refer to the vehicle energy consumption of rail line j and the station energy consumption of station k in rail line j, respectively.

Using the energy consumption obtained through the above model and the CO_2 emission factor of each fuel category in ICPP, in combination with the proportion of coal electricity out of overall electricity supply and CO_2 emission factor for electricity generation in the grid, the overall GHG emissions of urban transport of this metropolitan can be calculated with the following model:

$$C = \sum_{i=1}^{3} (E_i \times EF_i) + (E_e \times \zeta \times \psi) \tag{49.5}$$

where C denotes the overall GHG emissions of urban transport per year; E_i stands for consumption of fuel category i, including diesel fuel, gasoline, compressed natural gas (L or kg); EF_i is the emission factor for fuel category i (kgCO_2/L or kg CO_2/kg); E_e refers to electricity consumption of urban transport of this metropolitan, including consumption of electricity-based buses, road illumination system and urban rail transit system (k·Wh); ζ denotes the sharing of coal electricity out of overall electricity generated in the grid, which is 81.81 % (China electricity council 2011); ψ is CO_2 emission factor for coal electricity during generation stage in the grid (Ma 2002) (CO_2 kg/k·Wh).

49.3 Scenario Analyses on GHG Emissions of Urban Transport of the Metropolitan in 2020

49.3.1 Baseline Scenario

In terms of the projected calculation data obtained above, with the rail transit network planning details and passenger volume forecasting, the GHG emissions of baseline scenario for the transport of this metropolitan in target year 2020 was projected, which is 30.085 million tCO_2.

49.3.2 Low Carbon Scenarios

(1) Scenario 1: More strict control on vehicle population

The vehicle population of non-operating cars will reach 5.96 million in 2020 under the baseline scenario. It is necessary to hold more strictly control on vehicle population's growth so as to make sure the population of private cars and buses in is controlled at 5.5 million in 2020. In that case the GHG emissions of transport will be 28.203 million tCO_2, with emission reduction of 1.882 million tCO_2, or 6.26 % compared to the baseline scenario.

(2) Scenario 2: Decrease average trip distance

Optimization of urban layout will result in gradual decrease in average residential trip distance. In the baseline scenario, the average trip distance of non-operating cars is 10.78 km; and that of rail transit is 16.35 km. Relevant low-carbon scenario is set as: average trip distance of private car is 8 km, whereas the average trip distance of rail transit is 12 km. Under this situation, the GHG emissions of transport will be 25.648 million tCO_2, with emission reduction of 4.437 million tCO_2 or 14.75 compared to the baseline scenario.

(3) Scenario 3: Increase the ridership of public transport

In the baseline scenario, the structure of the traffic of this metropolitan is: the ridership of buses is 28.9 %, urban rail transit accounts for 10.0 %, taxis occupies 7.1 %, and the ridership of non-operating cars is up to 34.0 %.

Under the guidance of the "public transit priority" policy, with the rapid development of rail transit network in this metropolitan, the ridership of public transport modes, especially that of rail transit, will rise sharply. Accordingly, the low-carbon scenario is set as following: In 2020, the ridership of public transportation is up to 50 %. Specifically, the ridership of buses is 20 %, urban rail transit 30 %, taxi 5 %, and bicycles 25 %. In contrast, use of private cars decreases to 15 %, while the rest share of trip is assumed by walking. In terms of the scenario setting, GHG emissions in 2020 will be 23.426 million tCO_2, achieving a decrease of 6.659 million tCO_2 (Table 49.1).

Table 49.1 Comparison of scenarios 1, 2 and 3

Scenarios	Baseline scenario	Low-carbon scenario 1	Low-carbon scenario 2	Low-carbon scenario 3
GHG emissions (million tCO_2)	30.085	28.203	25.648	23.426
Emission reduction (million tCO_2)	/	1.882	4.437	6.659
Proportion (%)	/	6.26	14.75	22.13

49.4 Conclusion

The article completed the following researches and reached the corresponding conclusions:

(1) Under the current developing trend in policy environment and technical specifications, the total projected GHG (CO_2) emissions from transport sector at 2020 in the researched metropolitan of China will reach 30.085 million tCO_2; private-vehicle is the major contributor among all transport modes at 16.89 million tCO_2.

(2) As indicated by the analysis of low carbon scenarios, limiting the growth in private-vehicle ownership, reducing the frequency of mid-to-long range travel and the average trip distance, and prompting the public transit oriented policies are all possible solutions to reduce carbon emission. The most effective practice involves a shift in public travel behaviour.

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Chapter 50
Impact Study of Carbon Trading Market to Highway Freight Company in China

Li Chen, Boyu Zhang, Hanping Hou and Alfred Taudes

Abstract This paper studied the influence of the introduction of carbon trading system to small size highway fright transport companies in China based on cost-benefit analysis. Considering a carbon trading market consists of large number of identically small size companies, where each company is distributed the same amount of carbon credits for free and could sell or buy extra credits from the market. If the market is perfectly competitive, it will reduce the profit of the companies in the long run. The government could regulate the profit indirectly by free carbon credits and penalty for over emission.

Keywords Carbon trading · Carbon market · Highway freight transport

50.1 Introduction

Transport industry is one of the most important industries for developing Low Carbon Economy because of its high carbon intensity. Since 2009 China started to pay great attention on the development of low carbon transport. In February 2011

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Transport Ministry of China published "the guiding opinions of establishing low carbon transportation system" report, which stated the targets and assignment of low carbon development for transport industry. According to the report, the targets of CO_2 emission intensity reduction of road transport during 12th Five-Year are energy consumption per transport turnover of commercial vehicles decreased by 10 % by 2015 compared to 2005, of which passenger vehicles decreased by 6 % and cargo vehicles decreased by 12 %.

In order to achieve the goals of CO_2 emission reduction of 12th Five-Year's plan, several low carbon policies have been taken into effect. For example, fuel economy standards, motor vehicle license auction, motor vehicle limit line measures etc. However, there are no market-based policies in China.

In such context, this paper will conduct a detailed study in highway freight industry and demonstrates different degrees of carbon trading system impact to a single enterprise. The paper is organized as follows: Sect. 50.2 introduces the carbon trading schemes; Sect. 50.3 presents the effects of carbon trading scheme on road freight transport company, and demonstrates the company's optimal strategy under different situation; Sect. 50.4 analyzes the equilibrium price in the carbon trading market; Sect. 50.5 offers suggestion of regulation measurements to the government; and Sect. 50.6 concludes.

50.2 The Model

50.2.1 Carbon Trading Schemes

In accordance with many recent carbon market scheme proposals in China (Zhuang 2006), (Fu 2009), (Lewis 2010), this study follows the carbon trading regulations of EU ETS. According to EU ETS, carbon trading schemes can be taken out through two types. European Union Allowances (EUAs) are permits (called carbon credits) created and distributed under cap and trading (cap-and-trade) scheme which operates under the Kyoto Protocol. Companies receive carbon credits from their national allowance plans and the total quantity of credits is administered by EU state governments. Another type of carbon trading schemes is project based trading which is generated from projects that reduce greenhouse gas (GHG) emissions compared to a no-project scenario. Clean Development Mechanism (CDM) and Joint Implementation (JI) initiative are the two project based trading systems of EU ETS. CDM allows industrialized countries with a GHG commitment to invest in emission reducing projects in developing countries, such as China, India and Brazil. JI credits are from the projects which are cooperated within and implement in industrialized countries.

By 2009, Chinese road freight market comprised of more than 42,92,000 transport companies but lack of scale. Each company had only 1.7 trucks on average and 41 % of them had exactly one truck (Chen et al. 2011). In order to integrate with Chinese realities and keep the model simple, we only consider the cap-and-trade scheme where subjects are small size companies, but do not include project based trading schemes.

Assume that the road freight market consists of identically small size transport companies, where each company is distributed the same amount of carbon credits for free and could sell or buy extra credits from the carbon trading market. If a company emits CO_2 that exceeds what is permitted by its credits, then a penalty will be charged for the over emission.

50.2.2 Road Freight Market

Considering a highway freight market consists of large numbers of identical small size companies and assuming that these companies satisfy the following four assumptions:

(i) Perfect information: companies have perfect information for both the road freight market and the carbon trading market, which means freight rate and carbon credit price are known to all companies.
(ii) Perfect rationality: companies aim to maximize their profits, and they can make profit from road freight as well as carbon credit trading.
(iii) Identical service: each company has the truck with same load capacity T-ton and provides homogeneous service.
(iv) Identical cost: companies have the same operating cost C Yuan per ton-km.

From (i) and (ii), in a perfect information market which consists of many rational companies, homogeneous products have a unique equilibrium price (Nicholson and Snyder 2008). In the road freight market, both freight rate and operating cost are approximately linearly dependent on the distance travelled and the gross weight of the truck, as well as the CO_2 emissions (Forkenbrock 1999). Suppose that the equilibrium price of the road freight market is B Yuan per ton-km, and a truck emits E ton CO_2 per ton-km. Therefore, each company can gain net profit $p = T \times (B - C)$ Yuan per km, and produces $T \times E$ ton CO_2 emissions. Non-transportation emissions (e.g., from buildings or office work) are excluded in this paper since the percentage of non-transportation emission in total emissions of a company is very small (McKinnon and Piecyk 2009). In sum, a road freight market could be characterized by parameters p, T and E.

Following the four assumptions, in the case without carbon trading system, company strategy can be simply described by the monthly distance travelled d and net profit p. For instance, monthly profit of a company using strategy d is

$$P(d) = dp \tag{50.1}$$

Clearly, $P(d)$ is monotonically increasing in distance. Suppose a truck can run at most D kilometers per month under the limits of driving hours and speed. Therefore, a rational company ought to run the maximum distance in order to achieve the optimal payoff $P(D) = Dp$. The CO_2 emission is DTE ton.

50.2.3 Carbon Trading System

Under a carbon trading system, each company must have carbon credits for CO_2 emission, where the amount of credits specifies the maximum weight of CO_2 emissions that the company is allowed to emit per month. Since the government intends to reduce the current emission level, supposing that each company is distributed *N* carbon credits for free, *N* is less than *DTE*. In addition to the credits given by the government, companies can buy or sell extra credits through the carbon trading market. *z* denotes the price of a unit carbon credit which allows company emits 1 ton CO_2 per month. If a company produces CO_2 emission more than permitted, a penalty will be charged at rate of *y* Yuan per ton for extra emission. Therefore, the state of a carbon trading system can be described by a vector of three variables (*N*, *y*, *z*), where *N* and *y* are set by the government and *z* is regulated by the market.

In order to calculate the incremental cost caused by the carbon trading system, we further make two assumptions (Hourcade et al. 2007).

(v) No transaction fees means that transaction fees for carbon credits are negligible.
(vi) Invariant road freight market means that parameters *p*, *T* and *E* are constant and do not change with the carbon trading system (*N*, *y*, *z*).

Assumption (vi) implies that small size companies are unable to reduce the CO_2 emissions or operating costs by improving their technologies or trucks, and can not affect the freight rate of the road freight market, and are not allowed to pass the incremental cost to consumers. Therefore, all carbon market related incremental cost is the burden to companies and reflected by changes of their profits.

With the carbon trading system, the strategy of a company could be defined by (*d*, *n*), where *d* represents the monthly distance travelled and *n* is the amount of carbon credit transactions, where $n > 0$ means that the company buys *n* carbon credits from the market and $n < 0$ means selling the carbon credit. Therefore, a company using strategy (*d*, *n*) is allowed to emits $N + n$ ton CO_2 per month, and actually produces *dTE* ton CO_2 emission. A rational company will not keep the extra carbon credits since selling the rest credits can increase profits. Hence, variables satisfy $0 \leq N + n \leq dTE \leq DTE$.

For given road freight market (*p*, *T*, *E*), the impacts of carbon trading system to a small size transport company could be analyzed through a payoff function of the company strategy (*d*, *n*), the government policy (*N*, *y*) and the carbon credit price *z*

$$P((d,n),\ (N,y),z) = dp - nz - (dTE - N - n)y \tag{50.2}$$

Where *dp* is the profit from road freight transport, *nz* is the cost (income) of carbon credit transaction and (*dTE-N–n*)*y* is the penalty for over emission.

50.3 Strategies of Companies

In a perfectly competitive carbon credits market which includes large numbers of companies and carbon credits, the price z will not be affected by the decision of a single company. Therefore, we rewrite Eq. (50.2) as

$$P_{(N,y,z)}(d,n) = d(p - TEy) + n(y - z) + Ny \tag{50.3}$$

Where $E_{(N,\ y,\ z)}$ (d, n) denotes the payoff to a company using strategy (d, n) in a carbon trading system (N, y, z).

Denote the strategy that leads to the optimal payoff by (d^*, n^*), we call it the best response to state (N, y, z). Notice that $P_{(N,\ y,\ z)}$ (d, n) is a linear function of d and n, for any given (N, y, z), the best response strategy is unique and the values (d^*, n^*) are decided by the sign of $(p - TEy)$ and $(y - z)$. According to the order of p/TE, y and z, there are three different cases.

(a). If $y > p/TE$ and $z > p/TE$, the best response strategy is $(d^*, n^*) = (0,-N)$, which means the company stops transport operating and sells all its credits. In this case, the income is entirely from the carbon transaction, and the company gets profit $P_{(N,\ y,\ z)}$ $(0,-N) = Nz$.

(b). If $y > z$ and $p/TE > z$, the best response strategy is $(d^*, n^*) = (D, DTE - N)$, which means the company maximizes the distance and buys carbon credits for its extra emission. In this case, the payoff is $P_{(N,\ y,\ z)}$ $(D, DTE - N) = Dp - (DTE - N)z$, which is always less than the optimal profit without the trading system, Dp.

(c). If $p/TE > y$ and $z > y$, the best response strategy is $(d^*, n^*) = (D,-N)$, which means the company maximizes the distance but sells all the credits. In this case, the company pays the penalty for its emission but earns money from both the freight transport and carbon trading. The profit is $P_{(N,\ y,\ z)}$ $(D, -N) = Dp - DTEy + Nz$.

50.4 Equilibrium Credit Price

In the carbon trading market, transport companies are both buyers and sellers and the price of a carbon credit is decided by demand and supply. Since these companies are identical, they have the same best response strategy. In cases (a) and (c) where the price z is larger than p/TE or y, the companies tend to sell their credits which result in the decrease of price. On the other hand, in case (b) where z is less than both p/TE and y, the companies are willing to buy credits which will increase the price. Equilibrium price of the carbon trading market is the price when carbon credit demand equals to the supply. Therefore, the unique equilibrium is $z^* = \min\{p/C, y\}$, which means the price of unit carbon credit equals to the smaller one of the transport profit and the penalty.

At this equilibrium, all companies have the same payoff

$$P((d*, n*),\ (N, y), z*) = Dp - DTEy + Nz* \tag{50.4}$$

and no company can get higher by changing its strategy while the others keep theirs unchanged. Notice that parameters in Eq. (50.4) satisfy $N < DTE$ and $z^* \leq y$, we have $P((d^*, n^*), (N, y), z^*) < Dp$. As a result, although a company may gain higher payoff from carbon trading in some situations, such as in cases (a) and (c) in Sect. 50.3, the long run profit is always reduced by the system.

50.5 Government Regulation

Equation (50.4) implies that the benefit of the transport companies at the equilibrium price is entirely decided by the government policy (N, y). For convenience, denote $P((d^*, n^*), (N, y), z^*)$ by $P^*(N, y)$. If $y < p/TE$, $z^* = y$ and the payoff function is written as $P^*(N, y) = Dp - (DTE - N)y$. Notice that $DTE > N$, $P^*(N, y)$ is linearly decreasing in the penalty y and linearly increasing in the amount of free carbon credits N. On the other hand, if $y > p/TE$, $z^* = p/TE$ and the payoff function is written as $P^*(N, y) = Np/TE$. In this case, the payoff is independent of y but linearly increasing in N.

Therefore, the government can regulate the carbon credit price by changing the penalty y in interval $[0, p/TE]$. However, the regulation carbon credit price is not effective when $y > p/TE$. Because then the penalty is higher, and the price will stabilize at the transport profit per unit CO_2 emission. In both cases, the company's average profit can be improved by increasing the free carbon credits.

50.6 Conclusion

Based on the analysis in Sects. 50.3–50.5, this paper found that when the transport profit per unit carbon emission is less than the penalty of extra emission per unit and the price of unit carbon credit, the optimal strategy of the transport company will be to stop road transport operations and sell all the carbon credits. In contrast, when the transport profit per unit carbon emission is higher, the optimal strategy is to maximize the transport distance, and sell the distributed carbon emission credits if the penalty of extra emission per unit is less than the price of unit carbon credit,

If the carbon trading market is a perfectly competitive market, the carbon trading system will always reduce profit of small size transport company in the long-term. It's because when the supply meets the demand in the carbon market, the market price of carbon credit z^* will tend to stabilize to the equilibrium $z^* = \min\{p/TE, y\}$. The profit of highway freight company in the market is equal to the previous profit minus the cost of carbon trading, therefore, the carbon trading system will always reduce long-term profit of small transport companies.

The government can regulate the long-term profit of the small highway freight companies through free carbon emission credit and carbon emission fines. On the one hand, the government can improve the company's average profit by the increase of free carbon emission credits. On the other hand, when the extra emission penalty is less than the profit of the transportation per unit carbon emissions, reducing the punishment can also increase company's total profit. However, when the penalty is higher than the net transport profit, the second regulation method will no longer be effective.

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Chapter 51
The Importance and Construction Measures of Chinese Low-Carbon Transportation System

Xinyu Wang and Yurong Gong

Abstract With the rapid development of transportation industry and China's economy, the construction and development of low-carbon transportation system is an important support to the development of low-carbon economy and sustainable economy in China, and is the only way to realize the low-carbon and sustainable development of the transportation of the transportation industry. Based on the existing problems in the transportation system, the article analyses the importance of developing the low-carbon transportation system, and propose measures of establishing the low-carbon transportation system.

Keywords Low-carbon transportation system · Energy · Development

51.1 The Importance of Chinese Low-Carbon Transportation System

Transportation industry is the second large oil consumption industry, and China's low carbon energy saving key industries. In 2009, China had become the world's largest car producer. The automobile purchasing and consumption quantity is ranked first in the world. Rapid growth in automobile production and consumption stimulate and promote the huge domestic market demand potential, increase the

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fossil resources consumption and utilization. With the development of automobile industry, transportation energy consumption increases. At present it has already accounted thirty percent of the total energy demand Jun (2010). Therefore, construction and development of low-carbon transportation system can make the transportation industry to minimize the energy consumption and energy saved, emission reduced and scientific development, also it is the objective demand and inevitable choice for promoting the transportation industry's sustainable development.

51.1.1 The Development and Construction of Low-Carbon Transportation System can Save Energy and Reduce Energy Consumption

The transportation industry's energy consumption is high, energy consumption in national energy consumption accounted for a high proportion. With the development of economy, the traffic transportation industry energy consumption ability appears an upward trend. During the period of the 11th Five-Year Plan, the transportation industry energy consumption growth rate is higher than that of the whole society energy consumption growth rate all the time, except the year of 2006 and 2007 Zhou (2010). Since 2010, the growth rate started to get larger. In this context, development and construction of low carbon transportation system, has a positive significance, no matter for the transportation industry or for the macro economy situation.

51.1.2 The Development of Low-Carbon Transportation System is Our Country's Active Response to Global Climate Change

Vehicle exhaust is an important factor, leading to air pollution and climate change. At present, as clean energy is still not been large-scale promoted, diesel oil and gasoline is still the main fuel for transportation. For example, automobile exhaust fumes will contain much harmful substances, its composition is very complicated, more than 100 species, including carbon monoxide, hydrocarbons, nitrogen oxides, suspended solid particles and so on. According to statistics, the harmful gas discharged by a car a year is 3 times greater than the car's weight. According to the department of transportation prediction, by 2020 the number of China's private cars will exceed 100 million and exhaust quantity will be very great. Vehicle exhaust emission has become one of the main sources of pollution of China's major city. Exhaust pollution caused by vehicle increasingly affects the life of people.

Now, China's various types of vehicle average fuel consumption per 100 km is larger than the developed country over 20 %. Besides, China's per capita energy amount is very low. However, traffic transport industry's development needs energy support. Effective conservation and rational using of energy is not only related to the sustainable development of transportation industry, but also related to the safety of energy resource in China. Therefore, to reduce transportation energy consumption, reduce environmental pollution, build and develop low carbon-transportation system has become the primary task faced by China's transportation industry's development.

51.1.3 Development and Construction of Low-Carbon Transportation System is Transportation Industry's Inevitable Choice to Make Sustainable Development Come True

Since 2000, China's transportation industry gets quick development. Electric railway's length grows from 14,900 km in 2,000 to 36,200 km in 2010 and freeway's length develops from 16,300 to 74,100 km. Waterway and the pipeline transportation have also been developed rapidly. But, the sustainable development ability of the transportation industry is faced with grim challenge. According to the statistics, China's highway, waterway transportation energy consumption accounts for over 1/3 of the total national petroleum consumption, it has already become the main source of green gases and air pollutions. Transportation energy utilization rate is obviously lower compared with developed countries in the world. With the investment that the state gives to the transportation industry increases and a variety of modes of transportation develops, energy consumption will increase gradually. To accelerate the construction of low-carbon transportation system is in urgent need.

51.2 The Construction Measures of Chinese Low-Carbon Transportation System

51.2.1 To Adjustment the Transportation Tools Combination and Energy Consumption Structure and to Develop the Low-Carbon or Carbon Free Transportation Tools

Transportation tools are the protagonist to realize the construction of low carbon transportation mode, we should construct the inland waterway infrastructure, including water, groundwater, rivers and lakes, improve the proportion waterway transport accounted in an integrated transport, produce waterborne energy-saving emission reduction effect Dai (2009). We should pay attention to the seamless joint between water, land, air transportation. On the combination of transportation, we should develop the low carbon or carbon free transportation tools, including city subway, light rail, bicycle, electric railways and other low carbon of carbon free public transportation tools. At the same time, we also should adjust the energy consumption structure in the transportation system, change the petrochemical energy utilization structure gradually to realize low carbon clean energy driving of the transportation system Table 51.1.

51.2.2 To Strengthen Energy-Saving Emission Reduction Research and Develop Traffic Low Carbon Technology

The low carbon technology in the transportation area refers to the new technology that can efficiently control greenhouse gas emissions existing in various links of transportation. The low carbon technology can be divided into two types: one is the carbon reduction technology, refers to energy saving and emission reduction technology, such as the clean and efficient utilization of coal, oil and gas resources and the coalbed gas exploration and development, focusing on improving energy efficiency. The second class is carbon removing technology, typical is carbon capturing and storage, carbon dioxide recovery and utilization of polymerization.

Table 51.1 Transportation line odometer of five transportation ways

	Railway		Road		Waterway	Airport		Pipeline
	Total mileage	Electric mileage	Total mileage	Highway	Inland waterway	Total mileage	International line	Oil and gas mileage
2000	6.87	1.49	140.27	1.63	11.93	150.29	50.84	2.47
2001	7.01	1.69	169.80	1.94	12.15	155.36	51.69	2.76
2002	7.19	1.74	176.52	2.51	12.16	163.77	57.45	2.98
2003	7.30	1.81	180.98	2.97	12.40	174.95	71.53	3.26
2004	7.44	1.86	187.07	3.43	12.33	204.94	89.42	3.82
2005	7.54	1.94	334.52	4.10	12.33	199.85	85.59	4.40
2006	7.71	2.34	345.70	4.53	12.34	211.35	96.62	4.81
2007	7.80	2.40	358.37	5.39	12.35	234.30	104.7	5.45
2008	7.97	2.50	373.02	6.03	12.28	246.18	112.0	5.83
2009	8.55	3.02	386.08	6.51	12.37	234.51	91.99	6.91
2010	9.10	3.62	400.82	7.41	12.42	276.5	107.0	8.5

Unit ten thousand kilometers

51.2.3 To Develop Bicycle and Bicycle Pedestrian System Actively, and Improve the Bicycle Service Industry's Level

Firstly, we should establish dedicated bicycle road system, improve the pedestrian system, making the motor vehicle and non-motor vehicle shunting to provide a safe, comfortable, efficient bicycle traffic environment.

Secondly, we should establish and improve bicycle rental and service network. For example, in Denmark Odense bicycle service industry is very developed, cyclists enjoy numerous "convenience", Bremen 42 bicycle club sites are densely covered high streets and back lanes, replacing 1,000 private cars. Improving bicycle rental and service network is the guarantee of low carbon (zero carbon) traffic or the foundation of the realization of public transportation modes Xiong (2010).

51.3 Conclusion

The development of transportation industry needs the support of energy, effective conservation and rational using of energy, is not only related to the sustainable development of transportation industry, but also related to the safety of energy resource in China. Transformation the transport development mode and development of low power consumption mode of transport has already become the key and main content of controlling the deterioration of the environment, alleviating zoology pressure, building a resource-saving, environment-friendly society, stimulating person and natural's harmonious development.

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Chapter 52
Planning Model of Optimal Modal-Mix in Intercity Passenger Transportation

Makoto Okumura, Huseyin Tirtom and Hiromichi Yamaguchi

Abstract Environmentally sustainable transportation becomes an important issue as well for intercity passenger transportation, where modal shifting from energy consuming airline and bus service to energy efficient high speed railway is the most feasible measure. But due to the less flexibility and fixed to locations of railway improvements, strategic redistribution of network-wide demand onto the improving rail lines is required (Okumura and Tsukal 2007). This paper presents an optimal modal-mix planning model in intercity passenger transportation, which aims to design a modal mix network of least CO_2 emissions and less total travel time, as well as less intermediate transfer cost, considering feasibility and economical sustainability of the service frequency. The proposed model is formulated as a mixed integer linear programming model, which can be numerically solved by general solver programs.

Keywords Modal-mix · Intercity transportation · Network design · Sustainability

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52.1 Introduction

Environmentally sustainable transportation concept was first proposed by OECD as urban transportation and urban planning context, but recently discussion were going on intercity passenger transportation field as well, for example EU's idea of high speed railway service substitution of shorter feeder airline service. Considering large difference of energy intensity and unit CO_2 emissions, we can say that modal shifting from energy consuming airline and bus service to energy efficient high speed railway is the most feasible measure (Meng and Wang 2011).

We want to check such possibility of strategic redistribution of network-wide demand onto the improved rail lines, and resulted reduction of energy-use and CO_2 emissions. This paper presents an optimal modal-mix planning model in intercity passenger transportation, which aims to design a modal mix network of least CO_2 emissions and less total travel time, as well as less intermediate transfer cost, considering feasibility and economical sustainability of the service frequency.

52.2 Outline of Planning Problem

As the objective of network design problem, total travel time, total generalized cost, asset cost, as well as total CO_2 emissions can be considered (Andersen et al. 2009). In order to formulate a multi-criteria optimization problem, a single objective function is often synthesized by weight parameters for each single component objective (Balakrishnan et al. 1997). Recently, minimax problem which minimize the largest unsatisfactory level in several objective component was formulated into linear minimization function (Chang et al. 2000).

This paper considers the problem of finding multi-modal route traffic flow shares for given OD traffics and necessary rail, bus and air frequencies on each link which minimize total CO_2 emissions. In order to avoid too long detouring of passengers and too many transfers between different modes, we consider total travel time and total transfer cost of passengers as other objective components to be minimized. In order to secure the feasibility and economical sustainability of the service frequency on each link, we set the frequency providing enough capacity for the assigned traffic flow on the link. Furthermore, the assigned passenger numbers on that link must be larger than the required passenger number to sustain the frequency level.

52.3 Model Formulation

52.3.1 Variables and Parameters

In our network design, each city is represented by a node n $(n \in N)$ and connecting arcs between nodes i, j through different modes m $(m \in M)$ are indicated by

$(i,j) \times m \in A$. In order to express transit connection between modes explicitly, each node is divided into arrival node by mode m as $n_- \times m$ and departure node by mode m' as $n_+ \times m'$, and transit arc between them is indicated by $(m,m') \times n$. Also, amount of OD traffic between zones $(k,l) \in K \times K$ is given by T_{kl}. Endogenous and exogenous variables are explained in Table 52.1.

52.3.2 Objective Function and Minimax Problem

In this model, we pick up total passenger travel time P, total passenger transit cost Q and total CO_2 emissions associated with transport operations V as the objective components to be minimized:

$$P = \sum_i \sum_j \sum_m t_{ij}^m \sum_k X_{ij}^{km} \tag{52.1}$$

$$Q = \sum_n \sum_m \sum_{m'} \tau_n^{mm'} \sum_k Y_n^{kmm'} \tag{52.2}$$

$$V = \sum_i \sum_j \sum_m c_{ij}^m F_{ij}^m. \tag{52.3}$$

These 3 objective components are not suitable for integration because their scales are different. Therefore, we set new p, q, v values below to be scaled down between 0 and 1 by using ideal values P^*, Q^*, V^* and evaluation values P_0, Q_0, V_0.

$$p = \frac{P - P^*}{P_0 - P^*}, q = \frac{Q - Q^*}{Q_0 - Q^*}, v = \frac{V - V^*}{V_0 - V^*} \tag{52.4}$$

Here, in order to optimize all of three objectives, we consider minimax problem by the introduction of λ representing the most inferior objective, and sufficiently small positive constant ε, as follows:

Table 52.1 Endogenous and exogenous variables

Variable	Explanation
X_{ij}^{km}	Traffic amount on an arc originated from node k by mode m
$Y_n^{kmm'}$	Amount of transit passengers from mode m to m' at node n
B_k^m	OD trips originated from node k using mode m
A_n^{km}	OD trips between k and n using mode m
Z_{ij}^m,F_{ij}^m	Existence of service and frequency on an arc for mode m
t_{ij}^m	Travel time on an arc for mode m
$\tau_n^{mm'}$	Transit cost between modes m and m'
h^m,g^m	Seat capacity and max. operable frequency of mode m
c_{ij}^m	CO_2 emissions per one service/flight on an arc
d_{ij}^m and e_{ij}^m	Fixed and variable cost of maintaining service on an arc

$$\min_{X,Y,B,A,Z,F} \lambda + \varepsilon(p+q+v),\ p \leq \lambda,\ q \leq \lambda,\ v \leq \lambda \tag{52.5}$$

52.3.3 Constraints

First, we describe the conditions for the preservation of traffic amount. Regarding to the arriving traffic at each node n, the following two equations are satisfied:

$$\sum_{i \in N^-(n)} X_{in}^{km} = A_n^{km} + \sum_{m' \in M} Y_n^{kmm'} \forall n \in N, \forall k \in K, \forall m \in M \tag{52.6}$$

$$\sum_m A_n^{km} = T_{kn} \forall n \in N, \forall k \in K \tag{52.7}$$

Similarly, regarding the passengers departing from each node n, following two equations are satisfied:

$$B_n^m + \sum_{m' \in M} Y_n^{km'm} = \sum_{j \in N^+(n)} X_{nj}^{km} \forall n \in N, \forall k \in K, \forall m \in M \tag{52.8}$$

$$\sum_{l \in K} T_{nl} = \sum_{m \in M} B_n^m \forall n \in K \tag{52.9}$$

Next, the constraints about the frequency set up will be described by Eq. (52.10)–(52.13).

$$F_{ij}^m \leq g^m Z_{ij}^m \forall (i,j) \times m \in A \tag{52.10}$$

$$\sum_{i \in N^-(n)} F_{in}^m = \sum_{j \in N^+(n)} F_{nj}^m \forall n \in N, \forall m \in M \tag{52.11}$$

$$\sum_k X_{ij}^{km} \leq h^m F_{ij}^m \forall (i,j) \times m \in A \tag{52.12}$$

$$\sum_k X_{ij}^{km} \geq d_{ij}^m Z_{ij}^m + e_{ij}^m F_{ij}^m \forall (i,j) \times m \in A \tag{52.13}$$

Finally, followings are added as the domain of variables.

$$X_{ij}^{km} \geq 0,\ Y_n^{kmm'} \geq 0,\ B_k^m \geq 0,\ A_n^{km} \geq 0 \tag{52.14}$$

$$Z_{ij}^m = \{0, 1\},\ F_{ij}^m \geq 0 \tag{52.15}$$

As mentioned above, the problem which takes Eq. (52.5) as objective function and takes Eqs. (52.1)–(52.4) and (52.6)–(52.15) as constraints turns into a mixed linear programming problem containing a small number of 0–1 variable (Z_{ij}^m). Therefore, proposed mixed integer linear programming model can be numerically solved by general mathematical software packages.

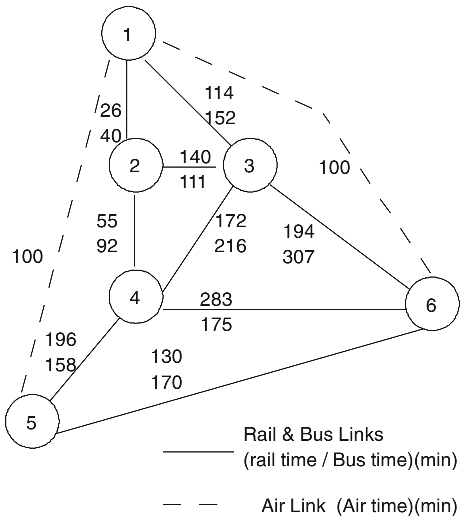

Fig. 52.1 Sample network

52.4 Numerical Example and Conclusion

The proposed model has been applied to a small network consists of 6 nodes and 20 links of 3 different modes (railway, bus and airline) as shown in Fig. 52.1.

We used LP Solve package for solving the equations by the methodology explained in Sect. 52.2 using above data. Resulting P, Q, V values are shown in Table 52.2. Figure 52.2 illustrates optimal network shape with link frequencies and passenger numbers on links. Considering the low unit emission of CO_2 by rail comparing to the air and bus, the result network is mainly consisted by rail links. However, for between city 1 and 6, where trip time by rail via city 3 is 308 min, too larger, direct air service of 100 min is provided. Similarly, bus service is provided on link 4–6, where trip time of rail is much longer than bus. For link 4–5, where bus service is slightly faster than rail, co-existence of bus and rail is observed. As described above, the proposed model successfully give a best-mix design of inter-city modal-mix network.

Table 52.2 Resulting objective values

Objective	Total travel time	Total transfer cost	Total CO_2 emiss.
Min. travel time (P)	3.890.636	18.240	113.590
Min. transfer cost (Q)	7.765.335	0	30.333
Min. CO2 emission (V)	6.004.489	0	22.558
Optimal solution (PQV)	5.413.639	0	35.781

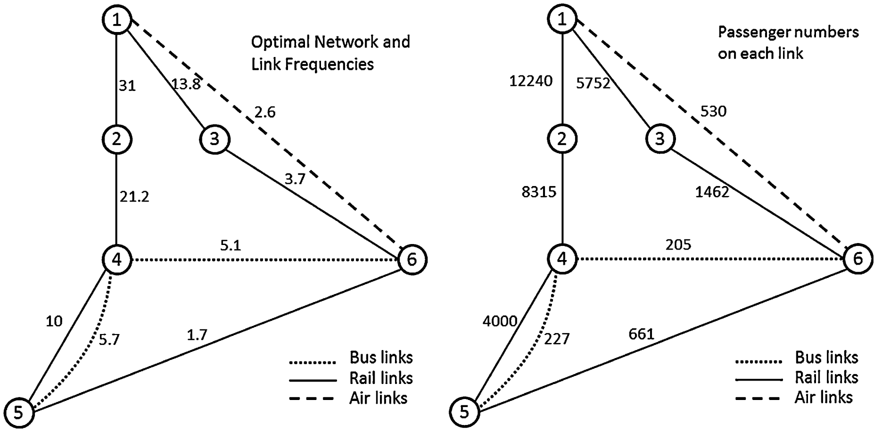

Fig. 52.2 Resulting network with link frequencies and passenger numbers on links

In conclusion, we have presented an optimal modal-mix planning model to design a modal mix network of least CO_2 emissions from the viewpoint of transport operators. We applied the model on a sample network successfully using mixed linear integer programing tools. Resulting optimal network shape and required frequencies for sustainable operation for given OD demand were also presented. This paper provides an upper-level model to consider operators behavior of the network design problem. For the future study, passengers' route choice behavior should be modeled as the lower-level of the network design problem.

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Chapter 53
Research on the Optimization Scheme of Beijing Public Bicycle Rental System Life Cycle

Kaiyan Jiang and Hao Wu

Abstract Public bike-rental system is a kind of green, low carbon, economical and convenient city public slow traffic system. In the management mode of government leading and enterprises participating, public bike-rental system's normal operation depends on close link of capital and liability. It is a large engineering system which needs strict control. Based on the theory of life cycle, this article analyzes and divides the life cycle of public bike-rental system into five stages. Taking example by the experience of the other countries and cities, we put forward the corresponding optimization scheme with the problems in different stages.

Keywords Public bicycle · Rental system · Life cycle · Rental mode · Beijing

53.1 Introduction

With superiority of being suitable for the short distance travel and providing "peer-to-peer" service, in Beijing, the optimization of public bicycle rental plan could greatly enhance the competitiveness of the public transportation, pull the coordination of the comprehensive transportation and promote the sustainable development of urban traffic.

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53.2 Public Bike-Rental System's Life Cycle

In the mode of government leading and enterprise managing, the public bike-rental system should be the all process including concept stage, building stage, promotion stage, using stage, and recovery stage. The recovery of two kinds of bicycles makes recovery and promotion stage and using stage change into each other. One is recycling discarded public bicycle, by material processing to use again; Another is recycling private vehicles and modifying them. The process would reduce the volume of private bicycle, may guide the needs to the public bicycles, and so the publicity function of public bicycle. As shown in Fig. 53.1.

53.3 Beijing's Development of Public Bike-Rental System of Necessity and Feasibility

53.3.1 Necessity

Traffic pressure. From 2003 to 2012, the proportion of green travel in Beijing fell to 18.1 % from 34.7 %. Beijing and Mexico City were listed as the city with the worst traffic by the worldwide appraisal of "IBM Commuter pain index".

According to the 2010 Beijing annual traffic report, compared to the double difficulties in transferring buses and car congestion in peak period, bicycle's movement speed is very competitive. From Table 53.1 we can see that the average speed of bicycle in the morning rush hour was only 0.3 km/h slower than the bus travel's speed.

Environmental pollution. France once banned motor vehicle travel for 13 h, reducing noise by 3/4, air environment also improved significantly. Promoting the use of bicycle with zero pollution benefits the improvement of the noise and environmental pollution.

53.3.2 Feasibility

Policy support. Building up the good bicycle traffic environment conforms to the "Beijing transportation development outline" (2004–2020) (Lu and Li 2010). According to the Beijing Traffic Committee's plan, by 2015, the travel proportion of bicycle will reach 20 % in Beijing (Dan et al. 2011).

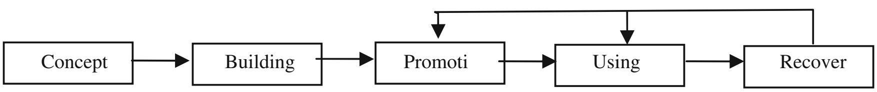

Fig. 53.1 Each stage of public bike-rental system's life cycle

Table 53.1 Comparison of 2010 Beijing vehicle's average travel speed during peak hours

Transportation	7:00 a.m–8:00 a.m (km/h)	17:00 p.m–18:00 p.m (km/h)
Bicycle	7.7	7.1
Bus	8.0	7.9
Car	17.8	18.1
Subway	13.0	14.2
Walk	4.0	4.2

Economic value. In view of wear, steal, preferences and other reasons, when the average car can be used for 2 years, the average market price is 300 yuan and bike maintenance costs 50–100 Yuan, then 2 years of private bicycle use cost about 350–400 yuan. Nowadays, the pilot public bicycles in Beijing cost only 100 yuan every year without maintenance cost (Wang and Li 2007). From the social perspective, a new bus costs about 0.4–1 million Yuan, though more buses of every line cannot cover all around the area. However, as 500 bikes cost only 150 thousand Yuan, shuttling by bicycles is far cheaper.

53.4 Beijing Bike-Rental System Development Course

Beijing bicycle rental service experienced the beginning stage, rapid spread stage, to be saturated tendency, gradually decline period, the government's rebuilding stage (Song and Crann 2008). At present, Beijing public bike-rental pilot operation is started up by government's capital investment, whereas the operators were in charge of specific business and bearing the expenses (Wang and Li 2008). Advantages of enterprises' operation and government sectors' functions can be embodied in the whole life cycle of the bike-rental service, making public bike-rental system long run down.

53.5 Lease Optimization Scheme of Public Bicycle Based on the Life Cycle

53.5.1 Concept Stage

The plan of lease point and bicycles. Summarizing the domestic and foreign experience, initial construction of lease points can be within the scope of 500–3,000 m away from rail transit sites, with a density of a point in per 700 m (Dai et al 2007). The number of bicycles in each point should be various according to the 4 kinds demand as transit point, settlement point, recreational point and campus point. Overmuch bikes are unfavorable. The plan can be adjusted according to demand again in the future.

Planning of bicycle lanes. Nowadays, in Beijing bike lanes are occupied by motor vehicles along the 70 % of subways of line 2 and the southern section of line 4. Independent bicycle right, high quality, safe and orderly bike lanes are the foundation to promote the bicycle transport. In addition to financial support, the government should provide rights to use the land, bike lanes and other aspects of security.

53.5.2 Construction Stage

High-tech security technology. In the operations of public bicycle-rental system, security is the guarantee of quality of service. Like main parts of public bicycles in France are not the general to ones in markets, Shanghai current public bicycles are installed GPS chips, these security measures reduced the possibility of stealing. However, Beijing's public bicycle is only equipped with a halo lock.

Global positioning technology to allocate bicycle. The location technology could help public bicycle-rental system administrators find the position of bicycles in time to implement the deployment or emergency aid program.

53.5.3 Promotion Stage

Social consciousness and publicity mechanism. In 2007,Paris's"VELIB" propaganda led the bicycle boom called "green revolution" (Hailei 2012); The government ministers, mayors, officials in Dutch cycle to work, and 70 % out workload of the civil servants is completed in B + R way, making an good exemplary role.

Formulation of deposit. Reasonable formulation of the deposit and price is the key to promote the use of public bicycles. The high cost of renting will make part of the potential customers leave, and finally turned to other means of transportation.

Formulation of use price. For the low price of bus and rail traffic in Beijing, as public welfare facilities, public bicycle rental prices should not be too high. Currently, Beijing adopts a "free & low cost" timing charging mode, namely: 1 h's ride for free, further $1 for per hour a day. Accumulated charge is no more than 10 yuan.

53.5.4 Using Stage

Perfect the management system. It is not only service hotlines are few for bicycle-rental points in Beijing, but also the repair and maintenance is not in time, causing bicycle-rental concerns. In the Netherlands, all the cities and rural areas have special bicycle thrusters, free repair tools and medicines were placed every bar and bicycle parking lot, avoiding the overtime debits for bicycles' failures.

The balance of cost and benefit. According to the figures, 2,000 bicycles of pilots in Beijing got rent 2,000 yuan for the first month. This means that the government needs to invest a great amount of capital for operation and maintenance. At present, however, 60,000 vehicles get Hangzhou about 5 million RMB a year by public bicycle rental and more than 30 million RMB by the hull advertising. In the earlier stage, government subsidies can be the main finance source. When the system developed mature, the urban traffic structure has been improved, it is an advice to make up for public welfare by the commercial development, and invest the part of original human and funds that were used to solve the traffic congestion into the day-to-day running and expanding of the construction.

53.5.5 Recovery Stage

Recycling link can extend the public bicycle-rental system life cycle, avoid recession. The recovery of private and public bicycles can present "cycle to cycle" of the product life cycle form.

The prevalence rate of Beijing bicycle is high while utilization rate is low. More than 90 % of residents have private bicycle, about 75 % of the residents use bicycle a day not more than 1.5 h. Bicycles are mainly used for leisure, shopping, commuting, etc., idle in the rest of the time.

After residents' idle bicycles having been modified as standardization and put into public bicycle transport system operation, the cost is lower than the purchase of a new bicycle. It can remove the citizens' troubles about the loss of bicycle parking places and steal. In order to recall massive private bicycles, operators can provide preferential policy about rental bicycle to sellers.

53.6 Endnotes

As more and more people pay attention to the importance of saving energy and environmental protection, bicycle rental will be important role of short-distance travel of Beijing residents, also an important tool for rule blocking. Beijing public bicycle-rental system is still in the exploration, but already showed the forehead of vigorous development prospects.

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Chapter 54
The Primary Condition of Bicycle Microcirculation System Benign Operation in Urban: Taking Hangzhou and Beijing for Example

Hao Wu and Xiao You

Abstract With increasingly fast urbanization process, motorization makes urban traffic crowded and air pollution. Considering about environmental protection and trip, the application of bicycle microcirculation system may these problems. This paper analyses the primary condition of bicycle microcirculation system demographically runs in urban by contrasting Hangzhou and Beijing. Government can promote the supply rationalization of bicycle microcirculation system and stimulate demand by funds, policy and technology, thus promotes bicycle microcirculation system demographically dunning in urban.

Keywords Bicycle rental · Low carbon transport · Microcirculation system · Benign operation

54.1 Introduction

Along with the rapid development of China's economy and the acceleration of urbanization, Chinese urban especially big cities traffic problems and air pollution is serious. Car growth too fast, to ensure the smooth operation of car, bicycle lanes are occupied in different degree, especially in the big city fewer and fewer people trip by bikes. However, congestion is still serious. We need reasonable allocation

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between urban road space and different transportation. Public management model of bicycle has become the consensus of the public and the government.

Today, congestion is the common fault of the major cities in China, facing the busy period and the busy road traffic load, many local shifted to bicycle microcirculation system construction. In foreign country, riding bike instead of walking has become a trend of solving the traffic problem, Paris, Copenhagen, London and other cities has become a successful model of bicycle microcirculation system construction (Liu 2009).

In May 2008, Hangzhou took the lead in putting out and implementing bicycle micro circulation system in domestic. According to principle of the government guidance, company operations, policy guarantee, social participation, relying on the public transport system, such a system has been created. Now, the bicycle microcirculation system operates in an orderly way in Hangzhou. It may relieve road traffic pressure of Hangzhou (Shi 2008). In 2011, the survey of satisfaction degree on ten people's livelihood projects, satisfaction degree of this project is far ahead by 99 %.

By the end of 2008, public bicycle microcirculation system rental model takes the lead in the Maizidian community of Chaoyang district in Beijing. Demand is very big, but ultimately failed because income can not cover outcome. By the end of 2010, Beijing advocated green environment protection trip, bicycle microcirculation system was brought up again to ease traffic congestion, But now, only a small portion of the area still is as pilot operation such as Chaoyang park.

Benign operation of bicycle microcirculation system requires a certain conditions, not all of cities the can smoothly establish and implement the system (Zhou 2010). This paper analyses the primary condition of bicycle microcirculation system benign operation through contrasting Hangzhou to Beijing.

54.2 Analysis of Bicycle Microcirculation System in Hangzhou

54.2.1 Analysis of the Status

1 May 2008, public bicycle service system officially began to operate in Hangzhou. Since 2007, Hangzhou has put forward to learn French Paris in the building of public bicycle service system. Therefore, the public bike system has been taken into the public traffic system planning and city public transport system of Hangzhou, namely the subways, buses, taxis, water bus, public bicycle, and put forward the public bicycle is an important component of urban public transport. Hangzhou municipal government thinks that public bicycle as public products must be led by government, so it is operated and managed by Hangzhou city public transport group. In 2008, the government invested 150 million yuan, other funds is borrowed through the bank financing by enterprise. In 3 years, Hangzhou public

bicycle service net quickly expanded whole city from the west lake scenic area. In the center area of Hangzhou, public bicycle service point is able to be found about every 300 m. 40 service points can realize the self-service 24 h. According to the planning of the Hangzhou, to 2015, the quantity of public bikes is about 100,000.

54.2.2 Government's Status in Public Bicycle Service System

Government plays a leading role in the public bicycle service system. Although cover area of Hangzhou is incomparable to Beijing or Shanghai, traffic pressure of Hangzhou is no less than Beijing's. Development of the tourism industry led to the traffic problems, lake traffic pressure near the west is big, parking influence the visitors and citizens to travel. Based on the development of the public demand, the public transport group-only a bus company, pure state-owned enterprise, is responsible for the development of public bicycle service system. The public transport group has set up wholly owned holding of the Hangzhou Public Bicycle Transport Service Development Co., LTD, which will be in charge of operations.

By the end of 2011, Hangzhou has invested to public bicycle service system nearly 400 million yuan. In view of the business development process, Hangzhou municipal government think that if commercial operation funds will not be sufficient to make up for the whole operation, the government will subsidy and ensure public bicycle normal operation by public finance. Since then, bicycle microcirculation system forms by the government supporting resources and enterprise developing resources through benefits, and normally operates. So government has no doubt such effect on the bicycle microcirculation system in Hangzhou.

54.3 Analysis of Bicycle Microcirculation System in Beijing

54.3.1 Analysis of the Status

Traffic congestion has become a serious problem that obstructs citizens' work and life and the city's rapid development in Beijing. Traffic congestion has caused air pollution. In 2005, public bicycle rental service network first was set in Maizidian community. Network operation bills for business after less than three months. In 2008, during of Beijing Olympic Games, public bicycle rental market reached the peak. However, after Olympic Games, public bicycle rental industry operation is difficult. Leasing company business is difficult, the bicycles were damaged and lost, rental outlets were eroded, there was no attention. By December 2010, Beijing municipal government issued the comprehensive measures to alleviate traffic jam, limited motor vehicles, and advocated public transport and bicycle trip, bicycle rental system was taken into transport planning again. So far, bicycle rental outlets are trial operating in Xicheng district and Chaoyang district.

54.3.2 Analysis of Government Promoting Mechanism

As an obviously difference from foreign cities, Beijing's bicycle rental service is completely dominated by the enterprise, lacks government regulation and corresponding policy support. And a single enterprise financial and human resource is limited, so the process of network construction is slow. The Beijing municipal government invests billions every year for public transportation construction, but as public welfare undertakings, bicycle rental service was incorporated into the policy of the government consider category until 2010 year. Beijing has no unified promoting and management mechanism, because of multiple management of commercial bureau, the public security bureau, transport committee, industrial and commercial bureau, the application of bicycle rental project often need pass many hurdles that let the leasing company expend setbacks.

In addition, road planning problem is also important reasons of influence the bicycle rental according to the consumer reflect. The paths are narrow. In addition to government gives policy mechanism support, also should pave roads for benign operation of bicycle microcirculation system.

For enterprise, the government's unified planning support is very important in order to solve difficulty of different operation mode. In order to protect the environment, low carbon traffic is advocated, the government should take the bicycle rental industry into the whole public service system, and give capital and policy support, in order to promote the development of the bicycle rental service.

54.4 Comparative Analyses of Operation Conditions of Bicycle Microcirculation System in Beijing and Hangzhou

First, the government vigorously support bicycle microcirculation system will promote bicycle microcirculation market initially established. Compared to Beijing and Hangzhou, Hangzhou bike microcirculation market is established by the government leading, got $400 million government finance support capital; In contrast, the government supported only in policy, no successive funds and technology support, the bicycle microcirculation system can't benign operation in Beijing.

Second, in Hangzhou, government encourage the bicycle rental network operators to rent to each merchants around and the enterprise, the enterprise can be attracted to this through advertising of the inhabitants of the bicycle rental, and at the same time, the operations of the enterprise lease rental outlets around the store to get large profits, subsidies bike rental and brings due to maintenance cost; but in Beijing, bicycle microcirculation leasing points don't provide such services, the government does not provide the platform for each enterprise, so operators has no incentive to this activity. We found that the policy of the government will strongly affect the functioning of the bicycle microcirculation system.

In addition, the government limits user of bicycle microcirculation system will affect the benign operation. Bicycle microcirculation system and urban public transport system is closely related in Hangzhou, the public transport card can use freely in bike rental outlets; However, bicycle rental market is more controlled in Beijing, only residents living in Beijing for a full years can get leasing qualification. Such a control limits the bicycle microcirculation system benign operation. From the point of view of demand, the bicycle rental demand mainly comes from the floating population, and Beijing's policies limited the demand. Not only that, bicycle rental outlets lack reasonable layout, and failed to take into account the actual demand of residents.

54.5 Summary

Through analysis of Beijing and Hangzhou their respective bicycle microcirculation system, this paper thinks that the primary condition of bicycle microcirculation system benign operation is support from government. First, support from the government can promote to increase supply of bicycle service. Second, support from the government to bicycle rental industry operators can increase the demand of support. Third, support from the government can promote the network layout and construction of bicycle micro circulation system.

To sum up, the support from government is decisive condition for bicycle microcirculation benign operation. The government's support of capital, policy and technology can promote matching supply with demand of the bicycle rental service, at the same time, the capital and technology support from government can promote the bicycle rental outlets rationalization and effective, make the bicycle rental outlets real network. Eventually promote the bicycle microcirculation system benign operation.

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Chapter 55
The New Energy Buses in China: Policy and Development

Jingyu Wang, Yingqi Liu and Ari Kokko

Abstract With the advent of "low carbon" economy, new energy vehicles are increasingly favored by the Chinese government and manufacturers. New energy buses have become an important channel for the promotion of new energy utilizations. Based on the summary of policies, this paper conducts a thorough research on the technology and promotion achievements on new energy buses. We have found that the promotion achievements have difference with plans and gaps exist in different cities. In the paper we discuss the policy efficiency, the correlation between achievements, policies and the influence from oil price. We draw the conclusions that clear direction and detailed plans will enhance the new energy bus promotion and rising oil prices will promote new energy buses as well.

Keywords New energy bus · Promotion achievements · Government policies

55.1 Introduction

New energy vehicles– defined as vehicles with fuel or power systems that are not based on traditional internal combustion engines—include fuel cell vehicles (FCEV), hybrid power automobile (HEV) etc. In 2010, China's annual oil

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consumption reached 455 million tons, 55 % of which depending on foreign oil. Energy has undoubtedly become the constraints of China's automobile industry development. The government and a large number of automobile manufacturers have therefore focused on new energy vehicles. In January 2009, the Ministry of Science and Technology, Ministry of Finance, National Development and Reform Commission and Ministry of Industry and Information Technology jointly started a project called "ten cities one thousand new energy buses" which plans to launch 1,000 new energy vehicles per city in 10 cities annually in a period of 3 years to enable the new energy vehicles to occupy 10 % of the automobile market. Buses, taxies, service cars and etc. are all involved in the project. At present, the number of the cities that are involved has reached to 25. The first group of cities includes Beijing, Shanghai, Chongqing, Changchun, Dalian, Hangzhou, Jinan, Wuhan, Shenzhen, Hefei, Changsha and Kunming. The second group of cities includes Tianjin, Haikou, Zhengzhou, Xiamen, Suzhou, Tangshan, Guangzhou. The third group of cities includes Shenyang, Chengdu, Huhehaote, Nantong, Xiangfan. Subsequently, the government put forth a series of policies and measures to promote the development of new energy vehicles.

As the government lays emphasis on public transportation, the paper discusses the policy efficiency based on the research of the current status of the new energy buses and related policies. Section 55.2 summarizes the central government policies and the comparison between local government policies. Section 55.3 describes the current status of new energy buses from technology and quantity perspectives. Section 55.4 discusses the policy efficiency, relevance, achievements. Section 55.5 shows our conclusions: First, the government should give a clear definition of the development form to avoid wasting resources. Second, having detailed plans is the key point of promoting new energy buses.

55.2 Policies

55.2.1 Central Government

Facing high technology competition, China launched the National High Technology Research and Development (the so-called 863 program) in November 1986 to improve technological innovative capabilities. Through this program, the government attracts talent, personnel, colleges and enterprises to high-tech research by providing funding and preferential policy. The new energy industry is included in this program.

In January 2009, the four ministries launched a promotion program called "ten cities one thousand new energy buses" followed by a series of government documents to accelerate the new energy vehicle development in public transportation. Table 55.1 (National Development and Reform Commission 2009) presents the subsidies for new energy bus over 10 m from the central government.

Table 55.1 Subsidies for new energy bus over 10 m (10,000 Yuan/per vehicle)

Type	Efficiency of saving fuel (%)	Hybrid power system (VRLA)	Hybrid power system (Ni-MH,LIB,LIP,EC)	
			Max electric power (20–50 %)	Max electric power (over 50 %)
HEV	10–20	5	20	–
	20–30	7	25	30
	30–40	8	30	36
	40 以上	–	35	42
BEV	100	–	–	50
FCEV	100	–	–	60

We find that the central government provides strong financial support to the development of new energy buses. For example, the subsidies for electric buses reaches ¥ 500,000, which is 50 % of the average price of electric buses (¥ 100,0000), suggesting the consumer can buy the electric bus at half price even without local government subsides.

Based on the other new energy vehicle industry alliance, State-owned Enterprise Electric Vehicle Industry Alliance including Changan, Dongfeng, Yiqi, Shangqi Putian and etc. was established by State-owned Assets Supervision and Administration Commission of the State Council in August 2010. It indicates that substantive steps have been made to the new energy vehicle industry. The alliance was divided into three segments covering automobile group, battery group and service group and was expected to be the model of industry alliance and to provide the alliance specifications.

In summary, the Chinese central government has committed to providing lasting support to the new vehicle industry with incentives for both R&D and consumers.

55.2.2 Local Government

As the subsides of "863" program are mainly from central government, we will focus on the promotion policy of new energy buses from the local government

Table 55.2 Number of public buses to promote in Shenzhen, Shanghai and Beijing

	Type	2009	2010	2011	2012	Total
Shenzhen	HEV and BEV (bus)	380	470	930	2220	4000
Shanghai	HEV (bus)	150		550		
	BEV (bus)	120		883		1709
	FCEV (bus)	6		–		
Beijing	BEV (bus and car)	–	1000	4000	18000	
	HEV (bus and car)	–	–	1000	6000	30000

Table 55.3 Number of backup service plans in Shenzhen and Beijing

	Type	2009	2010	2011	2012
Shenzhen	Bus charging station (slow)	5	5	7	8
	Bus charging station (fast)	5	5	7	8
	Official car charging pile (slow)	500	600	700	700
	Public charging station (slow)	1625	2500	2750	3125
	Public charging station (fast)	36	46	54	64
Beijing	Charging pile	1200	6000	28800	36000
	Charging station	5	20	75	100
	Battery replacement station	0	1	0	1
	Battery recovery station	0	0	2	2
	Service station	1	3	6	10
	Information station	1	-	1	2

point of view. The selected cities have issued official documents since the pilot project was launched. Based on the economy situation, vehicle manufacturers and how open the city is, we selected three cities, Shenzhen, Beijing and Shanghai for deeper research and summarized their local promotion policies on new energy bus in Tables 55.2 and 55.3 (Shenzhen Government 2009; Shanghai Government 2009; Beijing Government 2009).

We can infer that Shenzhen has the largest number of new energy vehicles to promote and it has put emphasis on the hybrid power and electric buses, while Shanghai just plans to promote 1,709 new energy buses with FCEV also involved.

There is conspicuous difference between the two cities' policies. Shenzhen only includes charging station in its plans but with clear classification and numbers. Beijing does not classify the service station accurately, but with more battery replace stations and recovery stations involved in its service system (We cannot find the complete plan of Shanghai).

Shenzhen is the first city to provide subsidies to new energy vehicles from local government. Table 55.4 (Shenzhen Government 2009) shows its subsidies system. We find that Shenzhen gives clear subsidies plans about new energy bus and charging station while such official and clear plans are not found in Shanghai and Beijing.

Table 55.4 The subsidies for buses and service system from Shenzhen local government (10,000 Yuan)

	2009	2010	2011	2012	Total
HEV and BEV	8697	9870	9300	26328	54195
Bus charging station (slow)	3180	3180	4452	5088	15900
Bus charging station (fast)	1500	1500	2100	2400	7500
Official car charging pile	500	600	700	700	2500
Public charging station (slow)	1625	2500	2750	3125	10000
Public charging station (fast)	7200	9200	10800	12800	40000

55.3 The Development of New Energy Vehicles in China

55.3.1 Technology Development

New energy vehicles are defined as the vehicles using alternative fuel technologies including HEV, BEV and FCEV. Because of its challenge in material sourcing, high maintenance cost and imperfect service system, FCEV is out of favor with most manufacturers. So far, large and medium-sized manufactures are focusing on HEV and BEV.

Both Electric and hybrid power buses have higher energy efficiency and lower emitted carbon dioxide against regular bus. A hybrid power bus saves 6,300 liter of diesel per year and a plug-in hybrid power bus saves 8,400 liter of diesel per year.

55.3.2 Achievement of Promotion

China New Energy Bus Development Forum in 2010 indicates that the new energy bus development in public transportation is now in full swing. By the end of 2010, the number of new energy buses has reached 4,000. It is estimated that the number will reach 15,000 by the end of 2012. Figure 55.1 (Beijing Bus 2011; Shanghai Bus 2011; Shenzhen 2011) resents the number of new energy buses in Shenzhen, Beijing and Shanghai.

There is a gap between the actual and plan numbers, but the project did achieve good results. By 2011, the share of new energy bus has reached 6 % in Beijing and Shenzhen public transportation and 3 % in Shanghai.

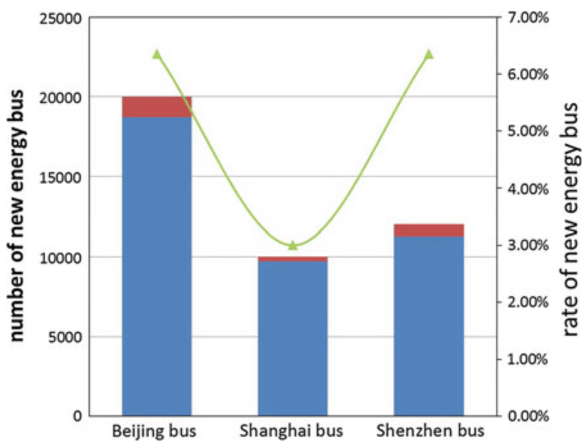

Fig. 55.1 Number and rate of new energy bus in Beijing, Shanghai and Shenzhen

55.4 Discussion

55.4.1 Policy Efficiency

According to the available data, the new energy bus basic technology indicators have met the public transportation requirement, which means the input and output of new energy buses are able, while the actual promotion number is less optimistic than the planned number.

First, most local policies ignored the exploration of marketing model, which led to the unclear future of new energy bus. Exploring marketing model on their own will no doubt add to the enterprises' burden and various different business models in parallel may disrupt vehicle markets.

Second, we can not see the focus of the government from its policies because the subsidies mentioned in the policies are all based on the bus cost and the fuel it saves.

Consequently, the policies are good in technology, but unclear direction and dimming marketing model have bad effects on their efficiencies.

55.4.2 Correlation Between Promotion Achievements and Policies

While what the selected cities get are the same from central subsidies perspective, each city's project involved in "863" program are not same, which results in different science funding and technology level. State-owned Enterprise Electric Vehicle Industry Alliance can not cover all the selected cities either. Viewed this way, the support the cities get from central government is still different.

Although the support that Shenzhen, Shanghai and Beijing get is not much different, there is a big gap among their achievements.

Shenzhen is the first city to provide subsidies to new energy vehicles from local government. Additionally, Shenzhen has its detailed plans for new energy buses and service system to help the consumers with the subsidies that they are entitled to.

Beijing has been actively exploring a business mode to look for better solutions to the battery purchase and its follow-up service. Therefore promotion plan of Beijing covers battery-recycle and information station. Furthermore, Beijing established new energy vehicle design and manufacture base in 2008 and the first new energy bus alliance in China in March 2009 called Beijing New Energy Vehicle Industry Alliance included Baic Group, Beijing Bus Group, Beijing Institute of Technology etc.

Shanghai has defined plans for only new energy vehicles involved in "863" program, but its plans for new energy bus seem not so clear.

So we infer that promotion achievements and local policies are closely related. The detailed plans of Shenzhen and the exploration of Beijing have encouraged the development of local new energy buses.

55.5 Conclusions

The paper analyzes the policies on new energy bus from central and local government and describes the promotion achievements of Shenzhen, Shanghai and Beijing. Then the paper discusses the policy efficiency, the correlation between achievements and policies.

Clear direction

Government should define the clear direction of new energy buses based on relevant research and experience. Moreover, government can promote certain type of new energy buses in certain cities based on its resources not only to make the direction clear but also to help to collect and analyze data and summarize experience.

Detailed and comprehensive plans

We have observed that the more detailed and comprehensive the plans are, the better achievements. Such plans should be provided to the consumers to make sound decisions.

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Chapter 56
The Determinants of Public Acceptance of Electric Vehicles in Macau

Ivan Ka-Wai Lai, Donny Chi-Fai Lai and Weiwei Xu

Abstract This study aims to examine the factors that influence individual intention towards the adoption of electric vehicles. Questionnaire survey was conducted in public area in Macau. Data collected were analyzed by confirmatory factor analysis and structural equation modeling. The results of data analysis show that environmental concern and environmental policy are the antecedent factors of perception of electric vehicles, and that influences customer's behavioral intension to purchase electric vehicles. This study also finds that perception of benefit is one of the factors that influence the adoption of electric vehicles. Vehicle operators are more sensitive to fuel economy. They are seeking for future long-term fuel savings. Thus, government striving to promote low-carbon transportation needs to scale up its efforts to enhance citizens' environmental concern, establish proper environmental policy, and provide long-term financial and strategic support for electric vehicles.

Keywords Public acceptance · Environmental concern · Environmental policy · Electric vehicles

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56.1 Introduction

"Building a low carbon Macau, creating green living together" is the vision of the first environmental planning of Macau (Macaunews 2011). As a world tourism and leisure center, air pollution has become a key problem affecting tourism in Macau. One of major sources caused air pollution is carbon emissions from vehicles. Over the past few decades, research has been conducted to investigate various aspects about the developments of low-carbon transportation technologies. As a result there are already a number of potential alternatives to the conventional diesel/petrol combustion engines (Schulte et al. 2004), such as electric vehicle engine. Although electric vehicles have been introduced for a long period of time, they are not popular. Thus, there is a need to examine the factors on influencing public acceptance of electric vehicles.

Macau is a small city (total area = 29.9 km^2) with narrow roads and streets (total length = 413.4 km). There were 182,765 vehicles with a population of 563 thousands in 31 March 2012 (DESC 2012). One of every three citizens has a vehicle. The typical driving range of vehicles is less than 40 km (Tse 2011). Therefore, electric vehicles are very suitable for Macau environment. Macau government is developing environment policies include introducing tax preference for environmental light vehicles.

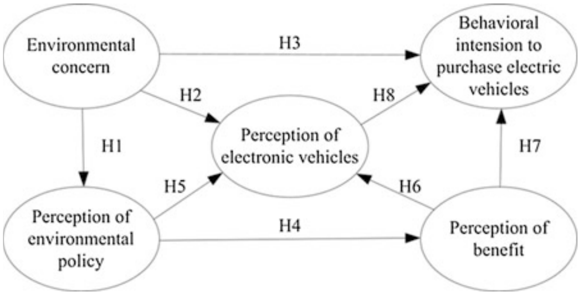
Many factors influence the car-purchasing behavior. These include situational factors such as regulatory environments (Collins and Chambers 2005). In addition to situational factors, psychological factors are equally important, for example, personal attitudes (Choo and Mokhtarian 2004). Although some empirical studies of public acceptance of hybrid vehicles have been conducted, there is little research that considers psychological factors and situational factors together. Also, there is a lack of research on the public acceptance of electric vehicles.

This study focuses on the public acceptance of full electric vehicles in Macau. This study addresses the need for an empirical study that estimates the situational and psychological factors that impact public acceptance of electric vehicles and tests the relationships among these factors. This research will contribute to help academic and government understand the factors that influence customer's purchase intentions of electric vehicles.

56.2 Factors Influencing Car-Purchasing Behavior

Twenty years ago, Ellen et al. (1991) identified important factors that motivate environmentally conscious behaviors. In this study, environmental concern and perception of environmental policy are combined with perception of benefit, perception of electric vehicles, and behavioral intension to purchase electric vehicles to form a research model as shown in Fig. 56.1.

Fig. 56.1 Research model



Environmental concern is a general attitude against environmental deterioration (Fransson et al. 1994). Kahn's (2007) study indicated that environmentalists are more likely to purchase hybrid electric vehicles than non-environmentalists.

H1: A customer's environmental concern has a positive impact on the customer's perception of environmental policy.

H2: A customer's environmental concern has a positive impact on the customer's perception of electric vehicles.

H3: A customer's environmental concern has a positive impact on the customer's behavioral intension to purchase electric vehicles.

Irwin and Wynne (1996) stated that political context affects the validation of new technology. Environmental policy is a situational factor that should affect customer's perception of electric vehicles.

H4: A customer's perception toward environmental policy has a positive impact on the customer's perception of benefit.

H5: A customer's perception toward environmental policy has a positive impact on the customer's perception of electric vehicles.

The acceptance of a product is often affected by personal perception of benefit. Consumers may consider these benefits when they are making decision on purchasing a new vehicle.

H6: A customer's perception toward benefit has a positive impact on the customer's perception of electric vehicles.

H7: A customer's perception toward benefit has a positive impact on the customer's behavioral intension to purchase electric vehicles.

Positive perception of a product can make a customer more likely to purchase the product (Viardot 1998). Thus, the perception toward electronic vehicles should influence customer's purchasing behavior.

H8: A customer's perception toward electric vehicles has a positive impact on a customer's behavioral intension to purchase electric vehicles.

56.3 Research Method

The research question of this study is: what are the factors that affect public acceptance of electric vehicles in Macau? A questionnaire survey is used. The interviewer-administered survey was conducted on the street in March 2012. A filter question "do you drive your own car?" was asked. A total number of 310 completed questionnaires were collected in a month. However, two questionnaires were eliminated (e.g., for giving the same rating for all items), leaving 308 questionnaires as valid for analysis.

56.4 Findings

Confirmatory factor analysis (CFA) was performed to evaluate construct validity regarding convergent and discriminant validity. Table 56.1 shows the means, standard deviation, reliability, and standardized factor loadings of the constructs. The Cronbach's alpha for all components are higher than 0.6 and all factor loadings are above 0.5. Based on the guidelines of Hair et al. (2010), the reliability and construct validity of the study are accepted. Table 56.2 shows the correlation matrix of the five constructs. All of the correlation values among the constructs of the model are significant (p value < 0.01).

Table 56.1 Reliability and construct validity

	Mean	Standard deviation	Cronbach's alpha	Factor loadings	EVA	CR
EC	5.553		0.905		0.764	0.906
EC1	5.507	0.776		0.854		
EC2	5.490	0.793		0.894		
EC3	5.662	0.852		0.873		
PEP	4.320		0.933		0.830	0.936
PEP1	4.497	1.093		0.864		
PEP2	4.234	1.045		0.923		
PEP3	4.231	0.966		0.944		
PB	5.128		0.916		0.787	0.917
PB1	5.166	0.681		0.911		
PB2	5.198	0.678		0.875		
PB3	5.020	0.744		0.874		
PEV	4.398		0.929		0.809	0.927
PEV1	4.419	0.897		0.903		
PEV2	4.351	0.892		0.887		
PEV3	4.425	0.967		0.908		
BI	4.927		0.912		0.758	0.904
BI1	4.990	0.678		0.853		
BI2	4.860	0.678		0.836		
BI3	4.932	0.634		0.921		

Table 56.2 Construct correlation matrix (standardized)

	EC	PEP	PB	PEV
PEP	0.155			
PB	0.068	0.440		
PEV	0.230	0.554	0.621	
BI	0.362	0.335	0.588	0.506

Correlation is significant at the 0.01 level (2-tailed)

Structural equation analysis (SEM) was performed to test the research hypotheses empirically. Figure 56.2 shows the results of SEM analysis. The results of SEM provide that the model fit is acceptable and all hypotheses are valid.

56.5 Discussions

The results of this study prove that environmental concern is an initial factor that finally leads customer's behavior intention to purchase an electric vehicle. Environmental concern is a psychological factor that directly and indirectly influences three kinds of perceptions that mediate the link between environmental concern and the acceptance of electric vehicles.

Unsurprisingly, the results of this study indicate that perception toward environmental policy is positively correlated with perception of benefit and perception

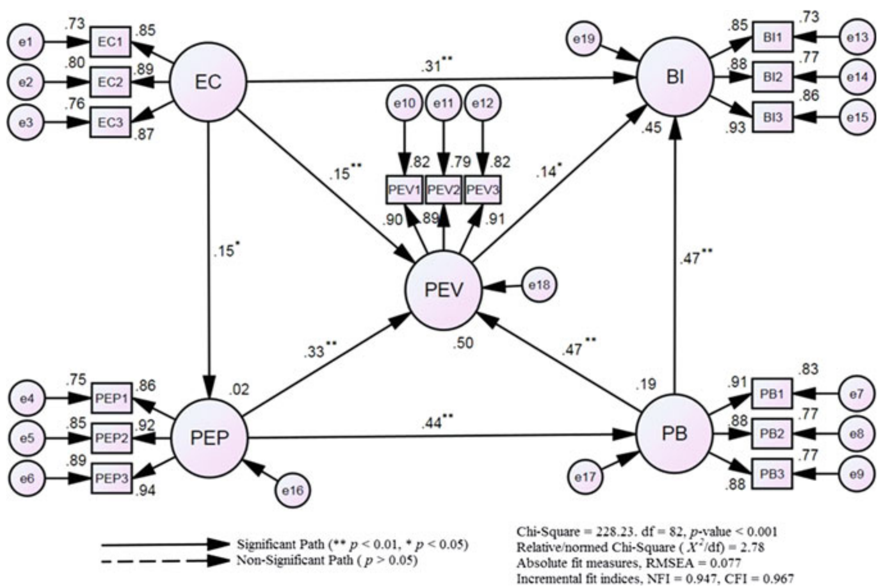


Fig. 56.2 Structural equation modeling results

of electric vehicles, and the perception of benefit and perception of electric vehicles directly affect the acceptance of electric vehicles. These findings are consistent with Kang and Park's (2011) study. Public becomes aware the environmental policy and believes the policy will be maintained continuously in order to build a low carbon society.

This study investigates an important factor—perception of benefit that economically affects consumers buying behavior toward electric vehicles. Vehicle operators are more sensitive to fuel economy. The cost saved from tax incentives is little and short-term compared with the cost of continually fuel savings. In case the price of gasoline is raised, the future fuel savings by the adoption of hybrid vehicles is less than the cost saving by the adoption of electric vehicles. Therefore, perception of benefit is the major determinant of public acceptance of electric vehicles in Macau.

This research model consists of psychological factors (environmental concern and perception of electric vehicles) and situational factors (perception of environmental policy and perception of benefit). The results of data analysis indicate that both factors play important roles in the adoption of electric vehicles as discussed above. This study contributes a research model that can be further investigated in order to explain the causal effects of these four factors for the adoption of environmental technologies.

For the practical implications, this study indicates that environmental concern is antecedent factor that stimulates the interest of electric vehicles. Macau government should educate public the importance of environmental protection and the environmental advantages of driving electric vehicles.

The introduction of electric vehicles requires forceful government's environmental policy. Macau is a small city. Limits on driving distance and lack of power should not be great issues for the adoption of electric vehicles in Macau. However, electric vehicles are expensive to own. Macau government can offer an electric vehicles program to subsidize vehicle owners to replace their exiting gasoline vehicle with new electric vehicle. Also, the batteries need to be recharged. Macau government should establish the supporting infrastructure for electric vehicles such as provide charging facilities in public car parks.

This study indicates that the acceptance of electric vehicle as a common transportation equipment will be major determined by the perception of benefit. That is the cost advantage of electric vehicles compared with vehicles that use gasoline. Consumers care long-term running costs. Macau government should provide long-term financial support such as free public parking for electric vehicles.

This study only focuses on the citizens on their acceptance of electric vehicles in Macau. This study may not be generalized to apply to other countries with basically different cultures. Future research is suggested to focus on other countries. Also, this study is only concerned about the public acceptance on electric vehicles. It may not be generalized for other environmental technologies. Future study is suggested to investigate whether the similar concept can be employed to other environmental products like LED lighting.

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Chapter 57
Synthetical Benefit Evaluation of High-Speed Rail, Take Beijing-Shanghai High-Speed Rail for Example

Han-bo Jin, Hua Feng and Fu-guang Cui

Abstract Through research and analysis on the status of domestic and international high-speed rail, this paper established the Theoretical Framework of the economic benefits, Social benefits and Synthetical benefits of high-speed railway. And this paper summarized and summed up the factors affecting the efficiency and evaluation methods, and finally got a more standardized evaluation criteria. Beijing-Shanghai high-speed rail, for instance, has a strong comprehensive benefits. The corresponding conclusions and policy recommendations in this article is below; firstly high-speed rail line that has been put into operation, planning or under construction, should be made the necessary adjustments and evaluation; Secondly, the Government should give different types of subsidies to high-speed rail for different comprehensive benefits; and last, for high-speed rail line, we should give full play to the advantage of high-speed rail such as obtain the largest passenger flow, and increase the transport density.

Keywords High-speed rail · Synthetical benefits · Economic benefits · Social benefits · Low carbon transportation

57.1 Introduction

Since the reform and opening up, China's economic development momentum is very rapid over the years. At the same time, Chinese society has also experienced various problems brought about by the economic boom, which for the

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development of China, both opportunities and challenges. With the improvement of people's living standards, basic living expenses other than living expenses are also increasingly diversified and enlarged, which, traffic travel expenses, and the degree of diversification of transportation travel demand go hand in hand. In today's society, life and work pace is accelerating, and high-speed railway has become the new ways for people's travel choice.

Background based on the above issues, as well as its practical and theoretical value, this paper set mainly the two research objectives. First, trying to find the synthetical benefits of the high-color rail to be assessed from two aspects of economic and social benefits; second, combined with the Beijing-Shanghai high-speed rail specific data to evaluate the synthetical benefits of the Beijing-Shanghai high-speed rail, and give a specific feasible optimization recommendations.

Clear the above research objectives and research methods, the technology roadmap of this paper is organized as follows (Fig. 57.1).

57.2 Literature Review

Theoretically, Kiyoshi Kobayashi (1997) Emphasized the high-speed rail system played an important role in affecting the regional economy by constructing a system model composed of a number of cities connected by high-speed rail system; U. Blum K (1997) proposed high-speed rail to a certain extent connected with the city with a transition to an expansion of the functional areas or the economy as a whole corridor, and from the near, medium and long term analysis of the economic zone's economic integrity.

Empirically, Feng and huang (2010) take Tianjin Intercity Railway for example, the high-speed rail will be able to achieve good economic and social benefits,

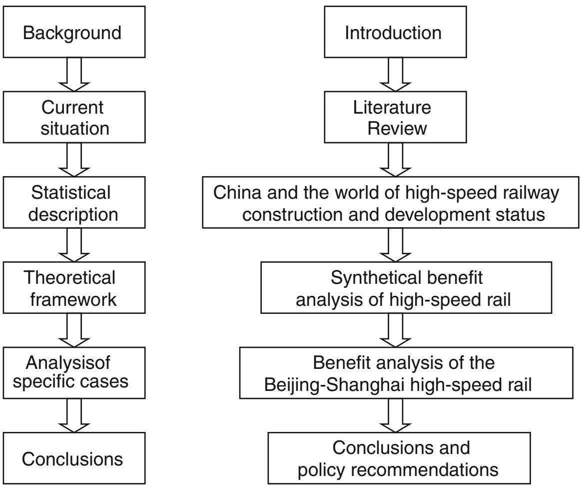

Fig. 57.1 This article line and content arrangements flowchart

and maximize the benefits of high-speed rail to make reasonable suggestions; Feng and Xue (2011) studied on synthetical benefits, with government support policy for high-speed railway in China, the article points out that in the long run high-speed rail can achieve not only the direct economic benefits, but also the great social good. Therefore, the high-speed railway construction and operation of effective government policy support.

57.3 China and the World of High-Speed Railway Construction and Development

Japan is the world's first country built for high speed railway line. In the late 1950s, Japan began to build a dedicated high-speed rail line. France following the Japanese Tokaido Shinkansen high-speed railway to proceed with economic and technical studies. 1971 the French government approved the construction of the Paris-Lyon TGV Southeast Line; Germany to build high-speed rail is the same in order to ease the growing tension capacity due to increased demand; America had little to build a high-speed rail. The U.S. Federal Railroad Administration in 2001 proposed the development of a high-speed rail vision to form a 13,600 km high-speed rail network.

Chinese-owned high-speed rail Beijing-Tianjin Intercity, Chang Ninetowns, Harbin-Dalian line, Passenger Line, Zhengzhou-Xi'an high-speed railway, Wen-Fu line, Beijing-Shijiazhuang line, Han-Yi Line, Hong Kong and broad and deep, the Beijing-Shanghai line. As of the end of 2010, China's new high-speed railway operating mileage of 5,149 km, separate 17,000 km mileage under construction. Operating mileage of 7,531 km is the longest of the world's high-speed rail operation mileage in the construction of the largest countries. Also the most technologically, the strongest integration capabilities, the highest speed.

57.4 Synthetical Benefits and Methods of Analysis of High-Speed Rail

57.4.1 The Economic Benefits of High-Speed Rail

$$\begin{aligned}&\textbf{The economic benefits of high} - \textbf{speed rail}\\&\quad = \textbf{operating income} - \textbf{operating costs} + \textbf{profit on sales}\end{aligned}$$

Operating income is the income of high-speed rail in the operation process, basically equal to the face value of the sum of high-speed rail operators sold tickets. Operating costs is the cost spent by the high-speed rail in the operation process, including the following factors: the train station depreciation expenses, administrative expenses, interest on loans and other. Sales profits, high-speed rail operations, vehicle sales profits, advertising revenue, station sales, profits, and so the sum of profit.

57.4.2 The Social Benefits of High-Speed Railway

The vigorous development of high-speed rail can bring what social benefits and social assessment of how to become a very meaningful subject. Ultimately, the social benefits of the following six high-speed rail.

(1) To promote regional economic development. (2) Economical use of land. (3) Low carbon transportation. (4) Time saving. (5) Transport capacity replacement. (6) Increase opportunities for employment. In summary, the social benefits of high-speed rail is more than the sum of the effectiveness of the six areas.

57.4.3 The Synthetical Benefits of High-Speed Railway

The synthetical benefits of high-speed railway, high-speed rail in the operation process of the economic benefits and social benefits collectively.

$$\begin{aligned}&\textbf{The synthetical benefits of high} - \textbf{speed rail}\\&\quad = \textbf{high} - \textbf{speed rail economic efficiency} + \textbf{high}\\&\qquad - \textbf{speed railway social benefits}\end{aligned}$$

Depending on the effectiveness, high-speed rail can be divided into three categories, as shown in Fig. 57.2.

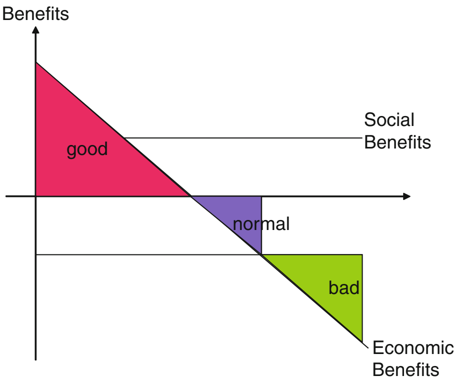

Fig. 57.2 According to the classification schematic of the overall efficiency of high-speed railway

Table 57.1 Beijing-Shanghai high-speed rail Beijing part of the statistical results

Date	Statistical number of days (day)	Daily average on the car number (people)	Average daily number of trains (train)
2011.12	18	38586	64.7
2012.1	29	45484	75.2
2012.2	29	42105	73.2
2012.3	29	48747	65.4
2012.4	14	51793	70.4
Total	119	45155	70.2

Source Beijing Railway Bureau

57.5 Benefit Analysis of the Beijing-Shanghai High-Speed Rail

57.5.1 The Economic Benefits of High-Speed Rail

Analysis of operating income

Beijing-Shanghai high-speed rail operating income is the amount of ticket revenue to calculate the known conditions of the ticket revenue for the number of passengers and fares.

According to my field research and study, I have 126 days from December 13, 2011 to April 2012 16 a total of 119 days in the Beijing bureau of the number of passengers, the statistical results shown in Table 57.1.

Ticket side, from the Beijing South Railway Station to Shanghai Hongqiao Station, first-class seat 960 yuan, second seat 555 yuan, the proportion of second-class seat is about 80 %. By this calculation, ticket revenue is up to the daily average of more than 48 million yuan, 17.5 billion yuan of annual ticket revenue. Estimated average annual ticket revenue in 2020 is stable at around 22.5 billion yuan.

Analysis of operating costs

The total investment of 220.9 billion for the Beijing-Shanghai high-speed rail project company registered capital ratio of 50 %, the rest of the approximately 110 billion yuan of investment through bank loans and issue bonds to raise. Preferential policies in accordance with the Bank to the Ministry of Railways "loan interest rates generally fall 10 %", the loan interest rate of around 6 %, interest payable annually at 6.6 billion yuan, which is a day to pay interest of 18 million yuan. Repayment of principal in accordance with the 20-year period, each year, 5.5 billion, or about 15.07 million yuan a day. According high-speed rail has opened the law, the annual depreciation rate of about 3–4 %, or 220.9 billion investment, the annual depreciation of fixed assets cost about 6.6–8.8 billion.

In summary, expected in 2012 as a whole, the economic benefits of the Beijing-Shanghai high-speed railway operating income of 17.5 billion yuan, 21.7 billion, operating costs, profit on sales of 350 million yuan, and the economic benefits of the sum to −38.5 billion; at the same time in 2020 economic benefits can be stabilized at about 1.25 billion yuan.

57.5.2 Social Analysis of the Beijing-Shanghai High-Speed Rail

The Beijing-Shanghai high speed railway line is line bridge 244, a total length of 1059.7 km, accounting for 80.4 % of the full range of the total mileage. Calculation, the value of the Beijing-Shanghai high-speed rail to save land for more than 20 billion yuan to 1,000 yuan per square meter of land.

Beijing-Shanghai high-speed rail operational vehicles CRH380A is energy saving and environmental protection of high-speed trains, mainly reflected in the low-power, lightweight, dirt collection. Kilowatt calculations, about $ 500 million worth of energy saving and environmental protection.

The experience of Japan and France Rail conservative forecast, the Beijing-Shanghai high-speed rail operators can create 200,000 labor positions, in accordance with the per-capita wages of 2,000 yuan, 400 million yuan of revenue.

Beijing-Shanghai line average transport density passenger of more than 30 million passengers, cargo of more than 8,000 tons, respectively 5 times and 3.5 times the average of the national railway, has reached the limit of passenger and freight mix of double track railway transport capacity. The opening of the Beijing-Shanghai high-speed rail can liberate part of the transport capacity to displace. Replacement-effective transport capacity is expected to about 80 billion.

Various parts of social benefits to the sum of processing available to the social benefits of the sum of the Beijing-Shanghai high-speed rail to 31.25 billion yuan.

57.5.3 Conclusion

Managed to support the situation compared to the national high-speed railway, Beijing-Shanghai high-speed rail is still relatively optimistic about the prospects. The one hand, the direct economic benefit of the Beijing-Shanghai high-speed rail is −38.5 billion can be expected after eight years into a 1.3 billion yuan, the Beijing-Shanghai high-speed rail without a government subsidy self-financing projections, but recovery of the funds of the project and also the pressure of this interest payment is expected to take 30 years or more to complete. On the other hand, the social benefits of the Beijing-Shanghai high-speed rail is enormous, and I believe over time scale will be greater. So for such a railway, the Government should build and give part of the subsidies.

57.6 Conclusions and Policy Recommendations

57.6.1 Re-Evaluation of High-Speed Rail Line has been Put into Operation

Of more than 350 km per hour and 250 km Passenger Dedicated Line has been in operation for more than one year from the current situation, the passenger line passenger seriously lower than expected, there is a serious loss in varying degrees, such as the Wuhan-Guangzhou Railway, Zhengzhou-Xi'an high-speed rail. Consider the current Ministry of Railways debt, thus re-evaluate the need for these high-speed passenger dedicated line item, the evaluation focused on the comprehensive benefits of the high-speed railway line. If the line is within the acceptable time to recover the cost or break-even, the line can continue to operate; serious line loss but enormous social benefits, the government can consider giving subsidies; if the comprehensive benefits of the line is negative, you can consider a moratorium on operation or the adjustment and optimization.

57.6.2 Consolidated Income and Government Subsidies

Author believe that can be high-speed rail line operations are divided into three categories: first, the economic benefits and the synthetical benefits are positive, such lines can be profitable without subsidies by the Government; the second is the economic benefits for the negative but the synthetical benefits are positive, the government should be the appropriate subsidies to ensure the normal operation of the line; the last one is the economic benefits and the synthetical benefits are negative, this line should stop operating.

57.6.3 Give Full Play to the Advantage of High-speed Rail Access to the Largest Passenger Flow, Increase the Transport Density

High-speed rail compared to other modes of transportation, some of its own characteristics: First, rail transport, economic and technological properties determine the rail with low tariffs, and a large volume competitive advantage, as the popularization of transport should be the main service most low-and middle-income travelers, so the Ministry of Railways need to correct market positioning, rather than blindly at the request of the high-end crowd quickly seek comfort. Second, high-speed passenger dedicated line could attract a larger passenger, depending on the value of high-speed rail passengers, which is determined by the economic value of travel time savings. China's per capita income is still very low, the economic value of travel time savings is very low. Rail passenger market in China, cheap and basic level of comfort is more important than saving a few hours of travel time.

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Chapter 58
Strategy Research on Planning and Construction of Low-Carbon Transport in Satellite Towns: The Case of Shanghai

Luwei Wang and Xinsheng Ke

Abstract China is in an important period of the urbanization and the rapid development of urban construction stage, in the backdrop of global climate change, the coordinated development of economy and the environment between the central city and satellite towns facing enormous challenges. In this paper, the case study of Shanghai, the main problems of the current satellite towns transportation planning and construction, from the angle of low-carbon, analysis methods to solve problems, to adapt to the trend of the development of low-carbon transport.

Keywords Low-carbon transport · The satellite towns · Urban railway

In recent years, an important period of our country in urbanization and the rapid development of urban construction, the big city as center gradually form the metropolitan area and many satellite towns appear. With the increased distance, the increase in passenger traffic between the city's areas and satellite towns, the enormous pressure brought to public transport system. With increasing scale of city, it brought new problems, such as overcrowding, traffic congestion. In recent years, the increasing demands of building the low-carbon city, Shanghai as represented of many cities are gradually exploring low-carbon transport of satellite towns.

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58.1 The Connotation of Low-Carbon Transport

Low-carbon transport is a fundamental characteristic of low energy consumption, low pollution, and low emission urban transport development mode. The core of building a low-carbon transport system is to promote urban transport systems, improve energy efficiency, and improve the structure of energy consumption (Huapu 2009). The low-carbon transport is not a new mode of transportation, but a new concept. Its core is to improve the energy efficiency, and optimize the development of transportation, guide people reasonable travel. Its purpose is to reduce energy consumption and carbon emissions, as passenger and cargo flow to provide a safe, convenient, comfortable and fair service, to meet demands of people's transportation.

58.2 The Main Problems of Transportation Planning and Construction in Current Satellite Towns

The development of satellite towns in Shanghai has been more than ten years, however, the integrated transport supporting is not perfect, resulting in these satellite towns in and out of the city public transport is inconvenient. Overall, in current satellite town transportation planning and construction has the following problems:

58.2.1 Transportation and Land-Use Planning is Not Enough Interactive

Traffic between the central city and satellite towns belong to a composite travel. Compound travel refers to use two or more modes in the whole travel process. Therefore, the configuration of them should not be limited to the analysis of characteristics of the various modes, need to consider end-to-end distributed patterns, reflecting the traffic and the intensification of land-use. Planning in satellite towns is still mainly traditional road grid-based land-use, especially rail transportation and the transportation hub of urban land-use don't layout embodies enough (Wenzhong 2003).

58.2.2 The Planning of Rail Transit Network is Not Enough in Satellite Towns

Comprehensive transportation planning only as a subsidiary of the content in satellite towns, depth and breadth are not enough. Between satellite towns and the center city, the traffic model is not clear enough, and rail transit network planning inadequate, construction of rail transit facilities have not done enough. The rail transit of Qingpu, Nanqiao, Nanhui in Shanghai don't connected to center city. Existing rail transit of Songjiang, Jiading, as Line 9 and Line 11 not only assumed the central city, but services for satellite towns, the travel speed is only 40–45 km/h.

58.3 Strategies on Planning and Construction of Low-Carbon Transport in Satellite Towns

The purpose of satellite towns closure the flow of the central city, control the size of population; transfer some economic functions of the central city, especially industrial, such as pollution industries to new satellite towns. Current satellite towns in China are not perfectly achieve, which mainly due to the construction of transportation facilities between the central city and satellite towns backward, influencing economic exchanges.

58.3.1 Build Public Transport-Oriented Systems

Various satellite towns are impossible to have the independent community function, therefore, the satellite towns to establish close contact with the central area is inevitable. For this reason, it is necessary to further build and improve the traffic system which large capacity, safe, fast, and cheap. The public transport-oriented system is a global planning, provides a new model of transportation construction and land-use (Zheng Ping and Cheng Na 2010).

Its model emphasizes comprehensive land-planning, at first set the urban railway station, the traffic in a within a radius of it via buses and the bus station link up with walking trails or bike lanes. The urban railway and loop of rapid transit, bike or walk lines superimposed together, they can seamlessly transfer. Traffic between the central city and satellite towns belong composite travel, the grading select model of composite transport trips shown in Fig. 58.1, and as a basis for the central cities and satellite towns, composite transport trips pattern as shown in Fig. 58.2.

Curitiba, in Brazil, is a world-recognized public transport model city, the city's transport axis along 5 high-density linear, transformation of the inner city; give priority to public transport instead of private cars. Currently, 75 % people in city

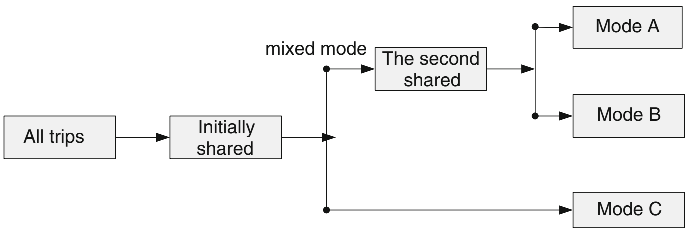

Fig. 58.1 The grading select model of composite transport trips

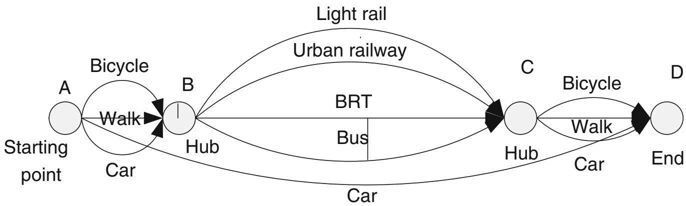

Fig. 58.2 The composite transport trips pattern

use public transport, 17,300 times one day, transport 1.9 million passengers, travel 230,000 miles, saving 700 million gallons fuel a year. We can see that public transport-oriented systems can not only ease the traffic pressure of satellite towns, as the land has been comprehensive planning and utilization, but also use energy more efficiently, reducing carbon emissions, to achieve low-carbon traffic.

58.3.2 Develop Low-Carbon Rail Transport Network

Compared with conventional ground public transport, rail traffic reflects the low-carbon characteristics: low energy consumption, low pollution, low emissions, low noise, and optimize the layout, contributing to industrial development (Dai Yixin 2009). The proportion of rail transit between satellite towns and central city should be higher than 60 % (Tokyo is 80 %).Shanghai as an energy-saving and new energy demonstration pilot city, naturally develop low-carbon rail transit network. Build a well-developed transportation network system and pay attention to develop urban railway, subway and light rail. Table 58.1 shows the characteristics of three rail transit system. Table 58.2 compared the energy consumption and emissions of different transportation modes.

Building rail transit (especially urban railway) as the backbone of the transportation system will be an important part of low-carbon traffic in satellite towns.

Table 58.1 The characteristics of three rail transit system

Item	Index	Light rail	Subway	Urban railway
The indicators of operational characteristics	Max speed (km/h)	70–80	80–100	80–130
	Operating speed (km/h)	20–40	25–60	40–70
	Max density (row/h)	40–90	20-40	10–30
	One-way capacity (row/h)	10000–30000	40000–60000	20000-–50000
	Reliability	High	Higher	Higher
Overall system performance	Station spacing	300–800	500–2000	2000
	Average travel distance	Short	Long	Longer

Table 58.2 The energy consumption and emissions of different transportation modes

Transportation	Bus	Car	Subway	Urban railway
Energy consumption/[kJ·(per·km)$^{-1}$]	714	2795.1	322.4	302.5
Average emissions of CO_2/[g·(per·km)$^{-1}$]	19.4	133.9	4.7	3.6

58.4 Conclusion

In recent years, Shanghai has really done much work and achieves certain results in satellite towns of low-carbon transportation system. Overall, however, the development of low carbon transport is still in its infancy, is still a long way away from the comprehensive requirements for low-carbon transport system. The planning of satellite towns is an important issue in urbanization. Its development has an irreplaceable role to solve the urban problems of excessive expansion. In the new century and situation, we must adhere to the principle of low-carbon development and build low-carbon satellite towns and develop low-carbon transportation, to keep the coordinated development between economy and environment.

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Chapter 59
Study on Intensive Design of Urban Rail Transport Hub from the Perspective of Low-Carbon

Haishan Xia and Xiaobei Li

Abstract As an important node of three-dimensional development of urban space, rail transportation hub plays a positive role in guiding low-carbon urban construction and intensive development. The construction of rail transit has promoted integration of urban functions of surrounding lots, which can be seen as a catalyst for urban development. Targeted to low-carbon city construction, the paper will analyze main problems of urban rail transport hubs through investigations on urban rail transportation hubs in Beijing, analyze the integration role of rail transit according to catalyst theory, explore and summarize the practices of foreign successful cases, and finally propose solving strategies, hoping to promote the low-carbon development of mega-cities.

Keywords Low-carbon city · Rail transport · Intensification · City catalyst

59.1 Introduction

The intensive development of urban rail transport hub space has a positive effect on low-carbon urban construction and brought a range of linkage effects to sustainable development of urban space. As rail transit for the carrier, the rail transit complex can become a catalyst for update and development of urban space and promote large-scale urban redevelopment of surrounding areas. This paper will

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take urban rail transportation hubs in Beijing for example to analyze main problems of rail transportation hubs in China, apply urban catalyst theory to explore catalytic roles of rail transport as well as intensive design strategies.

59.2 Problem Analysis

59.2.1 Investigation and Analysis of Rail Transportation Hubs in Beijing

In recent years, combined with rail transit construction, Beijing has built some large-scale transportation hub complexes. As two important rail transits in Beijing, Xizhimen and Xidan Joy City have gathered a lot of people and traffic. However, there are still some problems in intensive utilization of urban space.

(1) **Xizhimen rail transit complex**

In past three years, the questionnaires of Xizhimen rail transit complex have been disseminated thousands. The transfer space design has following problems: the crowd disorganized within the traffic transfer space; the transfer route is too long and the space-oriented unclear; the setting of pedestrian system imperfect and the continuity between indoors and outdoors is not strong.

(2) **Underground Commercial Street of Xidan Joy City**

Underground Commercial Street of Xidan Joy City is an extension of the commercial shopping center on the ground, large-scale and more types. However, in the research process it is found that the scene in Underground Commercial Street seems deserted. Through statistical analysis of the questionnaires, poor physical environment and poor sense of direction are two main reasons why shoppers do not want to go to the underground shopping (Fig. 59.1).

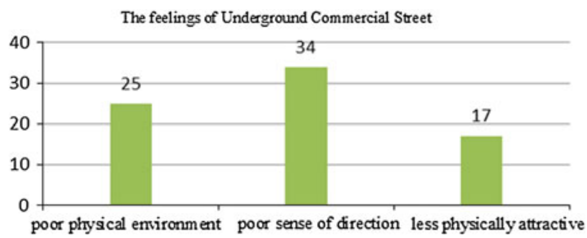

Fig. 59.1 The feelings of underground commercial street

59.2.2 Existing Problems of Rail Transportation Hub in China

Through above analysis and surveys about rail transport hubs in Beijing, there are following problems in construction of rail transportation hub in China:

(1) **The line network planning of rail transport is not closely linked with urban planning or urban design.** Urban design and analysis for the comprehensive development of the rail transport are not enough, causing functional convergence between rail transportation hub and urban space not close enough.
(2) **The development capacity of public space in rail transit station areas is small and single function.** Rail transit station has the important advantage of gathering crowd, which relates to a wide range of public activities in the city, but the development scale of commercial function is not enough, insufficiency, and fails to take full advantage of its economic and commercial value.
(3) **The underground pedestrian system in rail transit station areas is underdeveloped.** The underground pedestrian space is of fragmentation, the connection points with the ground is less and attracting scope small. Besides, space for walking is narrow and single form, lacking support of other city functions compatible with the walkathon, lacking of systematic and sustainability.
(4) **The design of transfer space is insufficient.** Traffic flow lines disorganized, poor reachability, space-oriented weak and other problems cause the contract between rail transportation hub complex and urban public transport weak, thus giving a lot of inconvenience to the transfer Shen (2009).

59.3 Urban Catalyst Theory: The Integration Role of Rail Transit Complexes

59.3.1 Urban Catalyst Theory

American architects Wayne Attoe and Donn Logan have proposed urban catalyst theory: there should be a series of limited effects in the city and each other plays a coordinating role by mutually stimulating. The introduction of urban catalyst as new elements can quickly stimulate related elements react and immediately cause a chain development of other projects. As a concept and method of urban design, how to play this promoting effect and guide low-carbon urban construction is worthy of further exploration.

59.3.2 The Catalytic Role of Rail Transit Complexes

During the construction of low-carbon city, a complex combining many functions into one can reduce land and transportation energy consumption and make pooling of resources and energy Xia (2006). This idea of intensification will be theoretical basis of design of urban rail transit.

Rail transportation complex should become a catalyst for the development of urban areas, catalyzing the development of surrounding areas through integrated functions of cluster effect and walking system of diffusion effect. According to this theory, the catalytic reaction of rail transit should have five basic elements: a catalyst—urban complex; excellent value—integrated functions of cluster effect and walking system of diffusion effect; catalytic mechanism—with the development of urban complex catalytic surrounding development to promote their excellent value; guide policy—put forward a series of controllability requirements to the development around rail transit stations; joint development—rail transportation and real estate, government and non-governmental jointly developed the urban complex.

According to urban catalyst theory, the construction of rail transit complex has injected new elements to urban development and is bound to drive the overall development of surrounding areas. The city catalysis of rail transit complex shows in the following three aspects:

(1) **The creation of positive space and gathering space of low-carbon city.** Combined with the construction of rail transit sites, the influenced area will have an effective urban design, increase parks, squares and other open space, improve the pedestrian system, set flag nodes, enhance the vitality of the region and the public's sense of belonging and improve the quality of urban space.
(2) **Rail transportation has promoted low-carbon space mode of metropolitan group-style.** The construction of rail transit can adjust the structure of urban space, guide urban land use to develop towards reasonable directions, drive the land of surrounding areas appreciation and construction density grow and promote urban spatial structure to transform to low-carbon space mode of multi-center group-style.
(3) **Three-dimensional urban space transformation and revival.** Rail transport can lead to large-scale urban development of the surrounding areas, drive the dynamism of the entire region, have a strong role in promoting the revival of old central area and improve land use efficiency of the new district. The three-dimensional development model of "Underground—ground—high level" has gradually become a standard trend Du (2006).

59.3.3 Intensive Means of Foreign Rail Transit Hubs

(1) **"Wing" integrated transport hub in Nagoya, Japan**

"Wing" integrated transport hub in Nagoya, Japan is located in the city center with land very tense, which is an ideal underground rail hub. In order to achieve intensive and efficient use of urban space, "Wing" integrated transport hub combines functional, spatial and transport organizations together, creating a huge space and value in a limited space and providing people with a perfect mode of multifunction integrated transport hub station.

(2) **Transbay hub in San Francisco**

Transbay hub in San Francisco is the gateway to New York City, an integrated transport hub of setting rail transit, coach passenger and urban road traffic as one. In order to adapt to the needs of urban new development and people travel, the project has conducted integrated arrangement. Different modes of transportation establish each transport function area and flow line system of relatively independent and full contact with surrounding areas. At the same time different levels, multi-directional channels have been set to facilitate passengers passing in and out and transferring, promoting the development and intensive use of the surrounding land.

59.4 Strategies Under New Perspective

The pursuit of a rational and efficient high-density urban space should be the premise of low-carbon urban construction. In order to achieve the intensive use of rail transit hub space, the following resolution strategies have been proposed:

(1) **Emphasis on urban design at rail transit hubs**

In order to solve the problem that the urban design of rail transit station area is weak, there should be an urban design on walking reasonable area as rail transit station for the core of spatial organization and radius of 500 m. Determine the function of comprehensive development and morphological mode of rail transport hub with the surrounding architecture, the scale of the space above and below ground and the underground pedestrian system, flat profile layout and so on Lu and Jing (2007).

(2) **Construct comprehensive walking system in the surrounding region of rail transit hub**

Rail transit complexes should vigorously develop underground pedestrian system and make full use of catalyst effect to stimulate development and construction of the underground walkway of surrounding areas. Concourse level of the station can be directly linked to the underlying of surrounding buildings by ways of overpass, underground sidewalks or commercial pedestrian streets and so on. Entrances should be set cross-blocks, maximize to suture the ground urban space severed by motorized transport, reduce the inconvenience of the ground vehicle flow, increase reachability of stations.

(3) **Focus on oriented design inside rail transit complex**

In response to the problem of weak oriented inside the rail hub, a simple and comfortable transfer space can be created by building means and unified, effective identification system. For example, the design of the entrance should be more visually significant and reflected in the morphology and identification; by strengthening certain spatial form (such as increase the main channels through space as well as atrium in the space center, etc.), elements (light, color, material, etc.), make passengers easier to determine a starting point, destination point and position in space, and guide the flow of people through building means as much as possible.

(4) **Enhance the landscape and environmental quality of rail transit station areas**

For low-carbon urban construction, centralization is not only to obtain space to have buildings clustered together, but focus on the protection of landscape environment. The construction of rail transit site provides an opportunity to the shaping of regional environmental quality. Urban public green spaces and squares should be set in conjunction with exits. Increase the rate of urban green space and public recreation space to effectively enhance the quality of local environment. At the same time integrate the architectural landscape of surrounding areas to form well landscape style of modern city.

59.5 Conclusions

During the construction of low-carbon city, compactness is an inevitable trend of urban architectural space. Through above research on intensive design and countermeasures of rail transport hub, the conclusions are as follows:

(1) According to urban catalyst theory, rail transit complex should play an active role in the construction of low-carbon city, promote intensive regions, functional efficiency and dimensional space.
(2) From the practical point, the rail transportation hub has great potential for integration of urban functions, promoting urban functional integration of surrounding areas and bringing vitality for the city with intensive spatial form.
(3) Successful rail transportation hubs have a variety of patterns to develop. Learn from intensive means of foreign rail transit hubs to direct the future construction for our country.

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Chapter 60
The Roles of Railway Freight Transport in Developing Low-Carbon Society and Relevant Issues

Guoquan Li

Abstract In this study, the situations of surface freights and potential demands to be suitable for railway container are analyzed, and the possible predominance ranges of railway in transport cost are estimated by the comparative analysis between railway and truck freight rates in transport distance. Moreover, by a case study, the effects of railway freight transport in the reductions of logistics costs and CO_2 emissions, and the savings of energy are derived. Finally, the relevant issues concerning the actual conditions are discussed.

Keywords Railway freights · Predominance range · Logistics costs · CO_2 emissions · Savings of energy

60.1 Introduction

When our world is just facing on the global warming problem, the great numbers of passengers and freights are increasingly flowing among different regions, different countries with the globalization of economy and industry. Although the flows among different countries can use ship, railway, motor, air or pipe, so many products in the Origin or Destination area or between OD are transported with surface means, especially trucks. Therefore, in order to construct a sustainable development and low-carbon society, Railway freight transport is expected to play

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more important roles. In the meantime, because of the circumstances of the severe competitiveness in the freight transport market, it is not easy to reinstate its former status in freight market, especially as the island country of Japan, only performing in the relevant policies.

Therefore, as the first step, it is essential to analyze and grasp the effects of railway freight transport in the actual socio-economic activities, and discuss relevant issues of railway transport based on the actual situations of surface freights.

There are some relevant studies with many academic values and actual meanings for railway freight transport, according to the different situations in freight transport market (Li 2003, 2009a, b; Hino et al. 2000; Bontekoning and Priemus 2004; Bärthel and Woxenius 2004; Li et al. 2012). These researches showed that we must improve relevant services and technology of railway freight transport.

This study, at first, investigates the possible freights to be suitable for railway container in Japan's domestic freights, according to the actual freight situations. Then, the potential railway freights passing the analyzed target corridor distributed on the concerning regions are elucidated through building the database of freight flows. Then we estimate the possible predominance range of railway in costs through comparing the actual rate of railway freight to that of truck. With a case study, we derive the effects of railway freight transport in the reductions of logistics costs and CO_2 emissions and the savings of energy. And the relevant issues are discussed.

60.2 Domestic Freight Situations

According to the relevant inter-regional freight flow survey of Japan's government (Ministry of Land, Infrastructure, Transport and Tourism 2003), we can describe the changing tendency of domestic or inter-regional freights. The domestic freight tonnages decreased from 6.96 billion tons in the early 1990 s to 5.32 billion tons in 2008. The decreased freight tonnages were about 1.5 billion tons. On the other hand, the inter-regional freights grew from 1.62 billion tons in 1991 to 1.83 billion tons in 2008, during the same period.

Furthermore, The investigations of actual surface transport situations revealed that road haulage accounts for an overwhelming transport proportion in short-distance, and even in long distance of over 1,000 km, road haulage's share was still more than three times larger than that of railway transport.

Although the modal shift policy from excessive road haulage to railway transport or coastal shipping in Japan has been proposed from the 1980 s, the freight share of road haulage in domestic transport market is increasing, and the relevant share of railway or coastal shipping freights is decreasing, continuously. As for the road haulage, the shares in tonnage have gone up from 90.2 % in 1985 to 91.2 % in 2005, and that in ton kilometer from 47.4–58.6 %, in the same period.

Contrastively, the railway freights' shares have gone down from 1.8 % to about 1.0 % in tonnage, and from 5.1 % to about 4 % in ton kilometer, respectively. Additionally, the shares of coastal shipping changed from 8.1–7.8 % in tonnage, and from 47.4–37.2 % in ton kilometer, respectively. It is really the reverse phenomenon of the modal shift to the relevant proposed policy.

All as mentioned-above can be depicted two extremes. One is meant that there are really no suitable freights for railway. The other is that the roles or significances of railway freight transport can not still be understood by the society.

60.3 Potential Railway Freights Based on the Analyzing Corridor

In this study, we focus on the surface inter-regional freights in manufacture, the freights among different transport means such as chartered truck, trailer, rail container and other, are comparatively analyzed, in production scales of users, the shipments' time of freight, transport lot. And then the concentration ratio of freight's transporting destinations, and freight items sent from different regions are investigated. It is found that there are so many similarities between the freights of current railway transport and road haulage by chartered truck and trailer. Therefore, the freights of the chartered truck and trailer can be also seen as the possible freights to be suitable for railway container. They are considered as potential demands for railway transport.

With the use of the actual transport routine database of railway freights built in this study, and goods survey of the government (Ministry of Land, Infrastructure, Transport and Tourism 2003), the corresponding freight flow routines in the influence range of each terminal related to relevant analyzed target corridor are investigated, which be called as the analyzing corridor, according to the actual situations of surface freights. Based on these, the possible freights to use the analyzing corridor when they are transported by railway, following the routines' database of the actual railway freights, are extracted.

In this study, we use the corridor in railway network that links Kyushu area to other areas of Japan as target analysis. The analyzing corridor is concerning 138 terminals almost covering all regions of the country. The detailed contents of the potential railway freights indicate that although the actual result of railway freight in transport share of surface freight is higher than the average level of entire country, the transport share of road haulage in the potential railway freights is about 84.8 %, and the railway container share is only 15.2 %. Therefore, the actual share of railway freights is very low in its potentials. Therefore, in the actual inter-regional surface freights, there are the freights suitable for railway transport.

60.4 Possible Predominance Range of Railway in Transport Costs

It is needed to discuss the possible predominance ranges of railway transport according to the actual situations in multiple respects. But there are many difficulties to grasp all of the real transport conditions, concerning the business practices of users and operators, many factors in the freight market. Therefore, this study focuses on the truck freight rate in the mileage system and investigates the truckload transport rates using actual data from the users' survey (Cargo News 2002, 2006). And then, through the comparison with the transport rate of railway container, we can find the possible predominance range of railway in transport cost.

The main factors involved in the setting of truckload freight rates based on the mileage system are truck type (i.e., vehicle tonnage) and transport distance. In the conventional tariff based on ton-kilometer, the freight rate generally tends to decrease with increased transport distance and/or vehicle tonnage. In reality, many factors influence truck freight rate. When a user chooses a carrier to transport freight, the whole range of carriers available is generally considered. Charges involved in using expressways or ferries if necessary, as well as the term of the contract with the carrier, have an influence on freight rates. In addition, when multiple means of transport are available, users have the advantage in transport contract negotiations with carriers.

About the freight rate of railway container, because it is based on the 12ft container in Japan, only if we find the relationships between the railway transport costs and relevant distance, based on the actual transport cost of users' survey, the freight rate of railway transport can be derived.

In the potential railway freights, it is clear that all of benefits are obtainable not by railway, but the extent to which railway transport is beneficial should be determined. Generally, one of criteria to understand the obtainable benefits by railway is transport costs. On the premise that users choose the cheapest transport means, the possible predominance range of railway in distance can described through following condition.

$$\textbf{Railway freight rate} \leq \textbf{truck freight rate}$$

It can also be seen as one of the fundamental standards against which the cost advantages of railway freight transport are judged. According to the comparative analyses of truck and railway freight rate, using the current transport data from the users' survey, the predominance range of railway container transport can be estimated as shown in Fig. 60.1.

For example, the freight rate of railway container will be cheaper than that of 10-tonnage truck when the transport distance is greater than 350 km. Naturally, the advantages of each transport means cannot be judged exclusively in term of the rates, but there do are freight convoys that may potentially be transported by railway with the cheaper freight rate.

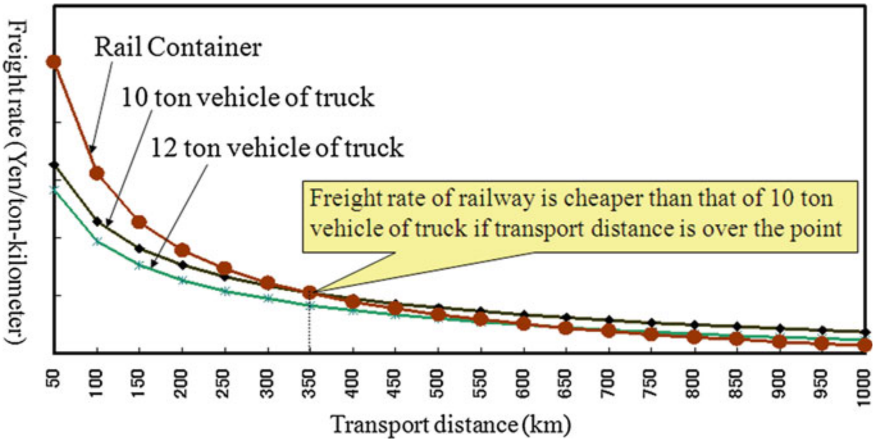

Fig. 60.1 Possible predominance range of railway freight in transport cost

60.5 Effects of Railway Freight Transport on Developing Low-Carbon Society

As stated previously, railway freight transport, in fact, can be described as current and potential freights, based on the current situations and restrictions on freight transport along the analyzing corridor. Social and economic benefits by railway include the current effects of the carriage of freight by railway and the potential effects that may be induced when the potential freights of railway could be shifted from road to railway.

The current effect denotes the level by which logistics costs, CO_2 emissions and energy consumptions are reduced due to goods currently being transported by railway.

First, the freight transported on the analyzing corridor is ascertained from the current inter-regional freight data, and logistics costs, CO_2 emissions and energy consumptions are estimated based on the routing of railway freight. Next, relevant amounts are estimated assuming that said freight is transported by road. The comparison of the two gives us the evaluated current effects of railway freight.

The potential effects are assumed that there will be the reductions in logistics costs, CO_2 emissions and energy consumptions if freight currently transported by road in the predominance range is shifted to railway.

Because the influential area of the analyzing corridors is concerning the entire country, the surface freight transported by road must match the relevant railway route along the analyzing corridor. As the results of a case study, the social and economic effects of railway freight transport can be derived as shown in Table 60.1.

The current effects in cost reductions are 7.8 billion yen per year, 390 thousand tons per year in CO_2 emissions reductions, and 150 million litre per year in savings

Table 60.1 Effects of railway freight transport based on the analyzing corridor

Effects (an year)	Cost reductions (Billion Yen)	CO_2 emission reductions (thousand ton-CO_2)	Savings of energy (million litre)
Current	7.8	390	150
Potential	16.3	810	310

of diesel. When the modal shift of potential freight transport from road to railway is really implemented, the railway freight transport would save 16.3 billion yen in costs, reduce 810 thousand tons of CO_2 emissions, and save 310 million litre of diesel.

60.6 Discussions on the Issues of Railway Freight Transport

In order to promote the railway freight transport for low-carbon society, some important issues must be sufficiently understood and discussed.

In freight transport market, the railway transport's merchandise is originally the train diagram with exact schedule to be offered to the users according to their needs. This is the basic and essential conditions for promoting railway freights. As for the actual situations of railway freight transport, it is difficult to make the corresponding freight diagram exactly matching with the needs of users, because the railway freight operator has to use the railway networks of plural passenger railway companies to run the freight trains in the gaps among the passenger trains. In the meantime, there are overcrowding schedule of passenger trains in many main corridors, where are called as bottlenecks. These bottlenecks are restricting the development of railway freights. How to arrange the freight trains, as affecting the whole railway network, is one of the most important issues to be soberly discussed further in the future.

And then, the operator of railway transport shall make greater efforts to provide the relevant services corresponding to the needs of users. Moreover, Corresponding to the change of socio-economy and industries, the radical issue in railway is to reconstruct the traditional system to be suitable for the new needs.

Government shall have more effectual and useful measures and policies in improving transport condition of the network, especially the bottleneck corridors, and in guiding users to use railway such as introducing the taxation of CO_2 emissions, environment-friendly grant, and so on. To the users, it is necessary to recognize the merits of railway transport not only in the environment-friendliness, but also in the efficiency of logistics and the savings of the energy and labor, and so on.

Therefore, the current issues of railway freight transport are not only concerning the relevant operators, but also concerning the entire society.

60.7 Conclusions

Through the comparative analysis of current railway transport and road haulage, based on a special case as Japan railway, this study can mainly be concluded as follows.

In the actual situations of domestic surface freights, there are still a large volume of potential freights to be suitable for railway. It is estimated that the possible predominance range of railway in transport cost is greater than 350 km of transport distance. With the case study of an analyzing corridor, using the criterion in transport cost, the effects of railway freight transport in the reductions of logistics costs and CO_2 emissions, and the savings of energy are derived. The results showed that it is possible that in developing low-carbon society, railway freight transport will play more important roles. Conclusively, the relevant issues concerning the actual transport conditions are discussed, in the improvement of railway transport system, government roles and users' recognitions. Only if the reasonable transport policies and measures to improve the relevant railway infrastructure and transport services are implemented, the railway freight transport will have furthermore effects.

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Part III
SS-Industrial Security Under Low Carbon Development

Chapter 61
Preliminary Study on Coal Industrial Safety Evaluation Index System Under Low-Carbon Economy

Lei Zhang and Cheng Chen

Abstract Coal industry occupies a dominant position in our energy supply and consumption, which is directly related to national security, social stability and sustainable development. However, under the environment of low-carbon economy, with resources and environmental problems becoming increasingly prominent, the constraints on economic development are increasingly influencing the stable and healthy development of the industry. Therefore, it requires taking resources and environmental factors into the evaluation index system of the industrial security. Based on the coal industry security factors and principles of indicators system designing, the policy that states to promote energy conservation to achieve the strategic objectives of the low-carbon development, and characteristics of coal industrial development, establish a more systematic, comprehensive evaluation index system of low-carbon development on the coal industry.

Keywords Coal industry · Low-carbon development · Industrial safety · Evaluation index

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61.1 Introduction

Energy is the basic factor constraining economic growth and the basis of the existence and development of human society, we must insist on energy as the strategic focus of economic development, make sure sustainable development and efficient use of energy to support sustainable economic and social development. Chinese energy structure-"Lack of oil, less gas, rich in coal" decides that coals occupy a dominant position in our energy supply and consumption. As the earliest development and use of primary energy in human society, coal occupies the irreplaceable foundation position in national development, which is directly related to national security, social stability and sustainable development, therefore it has been very important in the world's energy consumption structure. At the same time energy is also an important guarantee to the thriving of a country. Especially in the last few years, in the context of the world's strong economic growth and rising global oil prices, with coal-clean, the mature and use of efficient technology, the value of coal itself has been greatly improved, while it also stimulated a substantial increase in global coal production, consumption and trade.

Data published by BP World Energy Statistics (2012) shows that in 2011, coal now accounts for 30.3 % of global energy consumption, the highest share since 1969. BP data shows that in 2011, coal consumption grew by 5.4 % in 2011, the only fossil fuel to record above average growth and the fastest-growing form of energy outside renewable, reaching 3.72 million tonnes of oil equivalent and accounting for about 68.6 % of the total global consumption in the Asia-Pacific region.

In 2011, China's coal imports continue to remain high, the total imports build another new height in recent years, and the scale of exports is still small, with imports disparities. China's coal import is 182 million tons, an increase of 10.8 %; export is 14.66 million tons, down 23 %; net import is 168 million tons, an increase of 15.2 %. At the end of December 2011, the whole society in China stocks 253 million tons coal, an increase of 16.6 % compared with the beginning. In recent years, as a number of new constructions, renovation, expansion and integration of resources coal technological transformation completed in succession and put into production, the release of coal production capacity gradually speed up, in 2011 the production capacity of China's coal industry is 95 million tons.

In the next 30–50 years, although the new energy and renewable energy development and promotion, will make the consumption proportion of coal in primary energy decline, but the dominant position of coal still will not change. Thus, the coal in the rapid development of China's national economy will continue to play an important role. With the worldwide resource depletion, and advances in technology, the development of China's coal industry has begun to gradually enter the stage of the "qualitative change". But in the process of change on the coal industry, China's coal industry is running a lot of problems: the world's major coal-producing countries have increased the intensity of coal production and export in the stimulation of international coal prices rising. China's energy structure-"Lack of oil, less gas, rich in coal"—decides the only coal-based primary energy structure in the historical period towards the sustainable development, which requires promoting the progress of the coal industry to meet the national growing energy demand. The key to the development of China's coal industry is to strive to narrow the gap of the efficiency, effectiveness, safety and environmental protection with international industry, the coal industry not only need domestic competitiveness, but also need to improve the international competitive advantage. As a developing country, whether to get rid of extensive expansion of the development model in economic growth, to change the past high growth, high consumption and high pollution, to achieve high growth, low consumption, low pollution, is the key to transformation of China's energy of economic growth and achieve sustainable development. In this context, to explore the influencing factors of the Chinese coal industry safety and evaluation of China's coal industry security has become a strong reality and urgency of the major theoretical and reality during China's energy sector meet the world economy globalization's opportunities and challenges. Therefore, how to scientifically evaluate the operational state of China's coal industry, and build the coal industrial evaluation index system under low-carbon economy has great significance.

Foreign study on the evaluation of industrial security is still in the exploration of the initial stage. With the advent of economic globalization and China's accession to the WTO, China's economic openness enhances unceasingly, some scholars started to pay attention to industrial security, and have proposed metrics and evaluation indicators on industrial security.

Professor He Weida has quite contribution in the field of Industrial Security, in his text, Professor He Weida (2002), decomposed industrial security evaluation index system into international competitiveness evaluation indicators of industry, external dependency evaluation indicators of industry, the controlling power evaluation indicators of industry, and, respectively, assessed the international competitiveness of industry with trade specialization coefficient indicators, evaluated the industry dependence on foreign industry with industrial export degree of dependence on foreign trade and industrial capital indicators, used the foreign equity control indicators to evaluate the controlling power of industry, and it can better give consideration systematic, testability and other requirements of the index system. Industrial Safety evaluation proposed by Professor Yang Gongpu, and Xia Dawei (2005), Professor Shi Zhongliang (2005) is extended to four evaluation indicators on the basis of Professor He Weida. Jing Yuqin (2006) proposed industrial domestic environmental evaluation, industrial competitiveness evaluation and industrial control evaluation, analyzed six major influencing factors-government regulation environment, market environment performance, structure, industry controlled situation and the country concentration, took the government performance indicators into them, and eliminated the industrial capital and industrial technology dependence on foreign which are highly related to the control rate of foreign ownership and foreign technology. The evaluation of industrial security status must be combined with qualitative research, in addition to quantitative analysis.

However, such studies deserve to be discussed further and improved. Under the environment of low-carbon economy, with resources and environmental problems becoming increasingly prominent, the constraints on economic development are increasingly influencing the stable and healthy development of the industry. Therefore, it requires taking resources and environmental factors into the evaluation index system of the industrial security.

61.2 Analysis on the Influence Factors of the Coal Industry Safety

The factors affecting the safety of the coal industry involved in internal and external aspects.

61.2.1 Internal Factors

Internal factors Industrial security involved in two major categories of the living environment of the domestic industry and competitive environment.

61.2.1.1 The Living Environment

There is a very direct relationship between the industrial safety and industrial environment. The domestic living environment of the industrial is the basis of the industrial survival. The industrial environment in the broad sense, include the status of the industry and the various influence factors such as industrial development, natural geographical factors, macroeconomic factors, political and legal factors, and socio-cultural factors. Industrial environment described in the context of industrial safety issues includes production environment, market demand, environmental and industrial policy environment which affect the industrial safety development. In addition, there is also the resources environment. Per capita recoverable reserves of China's coal is less, only two-thirds of the world level; the development scale is large, and reserve-production ratio is less than one-third of the world average; the rate of resource extraction is low and consumption is large, about 48 % of the world. Resources development and utilization are difficult to support long-term economic and social development.

61.2.1.2 The Competitive Environment

In the theories of industrial economics, excessive competition and monopoly are not the ideal market structure, and both are the deviation from the optimal allocation of resources. If a country's enterprises have lost control and influence on a reasonable competitive landscape, excessive competition is bound to affect the reasonable adjustment of industrial structure, thereby affect industrial safety.

61.2.2 External Factors

External factors affecting the industrial security include capital, technology and products factors from foreign due to global economic integration and market opening conditions.

61.2.2.1 Foreign Capital

In recent years, with the strong demand of the Chinese market for energy, and the consolidation trend in the Chinese coal mining industry, a growing number of international financial capital are looking for investment opportunities in China's coal mining industry. Suddenly foreign investment in the China's mining is active; the coal industry has become the hot pursuit of foreign capital, foreign mergers and acquisitions are in the ascendant, the scale and pace of mergers and acquisitions is rapidly rising. Large-scale mergers and acquisitions of foreign investors in the coal industry have a significant impact on the control of the industrial chain and state-owned assets of China, and it likely causes local monopoly problem.

61.2.2.2 Foreign Technology

Technology import is the important supply channels of a country's technological progress, any country only depending on their own invention alone is far to meet the needs of technical progress. Coal machinery products are often long-term work in a harsh and complex environment, the requirements of overall technique is safe, reliable, and able to adapt to the harsh operating conditions. Compared with foreign countries, coal equipment manufacturing industry in China has made some progress in recent years, but the overall technical and technological level is not high, and there is still a certain gap compared with the international advanced level in automation and control, service life and reliability.

61.2.2.3 Foreign Monopoly of Raw Materials and the Price of Resource Products

Coal machinery and most of the raw materials are made of steel processing; the cost is affected by the steel price fluctuations. Steel raw material prices are closely related to the macroeconomic situation, and the periodic is strong. In recent years, the fluctuation in steel prices is frequent; coal machinery enterprises are facing greater cost pressures.

Table 61.1 Coal industrial evaluation index system under low-carbon economy

Target	One-class index	Level 2 index	Level 3 index
Coal industrial evaluation index system	Living environment of industry	Production elements environment	Capital efficiency
			Cost of capital
			Overall labor productivity
			Unit labor cost
		Market demand environment	The growth rate of market demand
		Institutional environment	The degree of marketization
			The government regulation performance level
		Resources environment	Coal consumption strength unit GDP
			"Three-wastes" emissions unit production value
			"Three-wastes" comprehensive utilization rate
			The main pollutants
			Unit value added of industry water consumption
			One million tons mortality in the coal mine safety production
			The reserve-production ratio of Coal resources
	International competitiveness of industry	Trade competitiveness	Trade special coefficient
		Performance competitiveness	Capacity utilization
			The added value of the coal industry
			Proportion of products sold
		Structure competitiveness	Market concentration rate
		Technology competitiveness	R&D investment Proportion in the mining
			Professional technology personnel proportion
		Scale competitiveness	Domestic market share
			The international market share
	External dependency of industry	Industrial export level	Industrial export degree of dependence on foreign trade
		Industrial import level	Industrial import degree of dependence on foreign trade
	Industrial control	Foreign capital market scale	Industry foreign capital market control
		Foreign capital scale	Industry of foreign capital control
		Foreign technology scale	Foreign technology industry control

61.3 Establishment of Coal Industrial Evaluation Index System

Based on the coal industry security factors and principles of indicators system designing, the policy that states to promote energy conservation to achieve the strategic objectives of the low-carbon development, and characteristics of coal industrial development, establish a more systematic, comprehensive evaluation index system of low-carbon development on the coal industry. The indicator system consists of 4 one-class index of the living environment of industry, the international competitiveness of industry, external dependency of industry and industrial control, 14 level-2 indicators of production elements environment, market demand environment, institutional environment, resources environment, and 28 level-3 indicators of capital efficiency, cost of capital, personnel labor production rate, etc. in Table 61.1.

61.4 Conclusions

Bring the resources environment indicators of the coal industry into the industrial safety evaluation system is correction and perfect to the measure of industry safety standards. To safety assessment on the industry, problems which need to further consider or take attention, include: (1) The data in industrial safety evaluation needs to reprocess under the existing statistical standards; (2) The industrial safety evaluation indicators have relative characteristics, and the industrial safety assessment is a dynamic process; therefore, different industry types could cause change of certain factors and their weighting; (3) It requires a combination of qualitative analysis and quantitative evaluation of industrial safety.

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Chapter 62
China's Energy Economy from Low-Carbon Perspective

Xiaonan Qu

Abstract Energy security issues related to China's economic lifeline and livelihood of our people, also of great significance to maintaining world peace and stability and promoting common development. With China's rapid economic development of China's energy demand is also increasing year by year in this article mainly analyzes the current development of China's energy industry, and development issues, and made recommendations on China's energy development.

Keywords Low-carbon · Energy · Sustainable development

62.1 China's Energy Situation

China has a 9.6 million square kilometers' land area, and territorial sea, continental shelf, exclusive economic zone area of approximately 3 million square km. From Table, China's mainly fossil energy reserves are rankings at the forefront in the world. China's fossil energy reserves from the total amount.

Our country's energy is mainly petrochemical energy at which made up by oil, coal and natural gas mainly at present. However, fossil energy is non-renewable energy, the reserves are limited. With the rapid development of economy and society in recent years, the demand for energy is more and more robust. This limited petrochemical energy reserves are then declining, prices are rising. Coal is the main

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Table 62.1 China's major energy reserves situation

Energy type	Recoverable reserves of the world	Recoverable reserves of China	Proportion of the world (%)	World ranking	Reserve-production ratio of the world	Reserve-production ratio of China
Oil	13.2832 trillion barrels	14.8 billion barrels	1.1	14	46.2	9.9
Natural gas	187.1 trillion cubic meters	2.8 trillion cubic meters	1.5	14	58.6	29
Coal	860.9 billion tons	114.5 billion tons	13.3	3	118	35

fossil energy in China, it takes 70 % of the whole energy consumption. BP statistics show the world's Reserve-production ratio of oil, coal and natural gas is 46.2 years, 118 and 58.6 years, however, the data in China are 9.9, 35 and 29 years.

At the same time, China's energy output and growth rate was significantly lower than the consumption and its growth rate. Oil, for example, between 2000 and 2010, the Chinese oil production increased by 24.85 % at the same time, oil consumption is simultaneous increase 91.2 %.

In 2007, crude oil apparent consumption of China reached 346 million tons, 159 million tons of net imports, the import dependence is as high as 46.1 %. According to the forecast, as China is increasingly dependent on overseas oil supplies, the oil imports from 350 million barrels/day in 2006 surge to 1,310 million barrels/day in 2030, the share of imports in its demand will rise from 50 to 80 %. Moreover, the world power demand annual rate will be 2.5 % by the year 2030, from a global perspective, by the end of 2030, the total amount of electric power production capacity will be 4.8 million megawatts. China will contribute 28 % of the total increasing amount. In China, the increasing demand for oil, gas and coal resources in electric power industry makes the energy security condition more severely.

The great consumption of fossil fuels leads to serious environmental disruption, the increasing carbon dioxide emissions will sharpen the greenhouse effect. Since 2007, China has became the world first emissions superpower. And because the U.S financial crisis, the energy consumption and greenhouse gas are continuous in negative growth emissions in recent years. However, China has 6–9 % high growth speed each year. China's per capital emissions in 2007 is more than the average level in the world, in many of the cities has surpassed many other developed countries, such as France, Sweden, and approached the European Union, Japan. In 2010, the calculated carbon dioxide emissions based on the Chinese National Bureau of Statistics is 7.693 billion tons. As the second place, carbon emissions in the U.S is 5.638 billion tons. Since the beginning of this century, China has increased its greenhouse gas emissions to account for about 40 % of the world. The greenhouse effect caused global warming, that brings increasing intensity and frequency of extreme weather or climate in recent years, and changes the law of natural disasters, which had a serious bad impact on global food production, human life and the natural environment. Gill Bates (2007) shows the climate of China occurred significant changes, it also greatly affect the eco-system. This is an unavoidable problem in the sustainable economic and social development.

62.2 Some Problems for China's Energy Industry

62.2.1 Some Structural Problems for Energy Industry in China

The majority energy production and consumption rely on the coal. Compared to the production and consumption of the other two energies, namely the gas and the petroleum, those of the coal take up 86.1 and 76.5 % respectively. In a word, it is an outstanding figure of Chinese energy structural that the coal holds the dominant position. According to the figure published in 2004, 36.8 % petroleum, 23.7 % gas, 27.2 % coal, 6.2 % hydropower, and 6.1 % nuclear energy construct the consumption of world's energy. However, Chinese figure is quite different: 22.3 % petroleum, 2.5 % gas, 69.0 % coal, 5.4 % hydropower, and 0.8 % nuclear energy. After such a comparison, Chinese energy structure drags because of its lower gas and nuclear energy consumption and the much higher coal consumption. China holds 13.3 % of world's total coal mining that is the third largest figure in the world, just following the US and Russia while our country products 48.3 % and consumes 48.2 % of world's total figure. Wei et al. (2007) proposed that contrary to the fact that the exploitation rate and power conversion rate of coal is lower than the figures of petroleum based on prevailing technology, overuse of low level energies such as the coal brings high level emission of Carbon Dioxide. According to the survey in 2010, 81.07 % energy consumption Carbon Dioxide comes from the consumption of the coal. Furthermore, China will stand as a heavier player for Carbon Dioxide emission with its higher economic development and increasing coal consumption.

62.2.2 A Big Issue of Low Efficiency for Energy Consumption

Hu and Wang (2006) refer that recently high speed economic growth of China is at the cost of the huge consumption of fossil energy and the resulting countless damage to the environment. Such an extensive development model is harmful to China's long term economic growth and not sustainable.

As the survey has shown, China experienced annual 9 % energy consumption for ten years, but its GDP only took up 4 % of the world's figure while China consumed world's 31 % coal, 8 % petroleum and 10 % electricity with a 30 % mine recourse recycle rate that is 20 % lower than more advanced level of recycle. This trend strengthens after 2010 because high energy consumption and high emission industries boomed with the recovery of backward production capacity. Such enormous energy consumption not only exhausted natural resources capacity but also brought serious environmental problems.

Chinese government executed a series of energy saving solutions for the micro and macro level with exhausting energy and polluted environment. As a result, China set the restricted index of 20 % lower energy consumption per 10 thousand GDP than that of 2005 and 10 % lower emission of major pollutants. However, the situation is passive: on one hand, energy production keeps the track of "high energy consumption, high pollution and low production" that is traditional; on the other hand, energy demand is increasing because of higher living standard and high speed economic development. Currently, China ranks the first place for emission of the wastes, and thus faces more serious emission reduction pressure during "after Kyoto era".

62.2.3 Some Problems with the Development of Net Energy

In spite of the fact that New Energy Industry is developing fast, Chinese new energy industry is still lagging in respect to the conditions of developed countries. Developed countries are always walking on the front edge of new energy industry. Even though the new energy industry of China also booms recently, and the fact that China is the largest wind power machine and solar cells producer, but the insufficient investment of basic research and development, limits of core technology field restrict the long term development of this industry. As to the firms of this industry, they rely on the core technology provider abroad but also throw themselves to the fierce competition over the world, however, limited cash held and scarce financing resources are the major problems that limit their ability of creation.

China has no price advantage because of relative higher cost of generating new energy. New energy only takes a small percentage of Chinese electric power industry, less than 1 % of renewable energy excluding hydropower. In addition, new energy power's cost is much higher than that of coal power, namely, 150 % coal's cost for biomass power generation, 170 % for wind power generation, 1100–1800 % for Photovoltaic power generation, new energy is a small part of the traditional power generation method. What's more, China's net energy industry relies on no strong and powerful laws and regulations published by government and no strategic planning in the long run. Overcapacity problem is also very serious in China. Take the wind power as an example, in 2008, there were 12.15 million wind watt's power generation machines finished, but only 10 million watts power can be generated. But the fact is that only 73 % of the planned machines were completed with the real wind power generation capacity 8.94 million. The deeper reason is that the system has not been constructed with any synergy between net energy development and electric net construction.

62.3 Suggestions for the Energy Development in China

62.3.1 Adjust the Energy Industry Structure, Promote the Upgrading of the Industrial Structure Optimization

In recent years, although China continues to adjust and optimize industrial structure, industrial energy consumption accounts for the proportion of total energy consumption is still large, especially compared with developed countries, China's energy consumption per unit of output is still high in the secondary industry. Adjust the industrial structure, promote the optimization and upgrading of industrial structure are still the major issue. Adhere to the principle of energy conservation priority, promote ecological civilization and saving culture. Popularize technology achievements, strive to reduce energy consumption. Create economical models of development and consumption, improve energy utilization efficiency. Balance supply and demand reasonably. That are the ways for realizing the sustainable and healthy development of China's economy.

New energy industry development is inseparable from national policy support. Since 2009, our attitudes to the development of new energy industry has changed from "actively guide" to " high strategic valued". During the 12th Five-Year Plan, the overall goal of China's new energy development is to establish the initial adaptation of large-scale development of new energy grid and other infrastructure systems. Promoting the growth and upgrading of new energy equipment manufacturing industry, and the expansion of the new energy market. Raise the proportion of non-fossil energy sources in energy consumption to about 12 % in 2015. With the exception of hydropower, renewable energy accounted for primary energy consumption will rise to 6 % in 2020. The state will invest more than 3 trillion yuan to promote the development of new energy including solar energy, wind power, biomass.

62.3.2 Improve Energy Efficiency

Management and technology are the two aspects to improve energy efficiency. On the management side, energy saving standards, goals and policy measures should be developed in all sectors. The energy consumption in various sectors will be supervised, reward and punishment are also needed to encourage enterprises improving energy efficiency continuously. In technical terms, through the transformation of high technology, promotion of the traditional industry production, developing and popularizing new energy-saving technology, improving the utilization rate of raw coal and crude oil, strengthen the investment in the coal washing and processing, moulded coal, coal desulfurization and the use of clean energy.

62.3.3 Strengthen the Research and Development of New Energy Core Technology, Promote Independent Innovation Ability

Developed countries always lead the trend of new energy development. Despite the rapid development of China's new energy industry, as the world's largest installed wind power country, the largest producer of solar cell, the basic investments for research and development are obviously insufficient, the core technology is always the bottleneck. This restricts the long-term development of new energy industry. The shortage of funds and financing are the main setbacks for the development of new energy and the ability of independent innovation. An effective solution is a detailed set of financing strategy and the faithfully implement of it. The best way for China's new energy industry is following the world's trend, improving the ability of independent innovation.

Blind production should be guided to the rational and orderly production. Enhance project approval management and the access policy of new energy market, eliminate backward production capacity, promote mergers and acquisitions, motivate economies of scale and economy of scope, improve the efficiency of the industrial structure. Regulate the order of market competition, execute the "Anti-Unfair Competition Law" strictly to prevent abuse of market dominance and excessive competition. Improve the new energy enterprise management level and promote the continuous upgrading technology under the market competition mechanism. Expanding domestic demand, foster domestic market, increase the use of new energy products. Shifting the production subsidies to the domestic consumer subsidies to encourage enterprises excavating the consumption potential of domestic market. On one hand, achieve the original intention of new clean energy interiorly. On the other hand, reduce exports will reduce trade friction and create a favorable export environment. In fact, it is impossible to exchange the core technology for market. developed countries will never transfer the latest technology to other countries especially developing countries. To break through the bottlenecks of technology, developing countries should establish long-term developing consciousness, increase research and development investment, enhance the capability of independent innovation and technological breakthroughs.

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Chapter 63
Analysis for Transformation and Development of China PV Industry

Shengzhen Ma

Abstract Under the targets of low-carbon environment, China solar industry developed fairly fast during the last ten years. However, as an important component of China solar industry, PV industry is facing the most difficult time. This paper analyses the problems along the development of China PV industry and some suggestions for a better development of the industry.

Keywords Low-carbon economy · PV industry · Technological innovation · New energy sources

63.1 Domestic and Overseas Research Actuality

Zhao Wenyu (2001) did a research about the development strategy of China PV industry. He started his article with the gap of China PV industry and other countries, the challenges for joining in the WTO. His work showed us the world PV industry's development trend, speed, and the strategy China PV industry should apply. He made a preliminary developing forecast of the early twenty-first century.

National Development and Reform Commission, the Global Environment Facility (GEF), World Bank, China Renewable Energy Development Project Office set up an expert group for Development Study Project of the China PV industry in October, 2004. They did a research for the development of China PV industry, and composed "China PV industry development report". The report

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summarized the current situation of China's solar energy resources, technology, development and market prospects. It also raised policy and action plan for further promotion of China PV industry.

Ma Shenghong and her team members (2005) presented the future direction of photovoltaic power generation in China's energy structure. They believed that in the next 10–20 years, China's photovoltaic power generation will be mainly used in the following areas: off-grid power supply in rural areas, power distribution, large-scale desert power station and other commercial applications. The first step was to intensify the ability of photovoltaic generation, which includes: resources survey and evaluation, research, training system, quality control service system.

Michael Rogol's (2005) "The solar industry outlook report" was the most authoritative solar energy industry report throughout the world. This report was known as Lyons report. In this report, it was said that although the investment volatility of solar energy industry will increase, the current profit status would continue to increase several times over now, solar stock still had a strong rising power. The report predicted that the entire industry sales revenue in 2010 would reach $36 billion, pre-tax profit will be atleast $6.4 billion.

"Global PV industry development research report" (2009) summarized the development of global PV industry and surplus production problems. The report introduced the tendency of PV industry in Germany, United States, Spain, Japan and China. It pointed out that China was a potential market, the installed capacity of China PV industry will surpass Japan by 2020.

UBS Investment Research said Germany was the country that gives the best policy support in solar photovoltaic industry. German government proposed PV roof plan in 1991, provided low-interest loans for rooftop PV systems from 1999–2003, "The Renewable Energy Act" in 2004 formulated renewable energy generation targets which spurred the rapid development of photovoltaic industry, the amendment of Renewable Energy Act in 2010 significantly reduced photovoltaic electricity price, a decline of 16–25 %, the subsidies range expanded as well.

63.2 Present Situation of China PV Industry

63.2.1 Ten Years of Rapid Development

Since 2002, China's PV industry mushroomed thanks to the pull of the European market. Its rapid growth attracted international notice. In 2007, China has became the world's largest producer of solar cells, China's solar cell production reached 13 GW in 2010, battery components production increased to 10 GW, accounting for 45 % of the world total production, and the first solar cell producer in the world for five consecutive years. The installation of photovoltaic power generation reached 500 MW in 2010, grand total of 900 MW, ranking the world's top tens.

63.2.2 Encounter the "Winter"

China PV industry is experiencing more severe conditions. Internationally, accompanied by the debt crisis in Europe, Germany, the United Kingdom have reduced the solar energy plan. As the second largest market, Japan's market demand has reduced because of the tsunami. The United States raised anti-dumping and anti-subsidy probe for China PV products' low price. Some European companies also planed to initiate anti-dumping proceedings against the Chinese solar manufacturers in the mid-2012es. PV industry in China needs to be integrated, to get rid of the vicious competition in a disordered development trend, and further developing of domestic PV application market.

63.2.3 Looking Forward to Transition

In fact, out of the high-profit welfare development a few years ago, China PV industry is facing the history opportunity of transition. China Central Economic Work Conference made a resolution to cultivate and develop the emerging strategic industries actively at the end of 2011. Two directly related plans were made by "The Twelfth Five-Year Guideline". Due to the development of photovoltaic technology, the on-grid price will decrease to a reasonable level in the near future. Photovoltaic power generation should no longer dependent on state subsidy, it will participate in the fully competitive electricity market. China photovoltaic industry is facing a "shuffle", PV companies with capital, technology advantages will continuously promote the technology and scale of production along the routes of reduce costs. Outdated capacity in many SMES will be eliminated, forcing the China PV industry's transformation, upgrading, and better development.

63.3 Plight of the PV Industry Development

63.3.1 Overcapacity and Vicious Competition

For the blind optimism of the PV market, the temptation of high profits in the last few years, and local governments' pursuing of large projects to improve the GDP, the PV industry in China experienced an unprecedented investment boom in 2007. These investments helped to ease the shortage of silicon materials, but the blind capacity expansion led to domestic and global overcapacity, so the Chinese enterprises found themselves in a vicious price war competition. For example, in the polysilicon industry, excessive domestic polysilicon project planning leaded to higher investment and energy consumption. Unless the polysilicon enterprises

Table 63.1 2009–2012 Comparison of capacity and output in China PV companies

	2009	2010
Capacity of polysilicon	51,850	11,5250
Output of polysilicon	19,000	45,3900

upgrade technology, there will be idle capacity and heavy losses because of high manufacturing costs and brutal competition in the industry.

With the continued weakness of the domestic PV market, polysilicon price began to fall into the historic low. By contrast, in this sagging market environment, many silicon material companies did not reduce the yield and lower capacity planning, but improve the capacity and output of polysilicon through the following data in 2012, allowing us to query the "overcapacity" (Table 63.1).

63.3.2 Insufficient Domestic Market Demand, Excessive Dependent on International Markets

63.3.2.1 The Risk of "Two Heads Out"

High purity silicon is the raw material in China PV industry, however, its 95 % dependent on imports, the major markets are currently abroad, more than 95 % of productions are aiming at exports. The domestic demand for finished productions is very small, this makes the solar photovoltaic industry controlled by others, subject to the fluctuations of the international market of raw materials and finished goods prices. That leads no good to the stable development of the industry. Actually, Chinese PV industry's export was hit by the downturn of international photovoltaic market recently (Table 63.2, Fig. 63.1).

63.3.2.2 Facing the Risk of Anti-Dumping

During the post-crisis period, some countries launched anti-dumping proceedings for the low price of China PV companies according to politics or trade protectionism. These measures increased market risk, affected the development of the industry to some extent. The U.S. Commerce Department announced the preliminary results of anti-dumping duties on Chinese photovoltaic cells and modules range, the rate was from 31.14–249.96 %, which is the most severe anti-dumping consequence in the history. The anti-dumping duty of solar photovoltaic cells and photovoltaic components was 31.14 percent for the Suntech company. Yingli Solar was 31.18 %. Trina Solar was 31.22 %. All the other Chinese producers were 249.96 %. The German PV company Solar World also planed to initiate anti-dumping proceedings for Chinese solar manufacturers in Europe in May 2012.

Table 63.2 Global and China PV installed capacity of the year (China PV Industry Development Report 2011)

	2006	2007	2008	2009	2010
Total global	1,603	2,932	5,950	7,380	16,000
China	10	20	40	160	500
China's share of the world (%)	0.60	0.70	0.70	2.20	3.10

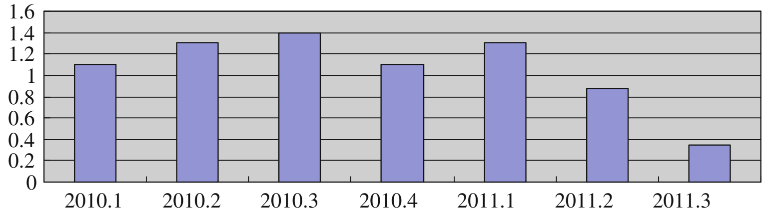

Fig. 63.1 Comparison of global PV equipment orders and shipments ratio (SEMI PV Group 2012)

63.3.3 Lack of Core Technology

Chinese solar energy companies are lack of independent research and development capacity, the key technology is basically resting in the hands of the foreign companies. Domestic enterprises are still in the "processing" stage, and making their living by low-cost, low energy and labor prices. This leads many companies to chase short-term returns, they are not willing to spend time on research and development, the capability of independent innovation is a serious deficiency.

At the same time, the matching technology for photovoltaic power generation is not mature in China. Such as grid-connected inverter could not produce independently, short life of the storage battery in autonomous system, lack of the core technology in high purity solar grade silicon.

63.4 Measures for the Healthy Development of Photovoltaic Industry

63.4.1 Explore Domestic Market Actively, Promote the Development of Industry Chain

63.4.1.1 Explore the Domestic Market Actively

Steps should be taken to explore and open up the domestic market, speeding up the industrialization and commercialization of photovoltaic technology. The government should support the procurement and construction of solar power plants, start lighting demonstration project. The support of the National Development and

Reform Commission is also significant, such as carrying out the pilot solar power plant construction, achieving grid-connected power generation, and promoting the application fields. Application in infrastructure and basic industries such as mobile communication base stations, gas stations, highway tunnels should be promoted.

63.4.1.2 Strengthen the Development of Industry Chain

Downstream enterprises in the PV industry include the production and installation of solar modules, application in power generation projects, combining use among solar PV cells, building materials and electromechanical industry, especially PV integrated buildings. In order to promote the development of related industries, revise and adjustment of the industrial technology roadmap is urgently needed. The extension of industrial chain will drive the complementation of related applications, while helping the enterprises pay attention to technology application and development according to the market. As an emerging energy industry with great developing potential, the solar energy industry's growth will also drive the boom of other application industries such as solar LED lighting.

63.4.2 Intensify Scientific and Technological Research and Development

63.4.2.1 Increasing Investment to Master the Key Technology

The government should encourage and support research institutions and enterprises to carry out research and development from basic theory to the production process. Looking for further breakthroughs in key technologies and processes such as polysilicon purification technology, the battery conversion rate, slice technology, systems integration. At the same time, deepening the research and development of thin film battery, concentrator cells, other new technologies and new products. Use economic measures to spur the enterprises' activity, guide the technical development in a comprehensive, balance and harmonious way.

63.4.2.2 Research Interaction within the Industry

In the long run, it is insufficient only rely on the support of government, we should rely on the intra-industry production, research and interaction to enhance the R & D capability and competitiveness, which will form a virtuous cycle, help the whole industry moving towards the peak level. The key enterprises should build a cooperation system with the world's best research institutions, to promote their independent innovation ability. Concentrate on breaking through the bottleneck of key technology, setting up technology innovation system of PV industry.

63.4.3 Strengthen the Self-Discipline, Formulate Industry Standards

There are some discordant voices over the past few years' rapid growth of PV industry, such as disordered competition within the industry, polluting the environment in order to reduce costs. Facing intense market competition in the future, PV companies must focus on self-growth and orderly development within the whole industry.

Photovoltaic industry has been called for relevant industry standards years ago. PV original, auxiliary materials specification, photovoltaic cells, the testing of products' performance, and application terminal of the power plant construction are in parts or even all lack of standards. Therefore, the state has set up a nationwide solar photovoltaic energy system standardization committee and the National Solar PV Products Quality Supervision Center. National Standards Commission also launched a photovoltaic research and construction work for the standard system, and introduced dozens of photovoltaic national standards. Within the PV industry chain, the PV companies should be encouraged to participate in the establishment of standards, regulate the industry's development, and make contribution to the quality and competitiveness of PV products in China.

63.4.4 Further Policy Support of the Government

63.4.4.1 Finance and Tax Policy Support

Preferential fiscal and taxation policies could encourage the development of photovoltaic industry. Special organization should be built as developed countries' fiscal and taxation policies in solar power industry, formulating specific policies to work with the overall planning for the solar power industry in China. Relevant national ministries should develop their policies, such as fiscal subsidies, credit support and tax incentives. Give financial discounts for PV industry infrastructure loans and provide scientific fees for technical research. Import productions and equipments needed for the PV industry will have tariff reductions provided by the state.

63.4.4.2 Form the National Strategy of PV Industry

Photovoltaic development plan should be promulgated to guide enterprises' decision-making. In recent years, European countries, the United States, Japan and other developed countries are vigorously promoting the development of solar photovoltaic industry. The introduction of supporting policies and substantial investments helped them to seize the cutting edge of technology. They also made it a bulwark against international financial crisis to revive the economy. Therefore, China should also seize the opportunity to develop photovoltaic industry, and publish a PV development plan over comprehensive survey and research. This is also a focal point to expand domestic demand, adjust the economic structure and maintain economic growth.

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Chapter 64
Non-decomposable Minimax Optimization on Distribution Center Location Selected

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Abstract The minimax optimization model proposed in this paper is an important model which has received some attention over the past years. In this paper, the application of minimax model on how to select of distribution center location was first introduced. Then a new algorithm using nonmonotone line search to solve the non-decomposable minimax optimization is proposed. Numerical results show the proposed algorithm is effective.

Keywords Non-decomposable · Minimax · Nonmonotone line search

64.1 Introduction

Since e-commerce developed prosperously, how to select the distribution center location plays a key role on a successful logistics company. Improving the operational performance, system cost reduction and other factors should be considered in this process. Suppose there are a number of locations for the logistics company to choose, the decision-making space is chosen as a set denoted by E^n as following:

$$E^n = \{x|x = (\text{transportation, facilities, system cost}\ldots)\}. \tag{64.1}$$

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Suppose $q_i(x)$ represents the degree of benefit of the ith distribution center location caused under x, and $R(x)$ the set made up of all of the distribution center location which can get the most degree of benefit under x. Thus the set $R(x)$ can be expressed as

$$R(x) = \{i|q_i(x) = q(x),\ x \in E^n\},$$
$$q(x) = \max\{q_1(x), q_2(x), \cdots,\ q_m(x)\},$$

where m is the total number of the locations.

Denote by $f_i(x)$ the risk caused by the ith distribution center location under x. Therefore the selection of location model can be formulated as

$$\min_{x \in E^n} \max_{i \in R(x)} \{f_i(x)\}. \tag{64.2}$$

From the above example (Jiao et al. 2005), we can know minimax is an important problems which can be applied in various primary areas of the cerebral cortex, economic model, control model and voting problem (Rolls 1998; Penrose 1989; Wen et al. 2007). This kind of special nonlinear programming which is called non-decomposable minimax optimization has been researched by many authors from optimal theories (DiPillo et al. 1993; Dem'yanov et al. 1974; Grippo et al. 1986; Li 1997; Zhou and Tits 1993) to computing algorithms, such as the value function method, the weighting method, the goal programming method and the interactive method, etc (Gal et al. 1999; Wang and Xu 2004). This non-decomposable minimax optimization can be defined as follows,

$$\min_{x \in E^n} \max_{i \in R(x)} \{f_i(x)\}\ , \tag{64.3}$$

where

$$R(x) = \{i|q_i(x) = q(x),\ x \in E^n\},$$
$$q(x) = \max\{q_1(x), q_2(x), \cdots, q_m(x)\}.$$

Equation (64.3) is called unconstrained non-decomposable minimax optimization. The necessary and sufficient conditions of continuity and differentiability for Eq. (64.3) have been studied in (Dem'yanov et al. 1974; Grippo et al. 1986). In this paper, we focus on devising a new algorithm to solve Eq. (64.3) and we give the numerical results.

64.2 Algorithm

The sequence $\{x_k\}$ can be defined by

$$x_{k+1} = x_k - \alpha_k g_k, \alpha_k \in (0, 1],\ k = 0, 1, 2, \cdots, \tag{64.4}$$

Considering the drawback of line search which guarantees a monotonic decrease of the objective function, a nonmonotone line search technique has been proposed in (Rolls 1998; Li 1997). In this paper, we define the nonmonotone line search as follows,

$$f(x_k - \alpha_k g_k) \leq \max_{l=0,1,2} f(x_{k-l}) - \gamma \alpha_k \|g_k\|^2. \tag{64.5}$$

Now we give the algorithm using nonmonotone line search Eq. (64.5).

Algorithm 3.1 Parameters. $\gamma \in (0, \frac{1}{2}),\ \delta \in (0, \frac{1}{2})$.
Data. $x_0 \in E^n$.

Step1.
i. Initialization. Set $k = 0$, and $x_{-2} = x_{-1} = x_0$.
ii. Compute the index set $R(x_k)$ and $f(x_k) = \max_{i \in R(x_k)} \{f_i(x_k)\}$.

Step2.
i. Set $\alpha_k = 1$.
ii. Compute g_k by solving the quadratic program

$$\min g^T g$$

s.t. $g \in G(x_k)$,if $\|g_k\| < \delta$, stop.

Step3.
i. Compute $R(x_k - \alpha_k g_k)$ and $f(x_k - \alpha_k g_k) = \max_{i \in R(x_k - \alpha_k g_k)} \{f_i(x_k - \alpha_k g_k)\}$.
ii. If $f(x_k - \alpha_k g_k) \leq \max_{l=0,1,2} f(x_{k-l}) - \gamma \alpha_k \|g_k\|^2$, go to step 4.
iii. Set $\alpha_k = \frac{1}{2}\alpha_k$, go to step 3.

Step4.
Set $x_{k+1} = x_k - \alpha_k g_k, k = k + 1$, go to step 2.

64.3 Numerical Results

In this section we report the numerical results obtained for a set of test functions, by means of the algorithm 3.1. Typical values for the parameters are: $\gamma = 0.1$, $\delta = 0.05$. This program is made in Matlab 6.5, running on the DELL OPTIPLEX GX270.

Functions 1.

$$f_1(x) = x^2,\ f_2(x) = (x-5)^2 - 4;$$
$$q_1(x) = f_2(x),\ q_2(x) = f_1(x).$$

Table 64.1 Numerical results for a set of test functions when $\gamma = 0.1, \delta = 0.05$

Functions	x_0	k	$g*$	$x*$	$f(x*)$	Time
Functions1	10	4	0	0	0	<1 s
Functions2	(5, 5)	29	(0, 0)	(0, 0)	0	2 s

Functions 2.

$$f_1(x_1,x_2) = x_1^2 + x_2^2, f_2(x_1,x_2) = e^{(x_1^4+x_2^2)} - 1, f_3(x_1,x_2) = e^{(x_1^2+x_2^4)} - 1;$$
$$q_1(x_1,x_2) = -5x_1 + x_2, q_2(x_1,x_2) = x_1^2 + x_2^2 + 4x_2, q_3(x_1,x_2) = 5x_1 + x_2.$$

The Table 64.1 gives the results.

64.4 Conclusions

In this paper, a kind of generalized minimax optimization which is called the non-decomposable minimax optimization is discussed. A new algorithm using non-monotone line search to solve the unconstrained non-decomposable minimax optimization is given. Numerical results show the proposed algorithm is effective.

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Chapter 65
Green Finance and Development of Low Carbon Economy

Shuo Chen

Abstract Finance is the core of modern economy, and green finance is the key of low carbon economy. The development of low carbon economy can not be separated from the green finance. Low carbon economy is becoming the new trend of international economic development. This paper, based on the analysis of the 'low carbon economy' development and green finance foundation, suggests how to develop green finance to promote low carbon economy development.

Keywords Green finance · Low carbon economy · Development

65.1 The Definition of Green Finance

Green finance and low carbon economy are closely related concepts, and its essence is the financial sector to make the environmental protection as a basic policy, considering the potential environmental influence when we make the investment and financing decision. The environmental conditions are related to the potential return, the risk and cost is integrated into the daily business. In the financial management activities, we should pay attention to the ecological environmental protection and pollution control, through social environment and resource guide, to promote the sustainable development of society. Green finance specifically has two aspects: one is the financial industry how to promote environmental protection and sustainable development of economy and society; another refers to the financial industry's sustainable development. The former green finance's major role is to guide the flow of funds to save resources

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technology development and ecological environmental protection industry, and to guide enterprises to the production of green environmental protection, to guide consumer form the concept of green consumption. The latter makes clear that the financial industry is to maintain sustainable development, and pays attention to short-term interests to avoid excessive speculation.

Green finance was born in the United States in 1990s as the times require. People of the United States' financial circles, who pay attention to environment and global climate change, put the environment factor into financial innovation, and research how to evaluate the environmental risk, which in order to develop a successful environmental financial products, formed a suitable product structure, develop circular economy, and protection environment fund. After the concept of "Green finance" put forward, world governments, international organizations, financial institutions and non-governmental organizations in the field of environmental protection has tried a lot. Early in 1974, the former West Germany established the world's first environmental bank. In 1991, Poland has also set up environmental protection bank to support for promoting the environmental protection investment project. In 2003, the World Bank Group's International Finance Corporation in international banking industry has launched the "Equator Principles", and by Citibank, Barclays Bank, Bank of Holland and the West German State Bank of 7 countries of 10 leading international bank has announced the implementation of. The so-called "Equator Principle", i.e. on a voluntary basis, is a judgment, evaluation and management of project financing in environmental and social risks of the financial industry benchmark. It also provides a framework of project financing in environmental and social risk assessment, including different types of project risk classification, and lists with the environmental assessment process, monitoring and following-up guide related issues. In 2006, the equator principles financial institutions account for the global project financing more than 90 % of the market around the world. The financial product innovation and green finance business of "Green insurance", "green capital market" green areas develop very quickly in recent years in the United States, Britain and other developed countries.

65.2 Green Finance and Development of Low Carbon Economy

Low carbon economy is a new mode of economic development which different from the traditional pattern (high efficiency, low energy consumption, low pollution, low emission) in response to global climate change. It emphasizes less greenhouse gas emissions to obtain bigger economic output. Its essence is the energy efficiency and clean energy structure problem, and its core is the energy technology innovation and system innovation. The goal of low carbon economy is to slow climate change and to promote sustainable development. On the surface, low carbon economy is the result of hard work to reduce greenhouse gas emissions, but in essence, low carbon economy is a new change of the mode of economic development, energy consumption patterns, and the human way of life. It will be reform the modern industrial civilization which based on fossil fuels all-around the ground to ecological economy and ecological civilization.

The modern financial development is the driving force of the development of a modern market economy. The financial industry based on market mechanism, which in the pursuit of profit, can improve efficiency at the same time, and play actively fulfill social responsibility as a corporate citizen, to adjust the economic structure, to promote independent innovation, to conserve the energy, to protect the environment and to play a greater role in other aspects. In the short term, the transformation of the traditional financial industry to the green financial sector may experience improve challenges of customer threshold and increased the new mechanism cost, their interests will be temporary impact. But in the long run, green finance is not only beneficial to the coordination of economic development and environmental protection, maintain human long-term social interests and long-term development, alleviate the traditional banking business negative effect, but also to prevent the financial risk, put a environmental protection firewall for sound operation, and create more green business. The transform of traditional high carbon economy to a low carbon economy transformation calls for the traditional financial system to green financial restructuring and development.

China is the world's largest carbon emitter of the state which in rapid industrialization and industrialization development stages. The situation of the energy-saving emission reduction is increasingly serious. The environmental pollution and resources capacity have approached the limit state in many places, the government is increasingly strict bound to the enterprise environmental pollution liability, because the polluting enterprises' credit risk started to increase. The financial sector is also facing the potential crisis in the promoting energy-saving emission reduction, carrying out harmonious development of economic and natural, and realizing sustainable development. In the big background of the global attention to sustainable development of financial industry, economy and society, the implementation of the "green finance" is not only the implementation of scientific outlook on development the reality needs, but also conform to the international trend of China's financial industry, realize the inevitable choice that conforms with international.

65.3 Develop Green Finance, and the Policy Recommendations to Promote the Development of Low Carbon Economy

65.3.1 The Construction of Multi-Level Financial Support System

First is the support and the guide of policy finance. Policy financial institutions should play an important role in green financial system. The support for the development of low carbon economy's infrastructure investment, low carbon technology research, production and use of clean energy projects should be focused on. We should actively guide the social funds into the construction of low carbon economy. Second is the financial support of commercial banks. We can encourage commercial banks to actively participate in the CDM project's loan business, and carry out the "green credit" accountability system. We must make clear the "green credit" policy's request and market access's standards. The environmental protection standards and credit risk management requires organic combination. We can use the implement of "one ticket overruled make" for environmental protection, and carry out to the customer survey, loan marketing, credit, project evaluation, credit review, credit management and so on each link. To prevent credit risk from the source which brings from the changes of enterprises and project construction for environmental protection requirements change.

65.3.2 Innovation of Green Financial Products and Services

First is the creative product. Green credit as a starting point, we should promote carbon mortgage financing loan. We can explore the issue of green bonds, and absorb relatively stable long-term capital into low carbon economic projects of high demand capital and good comprehensive benefit. Second is to promote international financial cooperation. In the bank credit, we encourage commercial banks to study the equator principles, and put environmental factors into their loans, investment and risk assessment procedure. Through the cooperation with the International Finance Corporation, we can carry out a wide range of international project financing based on the new model of green credit. In carbon trading services, encourage the qualified financial institutions actively corporate with international investment banks and carbon fund, make a full grasp of the international carbon emission right transaction information, to enhance the intermediary service trade competence.

65.3.3 Make Preferential Policies to Encourage Low-Carbon Technology Innovation and Green Consumption

Financial institutions increase the financial support for carbon technology innovation, encourage the application of clean coal technology, the transformation of energy-saving technological, the development of new energy, renewable energy, alternative energy technology, and the comprehensive utilization of energy and other green low-carbon industry development. We should incent individual and units' "green consumption". On consumers' purchase of environment-friendly consumer goods, such as environmental protection, automobile, environmental protection appliances, banks can be joined together to launch business interest even interest-free loans to encourage consumption; conversely, if the purchase of serious environmental pollution in the consumer goods, such as luxury cars, high energy consumption, banks can refuse to loan to curb consumption loan effectively.

Part IV
Workshop on Green Supply Chain Management

Chapter 66
Research on Network Optimization of Green Supply Chain: A Low-Carbon Economy Perspective

Cuizhen Cao and Guohao Zhao

Abstract Based on the theory of low-carbon economy, this paper evaluates the influence of carbon emissions on supply chains' overall value using carbon footprint. It is showed that three objects, namely, profitability, service level and environmental protection should be coordinated, and to balance cost, response time and carbon footprint, the penalty function coefficient is introduced, which coverts a multi-objective optimization problem to a single objective one. Also, a network optimization model is formulated to offer a supplementary solution for optimization design of green supply chain network.

Keywords Low-carbon economy · Carbon footprint · Green supply Chain · Network optimization

66.1 Introduction

Since the beginning of twenty-one century, climate change has become a challenge mankind has to meet in the economic and social development. Carbon emission is one of the main causes of global warming. China, one of the top countries in terms of carbon dioxide (CO_2) emission, faces great pressure to reduce carbon emission.

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As an important part of the Third Industry, green supply chain is an ecological industry system characterized by low carbon emissions, and so it is the government's possible policy choice to develop low-carbon economy. Green supply chain optimization drives at a balance between environmental protection and profitability, achieving systematic coordination in order to improve both environmental quality and competitive edge in a dynamic way and for a win–win effect. To use carbon footprint to measure carbon emissions as an environment index is a reliable way in dealing with environmental pollution, caused mainly by carbon emissions. Carbon emission has great bearing on the design of supply chain network, so to take the factor of carbon emissions into account is inevitably a tendency in the network design of supply chain (Fang and Xu 2012). Therefore, in the context of low carbon economy, to introduce the notion of carbon footprint to measure the influence of carbon emissions on the overall cost of supply chain is of great theoretical and pragmatic meaning to developing low carbon logistics, undertaking green supply chain management, and facilitating sustainable development strategy.

66.2 Literature Review

Green supply chain has been one of the hottest topics in recent years' supply chain management research (Zhang and Xu 2009), and many people pay their attentions to the green supply chain network optimization and design. Wang et al. (2011), analyzing environmental issues, build a related multi-objective model, and solve the model with heuristic algorithm. Sundarakani et al. (2010) formulates a model of carbon footprint across supply-chain under both static and dynamic situations, and checks it numerically, demonstrating the importance of carbon footprint in supply chain design. Chaabane et al. (2011) analyzes the green supply chain network design problem in carbon exchange market, and try to help decision makers find the efficient solution that balances the increase of supply chain cost and emission reduction. In China, thorough analysis of green supply chain network optimization is far from enough. Fang and Xu (2012), drawing on research findings in network designs of the green supply chain and sustainable supply chain, elaborates some important relevant issues in supply chain network design with carbon emission taken into consideration. However, up to now there has been no in depth, detailed design model for establishing a green supply chain network, overall there is no quantitative research in this respect, either.

Based on low-carbon economy theory, this paper evaluates the influence of carbon emissions on supply chains' overall value using carbon footprint, and seeks to balance the three targets,namely, supply chain profitability, service level and environmental protection, so as to achieve a green, low-carbon supply chain. Penalty function coefficient is introduced to balance cost, response time and carbon footprint, converting the multi-objective optimization problem to a single-objective one. An optimization model is developed to offer supplementary decision solutions for the optimization and design of the green supply chain network, aiming at pushing effective implementation of green supply chain management and realizing low-carbon development.

66.3 Thought and Assumptions of Network Optimization

66.3.1 Basic Idea of Green Supply Chain Network Optimization

The difference between general supply chain network design and the green supply chain lies in that the green supply chain not only needs to optimize cost and service level at the same time and reach the network structure solution at Pareto curve (He and Meng 2009), but also needs to consider the influence of carbon emission on the overall value of the supply chain and sustainable development. Therefore, the research on the green supply chain network optimization based on low-carbon economy's perspective should first clarify the internal mechanism of carbon emissions' influence on the overall cost of the supply chain network, measure the emission accurately on the supply chain level (Sundarakani et al. 2010) and analyze the cost influence. Then considering the effect of carbon emissions on strategic and tactical factors of the green supply chain network design, it should apply carbon emissions' limit to the selection of network nodes strategically, and network channels tactically, thus effectively building a green supply chain network.

66.3.2 Model Assumptions

In the paper, we use carbon footprint to measure the carbon emissions at all the nodes and channels of the supply chain, and the penalty function is applied to realize the balance of cost, response time and carbon footprint. Two coefficients of the penalty function are introduced: one is penalty coefficient of late delivery, which is defined as the unit increase in objective function because of late response to customer needs in the supply chain system; the other is penalty coefficient of carbon emission, which is the unit increase in objective function when the carbon emission exceeds the system's limit. Thus, the penalty coefficients can be set differently according to different regions, products, and phases to balance supply chains' cost, response time, and carbon footprint. Now the assumptions are as follows:

(i) All facilities to be built are only built at places that are given, and all these places can be scientifically simulated in systems' daily operation and satisfy needs of the green supply chains' management very well;

(ii) The capacity of all nodes, the building and operation cost, and carbon footprint can be tracked and acquired in real time via the supply chains' sharing system of information;
(iii) The unit transport cost, time, and carbon footprint between any source node and any destination node can be learned from system simulations and they have linear relations with transport quantity in the mean time.

66.4 Network Optimization Decision Model

66.4.1 Model Notations

For convenience, here we give some notations which are used in the sequel. P, D, R denote the set of nodes for manufacturing facilities, the set of nodes for distribution centers and the set of demand nodes, respectively. DC_e denotes the distribution center e and R_j denotes the demand quantity for demand node j. P_i, $C_i^{\mathrm{P}}, T_i^P, CF_i^P$ denote the manufacturing capacity, the construction and operation cost, the unit production time and the carbon footprint of unit production activity of plant i, respectively. $D_e, C_e^D, T_e^D, CF_e^D$ denote the capacity, the construction and operation cost, the unit processing time, the carbon footprint of unit processing activity of DC_e, respectively. $T_{GSN}, CF_{\mathrm{GS}N}$ denote the target response time, the limit carbon footprint of the network, respectively. Let $C_{ie}^D, T_{ie}^D, CF_{ie}^D$ denote respectively the unit transport cost, the unit transport time and the unit transport carbon footprint from plant i to DC_e, and let $C_{ej}^R, T_{ej}^R, CF_{ej}^R$ denote respectively the unit transport cost, the unit transport time and the unit carbon footprint from DC_e to demand node j. $CT_{\mathrm{GS}N}$ denotes the penalty function coefficient for late delivery and $CCF_{\mathrm{GS}N}$ denotes the penalty function coefficient for carbon footprint.

In addition, let x_{ie} be the transport quantity from plant i to DC_e and y_{ej} be the transport quantity from DC_e to demand node j. Let u_i be the binary variable with 1 representing building plant i and 0 otherwise; let v_e be the binary variable with 1 representing building DC_e and 0 otherwise.

66.4.2 Math Model

$$
\begin{aligned}
&\textit{Minimize } TC \\
&= \sum_{i\in P}\sum_{e\in D} C_{ie}^D x_{ie} + \sum_{e\in D}\sum_{j\in R} C_{ej}^R y_{ej} + \sum_{i\in P} C_i^P u_i + \sum_{e\in D} C_e^D v_e \\
&\quad + CT_{GSN} \times \Big(\sum_{i\in P}\sum_{e\in D} T_{ie}^D x_{ie} + \sum_{e\in D}\sum_{j\in R} T_{ej}^R y_{ej} + \sum_{i\in P} T_i^P u_i \sum_{e\in D} x_{ie} + \sum_{e\in D} T_e^D v_e \sum_{j\in R} y_{ej} - T_{GSN}\Big) \\
&\quad + CCR_{GSN} \times \Big(\sum_{i\in P}\sum_{e\in D} CF_{ie}^D x_{ie} + \sum_{e\in D}\sum_{j\in R} CF_{ej}^R y_{ej} + \sum_{i\in P} CF_i^P u_i \sum_{e\in D} x_{ie} + \sum_{e\in D} CF_e^D v_e \sum_{j\in R} y_{ej} - CF_{GSN}\Big)
\end{aligned}
$$

Subject to

$$\sum_{e \in D} x_{ie} \le P_i u_i, \quad i \in P \tag{66.1}$$

$$\sum_{j \in R} y_{ej} \le D_e v_e, \quad e \in D \tag{66.2}$$

$$\sum_{e \in D} y_{ej} \ge \mathrm{R}_j, \quad j \in R \tag{66.3}$$

$$\sum_{i \in P} x_{ie} = \sum_{j \in R} y_{ej}, \quad e \in D \tag{66.4}$$

$$u_i \in \{0, \quad 1\}, \quad i \in P; \quad v_e \in \{0, \quad 1\}, \quad e \in D \tag{66.5}$$

$$x_{ie} \ge 0\,, y_{ej} \ge 0, \quad i \in P, \quad e \in D, \quad j \in R \tag{66.6}$$

where the first part of the objective function is construction and transport cost, the second part is the penalty cost indicating the failure in responding to customer needs, and the third part is the penalty cost caused by carbon footprint which exceeds the system limit. Constraints (66.1) and (66.2) are the capacity limits; (66.3) is the limit of demand quantity; (66.4) is the limit of balancing node capacities; (66.5) and (66.6) limit the range of variables.

66.5 Analysis of Example

A multinational company TC needs to optimize supply chain network. Currently two high value-added innovative products have been developed to be launched in three markets. The response time to product orders is set to be 1 week. The whole supply chain's carbon footprint is 8,500 ton. There are three candidate plants and three distribution centers for these products. The detailed data is shown in Tables 66.1, 66.2, and 66.3.

Usually, innovative high value-added products need very agile and adaptable supply chains, and in the investment period, a higher response ability and service level for customers are required. So by combining market investigation with empirical analysis, and applying LINGO 11.0 to test the model repeatedly, we find that the penalty function coefficient CT_{GSN} should be set as the greater number 999, while CCF_{GSN} can be set as 650 by reference to the carbon taxes in different regions. After coding and solving the problem, the optimized solutions can be obtained: strategically, nodes selected are plants 1 and 3, DC 1 and 2; operationally, detailed distribution path can be optimized real time by using this model. This can guarantee the feasibility and effectiveness of the model.

Table 66.1 Unit transport cost, unit time, and unit carbon footprint between nodes

From	To	C ($)	T(h)	CF(t)	From	To	C ($)	T(h)	CF(t)
P1	DC1	2000	1	780	DC1	C1	4000	2	983
P1	DC2	4000	2	890	DC1	C2	1000	3	786
P1	DC3	3000	1	560	DC1	C3	3000	2	698
P2	DC1	2000	2	800	DC2	C1	6000	2	889
P2	DC2	1000	3	780	DC2	C2	4000	1	459
P2	DC3	4000	1	569	DC2	C3	2000	3	859
P3	DC1	8000	2	1120	DC3	C1	10000	3	963
P3	DC2	6000	4	790	DC3	C2	5000	6	569
P3	DC3	1000	2	799	DC3	C3	4000	4	698

Table 66.2 Capacities and construction cost of all nodes on the network

P	Capacity	Cost($)	DC	Cost ($)	Capacity	C	Demand
P1	700	45000	DC1	200000	400	C1	400
P2	600	65000	DC2	100000	800	C2	500
P3	500	90000	DC3	150000	1000	C3	300

Table 66.3 Unit processing time and carbon footprint of all nodes on the network

P	Time (h)	Carbon footprint (T)	DC	Time (h)	Carbon footprint (T)
P1	7	650	DC1	10	890
P2	9	890	DC2	13	987
P3	5	1000	DC3	12	780

66.6 Conclusion

The research on the green supply chain network optimization based on low-carbon economy's perspective should first clarify the internal mechanism of carbon emission's influence on the overall cost of the supply chain network, measure the emission accurately on the supply chain level and analyze the cost influence. Then in view of the influence of carbon emission on strategic and tactical factors of the green supply chain network design, penalty function coefficient is introduced to balance cost, response time and carbon footprint, which converts the multi-objective optimization problem to a single-objective one. By balancing the supply chain's profitability, service level, and environmental protection, a green, low-carbon supply chain network can then be built effectively.

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Chapter 67
The Research on Evolutionary Game of Remanufacturing Closed-Loop Supply Chain Under Asymmetric Situation

Jian Li, Weihao Du, Fengmei Yang and Guowei Hua

Abstract Remanufacturing is an effective means to realize energy saving and emission reduction. The remanufacturing industry makes important contribution to achieve the goal of low-carbon economy. This paper develops an evolutionary game model with a two-echelon closed-loop supply chain to study evolutionary stable strategies (ESS) of manufacturers and retailers. Through analyzing evolutionary path of the game, we find that there are two possible evolutionary results affected by the profits of manufacturers.

Keywords Remanufacturing · Closed-loop supply chain · Evolutionary game · ESS

67.1 Introduction

Enterprises are the main carriers of energy consumption and carbon emission. How to combine enterprises' business decisions with low-carbon economy goals is important to drive the development of low-carbon economy. Because the quality and performance of remanufacturing products are not inferior to new products,

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but energy consumption and materials consumption are both under half of original manufacturing (Ferrer 1997a, b; Zhang et al. 2009; Xu 2010).

A lot of articles related to remanufacturing closed-loop supply chain always consider economic and environmental benefits within short term, while there is a growing number of research papers studies remanufacturing closed-loop supply chain in consideration of long term. Many literatures study remanufacturing closed-loop supply chain mainly consider symmetric situation of small population difference (Xiao and Yu 2006; Dong 2012). But the research for asymmetric situation of big population difference is few. Therefore, this paper extends short term issue to long term issue on the base of Stackelberg model established in the paper of Du et al. (2012). This paper considers the dynamic game between manufacturers and retailers. We find the ESS of two populations by replicated dynamic equation and further analyze the possible factors which affect the ESS. The rest of the paper is organized as follows. Section 67.2 presents the research issue and builds the model. Section 67.3 tries to solve the model and find ESS of the model under market mechanism. Section 67.4 draws some conclusions and outlines some directions for future research.

67.2 The Evolutionary Game Model

The following assumptions are made in this paper:

Assumption 1. This paper considers a two-echelon closed-loop supply chain consists of the manufacturer population and the retailer population. Retailers engage in the work of recycling waste.

Assumption 2. The waste products recycled by retailers are all repurchased by manufacturers. And the returned products can be all used into remanufacturing.

Assumption 3. The quality of remanufacturing products is same to the new products. The market of remanufacturing products is in short supply.

Assumption 4. The price of remanufacturing products is lower than the price of new products. We only think about the revenue related to the activities of remanufacturing in the process of game.

Assumption 5. It needs to use some new raw materials in the process of remanufacturing.

The following notation is used in the model:

Q quantity of recycled waste products;

p_1 unit transfer price of manufacturer in the process of repurchasing waste products from retailers;

p_2 unit wholesale price of manufacturer in selling remanufacturing products;

p_3 unit wholesale price of manufacturer in selling new products;

C_f unit fixed cost of manufacturer in the remanufacturing process;

C_p unit cost of repairing of manufacturer in the remanufacturing process;

C_m unit cost of manufacturing of manufacturer in the original manufacturing process;

C_{b1} procurement cost of new raw materials required by unit product in the remanufacturing process. It follows a normal distribution that $C_{b1} \sim N(u,\delta)$;

C_{b2} procurement cost of raw materials required by unit product in the original manufacturing process;

What's more, these notations satisfy $C_{b2} > C_{b1}$, $p_3 > p_2 > p_1$

This paper studies the game between suppliers and retailers under asymmetric situation. The game between the two populations is a dynamic game. The manufacturer makes decisions after the retailer. The strategies and payoffs of two players are both different. In addition, the game is played in a space of uncertainty and bounded rationality. The strategies of two players influence each other. Under this circumstance, we think about two pure strategies of the manufacturer and the retailer respectively.

The retailer have two pure strategies:

S_{r1} recycle waste products

S_{r2} not recycle waste products

The manufacturer also have two pure strategies:

S_{m1} use the recycled waste products to remanufacture

S_{m2} purchase new raw materials to manufacture directly

The strategy faced by the retailer is whether to recycle or not to recycle. Recycle waste products needs to pay recycling cost. Due to the possible situation that manufacturers may not repurchase waste products from retailers, retailers have the risk of loss. Then the strategy faced by the manufacturer is whether to remanufacture or not to remanufacture. The buyback cost of remanufacturing is lower than the procurement cost of original manufacturing. Manufacturers need to bear fixed cost like management cost, disassembly cost, cleaning cost, inspection cost and so on after taking remanufacturing strategy. Assumed that x represents the individual ratio of retailer population who takes recovery strategy. Then 1-x represents the remaining individuals who do not take recovery strategy. x satisfies the condition of $0 \leq x \leq 1$. Similar to the meaning of x, y represents the individual ratio of manufacturer population who takes remanufacturing strategy. Then 1-y represents the remaining individuals who do not take recovery strategy. y satisfies the condition of $0 \leq y \leq 1$. The adjustment of strategies is a dynamic adjustment process. When expected benefits of the manufacturer or the retailer is lower than their average benefits respectively, the two players will change their strategies in next selection to pursue the higher benefit.

The profit functions of the retailer are different. Firstly, when the retailer takes recovery strategy and the manufacturer takes remanufacturing strategy, the profit of the retailer will be $\prod_{r1}$, $\prod_{r1} > 0$. Secondly, when the retailer takes recovery strategy but the manufacturer doesn't take remanufacturing strategy, the loss of the retailer will be $\prod_{r2}$, $\prod_{r2} < 0$. Lastly, when the retailer doesn't take recovery strategy, the profit of the retailer is 0 whatever strategy does the manufacturer choose.

$$\prod_{r1} = p_1Q - C_rQ = (p_1 - C_r)Q, \tag{67.1}$$

$$\prod_{r2} = -C_rQ, \tag{67.2}$$

When faced same product demand, the profit functions of the manufacturer are different. ∏m1 is the profit when the manufacturer takes remanufacturing strategy. ∏m2 is the profit when the manufacturer takes original manufacturing strategy.

$$\prod_{m1} = p_2Q - p_1Q - C_{b1}Q - C_fQ - C_pQ = \left(p_2 - p_1 - C_{b1} - C_f - C_p\right)Q, \tag{67.3}$$

$$\prod_{m2} = p_3Q - C_{b2}Q - C_mQ = (p_3 - C_{b2} - C_m)Q, \tag{67.4}$$

Let ES_{ri} and ES_{mj} denote expected benefits of the retailer and the manufacturer respectively when they take different strategy combinations. $i, j = 1, 2$.

$$ES_{r1} = \mathrm{y}\prod_{r1} + (1 - \mathrm{y})\prod_{r2}, \tag{67.5}$$

$$ES_{r2} = 0, \tag{67.6}$$

$$ES_{m1} = \mathrm{x}\prod_{m1} + (1 - \mathrm{x})\prod_{m2}, \tag{67.7}$$

$$ES_{m2} = \mathrm{x}\prod_{m2} + (1 - \mathrm{x})\prod_{m2} = \prod_{m2}, \tag{67.8}$$

Therefore, we define $\overline{ES}_r$ and $\overline{ES}_m$ as the average benefits of the retailer and the manufacturer respectively when they take different strategy combinations.

$$\overline{ES}_r = \mathrm{x}ES_{r1} + (1 - \mathrm{x})ES_{r2}, \tag{67.9}$$

$$\overline{ES}_m = \mathrm{y}ES_{m1} + (1 - \mathrm{y})ES_{m2}, \tag{67.10}$$

.

67.3 The Evolutionary Analysis of Game Model Under Market Mechanism

According to Malthusian equation, the quantity's growth rate of strategy selected by players should equal to its fitness minus its average fitness. Then the replicated dynamic equations of S_{r1} selected by the retailer and S_{m1} selected by the manufacturer are denoted as follows.

$$f_1(x, y) = x(ES_{r1} - \overline{ES_r}) \quad (67.11)$$

$$f_2(x, y) = y(ES_{m1} - \overline{ES_m}), \quad (67.12)$$

Substitute formula (67.5) and (67.9) into the replicated dynamic Eq. (67.11), we have

$$f_1(x, y) = \frac{dx}{dt} = x(1 - x)[y\prod_{r1} + (1 - y)\prod_{r2}] = x(1 - x)(yp_1 - C_r)Q, \quad (67.13)$$

In the same way, we have

$$\begin{aligned} f_2(x, y) &= \frac{dy}{dt} = y(1 - y)x(\prod_{m1} - \prod_{m2}) \\ &= y(1 - y)x\left(p_2 + C_{b2} + C_m - p_1 - p_3 - C_{b1} - C_r - C_p\right)Q, \end{aligned} \quad (67.14)$$

67.3.1 The Evolutionary Game Analysis of Retailer Population

We can use the replicated dynamic equation to depict the evolutionary course of retailer population's strategy selection. Then we can get equilibrium point and ESS of the evolutionary game. According to the stability theorem of differential equation, the equilibrium point should satisfy $\frac{\partial f_1(x,y)}{\partial x} < 0$ if it's a ESS. To solve the partial derivative of $f_1(x, y)$, we have

$$\frac{\partial f_1(x, y)}{\partial x} = (1 - 2x)(yp_1 - C_r)Q, \quad (67.15)$$

According to formula (67.15), we can have Theorem 1 as follows.

Theorem 1

I. When $y = y = \frac{C_r}{p_1}$, there is no ESS.

II. When $y < \frac{C_r}{p_1}$, $x = 0$ is the ESS of retailer population's strategy selection.

III. When $y > \frac{C_r}{p_1}$, $x = 1$ is the ESS of retailer population's strategy selection.

67.3.2 The Evolutionary Game Analysis of Manufacturer Population

The same way to the content of former chapter, we can get equilibrium point and ESS of the evolutionary course of manufacturer population. It should satisfy $\frac{\partial f_2(x,y)}{\partial y} < 0$. To solve the partial derivative of $f_2(x, y)$, we have

$$\frac{\partial f_2(x,y)}{\partial y} = (1-2y)x(\prod_{m1} - \prod_{m2}), \tag{67.16}$$

According to formula (67.16), we can have Theorem 2 as follows.

Theorem 2

I. When $x = 0$, there is no ESS.
II. When $x > 0$ and $\prod_{m1}$-$\prod_{m2} < 0$, $y = 0$ is the ESS of manufacturer population's strategy selection.
III. When $x > 0$ and $\prod_{m1}$-$\prod_{m2} > 0$, $y = 1$ is the ESS of manufacturer population's strategy selection.

To show the retailer population's and manufacturer population's replicated dynamic trend in a same coordinate plane as Fig. 67.1 depicts:

We can find that when the profit of remanufacturing strategy selected by manufacturer is lower than the profit of original manufacturing strategy. This game will gradually converge to the equilibrium point (0, 0). It's said that the retailer population gradually tends not to select recovery strategy and the manufacturer population gradually tends to select original manufacturing strategy. (No recovery, Original manufacturing) will be the only choice of the two populations. In contrast, while the profit of remanufacturing strategy selected by manufacturer is higher than the profit of original manufacturing strategy, the game will gradually converge to the equilibrium point (1,1). It's said that the retailer population gradually tends to select recovery strategy and the manufacturer population tends to select

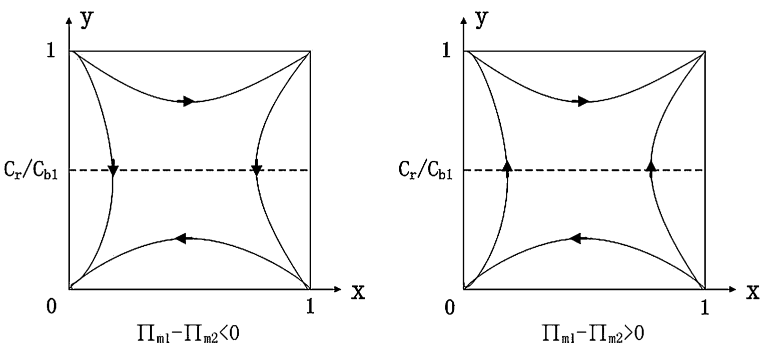

Fig. 67.1 The evolutionary graph of retailer group and manufacturer group

remanufacturing strategy. (Recovery, Remanufacturing) will be the only choice of the two populations. Through the above analysis, we can find that the ESS of the two populations are both determined by the profit of manufacturers.

67.4 Conclusions

Remanufacturing industry plays an important role in promoting the development of low-carbon economy as an emerging industry. But it's still immature. This paper analyzes the retailer population's and manufacturer population's long-term evolutionary course in the remanufacturing closed-loop supply chain. The analysis shows that the ESS of two populations is influenced by the profit of manufacturers achieved from remanufacturing activity. To strengthen the degree of technological innovation or improve employee skills is turned to be the main driving force of promoting the development of remanufacturing industry. This paper studies the evolutionary game of remanufacturing closed-loop supply chain from the perspective of two populations. The closed-loop supply chain in reality is more complicated. Therefore, to study the evolutionary game of remanufacturing closed-loop supply chain from the perspective of more populations is the direction for further research.

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Chapter 68
A Sequencing Problem for a Mixed-Model Assembly Line on Supply Chain Management

Hugejile, Shusaku Hiraki, Zhuqi Xu and Shaolan Yang

Abstract The sequencing problem for mixed-model assembly has a direct influence on the parts supply chain, production logistics and mobile sale logistics; it is also one of the key factors to design and organize low-carbon model logistics. The model in this paper assumed that the parts is supplied in JIT and assembled into products in a mixed-model line. A part of the products are transported to the distributor directly by car-carrier after production. In this circumstance, the essay proposes a new sequencing method on mixed-model assembly line, which considers keeping a constant speed in consuming each part in the line, leveling the load on each process within the line, and the products transportation planning above-mentioned. At last an example is given to illustrate the characteristics and effectiveness of the method in the paper.

Keywords Mixed-model assembly line · Sequencing problem · Production loads · Transportation schedule

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68.1 Introduction

Nowadays the customer's need varies frequently and the life cycle of products becomes shorter. In order to survive in such fierce competition, many enterprises have introduced the advanced theory of Supply Chain Management (SCM).

In order to solve the sequencing problem for a mixed-model assembly line, the previous researches have covered the following fields such as the researches on the objective of keeping a constant speed in consuming each part in the line (Miltenburg 1989; Inman and Bulfin 1991; Cakir and Inman 1993; Kurashige et al. 2002), leveling the load on each process within the line (Thomopoulos 1967; Okamura and Yamashina 1979; Bard 1992; Tsai 1995; Xiaobo and Ohno 2000), or considering the two objectives above simultaneously (Miltenburg and Goldstein 1991; Bard et al. 1994; Kotani et al. 2004; Xu and Hiraki 1996; Huge et al. 2011). These researches seek to realize the optimized goal for logistics from part supplier to automobile manufacture enterprises, but fail to consider the logistics from automobile manufacturers to distributors, which may lead to the delay of production transportation planning.

The sequencing problem for the mixed-model assembly line proposed in this paper, considers the road transportation plan for a part of products, on the base of the research above.

68.2 To Decide the Production Volume of Each Product for Shorter Periods

The paper will take two stage-approach by Xu et al. (1996) to decide the sequencing problem. At the first stage, product period has been divided into several shorter periods by the time of the part withdrawn. We will attempt to determine the production volume of each product for each period, by keeping a constant speed in consuming each part and considering production transportation planning.

68.2.1 Assumptions

(1) The cycle time of the mixed-model mobile assembly line is fixed.
(2) Parts withdrawals are performed at fixed intervals.
(3) A part of the products in the schedule are transferred to the designated distributor by car-carriers.
(4) It is provided that both the destination to distributor of each car-carrier and the products loaded on the car-carriers.
(5) The car-carrier has set the start time according to the arrival time agreed by the designated distributor.
(6) The number of the car-carrier is ranked by the set start time.

68.2.2 Notation

I the total quantity of product types $(i = 1, \cdots, I)$,
d_i total production quantity of product i,
K total production quantity of all products in schedule time,
J total quantity of parts types $(j = 1, \cdots, J)$,
a_{ij} necessary quantity of part j to be utilized for producing product i, (Table BOM)
R_j total necessary quantity of part j to be consumed for producing all products,

$$R_j = \sum_{i=1,\cdots,I} d_i \cdot a_{ij} \ (j = 1, \cdots, J)$$

r_j average necessary quantity of part j per unit product, $r_j = R_j/K$ $(j = 1, \cdots, J)$
sh^k production start time of product with sequence number k,
fh^k production finish time of product with sequence number k,
O_{jk} it takes one unit time when j is withdrawal in position k, otherwise it takes zero,
ω the set of k that one or more types of part are withdrawn in position k,

$$\omega = \{k|O_{jk} = 1 \ \ (j = 1, \cdots, J; k = 1, \cdots, K)\},$$

ω' put the factor in set ω into order from small to big, $\omega'(b)$ means the factor b in set ω,
δ_k the set of part j withdrawn in position k, $\delta_k = \{j|O_{jk} = 1$ $(j = 1, \cdots, J)\}$ $(k \in \omega)$
X_{ik} cumulative production volume of product i sequenced from position one to k,
Y_{jk} total volume of part j required to assemble the products sequenced from position one to k,
L total quantity of shorter periods, $L = |\omega|$,
T_{il} production volume of product i in periods l,
K' total quantity of production by road transportation,
N total necessary quantity of car-carrier in road transportation $(n = 1, \cdots, N)$,
$V_{i,n}$ quantity of product i to be carried by car-carrier n,
E the necessary transportation time from the finishing production to arriving at the loading area new car terminal,
g_n set start time of car-carrier n, G_n: real start time of car-carrier n,
σ_k the set car-carriers that has to start when the products sequenced from position one to k are loaded, $\sigma_k = \{n|fh^k + E \geq g_n \quad (n = 1, \cdots, N)\}(k \in \omega)$.

68.2.3 Formulation

We decide to minimize the function (1) which is the sum of squares of deviations of the cumulative withdrawal quantity of all parts till the withdrawn time, under the constraints (2)–(9). The production volume of each product in each period could be determined by solving the mathematical programming problem.

Evaluation function

$$f_1 = \sum_{k \in \omega} \sum_{j \in \delta_k} (k \cdot r_j - Y_{jk})^2 \tag{68.1}$$

Constraint:

$$X_{iK} = d_i \quad (i = 1, \cdots, I) \tag{68.2}$$

$$\sum_{i=1,\cdots,I} X_{ik} = k \quad (k \in \omega) \tag{68.3}$$

$$X_{ik} \geq \sum_{n \in \sigma_k} V_{i,n(k \in \omega; i=1,\cdots,I)} \tag{68.4}$$

Therein,

$$\sum_{n \in \sigma_K} \sum_{i=1,\cdots,I} V_{i,n} = K' \tag{68.5}$$

$$Y_{jk} = \sum_{i=1,\cdots,I} X_{ik} \cdot a_{ij} \quad (k \in \omega; j \in \delta_k) \tag{68.6}$$

$$X_{i\omega'(b-1)} \leq X_{i\omega'(b)} \quad (i = 1, \cdots, I; b = 2, \cdots, |\omega|) \tag{68.7}$$

$$T_{il} = X_{i\omega'(l)} - X_{i\omega'(l-1)} \; (i = 1, \cdots, I; l = 1, \cdots, L) \tag{68.8}$$

$$X_{i\omega'(0)} = 0 \; (i = 1, \cdots, I)$$

$$X_{ik}, Y_{jk}(i = 1, \cdots, I; k \in \omega; j \in \delta_k) : \text{non} - \text{negative integer} \tag{68.9}$$

68.3 The Scheduling Order for Products in Shorter Period

In stage 2, considering the operation delay time and the set start time of car-carrier of products in each shorter period, we determined the products schedule. The model could be the same method as Huge et al. (2011), which is omitted in the paper.

68.4 Example

In the example, total quantity of product types $I = 4$, total quantity of parts types $J = 4$, total production quantity of each product $d_A = 30$, $d_B = 40$, $d_C = 30$, $d_D = 20$, total production quantity of all product $K = 120$. The products schedule needs to be determined. Cycle time $c = 60$ s, conveyor speed $v = 0.1$ min/s, sh^0 means 8 A.M., $E = 1$ h.

The production quantity of each product types, Table BOM, the total required quantity for each part types and withdrawal time is showed in Table 68.1. The withdrawal time for parts is four times and is 8:40, 9:00, 9:20 and 10:00 respectively. The scheduling time is divided into four shorter periods, $L = 4$.

During the 120 products in the scheduling time, 60 products have designated distributor (or customer) order and lead time. Each car-carrier could take 5 cars, and the whole transport needs 12 car-carriers. The specific transportation schedule is illustrated in Table 68.2.

Table 68.3 illustrates the operation time of each product in each process, and the initial position of operator of shorter period 1 when he starts operation.

Table 68.1 Production quantity of each product, BOM table, withdrawal time

Product type		*A*	*B*	*C*	*D*	*Rj*	8:40	9:00	9:20	10:00
d_i		30	40	30	20		40	60	80	120
	1	1	0	1	0	60	1	0	1	1
Part	2	0	1	1	1	90	1	0	1	1
Type	3	1	2	0	0	110	0	1	0	1
	4	1	0	0	1	50	0	1	0	1

Table 68.2 Car-carrier schedule

Number of car-carrier Product type	1	2	3	4	5	6	7	8	9	10	11	12
A	1	0	1	0	5	0	0	1	2	3	3	4
B	2	3	1	4	0	3	5	2	2	2	2	1
C	1	2	1	0	0	1	0	2	0	0	0	0
D	1	0	2	1	0	1	0	0	1	0	0	0
Set start time	16:40					17:00		17:10		18:00		

Table 68.3 The operation time of each process (second)

Number of process Product types	1	2	3	4	5	6	7	8
A	65	50	70	52	70	45	59	65
B	60	40	45	60	60	65	50	48
C	50	56	62	40	40	58	57	50
D	40	55	50	50	45	48	60	50

Table 68.4 Production schedule for each period

l	Production volume				Mixed ratio of product	Production schedule
1	10	15	10	5	2:3:2:1	*DCBABCBA* (5th time)
2	5	5	5	5	1:1:1:1	*DABC* (5th time)
3	5	10	5	0	1:2:1:0	*BABC* (5th time)
4	10	10	10	10	1:1:1:1	*DABC* (10th time)

Table 68.5 Model production volume and schedule based on (Xu and Hiraki 1996)

l	Production volume				Mixed ratio of product	Production schedule
1	10	10	10	10	1:1:1:1	*DABC*(10th time)
2	5	10	5	0	1:2:1:0	*BABC*(5th time)
3	5	0	5	10	1:0:1:2	*DCDA*(5th time)
4	10	20	10	0	1:2:1:0	*BCBA*(10th time)

Table 68.6 Real start time of car-carrier when that all products to be assembled

n	g_n	*This model*			Xu and Hiraki 1996)		
		$Z_n.fh^{Z_n}.G_n$			$Z_n.fh^{Z_n}.G_n$		
1	16:40	5	15:05	16:05	7	15:07	16:07
2		13	15:13	16:13	19	15:19	16:19
3		17	15:17	16:17	23	15:23	16:23
4		27	15:27	16:27	39	15:39	16:39
5		28	15:28	16:28	26	15:26	16:26
6	17:00	35	15:35	16:35	45	15:45	16:45
7		55	15:55	16:55	55	15:55	16:55
8	17:10	61	16:01	17:01	83	16:23	17:23
9		65	16:05	17:05	87	16:27	17:27
10	18:00	70	16:10	17:10	91	16:31	17:31
11		74	16:14	17:14	95	16:35	17:35
12		76	16:16	17:16	97	16:37	17:37

According to the known conditions, we could achieve the results below.

Table 68.4 illustrates this research result of production volume and Determine the scheduling order of each shorter period.

Table 68.5 showed production volume and production schedule in each shorter period, regardless of transportation planning.

Table 68.6 illustrates the real start time for car-carrier in the two models.

The result of this research illustrates that the set start time of all car-carrier have no delay. In the result of Xu et al. (1996), the set start time for numbers 8 and 9 car-carriers have delayed for 13 and 17 min respectively.

68.5 Conclusion

In this research, it is considered that only part of the scheduled products would be transported by car-carrier to the car distributor. Therefore it is proposed that a scheduling method for mixed-model assume objectives, the effectiveness of the research is testified. In order to solve the scheduling problem, this research has realized the objective of integrative optimization of the supply chain from part supplier to distributor.bly line would satisfy a constant speed in consuming each part, leveling the load on each process and production transportation plan. After compared with the research of Xu et al. considering two objectives, the effectiveness of the research is testified. In order to solve the scheduling problem, this research has realized the objective of integrative optimization of the supply chain from part supplier to distributor.

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Chapter 69
Price Competition in Tourism Supply Chain with Hotels and Travel Agency

Yun Huang

Abstract Tourism was considered a “smokeless industry”, depending on using and developing the natural and cultural resources of a country to attract visitors. This paper studies the impact of different power structures on the room rates decisions in a tourism supply chain with two hotels, one luxury and the other economic, and one travel agency. Stackelberg game and Nash game models are formulated to analyze the pricing decisions in the power structures. We conduct comparative study between the three structures and explore the effects of different parameters on equilibrium prices, demands and profits.

Keywords Tourism supply chain · Hotel · Travel agency · Pricing · Stackelberg game · Nash game

69.1 Introduction

Tourism is considered a “smokeless industry”, largely dependent on using and developing the natural and cultural resources of a country as attractions for visitors. Increasing tourists’ concerns on environmental issues also force companies to adopt sustainable supply chain management strategies. As the development of tourism supply chain, the relationships between different entities play important roles in business, tourism, academic exchange and so on (Zhang et al. 2009).

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Different market power has profound influence on equilibrium prices and profits of the supply chain members (Choi 1991).

This paper is sparked by this conflict and coordination relationship between hotels and their channel partners (travel agencies or tour operators) of the tourism supply chain. A travel agency cooperates with hotels to provide tour packages of accommodation and sightseeing. The sightseeing routines are identical for all tourists; meanwhile the accommodation is divided into different levels to meet different demands of tourists. For example, the Hong Kong Student Travel agency (http://www.hkst.com.hk/) provides different Greece Romance travel tourism packages to the tourists (http://www.hkst.com/fileshow.asp?id=2991). The packages include a 4 days' visit to Athens and three nights' accommodation. The difference between them is the three night's accommodation, including economic and luxury accommodation provided by different hotels.

In order to study the pricing strategy of different hotels and travel agency under different market power, we consider a tourism supply chain with two types of hotels, one luxury and the other economic, and a travel agency. We mainly focus on the competition on room rates decisions between the hotels and travel agency. Three power structures are considered in this paper. The first two cases study the hotels and the travel agency take the chain leadership, respectively. Stackelberg game is used to model the two cases. In the third case, we study the situation that the hotels and the travel agency are of equal market status and a Nash game is played between them.

The rest of this paper is organized as follows. Section 69.2 reviews the literature on tourism supply chain, pricing strategy and game theory application. The subsequent section presents different game models in the tourism supply chain. Section 69.4 derives the optimal pricing decisions and profits in the tourism supply chain with hotels and travel agency under three different power structures. In Sect. 69.5, we conduct comparative studies on the effects of different power structures and different parameters. The paper concludes with some suggestions for further research.

69.2 Literature Review

There are two subject areas related to our work: tourism supply chain, pricing strategy and the application of game theory to supply chain management and tourism industry.

In general, the literature on tourism supply chain is very limited. Some studies have focused on the relationships between tour operators and the accommodation or hotels. Buhalis (2000) and Medina-Muñoz et al. (2003) examined the competitive and cooperative relationships between tour operators and hotels in a distribution channel. Zhang et al. (2009) systematically reviewed the literature of current tourism studies from the tourism supply chain management perspective and developed a framework for TSC management research.

Game theory is a powerful tool extensively used in manufacturing supply chains to study competitive and cooperative relationships. Choi (1991; Choi 1996) investigated a pricing competition problem for a channel structure consisting of two competing manufacturers and one common retailer who sells both manufacturers' products. Minakshi (1998) analyzed three channel structures dealing with two competing manufacturers and two retailers to examine the channel competition problem. Huang et al. (2011) studied supplier selection, pricing and inventory coordination problem using a dynamic game model. In recent years, applying game theory in tourism has attracted considerable attention. Aguiló et al. (2002) studied an oligopoly tourism market in which the tour operators have the market power to determine a higher price and keep their market share. Wachsman (2006) employed a Nash game model to study the interactions among hotels and airlines. Song et al. (2009) conducted investigation into pricing competition and coordination between Hong Kong Disneyland and a tour operator using game models. Many of these studies considered only one hotel and one travel agency, and the analysis of competition and coordination was confined to members in the same channel or echelon. When several different channel systems are considered, the interactions among channel members become more complicated. In this paper, we show that the different power structures play a critical role in determining the price decisions of the members in tourism supply chain.

69.3 Game Model

We consider the tourism supply chain with two hotels competing to provide two types of accommodation, luxury and economic respectively, to a travel agency. Then the travel agency sells the different hotels directly or combines with other tourism products as tourism packages to the tourists. The hotels and the travel agency are independent decision makers and optimize their own profits individually. Three cases are studied. One is the hotels take the leading role of the tourism supply chain. Suppose the hotels make the first move on room rate decisions and propagates the rooms to the travel agency. The travel agency as the follower then decides the optimal room rate for the tourism packages. The second one is the travel agency takes the chain leadership. That is the travel agency first prices the rooms and the hotels decide the optimal prices as the followers. The last one is the two hotels and the travel agency of the same market power. They make their pricing decisions simultaneously. No one dominates over others.

The revenue of the tourism hotels is as follows

$$\pi_i = D_i w_i \tag{69.1}$$

where $i = L,E$, L stands for luxury hotel, and E for the economic one. w_i denotes the room rate set by the hotel i.

And the revenue of the travel agency T is

$$\pi_T = D_L(p_L - w_L) + D_E(p_E - w_E) \tag{69.2}$$

where p_i is the room rate decided by travel agency for rooms of hotel i.

The hotels and travel agency make pricing decisions non-cooperatively, and their objective is to maximize their own revenue. The capacity of hotel is neglected in this paper, which does not affect the discussion in this paper.

The tourist experience of luxury room is more desirable than that of the economic one. We denote tourist experience of the hotel i as s_i. Thus, we assume that $s_L > s_E$. $\Delta s = s_L - s_E$. Reflects the difference in tourism experience between the two different hotels.

We denote tourism preference of a hotel as θ. θ is a random variable following uniform distribution normalized to [0, 1]. The tourist utility is defined as a function of perceived experience and room rate to the tourists (Keane 1997).

$$u_i = v + \theta s_i - p_i, i = L, E \tag{69.3}$$

where v is a basic utility of a hotel room and homogeneous among all tourists to the two types of rooms. We should know that positive preference does not means positive utility. And if the utility is lower than zero, tourists will not purchase any of rooms. Given s_i and p_i, when $u_E = 0$, then $\theta = \hat{\theta}_E$, where $\hat{\theta}_E = \frac{p_E - v}{s_E}$. When $u_L = 0$, then $\theta = \hat{\theta}_L$, where $\hat{\theta}_L = \frac{p_L - v}{s_L}$. And when $u_L = u_E$, a tourist will be indifferent between the luxury and the economy rooms and we get $\theta = \theta^* = \frac{p_L - p_E}{s_L - s_E}$.

According to (Song et al. 2009), the demand of the luxury rooms is,

$$D_L = 1 - \theta^* = 1 - \frac{p_L - p_E}{s_L - s_E} \tag{69.4}$$

And the demand of the economic rooms is,

$$D_E = \theta^* - \hat{\theta}_{\mathrm{E}} = \frac{p_L - p_E}{s_L - s_E} - \frac{p_E - v}{s_E} \tag{69.5}$$

69.4 Solution

Three power structures are considered in this paper, two leader–follower structures and one independent structure. We use Stackelberg game to model the first two structures and Nash game for the independent one.

69.4.1 Hotel Stackelberg

We use Stackelberg game to model the leader–follower power structure. For convenience, we call this game model as Hotel Stackelberg (HS). In this game, the hotels take the travel agency's reaction functions into consideration for their pricing decisions. The equilibrium is a set of pricing decisions in which both the hotels and the travel agency have no incentive to change their prices unilaterally.

69.4.2 TA Stackelberg

We then consider the structure that the travel agency takes the channel leadership. Stackelberg game is also employed to model this scenario. We call this game model as TA Stackelberg (short for TS). In this game, the travel agency takes the hotels' reaction functions into consideration for its pricing decision. We can obtain the Stackelberg equilibrium of the TS game as a solution for the travel agency Stackelberg model.

69.4.3 Vertical Nash

The third independent power structure is formulated as a Nash game. In this game, the hotels and the travel agency make pricing decisions simultaneously and non-cooperatively. Again for convenience, we call this game Vertical Nash (VN). In this game, the hotels choose their room rates conditional on the travel agency's pricing to maximize their profits. The travel agency chooses its optimal prices conditional on the hotels' pricing decisions.

69.5 Discussion

To understand the impacts of different power structures, we conduct a comparative study between the three cases.

Proposition 1 The basic utility v has positive impacts on the equilibrium prices, demands and profits.

This proposition shows us that the increase of v will increase the equilibrium room rates, demands and profits of all the chain members. High utility means high quality of the tourist experience, so the rooms would be more desirable. The proposition is very intuitive. A well-pleasing tour will attract more tourists and the tourists will accept a higher price easily.

Proposition 2 The tourism experience of economic tour package s_E has negative impacts on pricing, profits, but positive impact on demands of luxury tour package.

Proposition 2 indicates that the increase of tourist experience for economic room brings down the room rate of luxury hotel and its profit although their demand increases. Due to the competition between the hotels, the luxury hotel will reduce its hotels prices to attract more tourists to counter the impact of the increasing tourist experience from the economic hotel. The reduced price attracts more tourists, so their demand increases, but their profit still decreases.

69.6 Conclusion

Most previous studies have focused on tourism supply chain with one single member in each echelon. In the contemporary real market, coordination for the multiple members with different power structures is inevitable and necessary. This paper extends the growing literature of channel studies by analyzing pricing strategies in a two-level tourism supply chain with two hotels and one travel agency under three different power structures. Stackelberg and Nash games are used to model different structures. We investigate the effects of power structures, different parameters on the pricing decisions and profits for chain members.

This paper suffers from several limitations. The models in this paper only consider tourism supply chain with one or two members in each echelon. A more general model with multiple hotels, travel agencies could be developed. Besides, a range of distribution channels could be considered. For example, the hotels can sell their rooms to the travel agencies and customers directly. Such situations could also be studied. Thirdly, we consider only one strategic variable—pricing. A major direction for future research could involve some other strategic variables, such as quantity, advertising.

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Chapter 70
Evaluation on Bus Rapid Transit in Macau Based on Congestion and Emission Reduction

Huajun Tang, Xinlong Xu and Bo Huang

Abstract With the fast development of the tourism industry, the land transportation system at present can barely sustain the overpopulated city. Based on the merits of the cheaper investment, massive capacity, less contamination, effectiveness and the short construction cycle, Bus Rapid Transit (BRT) is one of the best alternatives to enhance urban transportation service levels in a short period. This study takes an example of Macau and tries to identify the features of the public transportation system as well as analyzing the existing problems. Then the study conducts an assessment of the significance of launching a BRT in Macau with respect to the underlying economic revenue and exhaust reduction. Finally, it is supported that the BRT system can effectively reduce the traffic congestion and CO_2 emission.

Keywords Public transport priority · Bus rapid transit · Congestion reduction · Emission reduction

70.1 Introduction

With the rapid development of Macau economy, the number of vehicles in Macau increases dramatically. Particularly, since the year of 2003, in which the Sands and Wynn casinos opened, free shuttle buses have come into service, so as to provide convenient and quick travel for those who visit the casinos in Macau. Because of the quick development of the casinos and the lack of the local government's

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effective management, the population of vehicles (including public and private ones) grows remarkably, which not only leads to great traffic pressure, but also increases the vehicle emission in Macau. In addition, as a special region with famous tourism, it is fundamental for Macau to have an advanced, green and smooth transportation system. Therefore it is urgent and challenging to improve the transportation system to reduce its negative impacts and improve the environment in Macau.

70.2 Current Traffic Conditions

So far Macau has been the region with the highest vehicle-density. The streets in Macau are very narrow, while the roads available are very few, which leads to serious congestion, and many traffic accidents.

Vehicles in Macau can be classified into two categories: public and private motors. The public vehicles consist of taxis, buses and traveling buses. According to the statistic report from Macau Government, the population of taxies in 2011 reached to about 1,000, which is fewer than any other regions in Great China. However, they usually run in some busy streets so as to serve more passengers, which leads to much traffic congestion, since these streets have at most two lanes.

Private vehicles mainly consist of two-wheel and four-wheel motors. Since the return in 1999, the population of private motors increases rapidly. According to the report in Year 2012 from Macau Government, there are 81,684 four-wheel and 111,717 two-wheel vehicles, which is almost as twice as those (51,510 four-wheel and 57,292 two-wheel vehicles) in Year 2002. The population of the private vehicles in recent 11 years is given in Table 70.1.

Based on the current traffic conditions, it is urgent and challengeable to ease the traffic congestion and reduce its negative impact on the tourism in Macau.

Table 70.1 The population of private vehicles in macau in recent 11 years

Years	Four-wheel vehicle	Two-wheel vehicle
2002	51,510	5,7292
2003	52,379	5,8250
2004	55,809	62,164
2005	59,556	66,389
2006	63,916	72,528
2007	68,334	78,816
2008	71,726	85,368
2009	76,117	92,296
2010	78,753	97,724
2011	80,499	102,566
2012	81,684	111,717

70.3 Public Transport Priority

Considering that the current traffic conditions in Macau become more and more serious, Macau Government has set up an institution (i.e., Institution of Integrated Traffic and Transportation, IITT) to build a green, safe, and smooth integrated transportation system, so as to improve the traffic conditions.

In the literature there are several publications to study city transportation systems. For instance, Wang introduced several methods to improve public transport systems, according to different traffic conditions (Wang 2012). Zuo and Shao discussed some policies and strategies about public transport priority (Zuo and Shao 2012). Zuo et al. explored the difference between travel speed of buses and cars, and provided one model to express the shift relationship (Zuo et al. 2012). Furthermore, there also exist some publications on the construction and evaluation of public transit priority. For instance, Chen and Yan investigated on signal timing for urban intersections with genetic algorithms optimizing with the idea of bus priority (Chen and Yan 2005). Zhang et al. optimized the signal-planning method of intersections based on bus priority (Zhang 2004). However, to our best knowledge, there exists little research on the evaluation of public transport priority in Macau. Hence this study aims to focus on the application of BRT in Macau.

Based on the research in the literature and practical situations in Macau, it is emergent and fundamental to take public transport priority into account. This study will discuss the feasibility and positive impact of bus rapid transport (BRT), which is one of the best measures of public transport priority.

BRT system aims to use advanced buses to run along bus lanes, introduce the advantage of the rail transport, and keep the flexibility of buses. It is the combination of the rail transit and the public transit. According to its strength and real situations in Macau, IITT firstly provided one sample lane for BRT, the feasibility and effectiveness of which need to be evaluated. In the following this study will apply several models to prove the benefit of BRT with respect to congestion and emission reduction.

70.4 Evaluation of BRT

According to the spot investigation, one sample BRT may start from Mage, through River New Street, to Border Gate, so as to integrate the first-stage light railway, which will be completed in 2014. This BRT can provide rapid bus service for the residents at Cheongju, Fai Chi Kei, and Border Gate.

To analyze the benefit of the BRT sample road, taking into account practical distribution of the population, present bus service, and future blueprint from Transport Bureau in Macau, this study divides the sample road into two segments. The first segment starts from Mage to Si Dakou, and the second starts from Perfect the Road to Border Gate. In the following, the study will apply two models to conduct benefit analysis with respect to environment improvement and traffic congestion reduction.

70.4.1 Benefit Analysis of Traffic Congestion Reduction

New buses with environment protection (e.g., Dennis Type Buses) are used in the BRT sample road, which can reduce more noise and vehicle emission than those applied in common bus systems. In addition, the vehicle schedule adopts more frequent shifts and bigger bus capacity to reduce the population of vehicles and traffic congestion.

In the following the paper will use one model to evaluate the benefit on traffic congestion reduction. $X = (L/V_B - L/V_A) \times 1.25 \times M_t$, where X denotes the benefit (MOP$) of traffic congestion reduction from vehicles, V_B and V_A represent the running speed (km per hour) of vehicles before and after the implementation of the BRT system, respectively, L is the length (km) of the BRT road, and M_t stands for the value per unit time (MOP$ per hour), which can be computed as below:

$$M_t = \overline{GDP}/(365 \times 8).$$

According to the spot investigation, the distance from Mage to Border Gate is 4.3 km, and the reverse distance is 4.9 km, then its average distance $L = (4.3 + 4.9)/2 = 4.6$km. The current average speed of vehicles running along this road is 15 km/h, which is much lower than the limited speed 35 km/h. The average GDP per person in 2011 is MOP$ 398,073, which leads to M_t = MOP$136/h.

Once the BRT sample road is open, the average speed can reach to the limited value. The benefits corresponding to the different average speed are listed in Table 70.2.

According to the data in Table 70.2, the average loss per vehicle will be MOP$26.07 if the current traffic condition is kept until Year 2020. However, if the BRT road is open, then different running speed will lead to different benefit for each vehicle. When the running speed reaches to 35 km/h, then the average benefit for each vehicle will be MOP$ 29.79.

Table 70.2 The benefits corresponding to the different average speed under BRT

	Present	2020	BRT 1	BRT 2	BRT 3	BRT 4
V_B(km/h)	15	15	15	15	15	15
V_A(km/h)	15	10	20	25	30	35
M_t(MOPS/h)	136	136	136	136	136	136
X(MOP$)	0	−26.07	13.04	20.85	26.07	29.79

Table 70.3 CO_2 emission corresponding to the different average speed under BRT

	Present	2020	BRT 1	BRT 2	BRT 3	BRT 4
V_A(km/h)	15	10	20	25	30	35
E(L/100 km)	42.49	44.33	40.81	39.31	37.97	36.79
E (L)	3.91	4.08	3.75	3.62	3.49	3.38
Eco2d(kg)	911.00	950.45	875.12	842.81	814.07	788.90
Eco2y(kg)	3197.26	3335.70	3071.34	2957.94	2857.07	2768.72

70.4.2 Benefit Analysis of Environment Improvement

In this subsection, the benefit of environment improvement will be analyzed. As it is known that BRT buses and the other buses use different roads, and they are independent. Once the BRT road is open, all the buses in the BRT road has less operational time, and less traffic congestion, which leads to less CO_2 emission. In the following this study adopts one model to evaluate the benefit of emission reduction.

Let E be total oil consumption on the sample road, M_v be the mileage of different vehicles running along the sample road, and E_v be the oil consumption for some vehicle along the road. In this study, E_v can be obtained through the equation $E_v = 0.001784842 \times V_A - 0.256157175 \times 35 + 17.94117582$. Hence, the vehicle emission can be evaluated as follows.

$$E = \sum (M_v \times E_v).$$

Then the emission of CO_2 can be computed through the following equation, $E_{CO_2} = f \times E$, where f is the coefficient of CO_2 emission, and is fixed as 2.241(kg CO_2 per liter oil), according to the D-type bus. Define E_{CO_d} and E_{COy} as the total CO_2 emission for the vehicle along the sample road in 1 day and in 1 year, respectively. Different vehicle speed along the road will lead to different CO_2 emission, which is shown in Table 70.3.

According to the data in Table 70.3, it is obvious that the CO_2 emission can be reduced through the increase of the vehicle speed.

70.5 Conclusions and Future Research

This study firstly presented the current traffic conditions in Macau, and suggested that it was urgent and fundamental to improve the traffic system with the use of BRT. Then the paper provided one sample road for BRT based on the spot investigation, and applied two models to evaluate the benefits with respect to traffic congestion and CO_2 emission reduction. Finally, it was supported that BRT system can effectively reduce the traffic congestion and CO_2 emission.

Since this study only takes BRT system into account, which is only the one of the measures to remit traffic problems in Macau, it will integrate BRT system with other measures (e.g., introducing electronic motor and light railway) in the new future.

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Chapter 71
The Analysis and Strategy Research on Green Degree of Enterprise in Green Supply Chain

Lijin Liu

Abstract This paper firstly compares the meaning and the general conceptual model of traditional supply chain with those of green supply chain and finds out the green supply chain's advantages; then it puts forward an evaluation index system of enterprises green degree and builds a multifactor fuzzy comprehensive evaluation model of enterprises green degree. Finally, it puts forward some measures to improve enterprises green degree, in order to enhance a whole green level of enterprises and supply chain.

Keywords Green supply chain · Green degree · Fuzzy evaluation · Strategy

71.1 Introduction

Since the second half of 2009 China's emission reduction targets published and the Copenhagen climate conference, environmental protection and green economy development has been concerned very extensively and profoundly, green supply chain management has become a very hot topic.

Supply chain is an overall functional network structural model, which connects manufacturers, distributors, suppliers, retailers and the final user (Ma Shihua et al. 2000). Its procurement, production, sales and logistics processes are of high investment, high consumption and high waste output. The collaboration between enterprises pays more attention to economic benefits, and ignores the environmental protection, which is opposite to the economy sustainable development.

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So Many scholars have carried out comprehensive research on green supply chain theory since 1996.

Green supply chain is not a uniform definition as same as traditional supply chain. The author of this paper consults massive literature and information and believes that the green supply chain pays more attention to environment protection in the implementation of supply chain management and emphasizes on the harmonious development of environment and economy. It is a model of modern enterprise management that calls on an ecological design of the whole supply chain following a thought of green purchasing, green manufacturing, green marketing, green consumption, green logistics, and tries to make the whole supply chain management achieve environment harmonious and unified through close cooperation of the enterprise in chain, and finally tries to realize the economic benefits, environmental benefits and social benefits optimization with higher resource efficiency. Green supply chain management is based on the sustainable development theory, ecological economics theory and ecological ethics theory, which can realize economy and environment harmonious coexistence, and achieve a win–win situation.

71.2 The Analysis and Evaluation Study on Enterprises Green Degree in Green Supply Chain

"Green" is closely related to the environmental impact and is also a symbol of "environmental protection". The green degree is usually relevant with environmental regulations and standards as the benchmark, when the supply of environmental effects meets the requirement, it is green. Enterprise's green degree in green supply chain can be defined as the green degree or the environmental friendly degree, namely environmental impact quantitative. Negative environmental impact is greater, the green degree is smaller, whereas the larger (Wang and Sun 2005).

Evaluation model usually comprises of the evaluation index system and evaluation method. This paper firstly builds the index system of green degree, and then uses the fuzzy comprehensive evaluation model to analyze it, in order to help enterprises judge its supply of environmental compliance with environmental standard and regulatory requirements.

71.2.1 A Design of Evaluation Index System on Enterprises Green Degree in Green Supply Chain

The establishment of any evaluation index system is not imaginary, but must be combined with the characteristics of being evaluated object. In general, the green degree evaluation must be based on environmental protection and resource conservation principle to select the most appropriate index.

Due to legal and public pressure, businesses are increasingly trying to improve environmental performance. The index Environmental performance U_1 can effectively reflect enterprises' environmental protection implement level in green supply chain, so we can design for the wastewater discharge compliance rate x_1, emissions compliance rate x_2, solid waste emissions compliance rate x_3, noise pollution x_4, cleaner production level x_5;

The effective use of energy and resources gradually attracted the attention of enterprises. The index energy properties U_2 can reflect the extent that enterprises in green supply chain use effective energy-saving, so we can be design for energy efficiency x_6, energy output ratio x_7, product energy consumption x_8; the index resource properties U_3 can reflect green supply chain for the degree of efficient use of raw materials, equipment, etc., so you can design materials recycling rate x_9, equipment effective utilization of x_{10}, eco-friendly materials usage x_{11}.

The enterprises in supply chain should focus on products with reusable value, the recovery of parts or materials used to conserve resources, and achieve the goal of waste reduction, while the forward logistics and recycling more efficient. Therefore the recovery levels U_4 indicators can be designed for product recovery x_{12}, product disassembly x_{13}, recycling rate x_{14}, and logistics equipment recycling rate x_{15}.

Assessment of Green degree could not be separated from the green management level U_5, which can reflect an enterprise's environmental awareness and the level of investment in environmental protection, and reflect an individual for sustainable development and environmental protection, the degree of support. So we can design staff's green awareness x_{16}, proportion of environmental management x_{17}, green consumer product acceptance x_{18}, and environmental protection investment ratio x_{19} Li and Li (2010).

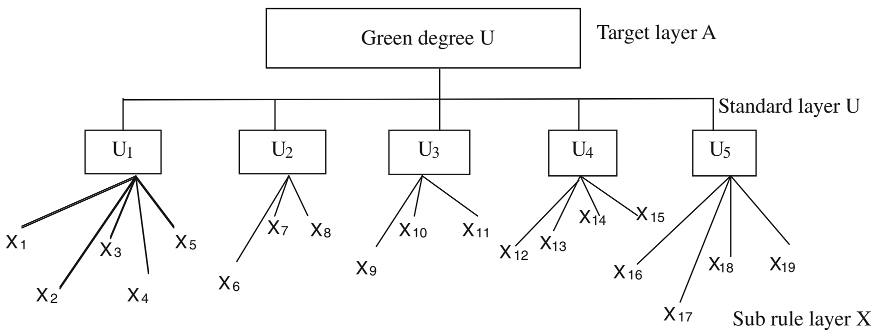

Fig. 71.1 The diagram of Multivariate hierarchical structure

In accordance with the principles of systematic, comprehensive and operability, this paper establishes a green degree evaluation index system of delivery access hierarchical model, as shown in Fig. 71.1.

71.2.2 The Fuzzy Comprehensive Evaluation Model of Enterprises' Green Degree in Green Supply Chain

In the evaluation index system, some indexes can obtain exact data, and others are very fuzzy. Considering the complexity and maneuverability and in order to reduce the arbitrary judgment subjectivity and to improve the objectivity and reliability of evaluation results, this paper uses a kind of two stage fuzzy comprehensive evaluation method combining the theory of fuzzy sets and analytic hierarchy process (AHP) (Chang and Zhang 1995).

(1) Determination of fuzzy set: Determining the evaluation object set: U = {u_1, u_2, u_3,u_4, u_3}, where u_i represents an ability of green degree evaluation of enterprises in the green supply chain; evaluation factors set: X = {x_1, x_2, x_3…x_{19}}. u_1 = {x_1, x_2, x_3,x_4,x_5} u_2 = {x_6, x_7, x_8} u_3 = {x_9,x_{10},x_{11}} u_4 = {x_{12}, x_{13}, x_{14},x_{15}} u_5 = {x_{16}, x_{17}, x_{18},x_{19}}; comment set: V = {v_1, v_2, v_3, v_4}, v_1, v_2, v_3, v_4 were expressed as "very good", "good", "general", "poor".

(2) Do the first level fuzzy synthetic evaluation after determining the index weight: This article uses AHP (Xu et al. 1988) to determine the weight of each index. This approach can express a complex problem as a orderly hierarchical structure, and rank the decision scheme through people's judgment, which is practical, systematic and concise. Some indicators of Evaluation index system cannot be directly quantified, but it is enough to use the expert scoring method and Delphi method to obtain the extent of n_{ijn} that x_i belongs to reviews, and thus get fuzzy judgment matrix R_i.

The value method of n_{ijn} is to collect evaluation comments of expert group members, and get that there are v_{j1} comments on v_1, v_{j2} comments on v_2, v_{j3} comments on v_3, v_{j4} comments on v_4 for index x_j, and they are listed as follows:

$$n_{iji} = v_{ji} \Big/ \sum v_{jn} (i = 1, 2, 3, 4) \tag{71.1}$$

$$\sum v_{jn} = v_{j1} + v_{j2} + v_{j3} + v_{j4} \tag{71.2}$$

So, fuzzy judgment matrix R_i can be obtained below.

$$R_1 = \begin{bmatrix} n_{111} & n_{112} & n_{113} & n_{114} \\ n_{121} & n_{122} & n_{123} & n_{124} \\ n_{131} & n_{132} & n_{133} & n_{134} \\ n_{141} & n_{142} & n_{143} & n_{144} \\ n_{151} & n_{152} & n_{153} & n_{154} \end{bmatrix} \qquad R_2 = \begin{bmatrix} n_{211} & n_{212} & n_{213} & n_{214} \\ n_{221} & n_{222} & n_{223} & n_{224} \\ n_{231} & n_{232} & n_{233} & n_{234} \end{bmatrix}$$

$$R_3 = \begin{bmatrix} n_{311} & n_{312} & n_{313} & n_{314} \\ n_{321} & n_{322} & n_{323} & n_{324} \\ n_{331} & n_{332} & n_{333} & n_{334} \end{bmatrix} \qquad R_4 = \begin{bmatrix} n_{411} & n_{412} & n_{413} & n_{414} \\ n_{421} & n_{422} & n_{423} & n_{424} \\ n_{431} & n_{432} & n_{433} & n_{434} \\ n_{441} & n_{442} & n_{443} & n_{444} \end{bmatrix}$$

$$R_5 = \begin{bmatrix} n_{511} & n_{512} & n_{513} & n_{514} \\ n_{521} & n_{522} & n_{523} & n_{524} \\ n_{531} & n_{532} & n_{533} & n_{534} \\ n_{541} & n_{542} & n_{543} & n_{544} \end{bmatrix}$$

The weights the X layer to the U layer Using AHP method is $N_i(i = 1,2,3,4,5), N_1 = (n_{11}, n_{12}, n_{13}, n_{14}, n_{15}), N_2 = (n_{21}, n_{22}, n_{23}), N_3 = (n_{31}, n_{32}, n_{33}),$ $N_4 = (n_{41}, n_{42}, n_{43}, n_{44}), N_5 = (n_{51}, n_{52}, n_{53}, n_{54})$ among them.

Let the level evaluation vector of U_i be B_i, then

$$B_i = N_i \hbar R_i = \{b_{i1}, b_{i2}, b_{i3}, b_{i4}, b_{i5}\} \tag{71.6}$$

among them:

$$b_{i1} = n_{i1} \cdot n_{i1n} \oplus n_{i2} \cdot n_{i2n} \oplus \cdots \tag{71.7}$$

$$a \oplus b = \min\{1, a + b\} \tag{71.8}$$

(3) Do the second level fuzzy comprehensive evaluation.

Regard each $U_i(i = 1,2,3,4,5)$as a factor, so that U is also a factor set, the single factor evaluation matrix for U:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & b_{42} & b_{43} & b_{44} \\ b_{51} & b_{52} & b_{53} & b_{54} \end{bmatrix}$$

You can get the weights of U layer to the A layer according to the AHP method, $A = (a_1, a_2, a_3, a_4, a_5)$ and you can obtain two stage evaluation vector

$$B = A \hbar R = (b_1, b_2, b_3, b_4, b_5) \tag{71.9}$$

among them:

$$b_i = a_1 \cdot b_{1i} \oplus a_2 \cdot b_{2i} \oplus a_3 \cdot b_{3i} \oplus a_4 \cdot b_{4i} \oplus a_5 \cdot b_{5i} \tag{71.10}$$

(4) The evaluation results: Make $B = (b_1, b_2, b_3, b_4, b_5)$ normalize, and then add b_1 and $b_{2,}$ the results can express the green supply chain green values better, which is an evaluation index value. If the result of b_1 and b_2 is more than 0.5, then enterprise's economic behavior is consistent with environmental standards.

71.3 Measures to Improve the Enterprises Green Degree in the Green Supply Chain

In general, it is a multi-objective program that improves the green degree value, which requires to achieve the emission reduction, energy saving, material saving, and to increase recycling efforts and enhance the green environmental protection level. Based on the results of the field research of green supply chain enterprises, this paper puts forward some measures to improve green degree, to enhance the green level of the enterprises and the whole supply chain.

(1) Focus on "three wastes" and other harmful emissions reduction.

Enterprises should strictly follow relevant environmental protection law and regulations, take the initiative to reduce emissions like waste water, waste, noise and harmful, toxic substances and others, and handle them inevitably caused by production process by using of physical, chemical and biological methods to discharge after purification or non-toxic harmless to reduce environmental pollution.

(2) Focus on energy saving and resource consumption

Energies like coal, electricity belong to non-renewable resources, so enterprises should use them safely, and improve equipment utilization and resource recycling rate as far as possible. Some materials such as steel, wood and other ones can be blanked to improve the utilization rate of raw materials by making full use of leftover materials. The production process of finished products should pay attention to the quality control and reduce scrap generated.

(3) Focus on Recycling

Enterprises should carefully do a good job of waste products and packaging recycling according to the "resource product recycling regulations," "packaging recycling management approach" and other regulations.

(4) Improve the level of green management

Enterprises should popularize environmental awareness, and allow employees to actively participate in the environment protection. Meanwhile it should dedicate environmental management workers, and increase investment to actively promote the environmental performance. Moreover it should actively produce green products, and develop consumer acceptance of green.

(5) Follow the Ideas of Green "Supply—Production—Sales" and Union the Business Strategy and Environmental Protection.

Green "Supply—Production—Sales" requires enterprises to do a good job of green procurement, green production, green marketing, green consumption and green logistics, and try to conserve resources and protect environments from the point of the green supply chain participants' view.

71.4 Conclusion

It's an inevitable trend of the research and implementation of international supply chain from traditional to green. This paper puts forward an evaluation index system and a model to evaluate enterprises green degree and gives several suggestions on improving enterprises green degree, hopeing to promote the enterprise's sustainable development.

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Chapter 72
The Ways for Improving the Operations of Hospital Industry: The Case in Macau

Yan Chen, Harry K. H. Chow and Ting Nie

Abstract Macau is one of the well-known tourism-dominated urban cities with high population density and limited natural resources. To maintain the reputation of tourism industry and cope with expanding public service demand, such as hospital service, hospital industry is now looking for solutions to enhance the service quality and efficiency. This paper proposes analysis and suggestions towards the improvement of operations activities in Macau's hospital industry. The analysis covers the impact of economic growth, employee distribution, population growth, current scale of hospital and infrastructure in Macau. Discussion about the suitability of adopting third party logistics at certain logistics activities is also conducted. Through the research contributions, it is expected that the globalized concept of "leisure and tourism oriented city" can be realized in Macau.

Keywords Macau · Hospital · Casino · Logistics · Supply chain management · Information system

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72.1 Introduction

As being a tourism and gambling oriented urban city, Macau is now suffering from the urban planning and public service demand problem. After the Macau government released the gambling market at 2002, more than 17 casinos coming from different countries have opened in Macau (The Statistics and Census Service 2012). These casinos not only provide gambling activities, but also offer multiple entertainment activities like international drama and exhibition infrastructures. Thus, the infrastructure developed by casinos does help the attraction of tourists. In recent years, the casino industry has provided significant contribution towards the growth of Macau's economic as well as tourism industry. Nevertheless, the economic growth does trigger number of environmental and public health problems, particularly the growing demand of hospital services. The increasing numbers of vehicle users and tourists, logistics movement of goods to casinos and public transport have further deteriorated the living environment and the health of public citizens. Power, industry and transport are the three major sectors responsible for fossil-fuel-related CO2 emission in each country in the world (Timilsina and Shrestha 2009). The vehicles that are powered by gasoline and diesel fuel, emit the vast majority of pollutants. Tang and Wang (2007) have conducted a study about the traffic-induced air quality and noise problems into different urban areas in Macau. They found that the greater street canyon effects in the historical urban areas, the higher the carbon monoxide concentration is generated by the vehicles. Thus, air pollution problem does affect the development of a local tourism industry, and more importantly, create health implication problems of Macau's citizens, including increase of public health care costs and loss of productivity.

In views of the importance of economic growth and public health care concern, hospital industry presents a great demand for further enhancing the hospital services' quality and reducing the cost of service. The objectives of this paper include (i) Review current logistics practices in hospital, the way of cutting logistics costs, information system support and coordination; (ii) Identify the current situation of hospital and potential development of hospital industry; (iii) Address feasible solutions towards the operations improvement of hospital industry. This paper is organized as follows: A review of logistics activities in hospital is provided in Sect. 72.2. Section 72.3 conducts the background study about the hospital industry in Macau. The factor analysis about the operations improvement of hospital industry in Macau is conducted at Sect. 72.4. Finally, a conclusion is presented in Sect. 72.5.

72.2 Logistics Activities in Hospital

Similar to other industries, hospital operations such as material management, food and medical supply are relied on using the supply chain concept to manage. Liao and Chang (2011) identify certain factors that affect overall supply chain of the hospital's logistics system including (i) Safety stock. (ii) Lead time. (iii) Transportation capacity. The hospital management is required to keep reviewing these logistics functions, classifying value added and non-valued added activities, and identifying the costs associated with these activities thereby decreasing non-valued added activities (Aptel and Pourjalali 2001).

The logistics department of the hospital supports three internal logistics activities including (1) drug distribution, (2) food service and laundry, and (3) supply and processing of sterilized items in hospital. At first, with regard to the drug distribution, (Fineman and Kapadia 1978) identify three models of drug distribution, Model 1: direct delivery to medical department through central warehouse. Model 2 is the semi-direct delivery via the warehouses of the medical department. The final model is direct delivery via daily replenishment of small medical department storage facilities.

Food service and laundry is the second type of logistics activities, in general, these activities are run internally so as to better control the quality of food and products. If these activities are subcontracted, hospital usually awards the activities to service providers who have certification. The job duty of logistics department is to control and evaluate the service providers (Aptel and Pourjalali 2001). The assessing criteria include the food quality, hygiene control and cost efficiency. Supply and processing sterilized items in hospital is the final type of logistics activities. These logistics activities are referred to handling and storing sterilized items. The sterilization processes include decontamination, washing, rinsing and packaging. Sterilization of hospital surgical and medical treatment supplies is to ensure instruments and equipment to be clean and with acceptably low level of microbial and viral infectious agents (Fineman and Kapadia 1978). These sterilized items are required special logistics handling and storage in order to avoid contamination. The level of special logistics handling and storage is subject to three categorized items including (Fineman and Kapadia 1978) 1. Critical items-item is introduced into the body such as hypodermic syringes. 2. Semi-critical items-item is introduced into body openings such as anaesthesia equipment, cystoscopes, thermometers,.., etc. 3. Non-critical items- item only contacts with intact skin, such as water bottles and ice bags. Given the special logistics handling and storage may require additional manpower and equipment cost, the way how to minimize the inventory and replacement stock of sterile items as well as the storage method is the major practice for this kind of logistics activities.

72.3 The Hospital Industry in Macau

Since 2012, Macau Government has opened its gaming industry which awarded six gaming concession and sub-concessions to companies based in Las Vegas (Wynn Resorts, Las Vegas Sands, and MGM Mirage) and Hong Kong (Galaxy Casino and Melco Crown), the economic is dramatically reformed to gaming-led tourism and recorded a substantially growth in recent year (Tang and Sheng 2009).

There are around 44,806 citizens who are working in the gaming industry of Macau which is equivalent to 11 % of the total employed population (The Statistics and Census Service 2012). The numbers of employees working in the gaming industry have been increased more than 47 % as compared with the figure recorded in 2004. The casino gaming industry is one of the economic pillars to support the local economy. The gaming industry contributes $18.6 billion, which is accounted for 77 % of government revenues DSEC: Employed Population by Industry, Retrieved April 20 2012). Despite the gaming industry sector brings the huge economic benefit to Macau, many casino employees have suffered from potential health problems in which they are exposed to second hand smoke (SHS) at work (Chan et al. 2012). Most of the casinos allow smoking, it is known that smoking can cause cancer, the types of cancer include lungs, larynx, esophagus, mouth, kidney and pancreas (U.S. Department of Health and Human Services: The Health Consequences of Smoking: A Report of the Surgeon General. Centers for disease control and prevention, National center for chronic disease prevention and health promotion, Atlanta, GA 2004). The second-hand smoking has the same impact to health problems and can also cause cancer of lungs as direct smoking (Cormany and Baloglu 2011). Currently, there are two public hospitals, Hospital Conde S. Januário Hospital Centre (CHCSJ) and Macau University of Science and Technology Hospital, and one private hospital, Hospital Kiang Wu providing a total of 1,172 beds in 2010. It is believed that the increasing number of new admissions will further increase the operating cost as well as medical material cost of the hospital operations budgets. Thus, to allow focus on medical treatment and improve the operation efficiency, the re-engineering and streamlining of some non-medical treatment activities such as supply chain and logistics are therefore taken as the major priority of the top management.

72.4 Suggestions of Improving Hospital Operations

72.4.1 Outsource of Logistics Activities

To cope with the expansion of logistics services demand and concentrate on the core competence, many industries have already outsourced their logistics functions to third party logistics providers. Lieb and Bentz (2005) address the growth of third party logistics (3PL) industry due to increased globalization, pressure to reduce cost and enhance the performance achievement. Koh and Tan (2005) state that the annual growth in 3PL industry in China has been increased 25 % on average, leading the U.S. (10–15 % annual 3PL growth). The distinctive advantages of 3PL providers include improve customer service, respond to competition and asset elimination (Handfield and Nichols 1999). Despite outsourcing logistics to 3PL shows the numerous potential, the research done by Sahay and Mohan

(2006) argues that nearly 55 % of the companies terminated the relationship with 3PL after 3–5 years. The reasons are due to the perception of the 3PL users are uncertain about the service levels and unrealistic expectation (Lambert et al. 1999). Further, Zhang et al. (2005) state that 3PL providers have to respond to changing customer needs. In order to do so, the establishment of performance measurement to evaluate 3PL providers is necessary.

Refer to the logistics outsourcing in hospital, research studies conducted by Aptel and Pourjalali (2001) show that food services and laundry services in certain U.S. and France hospitals have been outsourced to service providers which owned relevant certification. Apart from outsourcing the food and laundry services, outsourcing the medical related logistics activities shows the potential for the cost reduction of inventory. In fact, the medical material cost nearly consumes about 30 % of total hospital operations cost (Tung et al. 2008). Another advantage of outsourcing medical logistics activities is to help improve the usage of space. Due to limited supply of land use in Macau, outsourcing the medical storage areas allows better utilization of land use such as increasing the number of beds. Hospital management is therefore suggested to cooperate with 3PL providers to develop a long term partner relationship by establishing a series of performance indicators as well as standard operations procedures in order to better align the service level and expectation.

72.4.2 Development of E-health Information Management System

To control the hospital resources utilization and coordinate the information flow between supply chain parties in a hospital is another direction to cut cost and achieve competitive advantage in the medical sector. Many research studies proved the contributions of information systems towards the cost minimization and operational efficiency improvement. Gilbert (2001) addresses the value of an e-health system for reducing the procurement cost in hospital. More and Mcgrath (2002) clarify the e-health system is a kind of information and communication technology to help hospital management in decision-making, record and storage of relevant data of various supply chain participants including suppliers, hospitals and patients. Merode et al. (2004) try to review the potential of using the enterprise resource planning system (ERP) to support hospital management. In order to respond to the non-deterministic processes such as stochastic demand of front line patient services, visualizing the resources status and short term planning are essential in hospital. Anoraganingrum and Eymann (2009) advocate the application of radio frequency identification system (RFID) to improve the hospital efficiency. They propose using a RFID system to improve the performance of sterilization and equipment monitoring.

72.5 Conclusion

The substantial growth of economy and the development of gambling market in Macau has brought side effects of health problem to workers in casinos. In views of the importance of economic growth and public health care concern, the development of hospital industry shows a great potential value for the general public. Currently, there are three hospitals in Macau, and it is expected that the increased demand of the public health care will trigger the concerns of hospital management regarding operation efficiency enhancement and cost reduction of medical materials. Therefore, streamlining the supply chain and improving logistics activities in hospital industry is essential. The feasible suggestions for the development of hospital industry and improvement of the operations are summarized as follows:

Cooperate with external service providers in order to better concentrate on the core competence of hospital management. A long term partner relationship is suggested to develop between hospital and service providers through establishing a series of performance indicators as well as standard operations procedures in order to better align the service level and expectation.

Develop an e-health information system to improve the operation efficiency and inventory control of medical materials. The selection of information systems includes e-health, ERP and RFID systems. Different information systems show the potential value for improving the hospital efficiency and reducing costs. Nevertheless, the cost and benefit analysis, investment payback of information technology (IT) and influences of IT implementation towards the hospital industry are other important topics that the hospital management should not omit when adopting these technologies and systems.

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Chapter 73
The Social Costs of Rent-Seeking in the Regulation of Vehicle Exhaust Emission

Yan Pu and Xia Liu

Abstract The regulation of vehicle exhaust emission requires the regulators to establish the vehicle exhaust emission level desirable for the society and then select inspection agencies to check every registered vehicle periodically. Both these decisions create opportunities for rent seeking. In this paper, we present the incentives of rent-seekers for being selected as inspection agencies and analyze the consequences for social welfare. We find differences in firms' rent-seeking choices compared to a traditional rent-seeking model. We see that a fundamental aspect of firms' incentives to seek rent depends on the number of incumbent inspection agencies and the present value of every successful rent-seeker's rent income, which mainly depends on the distortion degree of inspection process and which is inversely related to social welfare.

Keywords Rent seeking · Regulation · Vehicle exhaust emission · Social costs

73.1 Introduction

Substantial resources are devoted to altering government policies in the form of rent-seeking in China. It is unanimous among economists that rent-seeking is socially wasteful, if rational from the rent-seeker's perspective. The entire

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literature on rent-seeking that has developed over the past 40 years has focused on (a) building rent-seeking contest models from different perspectives, such as under varying cost structure, under uncertainty, and with the assumption of rent-seekers being symmetric or asymmetric, risk-neutral or risk averse, and so on (Stein 2002); (b) discussing the scope of the social costs of rent-seeking activities; (c) studying how the following factors influence rent-seekers' expenditures at equilibrium: the marginal return of rent-seeking, the winning chance of rent-seeking, that is, the probability of being successful, and entry costs, etc. (Ritz 2008; Anderson and Freeborn 2010). So far, economists have almost clarified the scope of the social costs of rent-seeking, which, at first, were considered to consist of "Harberger Triangle" and "Tullock Rectangle", then include the social cost of improper selection of high-cost producers in the rent-seeking contest, the social cost of policy-making in the rent-seeking contest and the social cost that the whole economy incurred because of rent-seeking (Sobel and Garrett 2002; Ihori 2011; Gao 2011).

Rent-seeking is quite rampant and prevalent in the transition of China from the planning economy to the market economy with the Chinese characteristics and it has led to serious distortion of government policies. The regulation of vehicle exhaust emission is no exception. Rent-seeking in the regulation of vehicle exhaust emission has caused large social loss to the sustainable development of the Chinese economy, so the development of low-carbon transportation and logistics has attracted increasing attention in recent years in China. The purpose of this paper is to report our first-stab efforts in this regard. We build a slightly different model from Tullock's classic Efficient Rent-seeking model to analyze the social costs of rent-seeking in the regulation of vehicle exhaust emission. Our findings, based on the regulation of vehicle exhaust emission in China, verify the existence of the social costs to rent-seeking.

This paper is organized as follows. Some realistic rent-seeking cases in the regulation of vehicle exhaust emission in China are presented in Sect. 73.2. Section 73.3 contains a model slightly different from Tullock's efficient rent-seeking model to analyze the rent-seeking contest and a presentation of other social costs in addition to the direct rent-seeking expenditure in the regulation of vehicle exhaust emission in China. Section 73.4 offers conclusions and suggestions for further research.

73.2 Some Relevant Cases

In January 1998, Liu Gongchao, one car owner in Beijing, China, installed one automobile exhaust purifier produced in Korea, which was testified to overpass the vehicle exhaust emission standard stipulated by the relevant authority in Beijing. However, in July of the next year, the Environmental Protection Bureau of Beijing, the Transportation Bureau of Beijing, and the Traffic Management Bureau of Beijing jointly issued an announcement, which stated that all the minibuses fixed with carburetor that were registered after January 1, 1995 shall be equipped with an electronic air supply device and a three-element purifier; otherwise, they cannot be accepted for annual inspection. Liu's car was rejected for annual inspection. Liu thought that the three bureaus had abused administrative power and restricted car owners to purchase the designated goods, so he filed a case to the People's Court of Haidian District of Beijing against the Environmental Protection Bureau of Beijing.

The court held that because the announcement jointly issued by the Environmental Protection Bureau, the Transportation Bureau, and the Traffic Management Bureau of Beijing was not aimed at specific vehicles and could be used repeatedly, it belonged to abstract administrative behavior which is generally binding on all vehicles, and it should not be considered as administrative monopoly. The court turned down Liu's claim thereafter.

Some similar problems took place in other cities. In Nanchang, the capital of Jiangxi Province of China, in order to regulate the vehicle exhaust emission, the environmental protection authority firstly required vehicle owners to install filters, then carbon monoxide canisters, and then clean the cylinders during the past 10 years. These measures did not improve the environmental quality of Nanchang, only helping the relevant authority reap a large amount of easy money. Further, it was reported that in Xiangfan, one city of Hubei Province of China, Lanzhou, the capital of Gansu Province of China, and other cities, as long as the car owner purchased designated purifier, their car can pass annual inspection no matter whether the car owner install the purifier on the car or not. It was even reported that as long as the car owner paid money, he would get a certificate for his car.

73.3 Social Costs of Rent-Seeking in the Regulation of Vehicle Exhaust Emission in China

The regulation of vehicle exhaust emission has created a lot of opportunities for rent-seeking, which reallocates resources away for productive, positive-sum, activities into unproductive, zero-sum, activities. Therefore, it is unanimous among economists that rent-seeking is a socially wasteful activity. Theory tells us that the real social costs of rent-seeking are not only the expenditures of rent-seekers, but the opportunity cost of these resources in terms of forgone production, which are hard to observe and notice in reality. It can be seen from the above cases that, in addition to the traditional opportunity cost of rent-seeking, they included the social cost of higher efficient device being replaced by lower efficient device, the social cost of vehicles with high level of exhaust emission passing annual inspection and the social cost of various kinds of artificially created barriers which help breed rent-seeking activities.

(a) **The traditional cost of rent-seeking**

Rent-seeking in the regulation of vehicle exhaust emission in China is slightly different from other rent-seeking activities.

The purpose of rent-seeking in the regulation of vehicle exhaust emission in China is to obtain the inspection license of vehicle exhaust emission. At present, there already exist some inspection agencies in nearly every city. Rent-seekers can only obtain part of the rent if rent-seeking is successful. In the future, part of their rent will be absorbed away by the later successful rent-seekers. Therefore, the number of incumbent inspection agencies and the duration of the possible rent have a more significant effect upon the equilibrium expenditure of rent-seekers than in the other rent-seeking contest models.

Assume there are two identical risk-neutral players, A and B, where a stands for A's rent-seeking expenditures, b for B's expenditures, n for the number of incumbent inspection agencies, t for the average number of days that a new comer needs to enter the market, r for the interest rate for the time period of t and R is the total rent created within one day. Then the successful rent-seeker can get $\frac{tR}{(n+1)(1+r)}$ for the current term, and when the next inspection agency enters into the market, his rent will change to $\frac{tR}{(n+2)(1+r)^2}$. Similarly, we can get the present value of the total rent for a new comer when there already exist n inspection agencies as follows:

The present value (PV)

$$= \sum_{N=1} \frac{tR}{(n+N)(1+r)^N} \tag{73.1}$$

Because of entry barriers, such as fixed entry costs, close relationships with the relevant authority and so on, the number of new inspection agencies which can enter into the market, N, is limited.

Player A maximizes the expected value

$$E(a) = \frac{a}{a+b}(PV - a) + \frac{b}{a+b}(-a) \tag{73.2}$$

which is reduced to

$$E(a) = \frac{a}{a+b} PV - a \tag{73.3}$$

It can be seen that A's optimal investment depends on B's effort and the present value of the rent at stake.

B faces an identical choice and generates a similar reaction function. If both players behave according to their strategy of maximizing the expected value, a simply Cournot-Nash equilibrium appears, each player bidding $\frac{1}{4}$ of the present value of the rent at stake $\left(\frac{1}{4}PV\right)$. With m identical players the equilibrium investment by A is $\frac{m-1}{m^2}PV$ and the total expenditures by all the players reach $\frac{m-1}{m}PV$. If m is big enough, then complete dissipation of the rent will be realized.

The social loss is quite large because of a very high PV, which can be seen from the PV's equation. PV depends on five variables: the number of incumbent inspection agencies, the number of new inspection agencies, the interest rate for t days, the total rent R in the market and the average days that a new comer takes to enter into the market. The bigger t and R are, the smaller n is, the larger the present value is, the more social resources will be exhausted.

(b) **The social cost of higher efficient device being replaced by lower efficient device**

The second category of social cost caused by rent-seeking in the regulation of vehicle exhaust emission in China is the social cost of higher standard device being replaced by lower standard device. In order to control vehicle exhaust emission, the relevant authority often limit car owners to purchase their designated equipment by issuing announcements or notices. So long as the announcement or regulation is not aimed at specific objects and can be used repeatedly, it is legal and does not belong to administrative monopoly, which is subject to the Chinese Anti-Monopoly Law.

(c) **The social cost of vehicles with high level of exhaust emission passing annual inspection**

It has been mentioned above that in many cities of China, as long as car owners purchased the designated vehicle exhaust purifying equipment, they can pass annual inspection even if they do not install the purchased equipment on the car. In some places, as long as car owners make the payment to agencies or individuals, which have close relationships with the regulator and which have already developed into a huge industry in China, they can bet the certificate for their cars. On the basis of "hazard risk", cars with higher level of exhaust emission are more willing to turn to those agencies and escape real annual inspection, causing serious damage to the environment. Even in some cities where car owners must drive their cars to the inspection site and accept real annual inspection, they can also pass annual inspection even if their exhaust emission level fails to meet the standard, as long as they pay some "lubrication money" to the relevant "helpers".

(d) **The social cost of various kinds of artificially created barriers**

The next but not the last measure for inspection agencies to reap easy money is to set different kinds of inspection items as barriers. These measures have two purposes; one is to reap money directly and the other is to create opportunities for rent-seeking. The watchdog of environment issues standards, announcements or regulations on a frequent basis. Sometimes, it is only a short period of time between the implementation dates of the old and new announcements or standards. Although the old equipment is still useful and efficient, it should be discarded and replaced with the new purifying one, according to the new regulation, which constitutes a social loss of resources.

As for obscure obstacles, such as waiting time and psychological pressure while waiting to get cars inspected, car owners find it hard to overcome them except for rent-seeking. It is a well-known fact that car owners have to queue and wait at several places before getting inspection finished. The forgone productive activities constitute a social cost, too.

73.4 Conclusions

In this paper, we have explored several aspects of the social costs of rent-seeking activity in the regulation of vehicle exhaust emission. It seems that rent is under dissipated in the regulation of vehicle exhaust emission; however, the resources exhausted for rent seeking only account for a small share of the social costs and they constitute the direct costs of rent seeking. In addition to these costs, higher efficient device being replaced by lower efficient device, vehicles with high level of exhaust emission passing annual inspection by rent-seeking and various kinds of artificially created difficulties and obstacles which help breed rent-seeking activities constitute much higher social costs. Vehicle owners are easily exposed to rent-seeking in China. Even if he follows laws and regulations issued by the state, or purchase the most expensive and best exhaust purifier at the time, he will not necessarily pass annual inspection, if he does not observe the announcement or notice issued by the local authorities.

Therefore, how to regulate the regulator of vehicle exhaust emission may be the key issue to eliminate rent-seeking and reduce waste of social resources. According to the Chinese Administration Law, all abstract administrative behaviors, usually in the form of announcements and notices issued by industry regulators or local authorities, belong to legal behaviors and thereafter have legal effect. Only concrete administrative behaviors which are targeted as specific objects and cannot be used repeatedly may be taken as illegal. Such provisions create lots of rent-seeking opportunities for regulators and authorities. Therefore, the first step to control vehicle exhaust emission in China shall be the rigorous regulation of the regulator.

The second measure lies in the establishment of a transparent and uniform emission standard, which can eliminate confusion among vehicle owners. The next but not the last step is to rigidly combat any collusion between regulators and inspection agencies, inspection agencies and vehicle owners, and inspection intermediaries and vehicle owners. Only in this way can the blue sky return to China.

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Part V
Low Carbon Logistics

Chapter 74
CO_2 Emissions Embodied in 42 Sectors' Exports of China

Yufeng Wang, Shulin Liu and Changcai Qin

Abstract This article estimates CO_2 emissions intensity embodied in 42 sectors' products based on the Input–Output Table in 2007 from the whole life of product process, including 4 energy sectors and 38 non-energy sectors. And then we distinguish energy and non-energy products to estimate CO_2 emissions embodied in 42 sectors' products' exports in 2007. The result shows that China is a net exporter of CO_2, CO_2 emissions embodied in the export trade increase with the increase of exports except for the 4 energy sectors. 54.5 % of the total emissions are caused by exports, which shows the typical characteristic of "consumption in foreign countries and pollution in domestic".

Keywords CO_2 emissions intensity · Embody · Export · Input–Output

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74.1 Introduction

China has become the most CO_2 emissions country in the world and accounts for 21 % of the world's total CO_2 emissions (National Bureau of Statistics of China 2009). The increase of CO_2 emissions in China is closely related to the economic development and social progress. One fact which cannot be ignored is that the increase in China's import and export trade is another significant cause for the increase of CO_2 emissions. The international trade, particularly the export, embodied huge amount of energy consumption and CO_2 emissions.

There are some literature on the international trade and environment. Tolmasquim and Machado (2003) have studied the energy and CO_2 embodied in the import and export by Brazil and conclude that 7 % of the CO_2 emissions of Brazil in the 1990 s were created by exports. Developed countries are transferring CO_2 emissions to developing countries through offshore manufacturing and domestic consumption. Shui and Harriss (2006) studied the CO_2 emissions caused by Sino-US trade from 1997 to 2003 and found that America cut its CO_2 emissions by 3–6 % by import from China while China had an increase of CO_2 emissions by 7–14 % due to export to America. Through input–output analysis for Australia, Lenzen (1998) reached a conclusion that Australia is a net CO_2 exporter with a net export volume of 85 Mt CO_2eq. Kondo and Moriguchi (1998) calculated the CO_2 emissions created by the import and export of Japan and drew the conclusion that the CO_2 emissions caused by the export of Japan were higher than those caused by import before 1985; this situation did not change until 1990. Some Chinese scholars (Wei et al. 2009; Qi et al. 2008; Xinrui and Ge 2009) have also studied about this and come to a common conclusion that more developed countries are transferring significant amounts of their environmental burdens to developing countries, but few scholars research this from the perspective of sectors and distinguish energy and non-energy products. So it is necessary to analyze CO_2 emissions embodied in the export of each sector.

74.2 CO_2 Emissions Mechanism in Product Process

Considering the product process in n sectors, we assume the embodied CO_2 emissions intensity in sector j is $e_j, j = 1, \cdots n$, then CO_2 emissions mechanism in product process of sector j is shown in Fig. 74.1, where x_j is the total output of sector j, the embodied CO_2 emissions in output are $e_j x_j$. δ_j is CO_2 emission coefficient of energy j, $\delta_j E_{j,earth}$ is the direct CO_2 input embodied in primary energy, and $\delta_j E_{j,import}$ is CO_2 emission embodied in imports. The indirect CO_2 input $e_i x_{ij} + \hat{e}_i z_{ij}$ is the sum of CO_2 emissions embodied in intermediate products x_{ij} of sector i and import products z_{ij}, $\hat{e}_i$, is the CO_2 emission intensity of import production in sector i, which is decided by the product technology level. For the non-energy products, $\hat{e}_i$ changes reversely with the product technology level, but the conclusion have some changes as to energy products.

Since there are numerous kinds of imported goods and no reliable data resources to provide every country's CO_2 emissions intensity and CO_2 emissions data, so we suppose $\hat{e}_i = e_i$. Then the input–output equation from the Fig. 74.1 is

$$e_j x_j = \sum\nolimits_{i=1}^{n} e_i (x_{ij} + z_{ij}) + \delta_j E_{j,earth} + \delta_j E_{j,import}, (j \in n). \quad (74.1)$$

Denote $x = (x_1, \cdots, x_n)'$, $e = (e_1, \cdots, e_n)$, $\hat{\mathbf{X}} = diag(x_1, \cdots x_n)$, $\mathbf{E} = (E_1, \cdots, E_n)$, $E_j = E_{j,earth} + E_{j,import}$, $(j \in n)$, $\hat{\delta} = diag(\delta_1, \cdots, \delta_n)$ is CO_2 emission coefficient diagonal matrix related to energy, $\mathbf{A} = (a_{ij})_{n \times n}$ is direct consumption coefficients matrix, then we can get the CO_2 emissions intensity:

$$e = E\hat{\delta}\hat{X}^{-1}(I - A)^{-1}. \quad (74.2)$$

74.3 Estimation of CO_2 Emissions Intensity

74.3.1 Direct Energy Input

Primary energies are the products used as the energy powers originating directly from natural materials, including fossil energy, nuclear power, water, wind and tide electrical energy, etc. The secondary energies are finished goods used as energies conversed from primary energies. As to the goods and service, the direct energy input refers to the domestic primary energy and the finished imported energy goods which participated in production process.

There are 5 energy sectors in the Input–Output Table of 42 sectors, namely, "Mining and Washing of Coal" ($j = 2$), "Extraction of Petroleum and Natural Gas" ($j = 3$), "Processing of Petroleum, Coking, Processing of Nuclear Fuel" ($j = 11$), "Production and Distribution of Electric Power and Heat Power" ($j = 23$) and "Production and Distribution of Gas" ($j = 24$). The primary energy productions from sector 11 and 23 are nuclear fuel and water, nuclear, wind energy respectively. Sector 24 produces the secondary energy.

The energy input in the production process can be defined as $E = p + im - ex - s$, where E, p, im, ex, s denote energy input, production, exports, imports and stock change, respectively. Energy production and consumption structure are shown in Table 74.1.

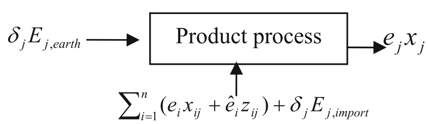

Fig. 74.1 CO_2 emissions mechanism of the production process (j)

Table 74.1 Energy production and consumption structure (2007) (unit: 10^4tce)

Item	Raw coal	Other coal	Coke	Gas	Crude oil[a]	Natural gas	Petroleum products	Heat	Electricity[b]
Production	180430.34	——	——	——	26617	9208.92	——	——	6865.44
Import	3156.46	591.62	0	——	23309.05	534.66	6092.23	——	52.24
Stock change	367.84	319.22	665.69	——	749.16	——	104.88	——	——
Export	3790.61	234.89	1486.17	——	554.83	345.8	2584.56	——	179.02
Net import	−634.15	356.73	−1486.17	——	22754.22	188.86	3507.67	——	−126.78
Sector(j =)	2	2	11	24	3/11	3	11	23	23

[a] Crude oil production and stock is recorded in the sector 3, other included in the sector 11; [b] stands for hydropower, nuclear power and wind power production; Other coal include cleaned coal, other washed coal; Petroleum products include gasoline, kerosene, diesel oil, fuel oil, liquefied petroleum gas, other petroleum products. *Data source* «China energy statistics yearbook- 2008»

74.3.2 Direct CO_2 Input

According to the direct energy inputs and CO_2 emissions coefficient (Table 74.2), we can get direct CO_2 input.

Some energy products are directly used by consumers, there are no embodied CO_2 emissions, Such products as plastic, fiber, paraffin wax, asphalt etc. are called "No-carbon emissions energy products". These energy products should be eliminated when we calculate the direct CO_2 input. No-carbon emissions energy products in the energy input account for more then 6 %, which should be eliminated from the direct CO_2 inputs. And then we get CO_2 emissions after eliminating no-carbon emissions energy in the process of energy consumption (Table 74.3). Finally, we get the direct CO_2 input (Table 74.4).

74.3.3 Estimation Results

We obtain the estimation results of CO_2 emissions intensity embodied in products and service of 42 sectors (Table 74.5) according to Input–Output Table in 2007.

Results in Table 74.5 can be interpreted as follows: CO_2 emissions in the energy sectors come from not only the manufacture and transportation of products but also consumption of the products by other sectors, but in the non-energy sector only come from the former (the products won't emit CO_2 when they are further used by other sectors).

74.4 CO_2 Emissions Embodied in the Export of 42 Sectors

According to the CO_2 emissions intensity and export data, CO_2 emissions embodied in the export can be estimated. But we have to distinguish energy and non-energy products, because energy products (except electricity) emit CO_2 not only in their production process but also in foreign consumption. For example,

Table 74.2 CO_2 emissions coefficient of energy (2006) ((tons/10^4tce))

Energy type	CO_2 emission coefficient	Energy type	CO_2 emission coefficient
Raw coal	2.7718	Kerosene	2.0951
Crude oil	2.1477	Diesel oil	2.171
Natural gas	1.6437	Fuel oil	2.2678
Water, nuclear	0	LPG	1.8487
Other coking products	2.3646	Other petroleum products	0
Gasoline	2.0306	Coke	3.1351

Data source IPCC (2006)

Table 74.3 CO_2 embodied in the process of the energy production and consumption (2007) (unit: tons)

Item	Raw coal	Other coal	Coke	Gas	Crude oil	Natural gas	Petroleum products	Heat	Electricity
Production	494411.70[a]	601.59[a]	——	-49.31*	56764.37[a]	12949.29[a]	——	——	0
Stock change	1019.57	884.81	5718.89[a]	——	−1608.96	——	−274.60[a]	——	——
Net import	−1757.72	988.78	−4659.29	——	48869.01	310.43	55741.52	——	0
Sector(j =)	2	2	11	24	3/11	3	11	23	23

[a] Stands for embodied CO_2 emissions after eliminating no-carbon emissions energy

Table 74.4 Direct CO_2 inputs in energy sector (2007) (unit: tons)

Code	Energy sector	Energy E (tce)	CO_2 input (tons)	Note
2	Mining and washing of coal	1808399842	4949455407	
3	Extraction of petroleum and natural gas	352660380.5	684151259.3	
11	Processing of petroleum, coking, processing of nuclear fuel	271127364	937704326	
23	Production and distribution of electric power and heat power	66006922.6	0	No-carbon power
24	Production and distribution of gas	0	0	

Data source «China energy statistics yearbook- 2008»

electricity and oil consumed in the process of coal mining cause energy consumption and CO_2 emissions in this process, which is less than that in direct coal consumption, but can not be ignored. So firstly we should estimate the CO_2 emissions in the production process $\sum_{j=1}^{n} E_{ij}\delta_j$. But for the non-energy products, they emit CO_2 only in their production process.

74.4.1 Energy Sectors' CO_2 Emissions Embodied in the Export

Denote the consumption of energy j by producing energy i by E_{ij} and the CO_2 emissions coefficient of energy j by δ_j, so the CO_2 emissions of producing energy i is $\sum_{j=1}^{n} E_{ij}\delta_j$. Then CO_2 emissions embodied in the export can be computed as $Ex_i e_i - \sum_{j=1}^{n} E_{ij}\delta_j$, where Ex_i and e_i are export sales and CO_2 emissions intensity of energy sector i respectively.

74.4.2 Non-Energy Sectors' CO_2 Emissions Embodied in the Export

CO_2 emissions intensity embodied in products and services of non-energy sectors is objective, i.e. it is only from the production of non-energy products, the products will never emit CO_2 even through they are further consumed in other sectors, so the CO_2 emissions embodied in products of non-energy sector i is $Ex_i e_i$. Finally we get CO_2 emissions of 42 sectors embodied in the export (see Table 74.6).

According to Table 74.6, the total amount of CO_2 emissions embodied in the export is 3.315 billion tons and the total CO_2 emissions in China in 2007 is 6.083 billion tons announced by IEA. Thus CO_2 emissions embodied in the export accounts for nearly 54.5 % (= 3.315/6.083) of total CO_2 emissions of China. Maybe the result is higher because this method is based on the energy and only

Table 74.5 CO_2 emissions intensity embodied in goods and service of 42 sectors (2007) (unit: tons/10^4 Yuan)

i	Sector	e_i	i	Sector	e_i
1	Agriculture, Forestry, Animal Husbandry & Fishery	1.19	22	Scrap and Waste	0.46
2	Mining and washing of coal	59.51	23	Production and supply of electric power and heat power	11.70
3	Extraction of petroleum and natural gas	9.86	24	Production and distribution of gas	10.05
4	Mining of metal ores	4.53	25	Production and distribution of water	3.49
5	Mining and processing of nonmetal ores and other ores	3.53	26	Construction	4.02
6	Manufacture of Foods and Tobacco	1.61	27	Traffic, transport and storage	3.93
7	Manufacture of textile	2.75	28	Post	2.00
8	Manufacture of textile wearing apparel, footwear, caps, leather, fur, feather(down) and its products	2.32	29	Information transmission, computer services and software	1.20
9	Processing of timbers and manufacture of furniture	2.80	30	Wholesale and retail trades	1.21
10	Papermaking, printing and manufacture of articles for culture, education and sports activities	2.91	31	Hotels and catering services	1.48
11	Processing of petroleum, coking, processing of nuclear fuel	14.70	32	Financial intermediation	0.73
12	Chemical industry	5.35	33	Real estate	0.57
13	Manufacture of nonmetallic mineral products	6.78	34	Leasing and business services	2.32
14	Smelting and rolling of metals	5.46	35	Research and experimental development	2.09
15	Manufacture of metal products	4.16	36	Comprehensive technical services	1.58
16	Manufacture of general purpose and special purpose machinery	3.53	37	Management of water conservancy, environment and public facilities	2.08
17	Manufacture of transport equipment	3.06	38	Services to households and other services	2.10
18	Manufacture of electrical machinery and equipment	3.66	39	Education	1.67
19	Manufacture of communication equipment, computer and other electronic equipment	2.65	40	Health, social security and social welfare	3.14
20	Manufacture of measuring instrument and machinery for cultural activity & office work	2.93	41	Culture, sports and entertainment	1.67
21	Manufacture of artwork, other manufacture	3.10	42	Public management and social organization	1.64

Table 74.6 CO_2 emissions embodied in the export in 2007 (unit: tons)

i	CO_2	i	CO_2	i	CO_2	i	CO_2	i	CO_2	i	CO_2
1	7936041.52	8	131741805.19	15	148019676.11	22	144675.76	29	5367686.38	36	0.00
2	139102152.09	9	67888024.12	16	202338543.64	23	7617496.15	30	48596137.92	37	0.00
3	17111768.02	10	65989961.04	17	100469051.62	24	0.00	31	10915094.31	38	5973113.87
4	3730379.35	11	112884091.94	18	249932050.17	25	689.17	32	626655.38	39	432039.30
5	5308341.70	12	387128213.20	19	565694643.34	26	16420693.69	33	0.00	40	1323336.30
6	30774843.38	13	100538336.35	20	94736807.75	27	156446142.69	34	74298094.71	41	5471795.52
7	225662868.25	14	281574735.06	21	40611075.64	28	970251.41	35	545106.29	42	688854.33

considers the direct energy consumption. But because of the complexity of the energy consumption, we can only estimate in this way.

74.5 Conclusion

Export trade is one important power to promote the economic growth in China, but it is also a double-edged sword. Export directly increases the domestic energy consumption and brings out a lot of environmental pollution and CO_2 emissions. Importing countries enjoy the welfare of the product, and we have to bear extra environment cost in international exchange process.

At present, China are facing multiple pressures of economic growth, resource and energy saving, and environmental emissions. Government needs to improve the export trade structure through the various policy measures and leads the trade to high added value and environment friendly transition to realize China's low carbon economy.

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Chapter 75
The Study on Risk Assess Model of Rail Transit Projects

Xiangdong Zhu, Xiang Xiao and Chaoran Wu

Abstract The urban rail transit system is widely adopted in big cities for its large transit capacity, fast speed, low power consumption, and comfortable riding experience. But recently frequent metro accidents appear and the subsequent social impact is very bad, which remind us of the risk in the rail transit system. Therefore, this paper analyzes the risk factors in rail transit project, divides them into different phases, and then specifies the risk in different phases. Then, an AHP-based fuzzy comprehensive evaluation model is developed for the urban rail transit system based on the identified risk factors.

Keywords Risk classification · Risk assessment · Analytic hierarchy process · Fuzzy comprehensive evaluation

75.1 Introduction

Nowadays, the rail transit system (both metro and light rail) has become an indispensable transit means for urban life. Featuring high-speed, security, punctuality, and comfort riding experience, rail transit system strongly influences the

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development of urban traffic and facilitates the daily urban life. Compared to urban road system, it occupies a small area and can carry more passengers, with traffic capacity almost 10 times of that of the urban road system. And the discharged polluting gases are much less. To sum up, the rail transit system is a green transit means featuring high-efficiency, low-carbon, security, and fastness. Thus, its development is both feasible and necessary and is also important for improving the urban environment, increasing the urban environmental capacity, building a new eco-city with relatively separated spacing, and achieving sustainable development. Till the end of 2010, 12 cities in China, including Beijing and Shanghai, have built 48 rail lines, with business mileage of 1,395 km. To 2020, the cumulative business mileage will reach 7,395 km. If 500 million RMB will be cost per km, 3 trillion RMB of financial investment (conservatively) will be needed. The dispute over the deterioration of financial conditions of local government causing by urban rail transit system construction already exists, and many metro accidents happen. In China, the next 30 years is a golden age for urban rail transit construction, but risks also exist. Rail transit is a huge and complex project with multiple specialties and a variety of knowledge involved; potential risks are various, which may lead to serious losses. Therefore, the study on risk identification and assessment in urban rail transit project construction has a high theoretical value and practical significance.

75.2 Literature Review

916 BC, the General Average system and cargo charge loan system appeared, which can be considered as the origin of the ideas of risk management. In 1952, the U.S. scholar Ruggles first proposed the term of risk management; in 1940s and 1950s, the extensive application of risk management in the U.S. insurance industry represents its blossom. In 1979, the U.S. Three-Miles Island Nuclear Generating Station exploded; in 1986, Chernobyl Nuclear Power Plant of the Former Soviet Union exploded. In the past, people only considered risks from the economic and technological perspectives. After these disasters, people began to associate risks with artificial performance and cultural and social background. After China adopts the market economic system, we gradually recognize the importance of risk management and begin the related research in projects like the Beijing-Kowloon Railway, Three Gorges Project, and Xiaolangdi project, achieving very significant results.

Mao (2007) introduces the status of risk management for rail transit security in China, oversea transit security risk management guidelines, security assurance for the engineering of the rail transit system, and risk acceptance criteria in Britain, France, and Germany. Ye (2008) performs a qualitative analysis on the public policy risk, market risk, technology risk, organization and management risk, and other risks for Wuhan urban rail transit (Line 2) project. Cui (2011) introduces the assess matrix method, analytic hierarchy process, and fuzzy comprehensive evaluation method. And he also describes how to assess and control the financial risk in urban rail transit projects. Gao (2005) carries out the risk identification and assessment on the civil engineering project in Tianjin-Binhai Rail Transit Line using the semi-qualitative and semi-quantitative WBS-RBS method. He believes the risk level in each stage is different and the organizer should focus on the one with high risk level and find the solution. Bai et al. (2007) introduce the application of risk management in Shanghai rail transit (Line 10) project. Guo and Tang (2008) introduce the formation, scope, and framework of dynamic risk management. They develop the dynamic risk management model based on the extra deep foundation pit in Shanghai rail transit (Line 4) project and apply it in the engineering practice.

Till now, there are few academic researches on risk assessment for rail transit in China. And there is no unified or canonical classification specification for risk classification or assessment.

75.3 Risk Identification and Classification for Rail Transit Projects

After considering the unique situation in China, that is, construction and operation separated, this article divides the risks for urban rail transit projects into risks at the construction stage and risks at the operation stage, which are summarized in Table 75.1.

Table 75.1 Risk Identification and Classification

Risks at the Construction Stage	**Politics Risks**	Political stability risk; Policy guidance risk
	Market Risks	Macro economy risk; Inflation risk; Social impact risk
	Organization Risks	Construction condition risk; Construction management risk; Efficiency risk; Loss control risk
	Security Risks	Safety risk of construction personnel; Occupational health risk of the personnel
	Technology Risks	Design risk; Bidding risk; Scheme selection risk
	Project Completion Risks	Financing risk; Project delay risk; Contract risk
	Environment Risks	Environment risk; Natural disasters
Risks at the Operation Stage	political risks; market risks; organization risks; financing risks; security risks; technology risks; environment risks	

75.3.1 Building the Risk Assessing Model for Rail Transit Projects

Author names and affiliations are to be centered beneath the title and printed in Times New Roman 11-point, non-boldface type. Multiple authors may be shown in a two or three-column format, with their affiliations below their respective names. Affiliations are centered below each author name, italicized, not bold. Include e-mail addresses if possible. Follow the author information by two blank lines before main text.

75.3.2 Comparison and Selection of the Risk Assessing Systems

There are many ways to ascertain the risk weight, such as the expert scoring method, decision-tree method, AHP method, and entropy weight method. In this article, we believe many factors may impact the behavior of the project subject and the subsequent risks will have multiple properties. Therefore, the corresponding risk assessing should combine the subjective and objective analysis. However, it is hard to simply use a number to quantitatively describe the risk of most behaviors. After the comparison, this article uses the AHP method to acquire the weight of the risk assessing system.

At present, many risk assessment models are used in the international project risk analysis. Among them, fuzzy comprehensive evaluation with its advantages of comprehensive, accurate, and easy-to-operate is suitable to deal with project risk assessment, the non-structural, inaccurately erratic, and nonlinear issue with a variety of factors involved. After the comparison, this article uses this method to assess the risks in urban rail transit projects.

75.3.3 AHP Method and the Improvement

The analytic hierarchy process can divide a complex problem into different components (decision factors) and then group them following the dominance relation to form an orderly hierarchy. It uses pair wise comparison to determine the importance level of the factors in the hierarchy and then integrates the experts' grading to sort these decision factors. In engineering risk analysis, the analytic hierarchy process is a flexible and easy-to-understand approach. Thanks to it, the engineers can have a comprehensive understanding of the project risks and can determine risk degree. The application of AHP in risk assessing contains seven steps, one of the key steps is to build the decision matrix. Traditionally, the experts will perform a pair wise comparison for the risk factors and use the acquired score—$1 \sim 9$ (corresponding to $1/9 \sim 1$)—to describe the related importance level. The experts can estimate the value of a_{ij} in decision matrix A with their knowledge and experience. However, restricted by the objective factors, the experts usually cannot get an accurate importance comparison level. To solve this problem, this article combines the fuzzy evaluation method in the assessment.

Principles of fuzzy evaluation: It will use the fuzzy membership function (built according to the evaluation criteria) to convert the fuzzy information and subjective judgments of the experts into the membership degree of each assessing indicator, so as to form a fuzzy relation matrix. Then it will build a weight coefficient matrix. After these operations, the computer can be used to further process the fuzzy relation matrix to get the membership matrix between the comprehensive indicator and the assessment level. According to the maximum membership degree law, in the final membership matrix, the level of assessing target will be the one that the indicator has the maximum membership degree with.

After the improvement, the experts still can give the assessment, which can be a comment, for example, very high, high, general, low, and very low, or a value range, for example, $3 \sim 7$. Then the assessment will be imported to the membership function for conversion. In case of risk analysis for construction projects, the result is usually converted to triangles or trapezoids.

Suppose variable $U = [0,\ u]$, the membership function can be defined as $A^{*} = (a_l, a_m, a_n, a_u)$, and $0 \le a_l \le a_m \le a_n \le a_u \le u$. It can be expressed as:

$$U_a(x) = \begin{cases} \dfrac{x - a_l}{a_m - a_n}, & \text{when } a_l \le x \le a_m \\ 1, & \text{when } a_m \le x \le a_n \\ \dfrac{a_u - x}{a_u - a_n}, & \text{when } a_n \le x \le a_u \end{cases} \tag{75.1}$$

The figure shape of the membership function is determined by the value of al, am, an, and au, for example, when $a_m = a_n$, the function figure is a triangle. Each membership function represents one expert's risk assessment. To unify the grading format, the experts' comments or scores are firstly converted into one format before the calculation. The mapping between the importance level and the membership function is listed in Table 75.2.

The assessment range of the experts should be converted.

$$a_{ij.n} = \frac{a_1 + 2(a_m + a_n) + a_u}{6} \tag{75.2}$$

Table 75.2 Experts' grading conversion table

Grading	Input variable	Output variable	Membership function conversion
a	*A*	Numerical variable	(*a*, a, *a*, *a*)
Between *a* and *b*	(*a*, *b*)	One range	(*a*, *a*, *b*, *b*)
Between *a* and *c* (possibly *b*)	(*a*, *b*, *c*)	Triangle fuzzy	(*a*, *b*, *b*, *c*)
Between *a* and *d* (possibly between *b* and *c*)	(*a*, *b*, *c*, *d*)	Trapezoid fuzzy	(*a*, *b*, *c*, *d*)

Because the social background, personnel experience, culture background, private demand, and individual preference of each expert are different, they may assess one issue differently. Therefore, the grading of each expert should be processed with reference to the specific circumstances.

Suppose s experts participate in the assessment, and their decision matrices are $A_1, A_2, \ldots,$ and A_s, where $A_k \approx (a_{ij})$ $(k = 1, 2, \ldots, s)$, $A = (a_{ij})$, and

$$\begin{cases} a_{ij} = \lambda_1 a_{ij.1} \ldots \lambda_2 a_{ij.2} \ldots \lambda_3 a_{ij.3} \ldots \lambda_s a_{ij.s}, \quad i, j = 1, 2, \ldots, n \\ \sum_{k=1}^{n} \lambda_k = 1 \end{cases} \tag{75.3}$$

Here, λ_1, …, and λ_s are the weight coefficient of each expert, a comprehensive numerical index for the expert's capability level.

75.3.4 Building the Fuzzy Comprehensive Evaluation Model

1. Calculate the importance level of the project risks. First, ascertain the factor domain of the assessing object, that is, $C = (C_1, C_2, \ldots, C_n)$, which is also the process to ascertain the evaluation index system.
2. The set is for the assessing target, that is, risk in this article, so the assessing set can be very low, low, general, high, and very high. Ascertain the standard membership degree set, that is, $V = (v_1, v_2, \ldots, v_n)$, $V = \{5$ (very high), 4 (high), 3 (general), 2 (low), 1 (very low)$\}$.
3. Perform a single-factor assessment between factor domain U and assessing scale set V. The built fuzzy relation matrix is:

$$\begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \tag{75.4}$$

In matrix R, r_{ij} is the membership degree of u_i (the i factor in factor domain U) with V_j (the j level in assessing scale set V). In this way, the assessing of the i aspect of the target is realized by m (number of r_{ij}, $j = 1, 2, \ldots, m$). Generally, the membership function is used to ascertain the value of r_{ij}. Select the membership function model for each indicator after considering the professional knowledge and data of the assessing target to estimate the model parameters. And then import the statistic data. That is, the fuzzy statistics law is used for the qualitative indicator.

Step 4. Obtain the fuzzy evaluation result.

Compose the weight vector $A = (a_1, a_2, \ldots, a_m)$, that is the weight vector $W = [w_1, w_2, \ldots, w_n]T$ acquired in step 2, with R to acquire the value of B. The basic model is $B = A\text{o}R$, where o is the composite operator.

$$B = A\text{o}R = [a_1, a_2, \ldots, a_m] \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} = [b_1, b_2, \ldots, b_n] \tag{75.5}$$

Use the weight of the assessing vector B to perform a weighted averageing for the score of each assessing level, and get the total score. Set $[b_1, b_2, \ldots, b_n]$, and calculate the total score G.

$$G = \frac{\sum_{i=1}^{m} b_i j_i}{\sum_{i=1}^{m} b_i} \tag{75.6}$$

Step 5. Repeat the above steps to perform the calculation for each level.

Then calculate the weight of each score in the total score to get the weight vector of the target level. Repeat the above steps till we get the total risk of the rail transit projects.

75.4 Conclusion

In this article, we identify the risks of urban rail transit projects and divide them into the two stages: construction and operation risks. In each stage, the risks are further divided into seven subcategories. Then the analytic hierarchy process and fuzzy comprehensive evaluation are used to build a risk assess model, combining qualitative and quantitative analysis with fuzzy mathematics. Besides, this model also considers to the uncertain factors in the project, making the risk assessment be identical to the actual condition. In the actual project, the constructor or operator can first perform a risk identification and assessment, and then adjust the project scheme to improve the risk control capability, reduce the risks, and minimize the losses brought by the risks while ensuring the overall objectives of the projects. To be specific, they can select proper risk counter measures, compile risk control scheme, and monitor the potential major risks, thereby enhancing the efficiency and effectiveness of risk management.

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Chapter 76
Low Carbon Supply Chain Performance Evaluation Based On BSC-DEA Method

Yunlong Li and Xianliang Shi

Abstract In this paper, based on the previous studies, we use the combination of the Balanced Scorecard (BSC) and Data Envelopment Analysis (DEA) method to study the low carbon supply chain performance evaluation. BSC-DEA model combines both the BSC and DEA common advantage. From the DEA's perspective, the model classify the input and output indicators to certain grade, for DEA model get a more complete index system and provide a balance constrains for any given DMU. From the perspective of the BSC, the model complement the shortcoming of BSC approach when carry out performance evaluation lack of quantitative analysis, and fulfilling the calculation of the relative effectiveness between the different low carbon supply chain.

Keywords Low carbon supply chain · Balanced score card · Data envelopment analysis · Performance evaluation

76.1 Introduction

The performance evaluation of low carbon supply chain plays a very important role in low carbon supply chain research. Through the performance evaluation of low carbon supply chain, we can not only find the bottleneck of low carbon supply chain system efficiency, but also give some valuable opinions for optimizing low carbon supply chain. Then we could eventually improve the performance of the whole supply chain to realize the sustainable development of low carbon supply

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chain. Therefore, low carbon supply chain performance evaluation is a valuable research topic.

This paper will combine the method of Balanced Score card (BSC) and Data Envelopment Analysis (DEA). This combining has two advantages. It can not only classify the index grade of input and output, but also fully evaluate DMU and make a clear evaluation boundary for every DMU avoiding there would be no standard index building model when we use DEA.

76.2 Establishment of Low Carbon Supply Chain Performance Evaluation Index System

76.2.1 Low Carbon Balanced Score Card

The balanced score card regards the financial, customer, internal processes and learning and growth in enterprises as an integral part of the performance evaluation system (Johnson 1998). It is better a lot than traditional performance evaluation. But with the development of society, some new management problems appear constantly. Traditional balanced score card has gradually displayed great deficiency. For example, there are some problems in environment of enterprise, social responsibility and several hot attentions at present like carbon footprint and water footprint and so on. But these problems are not found in traditional balanced score card. And on the other hand, every country in the world, particularly developed country, continuously put forward environmental terms, such as WEEE, which the European Union proposed between 2002 and 2006, ELV instruction and ROHS regulations. These terms force enterprises to carry out, or enterprises may at the edge of bankruptcy. So putting the environmental management into enterprise strategic management has become the primary goal of the enterprise managers. That prompted low carbon balance scorecard system (Low Carbon Balanced Score Card, LBSC) which contain something about social or environment to appear.

76.2.2 The Establishment of Low Carbon Supply Chain Performance Evaluation Index System Based on Low Carbon Balanced Score Card

The ultimate goal of low carbon supply chain is to realize the coordinated development of economic benefit, resource conservation and environmental protection. So we put environmental protection and the consideration of energy saving into traditional supply chain goals to form the low carbon supply chain (Michalis et al. 2004). So it prompts us to add the measurement index of environment and

Table 76.1 Low carbon supply chain performance measurement index

Level 1 index	Level 2 index
Finance (A1)	Supply chain total assets return rate (A11)
	Supply chain total asset turnover (A12)
	Supply chain net assets yield rate (A13)
	Supply chain environment investment rate (A14)
	Cost of supply chain due to environmental factors (A15)
Environment (A2)	Total energy usage (A21)
	The environment influence of product or service in the whole life cycle of carbon emissions (A22)
	The proportion of greenhouse fuel usage (A23)
	Carbon foot print (A24)
Customer (A3)	Market share (A31)
	Customer satisfaction (A32)
	The reliability of the supply chain (A33)
	Low carbon quality identities (A34)
Internal process (A4)	Supply chain response time (A41)
	The flexibility supply chain (A42)
	Capacity utilization rate (A43)
	Supply chain inventory (A44)
	Energy utilization rate (A45)
Learning and development (A5)	Employee satisfaction (A51)
	Training costs per employee (A52)
	The utilization rate of the information (A53)
	Low carbon resources utilization (A54)
	Low carbon product authentication of the employees cognitive degree (A55)

Remarks a unified scoring index is given by 1–5. And greater fraction mains greater influence

energy into the traditional supply chain performance evaluation index when we establish low carbon supply chain performance evaluation index, as shown in Table 76.1.

76.3 The Low Carbon Supply Chain Performance Evaluation Model Based on BSC-DEA Method

As the above low carbon supply chain performance evaluation index system built based on the idea of low carbon score, we can directly use the DEA model to calculate the relative effectiveness of the low carbon supply chain, rather than re-establish indicators. This index system can not only measure the economic performance of the low carbon supply chain, but also evaluate all aspects of environment, customers, internal processes and learning and development in low carbon supply chain. We can describe it as this: we put the frame structure of LBSC into DEA model when we calculate with DEA model. So the index system

Table 76.2 Assessment unit's input/output tables

			1	2	3	⋯	j	⋯	n	(评价单元)		
Input index	v_1	1→	x_{11}	x_{12}	x_{13}	⋯	x_{1j}	⋯	x_{1n}			
	v_2	2→	x_{21}	x_{22}	x_{23}	⋯	x_{2j}	⋯	x_{2n}			
	……		……									
	v_m	m→	x_{m1}	x_{m2}	x_{m3}	⋯	x_{mj}	⋯	x_{mn}			
			y_{11}	y_{12}	y_{13}	⋯	y_{1j}	⋯	y_{1n}	→1	u_1	Output index
			y_{21}	y_{22}	y_{23}	⋯	y_{2j}	⋯	y_{2n}	→2	u_2	
			……							……		
			y_{s1}	y_{s2}	y_{s3}	⋯	y_{sj}	⋯	y_{sn}	→s	u_s	

of LBSC is a balance constraint for DEA model's building. Taking advantage of these restrictions can help us avoid thinking a lot of some aspect of system performance because of our own preference when we establish the index. So we could get a more accurate result.

There three models (C^2R, BC^2 and Additive) that we can use DEA to evaluate the relative efficiency of decision making unit. And C^2R model is a more mature model now. Now we will show the description of C^2R model. Suppose there are n decision making units, and DMK_k (k = 1, 2, …, n). Each DMK has m input indicators and s output indicators (Ji and Guo 2009). The evaluation unit input and output data are given in Table 76.2.

x_{ij} is the total amount of investment in the jth evaluation unit of the ith enter. The data is known, and $x_{ij} > 0$.
y_{rj} is the total output of the jth evaluation unit of r type of output. The data is known, and $y_{rj} > 0$.
v_i is the weight of the i type of input. It is a variable of DEA model and i = 1, 2, …, m.
u_r is the weight of the r type of output. It is a variable of DEA model and r = 1, 2, …, s.
j = 1, 2, …, n.

Based on the above variables we set C^2R model. The evaluation unit efficiency evaluation index is:

$$h = \frac{U^T Y_j}{V^T X_j} \quad j = 1, 2, \cdots, n \tag{76.1}$$

The relative efficiency optimization model:

$$Max\, h_0 = \frac{U^T Y_0}{V^T X_0} \tag{76.2}$$

$$s.t. \frac{U^T Y_j}{V^T X_j} \leq 1 \quad j = 1, 2, \cdots, n$$

$$U \geq 0; V \geq 0;$$

Among them:

$$\begin{aligned} X_j &= (x_{1j}, x_{2j}, \cdots, x_{(m-1)j}, x_{mj}),\ Y_j = (y_{1j}, y_{2j}, \cdots, y_{(s-1)j}, y_{sj}) \\ V &= (v_1, v_2, \cdots, v_m),\ U = (u_1, u_2, \cdots, u_m) \end{aligned} \tag{76.3}$$

We use Charnes-Cooper linear transformation dispose the programming (2). Then we would get a linear programming. The dual form of the new linear programming is (D):

$$\theta^0 = \min\theta$$

$$s.t. \sum_{j=1}^{n} x_j \lambda_j + S^- = x_0 \theta \tag{76.4}$$

$$\sum_{j=1}^{n} y_j \lambda_j - S^+ = y_0$$

$$\lambda_j \geq 0,\ S^- \geq 0,\ S^+ \geq 0, \quad j = 1, 2, \cdots, n$$

When $\theta^0 = 1$, $S^{-0} = 0$, $S^{+0} = 0$, the supply chain model C^2R is effective in the DEA. So it is not only the technology effectively is effective scale. We usually said it is effective in the DEA under C^2R model. And we also can say overall effective which mains that in established under the output, minimum input with high resource utilization efficiency. When $\theta^0 < 1, S^{-0} \neq 0, S^{+0} \neq 0$, the supply chain model C^2R is not effective in the DEA (Chang and Graham 2010). We can say it is not overall effective which mains input and output is lower and production has the big waste of resources. And it is relative to other all DMU when we use C^2R model to evaluate the DMU is effective or not.

76.4 Conclusion

Low carbon supply chain performance evaluation is a key issue in the study of low carbon supply chain. This article pointed out the importance of BSC in low carbon supply chain, and gave a new thought of LBSC. Another innovative point of the research is that we combined BSC and DEA together when we analysed the problem of the performance evaluation of low carbon supply chain. Finally, we built a performance evaluation model for low carbon supply chain based on BSC-DEA method.

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Chapter 77
Research on a Reverse Logistics of Waste Household Appliances Includes the Impact of Carbon Tax

Youmei Gan and Xianliang Shi

Abstract This paper presents a multi-time-step, a single type of waste household appliances reverse logistics model. The model is formulated that using carbon tax to take into account the transport carbon emissions in the system, and subject to constraints that take into account business operating strategies and governmental regulations. Numerical example is presented to demonstrate the feasibility of the proposed approach.

Keywords Reverse logistics · Carbon emissions · Carbon tax

77.1 Introduction

Low-carbon is affecting people's lifestyle. Household appliance industry is one of the priority areas of low-carbon products certification. Household appliances often needs to use various of recyclable and pollution material and resources in production manufacturing process. Therefore, the work to reuse of waste household appliances and the research on reverse logistics cost become more and more important.

There is an increasing amount of research on reverse logistics cost (Lan et al. 2011; Jie et al. 2006; Hu et al. 2002), these studies specifically are based on activity-based cost method or under operation links, process analysis of reverse logistics reverse logistics costs, and thereby building related cost models. In previous literatures, (Luu 2012; Lu et al. 2011; Achillas et al. 2010a, b),

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Luu (2012) presents a mathematical programming model which minimizes the total processing cost of multiple types of WEEPs, with considering environmental factor. Based on the proposed model, the optimal facility locations and the material flows in the reverse logistic network can be determined; (Lu et al. 2011) presents a environmental cost-sharing model for the reverse logistics of discarded appliances. But there are few literatures taking into account carbon emissions factors. Currently there are two effective way to reduce carbon emission, that is carbon tax and carbon trading, this paper considers carbon tax. Chao (2011) pointed out that the introduction of carbon tax, government can achieve environmental benefits of CO_2 emission reduction. A carbon tax's impact within 10 years on GDP will at about 0.4 %, and the effect will become smaller, while the carbon effect tax cuts reach 20 %.

This paper based on the analysis and summarize of previous household appliances reverse logistics network design and operation model, designed a minimum and multi-time-step, a single type of waste household appliances reverse logistics model, which includes six activities: collection, storage, refurbish, disassembly, final disposal, and reuse.

77.2 Model

The conceptual model of the proposed reverse logistics system of waste household appliances is shown in Fig. 77.1, consisting of six activities: (1) collection, (2) storage, (3) refurbish, (4) disassembly, (5) final disposal, and (6) reuse.

To facilitate model formulation, five assumptions are postulated:

(1) The conceptual model are shown in Fig. 77.1. These include some primarily operations and related activities. Considering the recovery of waste household appliances from recovery points to collection points, after pre-treatment, then to final disposal or reuse operation processes; (2) The time-varying demands for the waste household appliances treatment are known; (3) The cost for internal transportation is ignored. Correspondingly, only the inbound transportation cost for collection from recovery points to collection points, and the outbound transportation cost for the activities of refurbish, reuse and final disposal are taken into account in model formulation. Assuming the recovery point range on the collection point which is the center of the circle; (4) Treatment and storage capacity is limited; (5) in the system, only consider to use carbon tax to decrease the carbon emissions in transportation. It will apportioned carbon tax to each ton of products.

Accordingly, a discrete-time linear analytical model is formulated to minimize the total operational cost of a multi-time-step, a single type of waste household appliances reverse logistics system. The proposed model is composed of a discrete-time linear objective function (see Eq. (77.1)) coupled with several constraints (see Eqs. (77.2)–(77.7)) representing the operational conditions of the reverse logistics system needed for the search of feasible solutions in terms of the

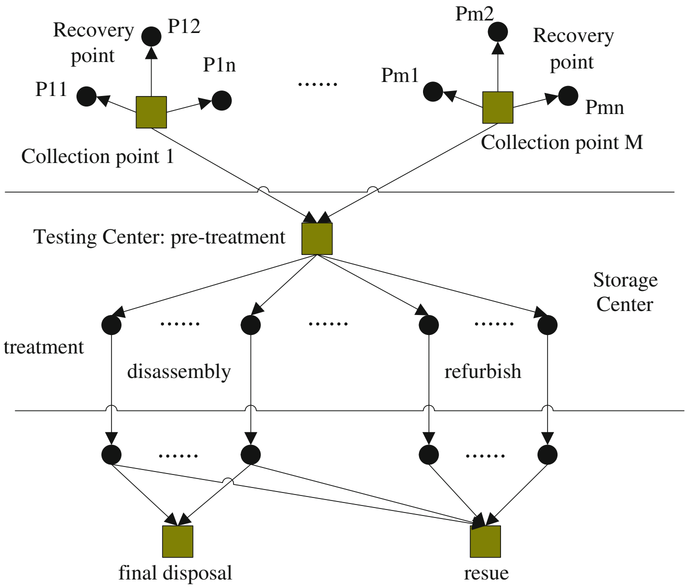

Fig. 77.1 Conceptual model of the proposed reverse logistics system

decision variables. The variables and mathematical formulation of the proposed model is detailed below.

The variables and parameters: a: the unit cost of storage; b: the unit cost of treatment; $C(k)$: the amount of collection at time step k; d: the unit cost of final disposal; g: the unit cost of refurbish; l^c: the total transportation distance for activity of collection coded with 'c';l^d:the total transportation distance for activity of final disposal coded with 'd';l^f:the total transportation distance for activity of refurbish coded with 'f'; l^r: the total transportation distance for activity of reuse coded with 'r'; M^C_{com}: the minimal collection amount in consideration of the basic requirements for business operations; M^C_{gov}: the minimal collection amount in consideration of the basic requirements for governmental regulations; M^T_{com}: the minimal treatment amount in consideration of the basic requirements for business operations; M^T_{gov}: the minimal treatment amount in consideration of the basic requirements for governmental regulations; r: the unit carbon tax; $R(k)$: the time-varying collection demand at time step k; $S(k)$: the time-varying storage demand at time step k; t^c: the unit cost in terms of transporting for activity of collection coded with 'c'; t^d: the unit cost in terms of transporting for activity of final disposal coded with 'd'; t^f: the unit cost in terms of transporting for activity of refurbish coded with 'f'; t^r: the unit cost in terms of transporting for activity of reuse coded with 'r'; $T(k)$: the time-varying treatment demand at time step k; T^{cap}: the treatment capacity; α: the ratio parameter for processed the activity of refurbish; β: the ratio parameter for processed the activity of disassembly; ω: the ratio parameter for processed the activity of reuse; θ: the ratio parameter for processed the activity of final disposal.

The total reverse logistics cost involved in the objective function includes six major time-varying cost items: ①total transportation cost from recovery points to collection points, ②total storage cost, ③total disassembly cost, ④total transportation cost for refurbishing processed wastes, ⑤total transportation cost for reusing processed wastes, and ⑥total transportation cost for final disposing processed wastes, as shown in Eq. (77.1).

$$
\begin{aligned}
& Min \sum_{k=1}^{K} ({}^{c} \times l^{c} + r)(k) + a \times \left[S(0) + \sum_{k=0}^{K-1} C(k+1) - T(k+1) \right] \\
& + \sum_{k=1}^{K} \left(b + t^{f} \times l^{f} + r \right) \times T(k) \times \alpha + \sum_{k=1}^{K} g \times T(k) \times \beta \\
& + \sum_{k=1}^{K} (t^{r} \times l^{r} + r) \times T(k) \times \beta \times \omega + \sum_{k=1}^{K} \left({}^{d} \times l^{d} + r + d \right) \times T(k) \times \beta \times \theta
\end{aligned}
\tag{77.1}
$$

In Eq. (77.1), $\alpha + \beta = 1, \omega + \theta = 1$. Herein, $C(k)$ and $T(k)$ represent two types of time-varying decision variables, which are determined in each time step according to the goal of minimizing the total reverse logistics cost. Six groups of constraints are involved in the proposed model, and their mathematical forms are given respectively:

$$\sum_{k=1}^{K} C(k) \geq \max\left\{ M_{com}^{C}, M_{gov}^{C}, 0 \right\}, \forall k \tag{77.2}$$

$$C(k) \leq \min\{R(k), T^{cap}\}, \forall k \tag{77.3}$$

$$\sum_{k=1}^{K} T(k) \geq \max\left\{ M_{com}^{T}, M_{gov}^{T}, 0 \right\}, \forall k \tag{77.4}$$

$$T(k) \leq T^{cap}, \forall k \tag{77.5}$$

$$\sum_{k=1}^{K} T(k) - \sum_{k=1}^{K} C(k) < = S(0); \forall k \tag{77.6}$$

$$S(k-1) + [C(k) - T(k)] \leq S^{cap}, \forall k \tag{77.7}$$

Equation (77.2) represents the lower-bound constraint in terms of waste household appliances collection which is specified in consideration of two potential factors: (1) governmental regulations in terms of the minimal waste household appliances collection amount, and (2) basic requirements for normal business operations.

Equation (77.3) is set in consideration of the upper bound for time-varying waste household appliances collection. The upper-bound collection constraint serves to limit the collection amount either its real time-varying demand or the treatment capacity.

Equations (77.4) and (77.5) represent the lower- bound and upper-bound constraints associated with the activity of waste household appliances treatment are involved in the proposed model. Herein, the lower-bound treatment constraint is determined by either one of the following two factors: (1) related governmental regulations and (2) basic requirements of normal business operations. Accordingly, the upper-bound treatment constraint serves to limit the treatment capacity.

Equations (77.6) correspond to the restrictions storage amounts. The time-varying storage amount should be subject to the storage capacity, as shown in Eq. (77.7). Note that in Eq. (77.7), $S(k)$ can be further denoted by $S(k) = S(k-1) + [C(k) - T(k)](8)$.

77.3 Numerical Example

77.3.1 Parameter Estimates

To simplify and describe the model, this paper design the time step 10, and other relevant data is shown in Tables 77.1, 77.2 and 77.3.

77.3.2 Optimization Analysis

Given the data shown in Tables 77.1, 77.2 and 77.3, five cases associated with different sets of supply-related parameters (i.e., Cases 1–5) were investigated. This

Table 77.1 Estimated parameters used in the objective function

	Parameter						
	$S(0)$ (ton)	a (\$/ton)	b (\$/ton)	g (\$/ton)	d (\$/ton)	r (\$/ton)	
Data	200	500	800	1000	700	10	
	t^c (\$/ton)	t^d or t^f or t^r (\$/ton)	l^c (km)	l^d or l^f or l^r (km)	α	β	ω or θ
Data	130	110	0.6	16	0.9	0.1	0.6

Table 77.2 Estimated parameters used in the constraints

	Parameter			
	M^C_{gov} or M^C_{com} (ton)	M^T_{com} or M^T_{gov} (ton)	T^{cap} (ton/time step)	S^{cap} (ton)
Data	2200	2200	250	250

Table 77.3 Real time-varying demands of waste household appliances (unit: ton/time step)

	Parameter									
	1	2	3	4	5	6	7	8	9	10
$R(k)$	230	235	229	220	232	236	222	222	219	227

Table 77.4 Optimal solutions associated with Case 1

Step	$C(k)$	$T(k)$	$S(k-1)$
1	230	250	200
2	235	250	180
3	184	99	165
4	220	220	250
5	232	232	250
6	236	236	250
7	222	222	250
8	222	222	250
9	219	219	250
10	200	250	250

Total reverse logistics cost: $6,053,200

paper uses the Lingo software to solve the cases. Case 1 is serves as the contrast case in which all the predetermined parameters as well as presumed. The result is shown in Table 77.4.

In the following scenario, we explored four different cases (i.e., Cases 2–5) by strategically loosening the basic operational requirements, including the minimal amount associated with the activities of waste collection and treatment, and change the cost of carbon tax. In contrast with Case 1, the constraints of Case 2 remain the same except for the minimal collection requirements, namely M_{gov}^{C} and M_{com}^{C}, from 2200 to 1100. Case 3 presents that not only the minimal collection requirements. but also the minimal treatment requirements $\left(M_{gov}^{T} \text{ and } M_{com}^{T}\right)$ are reduced to 1100. Case 4 represents an extreme deregulation case in which Eqs. (77.2) and (77.4), without considering the lower-bound constraints associated with the activities of waste collection and treatment. Moreover, the time-varying collection amount is set to be the same as the real demand. Case 5 remains the same parameter except to add the cost of carbon tax.

77.3.3 Results

Tables 77.5 and 77.6 summarize the changes in the total costs with these cases.

The following provides several results obtained in these study cases.

Table 77.5 Relative change in the total reverse logistics cost (compared to Case 1)

	Case			
	Case 1	Case 2	Case 3	Case 4
Total cost ($)	6053200	5935600	3076600	6142132
Change cost (compared to Case 1)		−117600	−2976600	+88932
Change ratio		−1.94 %	−49.17 %	+1.47 %

Table 77.6 Cost change on carbon tax associated with Case 5

	r ($/ton)			
	10	20	40	80
Total cost ($)	6053200	6093200	6185200	6361200
Increased cost (compared to Case 1)		40000	132000	308000
Increased ratio		0.66 %	2.18 %	5.09 %

- As can be seen in Tables 77.5 and 77.6, the total reverse logistics costs have been reduced by 1.94 %, and 49.17 %, respectively. Such a result seems supportive of governmental deregulation of hazardous-waste treatment companies.
- However, without the constrains of the minimal collection and treatment amount, the cost of the system increased by 1.47 %.
- Increasing the tax doesn't has a big impact of changing the optimal solutions.

77.4 Conclusion and Further Research

Reverse logistics system is a significant part of the supply chain. This paper developed a multi time step, a single type of household appliances waste reverse logistics model, increased the cost of carbon tax during transport and constraint to government, company strategic decisions. Compared to early literatures, the paper's innovation is that increased the consideration of cost of carbon tax during transport.

Except for the carbon tax, carbon trading is also a effect way to reduce carbon emissions. In further research, carbon trading can be taken into account in a supply chain management framework.

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Chapter 78
Electric Power Enterprises Supply Relationships Integration: Achieve Low-Carbon Procurement

Jingchen Gao, Jie Xu and Meiying Cheng

Abstract With the blooming of economics and development of supply chain management, the relationships between enterprises and suppliers are changing. Many companies began to consider environmental factors in procurement process, which mainly concentrated in green procurement. However, it hard to achieve procurement method transformation and supply system rebuilt. Supply relationship integration can optimize the purchase pattern and bring benign environmental effects in order to implement cost and energy savings and emission-reduction. This paper use an electric power enterprise as an example and build a supply relationship integration model including three steps: evaluating suppliers by trading data; dividing supply relationships into 6 categories by cluster analysis method; using the improved Kraljic model to analyze the pros and cons of different supply relationships, then compared with the ideal supplier and combined with the actual situation to draw out the recommendations of the supply relationship integration, finally analysis the environmental effects of it.

Keywords Supply relationship integration · Low-carbon procurement · Cluster analysis · Kraljic model

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78.1 Introduction

The relationship between suppliers and enterprises has been gradually moving from "opposition", "competition" into "cooperation" and "win–win". Supply relationship not only decides whether the enterprises can get high quality and low price materials but also affect the future strategy and common development. Supply relationship has great impact on the procurement and supplier management. To maintain a reasonable structure and number of suppliers is an important direction of improving the modern enterprise management. However, with the company's development and expansion of business scope, there are many large companies having such problems that the number of suppliers is excessive and the management focus is not prominent Liuhu (2009).

The Electric Power Enterprises closely link with economic development and social stability. Electric Power Enterprises have huge amount of procurement with different types and high quality requirement. To achieve low-carbon purchase in Electric Power Enterprise is very important to the development of low-carbon economy. Electric Power Enterprises urgently require supply relationship integration method to optimize the structure of the supplier and emphasize the management focus. This paper analysis the management and environment impact of supply relationships integration in the Electric Power Enterprise, build supply relationship integration method and analysis environment profit, to provide a new method of achieving energy-saving and emission-reduction and low-carbon office for Electric Power Enterprises.

78.2 Paper Preparation

The research of environmental issues during purchase-supply part is mainly concentrated in the areas of "green procurement", include enterprise and government purchase. The Content of green procurement include effect factors, evaluation index and model build. Guo (2011) build a model to analysis the internal and external influencing factors of green purchase. Xu (2011) study about the effect of government green purchase, to consider that government green purchase can make a significant contribution to ecological and economic effects, which can also bring a good demonstration effect. Ottar and de Luitzen (2009) study the role of municipalities and counties in green public procurement. And investigate the degree of green public procurement implemented in Norwegian municipalities and counties, then analysis the critical capabilities in successful green procurement. They found green procurement established in large municipalities is more significant than that in small ones because of increased environmental awareness and increased guidance from national authorities. In addition to green procurement, there are - other ways to achieve environmental protection. "Integration" thought is aim to save costs; reduce risk, which is very suitable for the integration point to enhance the management capacity and improve the environmental standards. The integration of the supply relationship for Electric Power Enterprises is meaningful to develop low-carbon economic society Liu (2009).

This paper is a study about the supply relationship integration problem of a large state-owned enterprise, in order to reduce resource consumption and carbon emissions, which plays a good role in promoting environmental protection.

78.3 LNCS Online

This paper analyzes the problem of supply relationship integration in Electric Power Enterprises by evaluation, classification and integration of supply relationship. The section of supply relationship evaluation sums up the evaluation indexes by reading literatures. Then refine into second level evaluation indexes and use supplier data as evaluation data. The supply relationship classification part uses cluster analysis method to divide 233 mainly suppliers into 6 categories, then analysis the characteristics and commonalities of various types of supply relationship. The third part, supply relationship integration, is based on the improved Kraljic model which considers three factors: supply relationship characteristics, material type and supply performance.

78.3.1 Building Supply Relationships Evaluation System

Articles show that there is no perfect theoretical base for supply relationship evaluation index selection. This paper improves the method of Xue Yan to search related articles, and determine statistical evaluation indicators after reading and learning. Then calculate the result.

The standards of supply relationship evaluation are dispersed. 23 indexes are used twice or more in 43 articles. The indexes have high frequency are trust, ability, information, cooperation and contract which respectively 16, 14, 11, 10 and 10. Frequency of environment and quality factors each is 7. This shows that the study about environmental indicators have already started, but not deep enough.

The principle of established indicators in second level is the integration of theory and practice, consulting reference and actual situation of the enterprise and refining the first level indicators into second level. To establish a complete supply relationship evaluation index system as Fig. 78.1

78.3.2 Supply Relationship Classification

This article use Q-type cluster analysis method based on the evaluation index system; expect to divide supply relationships into 6–9 category, then integrate

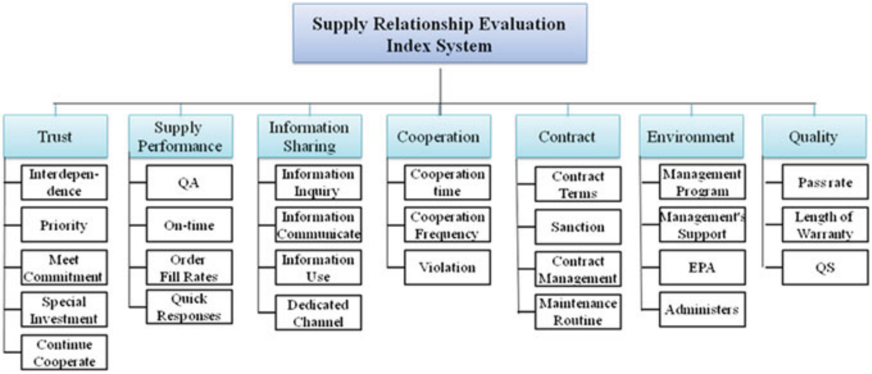

Fig. 78.1 Supply relationship evaluation index system

Table 78.1 Clustering results of supply relationship

Type	Number of suppliers	Characteristics of suppliers
1	35	High performance, strategic/leverage items suppliers. High information Sharing
2	20	High performance, strategic/leverage items suppliers. Have framework agreement. Have homogenous suppliers.
3	73	High performance, leverage suppliers items suppliers. Have annual agreement or temporary agreement.
4	13	Low performance, leverage suppliers items suppliers
5	63	Low performance, bottleneck suppliers items suppliers
6	24	Low performance, bottleneck suppliers items suppliers. Have homogenous suppliers.
7	5	Low performance, non-critical suppliers items suppliers. End cooperation relationships in this year.
Total	233	

supply relationship on this basis. Number and features of suppliers are shown as the Table 78.1.

78.3.3 Supply Relationships Integrative Approach

The purpose of supply relationship integration should be connected with the current problems and strategies for the future, which includes three integrated objectives:

Firstly, comb structure of supply relations through supplier relationships classification. Secondly, improve the procurement concentration, decrease amount of suppliers, reduce procurement costs and enhance the bargaining advantage.

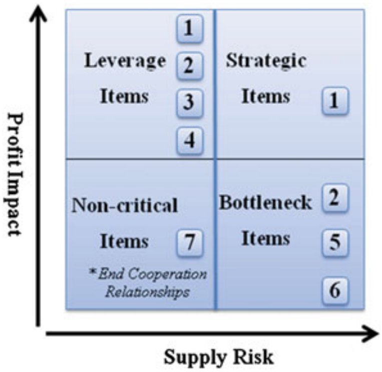

Fig. 78.2 Supply relationship integration model of the enterprise

Thirdly, enterprise should optimize procurement status by supply relationship integration, improve supply performance while Quality Assurance.

The data used in this article is part of the total, mainly the bottleneck and leverage materials. Leverage material has a low purchase risk. Electric Power Enterprise should improve the procurement concentration in order to get a low price. Homogenous suppliers will lead to low average purchase amount which cannot get preferential price. Enterprise should find suppliers that have quality assurance and advantage price, and then gradually reduce the suppliers with low performing Marjolein and Gelderman (2005). The bottleneck materials play an important role in enterprise, but it hard to achieve an advantage price because of the low purchase amount and high supply risk. Enterprise usually gets those materials by customization. Enterprises should be kept to a reasonable number of suppliers to balance the supply risk and price Gelderman and Van Weele (2005).

Summarizing the classification results and integration orientation, Fig 78.2 shows the supply relationship integration model.

78.4 Achieve Low-Carbon Procurement by Supply Relationship Integration

78.4.1 Reduce Cost

The concept of supply relationship integration is the integration of discrete information. The results show that 40 % procurement expenditures involve dozens or even hundreds of homogenous suppliers, which means huge management difficulty and bargaining space. Integration of discrete information could reduce difficulties of management and save procurement costs.

Supply relationship integration can effectively reduce labor costs. Because of the big amount of suppliers this enterprise needs 9 staff before integration. After supply relationship integration the number of suppliers became orderly only 2.

Classification of supply relationships could manage and maintain suppliers better than before.

The purchased items in various branches are basically the same, but the price is different regionally. After the supply relationship integration all branches and departments could check procurement and price through a unified data platform, which promote the development of the centralized procurement and save a lot of procurement funds. The enterprise began to subscription framework agreement with strategy suppliers at 2010. Now it gets the centralized procurement rate of 84.7 %.

78.4.2 Supply Relationship Classification

The supply relationship management integrates the supplier in remote areas in order to shorten the distance between the supplier and demand branch optimally. That could not only reduce transport costs, but also save a lot of resources. At the same time, supply relationship integration implemented centralized procurement and one-stop transport which can save energy during the whole supply chain.

78.4.3 Low-Carbon Business

Supply relationships integration also makes the framework agreement to be widely promoted. Compared with live bidding model before, online bidding could efficiently save human and material resources. Now enterprise could sign the "one-page" contract based on the framework agreement, so to reduce office costs and the use of resources.

Strategic cooperation suppliers could achieve exemption so that enterprise does not need to conduct site survey of supplier inventory and could ensure the quality and cost, and reduce management difficulty.

78.5 Consult

Supply relationship promotes intensive development internally, to achieve an overall perspective supply management, which can ensure high-quality supply and reduce material price at the same time. To drive cost savings through the integration of supply relationships, bring environmental effects of energy conservation and green office. Embodied in:

(1) Reduce the purchase frequency, increase procurement concentration, save procurement costs and raise the bargaining advantage. It also can improve transport efficiency and reduce carbon emissions.
(2) The promotion of Framework Agreement drives network bidding, saves human and material resources and reduces business costs and the use of resources.
(3) Reduce labor costs and the difficulty of managing. It also completes efficient management activities by using fewer resources.
(4) Reduce transportation costs. Optimal distance between the supplier and demand branch, which can reduce transport costs and save a lot of resources

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Chapter 79
Coordination of Low Carbon Agricultural Supply Chain Under Contract Farming

Guohua Sun and Shengyong Du

Abstract Low carbon agriculture is defined as new agriculture model based on low energy consumptions, low pollution and low emissions. We consider a two-echelon supply chain under contract farming and model a bilateral monopoly between a single agricultural producer and a single processor. The demand of market is influenced by the retail price and the level of low carbon technology. The optimal solution in a supply chain is studied in the model of Stackelberg game and centrally coordinated system. In the Stackelberg game model, the low-carbon technology, order quantity of the processor and the total profit of supply chain are all smaller than that in centrally coordinated system. Then revenue and cost sharing contract is designed to coordinate the supply chain. Then revenue and cost sharing contract is proposed. It's verified that supply chain profits are attained at the same level as in a centrally coordinated system with revenue and cost sharing contract.

Keywords Agricultural supply chain · Low-carbon technology · Contract farming

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79.1 Introduction

Low carbon agriculture is defined as new agriculture model based on low energy consumptions, low pollutions and low emissions. It is undoubtedly the future direction of economic and agriculture development. Using the methods such as reducing energy consumption and carbon emissions can realize a double win between agricultural production development and ecological environment protection.

Contract farming is a system for production and supply of agricultural/horticultural produce under forward contracts between producers and processors (Haque 2000). Contract farming is seen as a tool for fostering smallholder participation in new high-value product markets, and improving quality standards, thus increasing and stabilizing smallholder incomes. It is a case of bringing the market to the farmers, which is navigated by agribusiness firms (Christensen and Scott 1992). At present, contract farming has been already used for a wide variety of agricultural products. Jagdish and Prakash (2008) reported the effect of contract farming on income and employment generation and has identified constraints in and prospects of contract farming. Many studies (Haque and Birthal 1998; Key and Runsten 1999; Pari 2000; Rangi and Sidhu 2000; Simmons 1994; Singh 2002) which looked into the operations of contract faming of the different contracting firms, and the economic benefits, that accrue to the participating farmers are unanimously of the view that contract farming although leads to increase in gross returns of the farmers but cost of production also increases.

In this paper, we will research the low carbon supply chain under contract farming. This paper contributes to our understanding the optimal decision under contract farming especially the choice of low-carbon technology level. To raise the low-carbon technology, we will try to design the coordination contract.

79.2 Model Description

We consider a two-echelon supply chain and model a bilateral monopoly between a single agricultural producer and a single processor. Supply chain with agricultural producer and processor is considered, in which the producer is responsible for the production of crops and research of low-carbon technology and the processor is responsible for agricultural products processing and marketing.

As the level of low-carbon technology is raised, the producer S will used more green ecological agricultural materials and less chemical pesticides, fertilizers. Then the energy is saved, the product quality is improved and the harmful residues of pesticides and fertilizers are reduced.

Suppose that as the level of low-carbon technology of producer is raised, the production cost per unit is decreased, the level of food safety is increased. Assume the producer production cost per unit is: $c_s(x) = v - kx$, where $x(x \geq 0)$ is the level of low-carbon technology, v stands for the unit production cost while taking the traditional high-carbon production mode. As the level of low-carbon technology increased to x, the unit production cost will decrease kx.

In the mode of contract farming, the agricultural production is carried out according to an agreement between the producer and processor, which establishes conditions for the production and marketing of the agricultural product. The producer agrees to provide established quantities Q of a specific agricultural product, meeting the quality standards and delivery schedule set by the processor. In turn, the processor commits to purchase the product at a pre-determined price ω determined by the producer S. The retail price of processor is p.

As the level of low-carbon technology increases, the quality of agricultural product is improved. As a result, the product of the processor R becomes more safe and popular. Since the conditions of agriculture market are relatively stable, the processor can predict the demand of the agricultural product in the forthcoming selling season accurately while determining the order quantity Q. Given the low-carbon technology level x and the retail price p, the demand of agricultural product is: Dr(p, x) $=\alpha-\beta$ p + λx, where $\alpha(>0)$ is the basic demand in the high-carbon production mode, β, $\lambda(\geq 0)$ are the elasticity of retail price and low-carbon technology. cr is the unit selling cost of the processor.

In order to raise the level of low-carbon technology to x, the producer will incur certain R&D costs. To characterize the diminishing effects to investment, we use the R&D cost function: $F_s(x) = f + \frac{\phi}{2}x^2$, where the cost increases as the level of low-carbon technology is raised. As the level of low-carbon technology is raised to a higher level, the marginal R&D cost will be.

Assumption 1 To ensure the existence of positive demand, suppose $\alpha > \beta(c_r + v)$.

Assumption 2 To ensure the profit function is concave and the optimal solution is unique, suppose $\phi \geq \frac{(\lambda+\beta k)^2}{2\beta}$.

π_j^i denotes the profit function for channel member j in supply chain model i. Superscript i will take values S and C, which will denote the Stackelberg game and centrally coordinated models, respectively. The subscript j will take values r and s, which will denote the processor and the producer.

79.3 Model S: Stackelberg Game

In this model, the producer acts as the leader and the processor acts as the follower. The producer decides on the wholesale price ω and the low carbon level x first. The processor will decide the retailer price

Because the producer is the Stackelberg leader, we begin by characterizing the best-response function of the processor. For a given ω and x, the processor's problem is:

$$\max_{p \geq 0} \pi_r^S = (p - \omega - c_r)D = (p - \omega - c_r)(\alpha - \beta p + \lambda x) \tag{79.1}$$

Because the objective function is concave in p, the retailer's first-order condition characterizes the unique best response,

$$p_r^{S*} = \frac{\alpha + \lambda x + \beta\omega + \beta c_r}{2\beta} \tag{79.2}$$

The producer's problem can be stated as:

$$\max_{\omega, x \geq 0} \pi_s^S = [\omega - (v - kx)]Q - (f + \frac{\phi}{2}x^2) \tag{79.3}$$

The objective function is jointly concave in ω and x, and the producer's first-order conditions characterize the unique best response:

$$\omega_s^{S*} = \frac{2\phi - k(\lambda + \beta k)}{4\beta\phi - (\lambda + \beta k)^2}(\alpha - \beta c_r - \beta v) + v, \ x_s^{S*} = \frac{\lambda + \beta k}{4\beta\phi - (\lambda + \beta k)^2}(\alpha - \beta c_r - \beta v).$$

The optimal profit of producer S is:

$$\pi_s^{S*} = \frac{\phi(\alpha - \beta c_r - \beta v)^2}{2[4\beta\phi - (\lambda + \beta k)^2]} - f \tag{79.4}$$

Optimal retail price and order quantity can easily be found by substitution of ω_s^{S*} and x_s^{S*}. The results are listed as below:

$$p_r^{S*} = \frac{3\phi - \lambda k - \beta k^2}{4\beta\phi - (\lambda + \beta k)^2}(\alpha - \beta c_r - \beta v) + c_r + v, \ Q_r^{S*} = \frac{\beta\phi(\alpha - \beta c_r - \beta v)}{4\beta\phi - (\lambda + \beta k)^2}.$$

Then, the optimal profit of processor R is:

$$\pi_r^{S*} = \frac{\beta\phi^2(\alpha - \beta c_r - \beta v)^2}{[4\beta\phi - (\lambda + \beta k)^2]^2}. \tag{79.5}$$

The equilibrium channel total profit is:

$$\Pi^{S*} = \pi_r^{S*} + \pi_s^{S*} = \frac{\phi[6\beta\phi - (\lambda + \beta k)^2]}{2[4\beta\phi - (\lambda + \beta k)^2]^2}(\alpha - \beta c_r - \beta v)^2 - f \tag{79.6}$$

79.4 Model C: Centrally Coordinated System

The centrally coordinated system provides a benchmark scenario to compare the decentralized models with respect to the supply chain profits. Because there is a single decision maker, the wholesale price ω is irrelevant to the formulation of the objective function. Hence, the central planner optimizes

$$\max_{p,x} \pi^C = [p - c_r - (v - kx)](\alpha - \beta p + \lambda x) - (f + \frac{\phi}{2}x^2) \tag{79.7}$$

The simultaneous solution of the first-order conditions results in:

$$p^{C*} = \frac{\phi - k(\lambda + \beta k)}{2\beta\phi - (\lambda + \beta k)^2}(\alpha - \beta c_r - \beta v) + c_r + v, \ x^{C*} = \frac{\lambda + \beta k}{2\beta\phi - (\lambda + \beta k)^2}(\alpha - \beta c_r - \beta v).$$

The optimal order quantity of the centrally coordinated supply chain is:

$$Q^{C*} = \frac{\beta\phi(\alpha - \beta c_r - \beta v)}{2\beta\phi - (\lambda + \beta k)^2} \tag{79.8}$$

The optimal profit of the centrally coordinated supply chain is:

$$\Pi^{C*} = \frac{\phi}{2[2\beta\phi - (\lambda + \beta k)^2]}(\alpha - \beta c_r - \beta v)^2 - f \tag{79.9}$$

Proposition 1 The optimal retail prices are related as: (1) $\beta\phi \geq \lambda(\lambda + \beta k)$, $p_r^{S*} \geq p^{C*}$; (2) $\beta\phi \leq \lambda(\lambda + \beta k)$, $p_r^{S*} \leq p^{C*}$.

Proposition 2 The optimal level of low-carbon technology are related as: $x_s^{S*} \leq x^{*C}$.

Proposition 3 The optimal order quantities are related as: $Q_r^{S*} \leq Q^{C*}$.

Proposition 4 The total profit of supply chain are related as: $\Pi^{S*} \leq \Pi^{C*}$.

From Proposition 1 to 4, it's not hard to know that the low-carbon technology, order quantity of the processor and the total profit of supply chain in model *S* are all smaller than that in model *C*. In next section, we show that the producer can further improve the profits in the Model *S* via a single revenue and cost sharing contract. To highlight incentive issues, we consider an environment where all information are common knowledge to the supply chain members.

79.5 Design of Coordination Contract

Before the processor chooses the retail price p and order quantity Q, the producer and the processor agree to a revenue and cost sharing contract with two parameters. The first is the wholesale price ω the retailer pays per unit. The second γ is the retailer's share of revenue generated from each unit. The supplier's share is $1-\gamma$.

Given the retail price p, the total profit of supply chain is: $R(p) = p(\alpha - \beta p + \lambda x)$. The profits of the producer and the processor are:

$$\pi_r = \gamma R(p) - (\omega + c_r)Q - \gamma(f + \frac{\phi}{2}x^2) \tag{79.10}$$

$$\pi_s = (1-\gamma)R(p) + (\omega - c_s)Q - (1-\gamma)(f + \frac{\phi}{2}x^2) \tag{79.11}$$

If the producer can offer a wholesale price $\omega = \gamma(v - kx) - (1-\gamma)c_r$ to the processor, the profits of the processor and producer will be $\pi_r = \gamma\pi^C$, $\pi_s = (1-\gamma)\pi^C$. It's not hard to infer that in this case, the processor and the producer will choose p^{C*} and x^{C*} as his optimal decision. The profits of the processor and the producer are $\pi_r = \gamma\Pi^{C*}$, $\pi_s = (1-\gamma)\Pi^{C*}$. If $\frac{\pi_r^{S*}}{\Pi^{C*}} \le \gamma \le \frac{\Pi^{C*} - \pi_s^{S*}}{\Pi^{C*}}$, the profits of the processor and the producer satisfy: $\pi_r \ge \pi_r^{S*}$, $\pi_s \ge \pi_s^{S*}$. The processor and the producer will both have incentive to accept the revenue and cost sharing contract.

79.6 Numerical Example

Suppose the demand of the processor is: $D(p,x) = 500 - 5p + 10x$. The unit selling cost of the processor and production cost with the low-carbon level x are: $c_r = 25$ and $c_s(x) = 30 - 2x$. In order to raise the level of low-carbon technology to x, the producer will incur certain R&D costs. The R&D cost function is: $F_s(x) = 450 + 80x^2$.

(1) In model S, the producer acts as a leader and the processor acts as a follower, the Stackelberg equilibrium is $(x_s^{S*}, \omega_s^{S*}, Q_r^{S*}, Q_r^{S*}) = (3.75, 52.5, 92.5, 75)$. The optimal profits of the processor, the producer and the total supply chain are:

$$\pi_r^{S*} = 1125,\ \pi_s^{S*} = 1237.5,\ \Pi^{S*} = \pi_r^{S*} + \pi_s^{S*} = 2362.5.$$

(2) In model C, the optimal results are: $(x_s^{C*}, Q_r^{C*}, Q_r^{C*}) = (11.25, 77.5, 225)$. The optimal profit of the supply chain is $\prod^{C*} = 4612.5$.

It's not hard to verify: $x_s^{S*} \le x_s^{C*},\ p_r^{S*} \ge p_r^{C*},\ Q_r^{S*} \le Q_r^{C*},\ \Pi^{S*} \le \Pi^{C*}$

(3) If the revenue and cost sharing contract is used, when the share of retailer and the supplier are γ and $1-\gamma$, the producer will offer wholesale price: $\omega = \gamma(v - kx) - (1-\gamma)c_r = \gamma(55 - 2x) - 25$. The profits of the processor, producer and supply chain are:

$$\pi_r = \gamma(p - 55 + 2x)(500 - 5p + 10x) - \gamma(450 + 80x^2),$$

$$\pi_s = (1-\gamma)(p - 55 + 2x)(500 - 5p + 10x) - (1-\gamma)(450 + 80x^2),$$

$$\Pi^C = (p - 55 + 2x)(500 - 5p + 10x) - (45 + 80x^2).$$

It's not hard to infer: $\pi_r = \gamma\Pi^C, \pi_s = (1-\gamma)\Pi^C$.

When γ satisfies $0.24 \le \gamma \le 0.73$, the profits of the processor and producer satisfy: $\pi_r \ge \pi_r^{S*}$, $\pi_s \ge \pi_s^{S*}$. The processor and the producer will both have incentive to accept the revenue and cost sharing contract.

79.7 Conclusion

In this paper, a two-echelon supply chain under contract farming and model a bilateral monopoly between a single agricultural producer and a single processor is proposed. The demand of market is influenced by the retail price and the level of low carbon technology. The optimal solution in a supply chain is studied in the model of Stackelberg game and centrally coordinated system. In the Stackelberg game model, the low-carbon technology, order quantity of the processor and the total profit of supply chain are all smaller than that in centrally coordinated system. Then revenue and cost sharing contract is designed to coordinate the supply chain. The processor and the producer both have incentive to accept the revenue and cost sharing contract with proper conditions.

We have made a number of assumptions that must be relaxed in future research to develop a more comprehensive understanding of low carbon agricultural supply chain under contract farming. This paper is based on a perfect information game model. The asymmetry case will be considered in the future research.

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Chapter 80
Logistics Financial Innovation Mode Analysis in the Low-Carbon Economy: Based on Comparative Analysis Between the Logistics Enterprise and the Professional Market

ZeBin Wang

Abstract Logistics finance is a financial innovation business which just rise in recent years. Through the introduction of the third party logistics enterprise, it thus sets up the financing bridge between the banks and enterprises. But its business model has not yet have perfect and unified standard. In modern society a low carbon economy is energetically advocated, and how to realize low carbon and sustainable development of logistics finance has become a problem which logistics enterprise and financial institutions need to think of. This article is based on analysis of the basic operation mode of logistics finance, compares advantage differences between professional market and logistics enterprises, puts forward innovation mode of future development of logistics finance in low carbon economy, through using the results of logistics financial innovation mode which was carried out by Wujiang Oriental silk exchange.

Keywords Low-carbon economy · Logistics finance · Logistics enterprises · Professional market

Since the Copenhagen climate conference put forward "low carbon" concept in 2009, "low carbon" becomes a hot topic for a time. A low carbon economy is to point to lower high-carbon energy consumption, to improve economic efficiency, and eventually to achieve win–win economic development form of social development and environmental protection through the technology and system innovation, the industrial upgrading and transformation means under the guidance of the concept of sustainable development.

In the whole production, circulation, consumption and supply link, logistics enterprises become intersection of Information flow and logistics on supply chain,

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based on that logistics enterprises are the most effective partners when banks promote supply chain financing business, logistics finance emerges as a value-added derivative service which results from cooperation of logistics enterprise and financial institutions cooperation. As a kind of low carbon and effective financial innovation service, logistics finance changes traditional credit mode for a single subject of bank, make full use of the supply chain structure characteristics and its detail hold of goods, provide financing facilities to small and medium-sized enterprises in the up steam and down steam of a core enterprise, adapt to the trend of the development of industrial economy, realize multi-win–win situation of the financing enterprise, financial institutions and the third party logistics.

80.1 The Basic Operations of Logistics Financing Mode

According to the classification of Shenzhen Development Bank (SDB)[1] and self-liquidating trade financing basic products which are contained in enterprise financing, from the dimension of the difference of risk control system and orientation of solution to the problem, logistics financial business model can be classified into receivable accounts financing, advance payment financing and inventory financing three kinds.

Among them, accounts receivable and inventory is the international widely accepted financing products. That they are used for financing has a mature legal framework and practical basis; while the advance payment financing can be regarded as "future inventory financing", the risk control technology on it mainly reflects in control on the transition from supplier's delivery of the right to actual chattel.

Warehouse receipt pledge belongs to inventory financing mode, also called finance-transportation mode, which refers to a kind of financial innovation business model that enterprises in financing stowed special goods or raw materials in the purchase and sales process as pledges in the bank designated third party logistics enterprise and make a short-term loan with the evaluation certificates issued by the third party logistics. If the producers or trade enterprise can't repay the loan inside loan time limit, the bank or the third party logistics has the right to auction the goods to compensate for the loan principal and interest in the market. Its basic business process is shown in Fig. 80.1.

Warehouse receipt pledge business changes the traditional bank credit extension mode, mainly examine whether enterprises have stable inventory, any long-term cooperation deal and comprehensive operating conditions of the entire supply chain object, and uses the result as an important basis for credit extension decision-making, at the same time introduces the third party logistics, which is responsible for the pledge acceptance, value evaluation and supervision, and accordingly issue proof documents to banks, assists them assess and control risk.

[1] The Supply Chain Finance (2009).

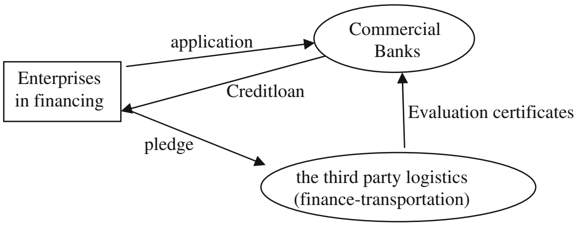

Fig. 80.1 Warehouse receipts pledge of the business process diagrams

80.2 Analysis of Third-Party Logistics Enterprises

It can be seen from the mode of operation of the Logistics and Finance that third-party logistics enterprises play an important role in the entire credit process. However, current situation of China logistics and financial business shows there are still many problems and constraints in logistics and financial services market.

At present, three levels of logistics enterprises exist in China. First is the logistics leader in the field, including three large state-owned logistics companies: Sinotrans, COSCO and Materials Storage and Transportation. These companies' business covers a wide range and they established professional warehousing regulatory team, besides, they have strong financial superiority and solvency; Second is the regional medium-sized logistics such as Guangdong South silos and Zhejiang Materials Industry Group, these companies have rapid market response and comprehensive regulatory system, which brings them a business advantage in regional market, while, financial strength of these companies is relatively weak compared with the large-scale logistics enterprises; The last level is a number of small and medium-sized logistics enterprises, mainly includes private logistic enterprises, they have flexible operation while weak financial support and poor normative and professional internal management.

Although professional management of the logistics in corporate governance and information has been improved, they still lack the ability of customer screening, collateral valuation and future price volatility trend analysis. Banks' most concerned issue is the credit status of the client companies and storage of the collateral value while dealing with logistics finance business. Thus, it requires the logistics to fully grasp information of client enterprise, and also have high capabilities of risk control and management on assessing quality and value of the collateral. However, logistics enterprises which have business of logistics financial keep purely business relationship with client companies, without fully grasping their credit information. At the same time, they are also lacking of full and dynamic logistics information, goods inventory management ability, cost control and supply chain solutions design capacity; what's more, they do not have in-depth study of the collateral valuation and price volatility changes. These aspects of the logistics enterprises defect, making it can not meet the bank customer credit recognition and management requirements of the collateral risk on price fluctuations.

It is for these considerations, logistics financial innovation model based on the professional market can well make up for the professional shortcomings of logistics companies, and push logistics financial business to further deepen the development.

80.3 Logistics Financial Innovation Model Based on Professional Market

80.3.1 Overview of Professional Market Development in China

Unlike the department store retail mall, the professional market, which specifically refers to those places are in the business of operating a specific category goods. There is a wide range of professional market in China. From the business products, containing both consumer goods such as clothing, commodity, building materials, and industrial raw materials such as steel, cloth, medicine; From function of the professional market, professional market can be divided into three different categories, including Sales-based professional market, Origin-based professional market and distribution-based professional market.

In recent China, the professional market is developing rapidly, and the transactions have been expanding. At present, the number of professional markets with turnover more than RMB100 million has been more than 300. Among them, the annual turnover of the Yiwu Small Commodity Market, Shaoxing Textile City and Wujiang China Eastern Silk Market have exceeded RMB30 billion, radiation covering most provinces and cities, and as far as Southeast Asia, Europe and other overseas markets. As China's largest textile industrial base, Shengze Oriental Silk Exchange take advantages of Shengze region's excellent geographic and information superiority to try to carry out the warehouse receipt pledge logistics finance business. This logistics financial business innovation model based on the professional market represents the future trend of development of the financial supply chain.

80.3.2 Overview of Oriental Silk Exchange's Logistics Financial Business

The 2008 global financial crisis has led to the shrinking demand of international textile market, domestic textile product exports were down, textile manufacturers in Shengze area have encountered great difficulties and lower prices, many small and medium textile enterprises have limited production, a small number of enterprises were in deeper difficulties for the shortage of funds makes. Against such a background, to support the development of the small and medium textile enterprises in Shengze area, Oriental market together with CITIC Bank (Suzhou Branch), launching the warehouse receipt pledge business in the Oriental market's Oriental Silk Market Exchange in May 2009. As of August 2010, Oriental market has a total of 94 pen warehouse receipts pledge business, raising more than 22,000 million for more than 30 textile companies in Shengze area, which has opened up new financing channels for enterprises.

As a professional market, Oriental Silk Exchange participates in the logistics financial business as a third party status. Oriental Silk Exchange is responsible for the collateral acceptance, value assessment and supervision, and accordingly issued to the bank documents, to help banks do better assessment and risk management, set up a finance bridge between the banks and enterprises. Different from general logistics enterprises, oriental Silk Exchange is not only responsible for transport regulation, but also use of their information advantages to provide the industry price index, which is used as a good tool for predicting the collateral price volatility.

80.4 The Comparison Between Traditional Logistics Enterprises and Professional Market

Through in-depth the analysis of the business of warehouse receipt hypothecation in Wujiang Oriental silk market known that, the logistics business model based on the professional market are more advantageous than the logistics enterprise based on simple business model, and can more highlight the low carbon economy advantages.

80.4.1 Professional Advantages

The professional market compared with logistics enterprises, its biggest advantage is professionalization. When logistics enterprises as the third party of logistics financing, it will evaluate the pledge only according to the requirements of the agreement, and issue the warehouse receipt, and supervision in the subsequent process. However, the professional market has a more in-depth understanding in not only the supervision of goods, value evaluation and circulation of the dynamic, which makes up of defects of the bank to the pledge control degree, but also can use its concentrated advantage of industrial clusters, to in-depth understand the financing enterprise and the pledge in the industry, which largely reduces the information asymmetry between enterprises and banks.

First, financing enterprises propose loan application requirements to the bank in the business of warehouse receipt hypothecation in Oriental Silk market. Banks realize qualification status, the pledge and the stability state of the whole industry chain of customers through the exchange, to decide whether to loan, and to clear the customer firstly should be a member of the exchange, so it greatly reduces the information asymmetry between banks and enterprises, reduces the moral risk; Second, if customers are raw materials agents, distributors, and so on, who have big sales and operational stability, sales good reputation in the industry, this guarantees that the loan will repay in time. Banks can reduce the collection costs and transaction costs of the credit information through the cooperation with exchanges and chain enterprises. Thus, it will arise the enthusiasm of bank lending.

80.4.2 Information Advantages

The formation of the professional market depends on that many enterprises of the industry group are together, therefore the concentration degree of the information is very high, this is logistics enterprise could not be compared. Different from common logistics enterprises, the professional market is not only charge of the transportation supervision to the pledge, but also will use its information advantage, to prepare and provide industry price index, which provides good tools for forecasting the price fluctuation of the pledge and controlling the credit risk. Oriental silk exchange who are in the country's largest distribution center for textiles and the information of collection and release base in textile industry, firmly grasps the products market sales, quality testing and price trend of fluctuations of the textiles industry, and according to the information it has, made Chinese • ShengZe silk chemical fiber index, which is considered as the "vane", "barometer " in textile industry, and strengthen the information guide to textile industry. This creates the advantageous conditions for that the supply chain in the financial business provides the business of warehouse receipt hypothecation.

80.4.3 Risk Monitoring Advantages

The professional market is in the industrial clusters, which is sensitive to the character, quality and price fluctuations change of the pledge, they can tightly control quality level of the pledge when they carry out the business of warehouse receipt hypothecation, to ensure that the liquidity and cashability of the pledge are good in the market, in a certain extent, it controls the moral risk that the pledge enterprises use the bad exchange the good; meanwhile, it can help banks authorize loans and loan-to-value ratio according to the types of the mortgaged property and market price trend to reduce the bank credit risk; In addition, professional market are extremely sensitive to the price volatility trends of the pledge or the industry's commodity, in a follow-up supervision and value evaluation of the pledge, it can regularly know the price of the pledge changes from the market, and forecast the track of the price, strictly to control the value of the pledge downside to risk tipping point, to ensure the safety of the loan.

80.5 The Prospect of Logistics Financial Business Development

Through the analysis of the business of warehouse receipt hypothecation in the Oriental silk market found that, compared to the logistics enterprises, the professional market has the more unique advantage. Different from common logistics enterprise, the professional market is not only charge of the transportation supervision to the pledge, but also will use its information advantage to provide industry price index, which provides good tools for forecasting the price fluctuation of the pledge. Meanwhile, in Suzhou, for example, the region has formed a few mature professional market, such as likou in Xiangcheng area formed the relatively mature furniture market, Changshu clothing market, the Shengze textile market in Wu jiang, and so on, usually around these professional markets gathered a large number of supporting small and medium-sized enterprises, they often form deposit accounts, receivable, etc., with upstream and downstream enterprises, so they are in urgent need of financing facilities. As a professional market, can not only to evaluation inherent quality with professional eye, and can keep track of the price changes of the commodity, to form a reasonable and correct price trend projections. Therefore, if it is based on these professional markets to provide financial service supply chain for small and medium-sized enterprises, not only can easily control the risk, but also can provide the financing facilities of the related enterprise, revitalize the funds, and can further promote the prosperous development of the professional market, with broad development prospects.

Therefore, the logistics financial development model based on the professional market adapted in the low carbon economy development concept, which can be better to promote economic and social development. At the same time, along with the expansion of the size of the business of warehouse receipt hypothecation, banks can award some credit according to the size and operation ability of the third party professional market, the professional market by directly is in charge of the loan operation and risk management of financing enterprises, so, it can simplify the process, increase the supply chain operation efficiency of financing enterprise, and it also can transfer the credit risk of commercial bank and reduce operating costs. In addition, the bank should also further cooperate and innovate with the professional market, expand the type and scope of the pledge, or bring in the fourth party guarantee, to further improve enterprise credit rating; this makes further matting for the expansion of the financial business and the scale.

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Chapter 81
Order Decision with Random Demand: A Research from the Perspective of Carbon Emission Cap and Carbon Trade Mechanism

Weihua Liu, Wenchen Xie and Guowei Hua

Abstract This paper mainly discusses the impact of carbon emission cap-and-trade mechanism on the order decision-making with random demand. First, considering the random demand, carbon emission cap-and-trade, a single-cycle order model has been established. Then this model is solved and the optimal order quantity is put forward. Many interesting observations which are different from the order decision-making for stable demand are found out. The research shows that: a value range of carbon trading price exists; Carbon cap-and-trade mechanism can motivate the organizations to reduce carbon emission effectively; whether the company should buy carbon credits depends on the actual carbon emission and carbon emission cap; Reducing carbon emission doesn't necessarily lead to high cost.

Keywords Low carbon supply chain · Carbon emission cap and carbon trade mechanism · Random demand · Order decision model

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81.1 Introduction

Recently, as the low carbon economy gets more and more attention, scholars begin to focus on the study of low-carbon supply chain. On main aspect of the research is on the operations decisions, like joint production, products mix and process reengineering under carbon emission regulations (Ali and David 2009; Benjaafar et al. 2010; Sundarakani et al. 2010; Hua et al. 2011; Chen et al. 2011; El Saadany et al. 2011; Jaber et al. 2012; Bouchery et al. 2012; Carbontrust 2006; Ellerman and Buchner 2007; Pan et al. 2010). From the literature review mentioned above, we can see there are few studies on the impact of carbon emission cap and trade mechanism towards order decisions. This paper mainly studies how firms make order decisions under carbon emission cap and trade mechanism, facing random demand condition. In this paper, we compare our results with those of Hua et al. (2011). Considering more comprehensively, we use the total revenue of the retailers, rather than the total cost, as our objective function and also examine the impacts of carbon emission cap and trade mechanism on optimal order quantity, total cost, and total revenue and carbon emissions. Besides, we also examine the impacts of the variation of carbon emission cap or carbon price. We get many interesting conclusions.

81.2 Optimal Order Decision Model with Random Demand

81.2.1 Problem Description and Assumptions

In the carbon trading mechanism, a firm is allocated a limit or cap on carbon emissions. If its amount of carbon emissions exceeds the carbon emission cap, it can buy the right to emit extra carbon from the carbon trading market. Otherwise, it can sell its surplus carbon credit. Obviously, this market mechanism can unify environmental objective and economic objective. We build an order model under stochastic demand and derive the optimal order quantity, then examine the impacts of carbon trading on the optimal order, carbon emissions, total cost and total revenue.

We assume that the customer demand faced by retailers is random and retailers must be careful to make order decision because, on the one hand, if the order is excessive, the oversupply of inventory will cause unsalable cost; otherwise, if the order is in short of supply, there will be loss of profit opportunities. On the other hand, the excessive order quantities will lead to large amount of carbon emissions in inventory and transportation processes, which will eventually transform into the corresponding cost of carbon emissions. On the contrary, if the order quantity is small enough to leave some carbon credit, which can turn to income from the trade market. Considering this two aspects, we establish a retailer's order decision model under random demand condition.

In order to discuss the modeling process, we introduce the following assumptions: the retailer's order decision model is a single-cycle mode; the demand is a random and continuous variables and its probability distribution function is known; throughout the transportation process, the means of transportation doesn't change, which means that the carbon emissions during transportation are only influenced by the quantity of order, carbon emissions in the inventory have a positive correlation with the stock quantity; the shortage cost exists as if the order quantity is too small to satisfy the demand, profitable opportunities will lose. The notations involved in the model are shown as follows.

k is the purchase price per unit of goods; p is the sale price per unit of goods, D is the total demand of customer in an order cycle, D is a continuous random variable, C_1 is storage cost per unit of goods, C_2 is shortage cost per unit of goods, Q is order size in units (a decision variable) Q^* is optimal order size with carbon emission cap and carbon trade mechanism, Q^0 is optimal order size without carbon emission cap and carbon trade mechanism, α is carbon emission cap in an order cycle, C is carbon price per unit, X is traded quantity of carbon emissions (a decision variable); if X is positive, it means that there are X units of carbon emission can be sold by retailer; if X is negative, it means that the retailer needs to buy X units of carbon emissions quotas; $H(Q)$ is carbon emissions when the order quantity is Q in an order cycle, $H(Q*)$ is carbon emissions when the order quantity is Q^* in an order cycle, $H(Q^0)$ is carbon emissions when the order quantity is Q^0 in an order cycle, E_0 is Fixed carbon emissions in transportation process in an order cycle, e is carbon emissions per unit of goods in transportation process, $E(Q)$ is total carbon emissions caused by transportation in an order cycle, G_0 is fixed carbon emissions in inventory process in an order cycle, g is carbon emissions per unit of goods in inventory process, $G(Q)$ is total carbon emissions caused by inventory in an order cycle, $V(Q)$ is the gains or losses in carbon trading market in an order cycle, $M(Q)$ is total storage cost in an order cycle, $N(Q)$ is total shortage cost in an order cycle, $W(Q*)$ is total revenue when the order quantity is $Q*$ in an order cycle, $W(Q^0)$ is total revenue when the order quantity is Q^0 in an order cycle, $TC(Q*)$ is total cost when the order size is $Q*$ units in an order cycle, $TC(Q^0)$ is total cost when the order size is Q^0 units in an order cycle.

81.2.2 Model Building

When retailers make order decisions, they need to consider the following costs and benefits: sales revenue, purchase cost, storage cost, shortage cost and carbon emissions cost (or gains). We set that retailers make order decisions based on the maximum profit. So we consider all these costs and benefits in our model and through maximizing the gains to derive the optimal order quantity.

Total storage cost:

$$M(Q) = \begin{cases} C_1(Q - D), D \le Q \\ 0, D > Q \end{cases} \tag{81.1}$$

Total shortage cost:

$$N(Q) = \begin{cases} 0, D \le Q \\ C_2(D - Q), D > Q \end{cases} \tag{81.2}$$

The gains (or losses) in carbon trading market:

$$V(Q) = C[\alpha - G(Q) - E(Q)] = CX \tag{81.3}$$

In Eq. (81.3), total carbon emissions of transportation:

$$E(Q) = E_0 + eQ \tag{81.4}$$

In Eq. (81.3), total carbon emissions of inventory:

$$G(Q) = \begin{cases} G_0 + g(Q - D), D \le Q \\ G_0, D > Q \end{cases} \tag{81.5}$$

So, total amount of carbon credits traded:

$$X = \alpha - G(Q) - E(Q) \tag{81.6}$$

Joint Eq. (81.1) to Eq. (81.3), the total cost is:

$$TC(Q) = kQ + M(Q) + N(Q) - V(Q) \tag{81.7}$$

Total revenue $W(Q)$is:

$$\begin{aligned} W(Q) &= p.\min\,[D, Q] - TC(Q) \\ &= p.\min\,[D, Q] - kQ - M(Q) - N(Q) + V(Q) \end{aligned} \tag{81.8}$$

Thus, the retailer's order decision-making model under carbon emission cap and carbon trade mechanism is as follows:

$$\max\ W(Q) = p.\min\,[D, Q] - kQ - M(Q) - N(Q) + V(Q) \tag{81.9}$$

$$\text{s.t}\ X + E(Q) + G(Q) = \alpha \tag{81.10}$$

Maximize the expected revenue of Eq. (81.9) and it will get:

$$F(Q) = \int_0^Q \phi(D)dD = \frac{p + C_2 - k - Ce}{p + C_2 + C_1 + Cg} \tag{81.11}$$

If given the demand distribution function, we can get an exact number of order quantity ($Q*$) from Eq. (81.11) and this order quantity $Q*$ is the optimal order which can maximize the expected revenue.

Similarly, let $C = 0$, we can get Eq. (81.12) from Eq. (81.11):

$$F(Q) = \int_0^Q \phi(D)dD = \frac{p + C_2 - k}{p + C_2 + C_1} \quad (81.12)$$

From Eq. (81.12), similarly we can get another order quantity Q^0.

81.2.3 Optimal Order Quantity with Normal Distribution Demand

The normal distribution demand is a very common random demand describing customers' needs. Here we use such distribution in our model and derive the optimal order quantity. Set the customer demand obeys $D \sim N(\mu, \sigma^2)$. From Eq. (81.11), the probability of the optimal order quantity Q^* is:

$$Q^* = \mu + \sigma\Phi^{-1}\left(\frac{p + C_2 - k - Ce}{p + C_2 + C_1 + Cg} + 1 - \Phi\left(\frac{\mu}{\sigma}\right)\right) \quad (81.13)$$

Carbon emissions of $Q*$:

$$H(Q^*) = E_0 + G_0 + eQ^* + G(Q^*) \quad (81.14)$$

Similarly, we can get Q^0:

$$Q^0 = \mu + \sigma\Phi^{-1}\left(\frac{p + C_2 - k}{p + C_2 + C_1} + 1 - \Phi\left(\frac{\mu}{\sigma}\right)\right) \quad (81.15)$$

Carbon emissions of Q^0:

$$H(Q^0) = E_0 + G_0 + eQ^0 + G(Q^0) \quad (81.16)$$

81.3 The Impacts of Carbon Emission Cap and Carbon Trade Mechanism

81.3.1 Optimal Order Quantity with Normal Distribution Demand

Even though the carbon emission cap-and-trade has been widely recognized, in reality its impact on order decision is not quite clear. In this subsection, we will examine the impacts of carbon emission cap-and-trade on order quantity, total cost, and total revenue and carbon emissions.

Theorem 1 *In carbon emission cap-and-trade system, when* $C > 0,\ Q^* < Q^0$ *and carbon emissions can be reduced.*

Theorem 1 shows that the carbon emission cap-and-trade system truly reduces carbon emissions and that's why this mechanism is so popular around the world. Carbon emission cap-and-trade mechanism reflects carbon emissions into costs and benefits system, which encourages enterprises to reduce carbon emissions.

Theorem 2 *Carbon emission cap-and-trade mechanism may result in the increase of the total revenue of retailer, may also result in the loss of it, which depends on the size relationship between carbon trading price C and other parameters, specified as follows:*

1. *if* $\alpha - G_0 - E_0 - grQ^* - eQ^* < 0,$ *then*

$$\text{when } C > \frac{(k + C_1 r)(Q^* - Q^0)}{[\alpha - G_0 - E_0 - grQ^* - eQ^*]},\ E[W(Q*)] < E\left[W\left(Q^0\right)\right];$$

$$\text{when } C < \frac{(k + C_1 r)(Q^* - Q^0)}{[\alpha - G_0 - E_0 - grQ^* - eQ^*]}, E[W(Q*)] > E\left[W\left(Q^0\right)\right]$$

2. *if* $\alpha - G_0 - E_0 - grQ^* - eQ^* > 0,$ *then* $E[W(Q*)] > E\left[W\left(Q^0\right)\right]$

Theorem 2 shows that whether the total revenue increase or not depends on carbon emission cap and carbon price. When $\alpha \geq \alpha_0 = G_0 + E_0 + grQ^* + eQ^*$ or $0 < C \leq C_0$, the carbon emission cap-and-trade mechanism can increase the total revenue $\left(C_0 = \frac{(k+C_1 r)\left(Q^* - Q^0\right)}{[\alpha - G_0 - E_0 - grQ^* - eQ^*]}\right)$.

Theorem 3 *Carbon emission cap-and-trade mechanism may result in the increase of the total cost, may also result in the reduction of it, which depends on the size relationship between carbon trading price C and other parameters, specified as follows:*

1. *if* $\alpha > G_0 - E_0 - eQ^* - grQ^*,$ *then* $TC(Q^*) < TC\left(Q^0\right)$

2. *if* $\alpha < G_0 - E_0 - eQ^* - grQ^*,$ *then*

$$when\ C < \frac{(K + C_1 r)(Q^* - Q^0)}{[\alpha - G_0 - E_0 - eQ^* - grQ^*]},\ TC(Q^*) < TC(Q^0),$$
$$when\ C > \frac{(K + C_1 r)(Q^* - Q^0)}{[\alpha - G_0 - E_0 - eQ^* - grQ^*]},\ TC(Q^*) > TC(Q^0)$$

Theorem 3 shows that whether the total cost decrease or not depends on carbon emission cap and carbon price. When $\alpha \geq \alpha_0 = G_0 + E_0 + grQ^* + eQ^*$ or $0 < C \leq C_0$, the cap-and-trade mechanism can decrease the total cost $\left(C_0 = \frac{(k+C_1 r)(Q^* - Q^0)}{[\alpha - G_0 - E_0 - grQ^* - eQ^*]}\right)$. Thus, government can adjust the size relationship between carbon emission cap and carbon price through macro-control to encourage companies reduce carbon emission, at the same time, increasing their revenues and reducing costs.

Theorem 4 *There exists a threshold*
α_0, $\alpha_0 = E_0 + e\left[\mu + \sigma\Phi^{-1}\left(\frac{p + C_2 - k - Ce}{p + C_2 + C_1 + Cg} + 1 - \Phi(\frac{\mu}{\sigma})\right)\right] + G_0 + G(Q*)$

1. *If $\alpha < \alpha_0$, then the retailer should buy $(\alpha_0 - \alpha)$ units of carbon credit;*
2. *If $\alpha > \alpha_0$, then the retailer should sell $(\alpha - \alpha_0)$ units of carbon credit;*
3. *If $\alpha = \alpha_0$, then the retailer should neither buy nor sell carbon credit.*

Theorem 4 shows that whether the retailer should sell or buy carbon credit depends on the carbon emission cap. When the cap is lower than the threshold, he should sell carbon credit; when the cap is higher than the threshold, he should buy carbon credit; and the transfer quantity is between the cap and the threshold. Otherwise, he should neither sell nor buy carbon credit.

81.3.2 The Impacts of Carbon Emission Cap and Carbon Price on Order Decision

Theorem 5 *Given a fixed carbon price C and C will not be affected by the carbon emission cap α, if α decrease, then the order size $Q*$ and carbon emission $H(Q*)$ remain no change; the transfer quantity X decreases and the total cost $TC(Q*)$ increases, meanwhile, the total revenue $W(Q^*)$ decreases.*

Theorem 5 is the same as Hua et al. (2011), which implies that carbon emission cap does not affect the retailer's order decision if C is not be affected by α. Since the optimal order quantity is decided by the carbon price, rather than the carbon emission cap. Theorem 6 is intuitive: with less carbon emission cap, the retailer has less carbon credit to sell $(X > 0)$, or has to buy more carbon credit $(X < 0)$, which of course increase the total cost and decrease the total revenue.

Theorem 6 *If the carbon price is a decreasing function of the retailer's carbon emission cap, that is* $C = C(\alpha),\ C'(\alpha) < 0$*, then*

When the carbon emission cap increases, the order quantity and carbon emissions will increase; When the carbon emission cap decreases, the order quantity and carbon emissions will decrease;

Theorem 6 shows that if the carbon price is connected with carbon emission cap, that is when the cap increases, the price decreases; when the cap decreases, the price increases. The carbon emission cap can influence order decision and carbon emissions through the change of carbon price.

Theorem 7 *Given a fixed carbon emission cap* α *and it will not affected by the carbon price C, then when C increases, the order quantity* Q^* *and carbon emission* $H(Q*)$ *decrease. When C decreases, the order quantity* Q^* *and carbon emission* $H(Q*)$ *increase.*

From Theorem 7, it can be learned that if the carbon emission cap α is fixed, the government can encourage retailers to reduce carbon emissions or increase order quantity through the change of carbon price. But the total cost may increase or the total revenue may decrease at the same time. So the government should consider all aspects and issue proper policies.

81.4 Conclusions

This paper studied how the firms should make order decision with random demand under the carbon emission cap-and-trade mechanism, compared the optimal quantity with conventional order quantity, and examined the impacts of carbon emission cap and trade mechanism on order quantity, total cost, total revenue and carbon emissions.

We found that the cap-and-trade mechanism will make retailers to order less quantity and encourage them to reduce carbon emissions. Besides, the mechanism may result in an increase of total cost or a decrease of total revenue under some conditions. However, the mechanism may result in a decrease of total cost, an increase of total revenue and a reduction of carbon emission simultaneously under other conditions. Moreover, the carbon price should have a value range, which can't be too large to inhibit the normal business activities or too small to have effects on the reduction of carbon emissions.

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Chapter 82
Evaluation of Low Carbon Inventory Control Policy for Creative Products in Hybrid Distributing Channels

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Abstract In this paper we consider a low-carbon inventory control policy planned for creative products sold in hybrid channels, where there is vertical and horizontal competition. We set up a tow-echelon base-stock model and under the assumption of demand transfer we analyze competitive stocking decisions with manufacture and retailer using base-stock inventory control policy. By numerical experiments, we analyze the impact of demand uncertainty and competition factor on manufacturer and retailer's stocking decision variables and the corresponding performance. Finally we conclude the management enlightenments.

Keywords Low carbon · Hybrid distribution channels · Inventory competition · Demand transfer · Base-stock

82.1 Introduction

More and more enterprises distribute products not only through traditional sales channel but also through internet channel which raises challenges for supply chain management. Creative products are the main ones sold in hybrid channels which

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have the characteristics of short life cycle and big demand fluctuation leading to the results of more inventory and product waste. For the products we consider a low-carbon inventory policy in which the manufacture and retailer both use base-stock replenishment policy which means they all maintain the inventory in base-stock level and each demand triggers a separate order. Base-stock policy can make the decision maker keep the service level at the same time control inventory cost.

Chiang and Monaha (2005) conceive of a two-echelon hybrid channels system, where the manufacture and the retailer all use base-stock policy but they suppose the centralized control policy in supply chain. Aydin and Christopher (2005) set up two series hybrid channels system with many hubs and selling points to decide the order and allocation policy in the hope of the lease distribution cost. Although they conclude the optimal base-stock level they still describe centralized control policy. As to hybrid channels problem there are many research on vertical and horizontal competition (Gabrielsson et al. 2002; Boyaci 2005; Parlar 1988).

82.2 Probleom Formulation

We impose the following assumptions in the model:

Each distribution channel has demand and holds inventory. Product in each channel is same and when one channel is out of stock part of customers transfer the other channel. We use $\beta_m (0 \le \beta_m < 1)$to stand for the rate from the direct to the traditional channel and $\beta_r (0 \le \beta_r < 1)$ the one from the traditional channel to the direct channel. After considering demand transfer other stock-out is conceived of delay. The manufacture and the retailer both use continuous check policy and the base-stock level are S_m and S_r respectively. Suppose $IN_m(0) = I_m(0) = IP_m(0^-) = S_m$ and $IN_r(0) = I_r(0) = IP_r(0^-) = S_r$. So the demands in direct channel and traditional channel are $D_m = \tilde{D}_m + \beta_r \left(\tilde{D}_r - S_r\right)^+$ and $D_r = \tilde{D}_r + \beta_m \left(\tilde{D}_m - S_m\right)^+$ of which $\tilde{D}_m$ and $\tilde{D}_r$are basic demand and they are independent. See Fig. 82.1.

L_m and L_r represent the replenishment lead time of manufacture and retailer and we assume they are all constant. The other parameters are $x =$ the basic demand for manufacture in lead time, $f(x) =$ manufacture's probability density function for demand in lead time, $F(x) =$ manufacture's probability − distribution function for

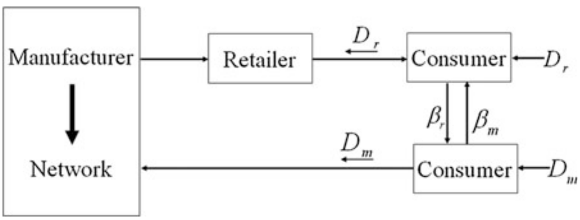


Fig. 82.1 Two-echelon hybrid distribution channel supply chain

demand in lead time, μ_x = manufacture's expected value for demand in lead time, δ_x = manufacture's standard deviation for demand in lead time, y = the basic demand of retailer in lead time, $g(y)$ = retailer's probability density function for demand in lead time, $G(y)$ = retailer's probability – distribution function for demand in lead time; μ_y = retailer's expected value for demand in lead time, δ_y = retailer's standard deviation for demand in lead time, h_m = manufacture's stock expense in unit time for one product, h_r = retailer's stock expense in unit time for one product, b_m = manufacture's stock – out loss in unit time for one product, b_r = retailer's stock – out loss in unit time for one product, $I(S_m)$ = manufacture's average quantity in stock level, $I(S_r)$ = retailer's average quantity in stock level, $B(S_m)$ = manufacture's average stock-out level, $B(S_r)$ = retailer's average stock-out level, $C_m(S_m)$ = manufacturer's average total cost, $C_r(S_r)$ = retailer's average total cots, TC = expected total cost of the supply chain in the whole hybrid channels.

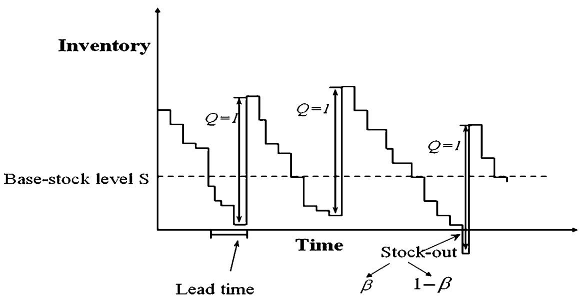
The target in the model is to obtain the optimal base-stock level: S_m and S_r. See Fig. 82.2.

82.3 Two-Echelon Base-Stock Model

According to the above assumptions we can get the average total costs of manufacturer and retailer:

$$\begin{aligned} C_m(S_m) &= h_m I(S_m) + b_m B(S_m) = h_m\left[E(S_m - D_m)^+\right] + b_m\left[E(D_m - S_m)^+\right] \\ &= h_m\left[\int_0^{S_r}\int_0^{S_m}(S_m - x)f(x)g(y)dxdy + \int_{S_r}^{S_r+S_m/\beta_r}\int_0^{S_m-\beta_r(y-S_r)}\left[S_m - x - \beta_r(y - S_r)\right]f(x)g(y)dxdy\right] \\ &\quad + b_m\left[\int_{S_r}^{\infty}\int_{S_m}^{\infty}(x - S_m)f(x)g(y)dxdy + \int_0^{S_r-\beta_m(x-S_m)}\int_{S_m}^{S_m+S_r/\beta_m}\left[x - \beta_m(x - S_m) - S_m\right]f(x)g(y)dxdy\right] \end{aligned} \quad (82.1)$$

Fig. 82.2 Base-stock order policy



$$\begin{aligned} C_r(S_r) =& h_r I(S_r) + b_r B(S_r) = h_r\left[E(S_r - D_r)^+\right] + b_r\left[E(D_r - S_r)^+\right] \\ =& h_r\left[\int_0^{S_m}\int_0^{S_r}(S_r - y)g(y)f(x)dydx + \int_{S_m}^{S_m+S_r/\beta_m}\int_0^{S_r-\beta_m(x-S_m)}[S_r - y - \beta_m(x - S_m)]g(y)f(x)dydx\right] \\ &+ b_r\left[\int_{S_m}^{\infty}\int_{S_r}^{\infty}(y - S_r)g(y)f(x)dydx + \int_0^{S_m-\beta_r(y-S_r)}\int_{S_r}^{S_r+S_m/\beta_r}[y - \beta_r(y - S_r) - S_r]\,g(y)f(x)dydx\right] \end{aligned} \tag{82.2}$$

So we can have the inventory model of two-echelon mixed channels supply chain:

$$C = C_m(S_m) + C_r(S_r) \tag{82.3}$$

Under some terms we can prove that $C(S_m)$ is convex function of S_m so there must be exist the optimal S_m^* which make $C(S_m)$ the least. So is the same with C_r to S_r.

We can get the first order condition:

$$\begin{aligned} \frac{\partial C_m}{\partial S_m} &= -b_m + (h_m + b_m)\frac{\partial E\left[(S_m - x)^+\right]}{\partial S_m} \\ &= h_m\left(\frac{\partial A}{\partial S_m} + \frac{\partial B}{\partial S_m}\right) + b_m\left(\frac{\partial \tilde{A}}{\partial S_m} + \frac{\partial \tilde{B}}{\partial S_m}\right) = 0 \end{aligned} \tag{82.4}$$

$$\frac{\partial C_r}{\partial S_r} = -b_r + (h_r + b_r)\frac{\partial E\left[(S_r - y)^+\right]}{\partial S_r} = h_r\left(\frac{\partial E}{\partial S_r} + \frac{\partial F}{\partial S_r}\right) + b_r\left(\frac{\partial \tilde{E}}{\partial S_r} + \frac{\partial \tilde{F}}{\partial S_r}\right) = 0 \tag{82.5}$$

From the above equation we can obtain the optimal base-stock levels for the manufacturer and the retailer under decentralized control condition:

$$S_{dm}^* = \arg^{-1}[\min(C_m)] \tag{82.6}$$

$$S_{dr}^* = \arg^{-1}[\min(C_r)] \tag{82.7}$$

82.4 Numerical Examples

Because of the complex form for the model we can not get the specific analytic formula of optimal decision variables so by the MATLAB software we conduct computational experiments to analyze the economic problem of two-echelon hybrid channels. We suppose demands of direct and traditional channels subject to uniform distribution and which is in a large scope. Because of the close power of manufacture and retailer in reality so we consider their inventory holding cost is

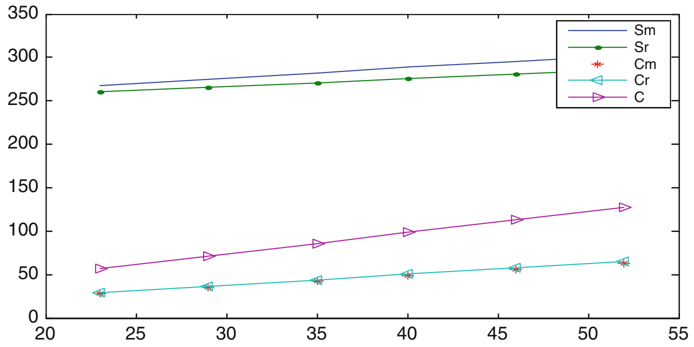


Fig. 82.3 Effect on performance of demand uncertainty

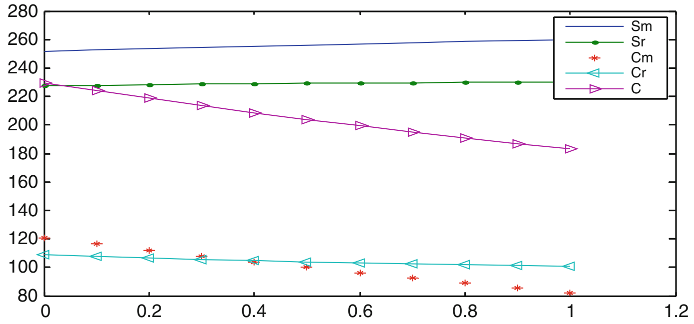


Fig. 82.4 Effect on performance of demand transfer

same and owing to holding the production cost the stock-out cost of manufacture is higher the that of retailer which is common assumption.

In order to study the effects of demand Uncertainty on performance of the manufacture and retailer we set section [200, 280] as the demand's primary value area and 20 as step size to increase the demand value area which means to increase the variance of the demand so we can get the corresponding performance which is shown in Fig. 82.3, of which $\beta_m = \beta_r = 0.5,\ h_m = h_r = 1,\ b_m = 5,\ b_r = 3$.

In order to study the effect of competition on the performance of manufacture and retailer we suppose [10, 300] as the demand's primary value area and 0.1 as step size to increase the demand transfer and get the result shown in Fig. 82.4.

From the experiments carried out the following observation are made:

Firstly with the demand uncertainty increasing both the manufacture and the retailer are tend to enhance the base-stock level so the performance of each of them decreases. Therefore to take some measures to decrease the demand uncertainty is common task of the whole supply chain and the coordination between manufacture and retailer in inventory control is more significant.

Secondly, increasing the rate of demand transfer has the direct effects on the optimal stock level of the manufacture and retailer, which is that because of competing on the limited customers increasing the demand transfer leads to the decision makers to enhance their base-stock level. But because the degree of decreasing average stock-out of manufacture is higher than that of retailer the average total cost of manufacture has higher speed of decreasing, which leads to better performance for manufacture than retailer. The above results show that in hybrid channels the manufacture is more flexible in controlling inventory than the retailer so if they carry out the joint policy to some extent the total inventory level will be decreasing.

Finally, compared to the state without demand transfer although both the manufacture and retailer have lower base-stock level the stock-out cost increases correspondingly so the equilibrium cost increases. Therefore we can conclude that in hybrid channel supply chain when the node enterprises use base-stock replenishment policy proper degree competition can have positive incentive effects.

82.5 Summary and Outlook

In this paper we make use of queuing system and inventory theory to set up two-echelon hybrid channels supply chain model to study the performance of the manufacture and retailer who both use base-stock replenishment policy. We prove the convex of the model to guarantee the existing of the optimal solution. Considering the complexity of the model we conduct numerical examples to study the competing stock problem and get the results that demand uncertainty and degree of competition can have obvious effects on stock capacity and order decision so impact on the performances of the node enterprises and the whole supply chain.

Of course there are several areas for further research on this topic such as the design of sharing policy between node enterprises and the influence of the demand substitution and the modification of the model involving arbitrary continuous or discrete distributions of demand.

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Chapter 83
Analysis of Cooperative Game in Low Carbon Supply Chain

Xiao-dong Zhang, Zhan-feng Zhu and Chun-rong Guo

Abstract In this paper we first consider the content and the importance of cooperation in low carbon supply chain and then set up cooperative game model to analyze the equilibrium policy. On the base of the above analysis we provide some advice to promote cooperating of low carbon.

Keywords Low-carbon · Supply chain · Cooperation · Game

83.1 Introduction

The modern competition is no longer the one among the firms, but the one among the supply chains. With the springing up of economy more and more problems arose, such as climatic anomaly, environmental pollution and resource crisis. Braithwaite and Knivett (2009) consider that the realistic difficulties make people to reconsider how to deal with such problems and the corresponding concepts of low carbon life, low carbon technology, low carbon production, low carbon logistics and low carbon economy have crept up the relevant agenda constantly. Friedman (1991) believes that based on the needs of survival and development

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enterprises have to carry out the development mode of low carbon and low carbon supply chain should be constructed actively between enterprises to deal with new competitive pattern. Therefore those enterprises with long development aim begin to make constructing low carbon supply chain as their development target.

83.2 Cooperation in Low Carbon Supply Chain

Nelson (1995) conceives of low carbon supply chain is the closed circular function structure consisted of supplier, manufacture, distributor, retailer, end customer and recycler, which integrates into the thinking of low carbon and environmental protection. By the methods of planning, organizing, coordinating and controlling efficiently of information flow, logistics, capital flow and product flow the enterprises can operate in virtuous circle of low emission, low pollution and low energy consumption in the whole process, See Fig. 83.1.

What needed by low carbon supply chain is not only that the central enterprise can operate effectively in low carbon state but also that the upstream and the downstream enterprises can form dynamic alliance closely so as to expand the thinking of low carbon all through the whole supply chain and then enhance the performances of node enterprises in supply chain and shorten the response time of supply chain therefore implement the target of low emission, low pollution, low energy consumption and effectiveness in the whole product cycle. Sundarakani (2010) believes that only by the implementation of low carbon in supply chain can low carbon logistics be realized actually and propel the development of low carbon economy, of which the cooperation between enterprises is the utmost important, therefore only the enterprises in the supply chain are willing to join in the alliance and endeavor to build it can realize the operation of low carbon supply chain efficiently.

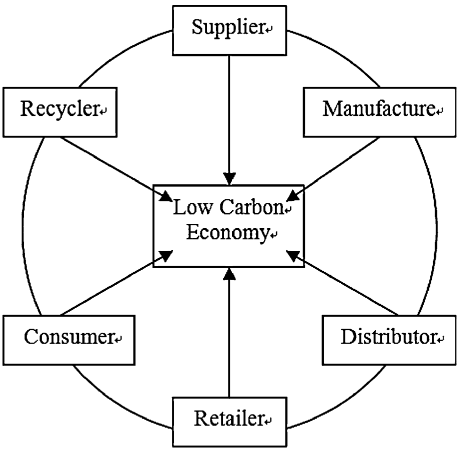

Fig. 83.1 Cooperation in low carbon supply chain

83.3 Analysis of Cooperative Game in Low Carbon Supply Chain

83.3.1 Cooperative Game Model in Low Carbon Supply Chain

Suppose there are only two enterprises of 1 and 2, which is common assumption in research, when they do not implement the strategy of constructing low carbon supply chain the revenues of them are R_1 and R_2. The total increasing gain of cooperating to built low carbon is R and ω_1 and ω_2 are revenue-sharing coefficient of enterprises 1 and 2, of which $\omega_1 + \omega_2 = 1$. The costs of the two enterprises are C_1 and C_2 under the terms of without carrying out the strategy of low carbon supply chain. The other assumptions in the model are imposed as following: b_1 and b_2 are the behaviors expended by enterprise 1 and 2 in order to build low carbon supply chain cooperatively, δ_1 and δ_2 are creative cost coefficients of enterprise 1 and 2 in the technology innovation and equipment upgrade when they carry out the policy of cooperation in low carbon supply chain, of which the cost of cooperation is increasing with the effort degree of the above behavior enhancing, so the corresponding costs are individually:

$$C(b_1) = C_1 + {}^1\!/_2\delta_1 b_1^2 \qquad C(b_2) = C_2 + {}^1\!/_2\delta_2 b_2^2$$

The revenues of building cooperatively low carbon supply chain are as following separately:

$$R(b_1) = R_1 + \omega_1 R - C_1 - {}^1\!/_2\delta_1 b_1^2 \quad R(b_2) = R_2 + \omega_2 R - C_1 - {}^1\!/_2\delta_2 b_2^2$$

Only under the guarantee of positive increasing revenue is there basic incentive role to motivate enterprises to construct low carbon supply chain cooperatively so:

$$\omega_1 R - C_1 - {}^1\!/_2\delta_1 b_1^2 \geq 0 \quad \omega_2 R - C_2 - {}^1\!/_2\delta_2 b_2^2 \geq 0$$

Suppose the probability of enterprise 1 in choosing to cooperate in constructing low carbon supply chain is p_1 and then the probability of not to cooperate is $1 - p_1$. The corresponding probabilities of enterprise 2 is p_2 and $1 - p_2$.

On the base of the above assumptions we can set up the cooperative game model in low carbon supply chain and the policies enterprise 1 and 2 choose are: 'cooperation' and 'non-cooperation', as to the game payoff matrix see Table 83.1.

The revenues for enterprise 1 of selection of 'cooperation in constructing low carbon supply chain' and 'non-cooperation in constructing low carbon supply chain' are R_{11} and R_{10} separately.

Table 83.1 The cooperative game in low carbon supply chain

		Enterprise 2	
		Cooperation	Non-cooperation
Enterprise 1	Cooperation	$R_1 + \omega_1 R - C_1 - 1/2\delta_1 b_1^2$ $R_2 + \omega_2 R - C_2 - 1/2\delta_2 b_2^2$	$R_1 - C_1 - 1/2\delta_1 b_1^2$ $R_2 - C_2$
	Non-cooperation	$R_1 - C_1$ $R_2 - C_2 - 1/2\delta_2 b_2^2$	$R_1 - C_1$ $R_2 - C_2$

$$\begin{aligned} R_{11} &= p_2 + \left(R_1 + \omega_1 R - C_1 - {}^1\!/\!_2\delta_1 b_1^2\right) + (1 - p_2)\left(R_1 - C_1 - {}^1\!/\!_2\delta_1 b_1^2\right) \\ &= p_2\omega_1 R + R_1 - C_1 - {}^1\!/\!_2\delta_1 b_1^2 \\ R_{10} &= p_2(R_1 - C_1) + (1 - p_2)(R_1 - C)_1 = R_1 - C_1 \end{aligned}$$

Then the average revenue of enterprise 1 is:

$$\begin{aligned} \bar{R}_1 &= p_1 R_{11} + (1 - p_1)R_{10} = p_1\left(p_2\omega_1 R + R_1 - C_1 - {}^1\!/\!_2\delta_1 b_1^2\right) + (1 - p_1)(R_1 - C_1) \\ &= p_1 p_2 \omega_1 R - {}^1\!/\!_2 p_1 \delta_1 b_1^2 + R_1 - C_1 \end{aligned}$$

The revenues for enterprise 2 of selection of 'cooperation in constructing low carbon supply chain' and 'non-cooperation in constructing low carbon supply chain' are R_{21} and R_{20} separately.

$$\begin{aligned} R_{21} &= p_1 + (R_1 + \omega_2 R - C_2 - {}^1\!/\!_2\delta_2 b_2^2) + \quad (1 - p_1)(R_2 - C_2 - {}^1\!/\!_2\delta_2 b_2^2) \\ &= p_1\omega_2 R + R_2 - C_2 - {}^1\!/\!_2\delta_2 b_2^2 \\ R_{20} &= p_1(R_2 - C_2) + (1 - p_1)(R_2 - C_2) = R_2 - C_2 \end{aligned}$$

Then the average revenue of enterprise 2 is:

$$\begin{aligned} \bar{R}_2 &= p_2 R_{21} + (1 - p_2)R_{20} = p_2\left(p_1\omega_2 R + R_2 - C_2 - {}^1\!/\!_2\delta_2 b_2^2\right) + (1 - p_2)(R_2 - C_2) \\ &= p_1 p_2 \omega_2 R - {}^1\!/\!_2 p_2 \delta_2 b_2^2 + R_2 - C_2 \end{aligned}$$

83.3.2 Equilibrium Analysis on Cooperation in Low Carbon Supply Chain

The replicate dynamic of enterprise 1 and 2 set up by the enterprise's revenue under strategy of 'cooperation in constructing low carbon supply chain' and the average revenues with strategy of 'cooperation' and 'non cooperation' are:

Table 83.2 Analysis on steady state under low carbon supply chain game cooperation

Equilibrium point	Value of determinant	Value notation	Trace notation	Stability
(0, 0)	$1/4\delta_1\delta_2 b_1^2 b_2^2$	+	+	ESS
(0, 1)	$1/2\left(\omega_1 R - 1/2\delta_1 b_1^2\right)\delta_2 b_2^2$	+	+	Unsteady
(1, 0)	$1/2\left(\omega_2 R - 1/2\delta_2 b_2^2\right)\delta_1 b_1^2$	+	+	Unsteady
(1, 1)	$\left(1/2\delta_1 b_1^2 - \omega_1 R\right)\left(1/2\delta_2 b_2^2 - \omega_2 R\right)$	+	+	ESS
$\left(\delta_2 b_2^2/2\omega_2 R, \delta_1 b_1^2/2\omega_1 R\right)$	$\delta_1\delta_2 b_1^2 b_2^2\left(2\omega_1 R - \delta_1 b_1^2\right)\left(2\omega_2 R - \delta_2 b_2^2\right)/16\omega_1\omega_2 R^2$	–	–	Saddle point

$$\begin{aligned} {}^{dp_1}\!/_{dt} &= \dot{p}_1 = p_1 + (R_{11} - \bar{R}_1) = p_1\left[\left(p_2\omega_1 R + R_1 - C_1 - {}^1\!/_2\delta_1 b_1^2\right) - \left(p_1 p_2\omega_1 R - {}^1\!/_2 p_1\delta_1 b_1^2 + R_1 - C_1\right)\right] \\ &= p_1(1 - P_1)\left(p_2\omega_1 R - {}^1\!/_2\delta_1 b_1^2\right) \end{aligned}$$

$$\begin{aligned} {}^{dp_2}\!/_{dt} &= \dot{p}_2 = p_2 + (R_{21} - \bar{R}_2) = p_2\left[\left(p_1\omega_2 R + R_2 - C_2 - {}^1\!/_2\delta_1 b_2^2\right) - \left(p_1 p_2\omega_2 R - {}^1\!/_2 p_2\delta_2 b_2^2 + R_2 - C_2\right)\right] \\ &= p_2(1 - P_2)\left(p_1\omega_2 R - {}^1\!/_2\delta_2 b_2^2\right) \end{aligned}$$

When $p_1 = 0,\ p_1 = 1,\ p_1 = {}^{\delta_2 b_2^2}\!/_{2\omega_2 R}$ replicate dynamic value of enterprise is 0 and when $p_2 = 0,\ p_2 = 1,\ p_2 = {}^{\delta_1 b_1^2}\!/_{2\omega_1 R}$ replicate dynamic value of enterprise is also 0, which show that when we assume these value the equilibrium of 'cooperation in constructing low carbon supply chain' is steady. Here are five equilibrium points: $(0,0),\ 0,1,\ (1,0),\ (1,1),\ \left({}^{\delta_2 b_2^2}\!/_{2\omega_2 R}, {}^{\delta_1 b_1^2}\!/_{2\omega_1 R}\right)$. We can take the derivative of replicate dynamic of enterprise 1 and 2 with respect to p_1 and p_2 and obtain Jaconbian matrix:

$$E = \begin{bmatrix} (1 - 2P_1)\left(p_2\omega_1 R - {}^1\!/_2\delta_1 b_1^2\right) & p_1(1 - p_1)\omega_1 R \\ p_2(1 - p_2)\omega_2 R & (1 - 2P_2)\left(p_1\omega_2 R - {}^1\!/_2\delta_2 b_2^2\right) \end{bmatrix}$$

According to the value and notation of Jaconbian Matrix in these five equilibrium points and the value and notation of Jaconbian matrix trace we can judge the local stability of the five equilibrium points. From the analysis results of equilibrium (see Table 83.2) we conclude that the five equilibrium point, the $(0,0)$ and $(1,1)$ are Evolutionary Stable Strategy (ESS) and the corresponding policies are (cooperation, cooperation) and (non-cooperation, non-cooperation). There also exist two unstable equilibrium points of $(0,1)$ and $(1,0)$ besides a saddle point: $\left({}^{\delta_2 b_2^2}\!/_{2\omega_2 R}, {}^{\delta_1 b_1^2}\!/_{2\omega_1 R}\right)$

83.4 Conclusions

83.4.1 *Perfect Operation Mechanism Set up in Low Carbon Supply Chain*

To enhance the effort degree of cooperation in low carbon supply chain and the effort degree coefficients (b_1 and b_2) of behavior constantly will make the probabilities (p_1 and p_2) of intention of cooperation in construction low carbon supply chain increase. That to design reasonable revenue-sharing mechanism in low carbon supply chain and make the allocation between ω_1 and ω_2 more reasonable can promote enterprises more willing to make effort to build low carbon supply chain.

83.4.2 Enhancing the Role of Government in Advancing Low Carbon Supply Chain

The government should strengthen the development and application of low carbon supply chain and construct complete infrastructure facilities so that provide for low carbon supply chain with finance, tax and intelligent protection and supporting. By decreasing creative cost coefficients (δ_1 and δ_2) can the government urge the enterprises to develop toward the equilibrium point of (cooperation, cooperation).

83.4.3 Public Participation and Supervision

We can take the measures of establishing non-governmental environmental protection organization, strengthening public participation in environmental institution building and change actively the present environmental mode of government dependence. The public can depend on their powerful base and prestige opinion to inspect enterprises to change to cooperate in low carbon supply chain.

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Chapter 84
Low-Carbon Economic Development Model on Road Freight Transport Industry in Beijing

Haoxiong Yang, Mengnan Zhang, Yongsheng Zhou and Zanbo Zhang

Abstract With the industry reform in progress, China's economic development model is in a gradual shift from extensive economy to intensive economy, low-carbon economy emerged as an economic development model and economic pattern. It can significantly improve resource utilization, reduce harmful gas emissions, develop clean renewable resources, making the sustainability of economic development possible. By analyzing the trend of urban development of Beijing, the paper drew the conclusion that Low-carbon economic development is the future trend, and listed requirements of road freight industry in developing low carbon economy such as the mode of transport, the mode of operation, etc. And the paper put forward suggestions and improvements referring to these requests.

Keywords Low-carbon economy · Beijing · Road freight

84.1 Introduction

Since the industrial revolution, economic development depends on the energy of coal, oil and gas, accounting for about 87 % of global energy consumption. Beijing's energy consumption structure is in a style of "high carbon": 65,777 million

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tons of standard coal in total were consumed in Beijing in 2009. Consumption of chemical energy accounts for about 95 %. However, wind, solar, geothermal, biomass and other resources which can be renewable and are clean energy accounts for only 2.5 %. High-carbon economy is promoting rapid economic development, but also brings the problem of resource depletion, global warming and environmental pollution.

84.2 Low-Carbon Model of Economic and Urban Development of Beijing

84.2.1 Low-Carbon Model is the Inevitable Choice of Beijing's Urban Development

In 2003, in response to the problems caused by the change of global climate raised from the consumption of large quantities of chemical energy, emissions of carbon dioxide (CO_2) and sulfur dioxide (SO_2), Britain first proposed the white Paper of "Our future energy—creating a low carbon economy, putting up the concept of low-carbon economy". The essence of "low-carbon economy" is to improve energy efficiency, the structure of energy, and the utility of clean energy, the core is a fundamental shift of the energy technology innovation and the concept of human survival and development .

In December 2009, the United Nations Climate Change Conference was hold in Copenhagen, Denmark. After arduous consultations and joint efforts of countries, the conference published the Copenhagen agreement refer to the United Nations Framework Convention on Climate Change and Kyoto Protocol. The Copenhagen agreement maintained the principle of "common but differentiated responsibilities" established by the United Nations Convention on Climate Change and Kyoto Protocol, made arrangements that developed countries should take the implementation of mandatory emission reductions and developing countries take voluntary mitigation actions.

With the development of China's economic development and the improvement of people's living standards, China's energy consumption increases at an average annual rate of 4 %. In 2008, the total energy consumption reached 2.85 billion tons of standard coal, and Chain has been among great powers of the world's energy consumption, and oil consumption reached 360 million tons, becoming the world's second largest oil consumer. China's energy reserves and production is far from being able to meet the energy needs of economic development, as a result, the dependence on foreign energy worsens the situation. As a major energy consumer in a developing country without the power of oil pricing, China will realize the fact that more than 50 % of its oil needs rely on the international market to meet will be very dangerous. Therefore, low-carbon model is not only the requirement of construction of the Green Beijing to achieve sustainable development, but the only way to protect human living environment by improving energy efficiency, adjusting energy consumption structure, developing low-carbon economy.

84.2.2 Low-Carbon Model is Dominant for the Future Development of Beijing

In recent years, in order to achieve the goal of "Green Beijing, livable city", Beijing keeps on industrial upgrading, takes positive innovation to maintain GDP growth by an average annual rate of 10 %, energy consumption of area with the GDP of 10,000 yuan decreased from 13.71 tons of standard coal in 1981–0.607 tons of standard coal in 2009 at the same time. (Energy consumption of area with the GDP of 10,000 yuan in Beijing from 1980 to 2009, Fig. 84.1.)

At the same time, from 2006 to 2008, Beijing has become the only province that achieve the annual target of energy saving of the "Eleventh Five Year Plan" in four consecutive years. And, water consumption and sulfur dioxide emissions of per 10,000 yuan of GDP have achieved a cumulative decline of 25 and 30.7 %, 2 years earlier than the "Eleventh Five Year Plan" whose target is 20 %. Energy consumption of per 10,000 yuan of GDP has completed 86.37 % of the target of "Eleventh Five Year Plan". It is expected to completed 1 year ahead of the goal of "Eleventh Five Year Plan". In 2008, "provinces, autonomous regions, municipalities, energy consumption per unit of GDP in 2007 and other indicators bulletin" issued jointly by the National Bureau of Statistics, National Development and Reform Commission and the National Energy Board shows that considering indicator of energy consumption per 10,000 yuan of GDP, Beijing get the first place in the country with consumption of 0.714 tons of standard coal per 10,000 yuan of GDP.

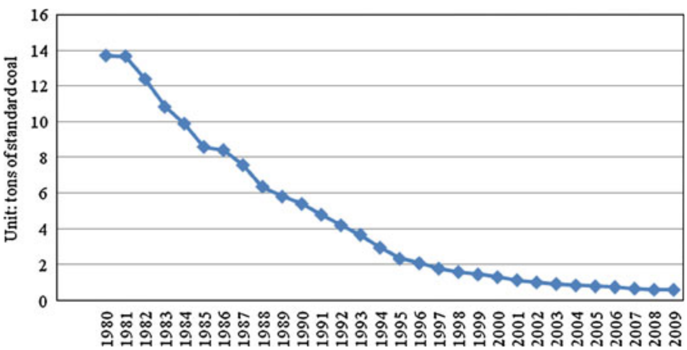

Fig. 84.1 Energy consumption of area with the GDP of 10,000 yuan in Beijing from1980 to 2009. *Source* Beijing Statistical Information Net

84.3 The Influence of Low-Carbon Model on the Road Freight Industry

Changes in the way of economic development will bring the adjustment of industrial structure and changes of people's lifestyles, thus causing changes in the road freight industry services of style and means. The impacts of developing low carbon economy on the road freight industry are shown in the following two aspects:

(1) Low-carbon model of economic growth have an impact on structure of road transport of cargo and goods

According to statistics released by the Beijing Municipal Bureau of Statistics, the intensity of energy consumption in the Beijing's primary industry, second and third industry is significantly different. In the primary industry, secondary industry, energy consumption intensity is strong. Especially, the energy consumption intensity in the secondary industry is the strongest. The third industry is the lowest energy, only 37.9 % of the primary industry, 35 % of secondary industry.

(2) New demands from low-carbon model of economic growth on infrastructure and mode of operation of the road freight industry

With the Beijing industrial optimization and upgrading, as well as the continuous improvement of the energy saving measures, energy consumption of each industry shows a tendency of differentiation. Among them, the industry energy consumption of primary, second illustrates a clear downward trend. While energy consumption in the third industry, energy consumption per 10,000 yuan increase of GDP shows a rapid growth. Energy consumption in the third industry has gone beyond the energy consumption of the secondary industry, reaching 28.444 million tons of standard coal, energy consumption per 10,000 yuan increase of GDP in the city reaching 52 %. Obviously, the focus of Beijing's energy saving will no doubt be the third industry. Beijing's industrial energy consumption shows in Fig. 84.2.

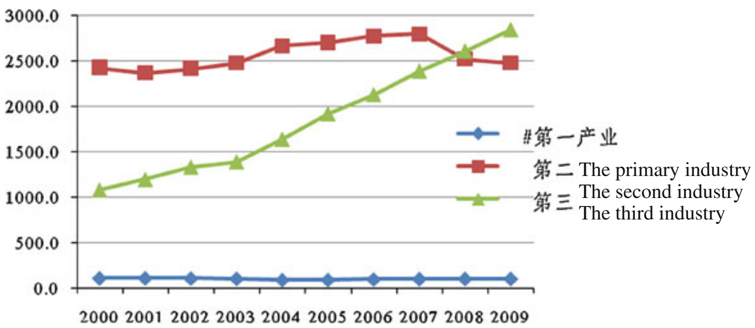

Fig. 84.2 Beijing's total industrial energy consumption from 2000 to 2009. *Source* Beijing Statistical Information Net

In Beijing's third industry, energy consumption and greenhouse gas emissions of road transport occupy a very large proportion. According to statistics of the traffic management department, by the end of 2009, the total number of motor vehicles in Beijing has reached 4.019 million, with an increase of 14.7 % over the previous year, of which freight cars are over 180,000. Bringing the growth of freight and cargo turnover, the rapid growth of vehicle also increases the consumption of gasoline, diesel and other chemical energy, and increases traffic congestion and greenhouse gas emissions. Vehicle exhaust and coal-fired power generation is recognized as the two major culprit causing carbon emissions and air pollution. Heavy chemical industry and these two members are called the three major killers of the environment. According to monitoring, the contribution rate of motor vehicle exhaust rate in the air-pollution accounts for 50 %, and it has become one of the main factors that affect air quality in Beijing. Therefore, the road freight industry which has a large number of freight cars is responsible for energy conservation, construction of the important task of the green Beijing and low-carbon economic growth mode.

84.4 Conclusions and Recommendations

Under the dual pressure of environmental protection and resource—limited, adjusting the industrial structure, improving resource utilization efficiency, taking the low-carbon model of economic development has become the inevitable choice of Beijing's urban development. And, this mode also means new requirements for the road freight industry in Beijing.

To address this challenge, it had better to improve the following aspects: (1) increasing the standards of truck exhaust emissions and the proportion of the number of new energy vehicles. On one hand, it can reduce the emissions of existing vehicles, on the other hand, the development of new energy and new energy vehicles will promote its popularity, and ultimately the new energy vehicles will replace traditional petroleum products, fuel trucks. (2) Constructing and improving the intelligent transport systems. The system will be the effective integration of advanced information technology, data communications transmission technology, the electronic sensor technology, electronic control technology and computer processing technology. It will be applied to the entire transportation management system, and used to build up a large range of available, accurate and efficient integrated transport and management system. Its outstanding feature is the collection, processing, release, exchange, analysis of information in the main line, to provide various and a full range of services for the transport participants. With the intelligent transport systems, we can not only achieve real-time monitoring by the managers on the road and vehicle, but can effectively reduce the number of no-load vehicle, improve freight vehicle utilization, and the overall level of the road freight industry. (3) Promoting the road freight industrial development, the outsourcing of freight and logistics business, and optimizing the allocation of resources to achieve sustainable economic and social development.

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Chapter 85
The Research of Carbon Footprint in the Manufacturing Supply Chain Management

Ruyan Hao and Shaochuan Fu

Abstract With the development of low-carbon awareness, integrating environmental criteria into supply management has become an important strategic issue for industries. All members in the supply chain, including suppliers, manufacturers, distributors, retailers and consumers, are facing increasing regulatory pressures to embrace sustainable operations and achieve better environmental and economic performance. This research examines the carbon footprint across the manufacturing supply chains and thus contributes to the knowledge and practice of green manufacturing supply chain management. This paper will use process analysis to calculate the carbon footprint in the whole end-to-end supply chain.

Keywords Carbon footprint · Supply chain management · Manufacturing industry

85.1 Introduction

During the past decade, whole society has awakened to the issue of climate change. Climate change and global warming are higher on the minds of consumers around the world than ever before. A number of companies in different industries

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are beginning to recognize the carbon issue as one of the critical factors and it is necessary to take action to reduce greenhouse gas emissions. The manufacturing industry is in particular a case that heavily relies on suppliers in the supply chain.

All members in the supply chain are facing increasing regulatory pressures to embrace sustainable operations and achieve better environmental and economic performance. At present, more and more organizations and government departments began to adopt “carbon footprint” to measure the greenhouse gas emissions of products, services, cities and countries.

It is necessary to study carbon footprint measurement across supply chains and to better understand, quantify and rigorously analyze the impact of carbon emissions in the supply chain. Thus, the objective of this article contributes to the knowledge and practice of measuring and controlling the carbon footprint across the manufacturing supply chains.

85.2 Literature Review

This paper establishes the calculation method across the manufacturing supply chain by introducing the green supply chain management and carbon footprint theory, so it’s important to study the literature before we start to move on.

85.2.1 The Green Supply Chain Management

Zhu and Sarkis (2006) referred to the green supply chain management, which can be defined as the integration of environmental thinking into supply chain management, including product design, suppliers selection and material sourcing, manufacturing processes, product packaging, delivery of the product to the consumers, and end-of-life management of the product after its use.

Handfield and Sroufe (2005) and Lee (2009) regarded ‘how and why’ green issues should be integrated into supply management, the core meaning of the terms can be understood as a focal company exercising supply management practices that integrate green issues into supply chain management in order to improve the whole supply chains’ environmental performance, thereby enhancing the whole supply chain sustainability competitiveness.

This paper is of benefit to academics and managers by providing a new way to integrate carbon emissions in supply chain management. It is necessary to increase our understanding of how to integrate carbon footprint in supply chain management, but little research has been seen in the manufacturing industry.

85.2.2 Carbon Footprint

A systematic definition of carbon footprint is offered by Wiedmann and Minx (2008), who writes “carbon footprint is a measure of the total amount of CO_2 emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product”. They asserted the importance of all direct and indirect emissions for measuring carbon footprint in business operations.

Lee (2011) improved our understanding of carbon footprint within the context of automobile supply chain management and increased our understanding of how to integrate carbon footprint in supply chain management.

While among the research, sophisticated quantitative analysis continues to appear, but in general it is not extensive; domestic research basically focuses on the qualitative analysis, quantitative research is less. In view of this, this article analyses the carbon footprint and its performance in operations. Rather than focusing on what happens within the factory, a process analysis perspective traces impacts through the entire production and supply chain of a business. The common focus of carbon footprint analyses is to shift reporting direct impacts from on-site processes to reporting indirect impacts embodied in the supply chain of a company. These indirect impacts are also increasingly important to identify and to measure carbon emissions quantitatively in the supply chain.

85.3 Methodological Notes

85.3.1 Research methods

Methodologically, ‘full life-cycle perspective’ has been addressed from two directions: bottom-up, based on process analysis, and top-down, based on input–output analysis (Wei and Lin 2010; Yu 2011).

Process analysis has been developed to understand the environmental impacts of individual products from ‘cradle to grave’. The process analysis method is necessary to draw the process diagram and it has to set a system boundary. This means that contributions from outside the system boundary are being cut off, leading to a significant underestimation of the full carbon footprint in most cases.

Environmentally extended input–output analysis provides an alternative, economy-wide approach, making system cut-offs unnecessary. It is applicable to the calculation of the macro-level and appropriate for larger entities. However, its suitability for assessing the impacts of individual products or processes is limited.

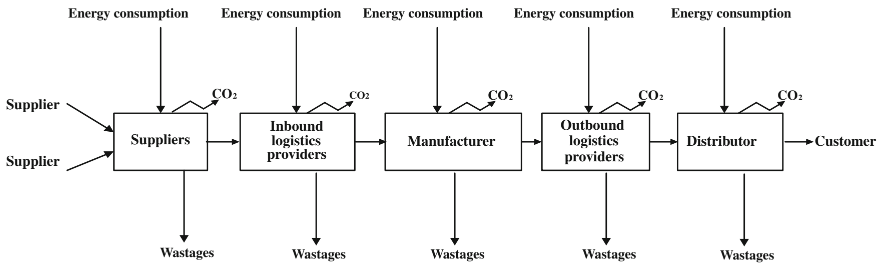

Fig. 85.1 Stages of the end-to end chain

85.3.2 Calculation Method in the Supply Chain

The carbon emissions in the supply chain arise from various processes. At the supplier stage, the processing of raw materials emits CO_2, CH_4 and so on. At the stage of the logistics service provider, the levels and types of carbon emissions depend on the mode of transportation, choice of fuel used, and distance travelled. The carbon emissions at the stage of the manufacturer can be measured from direct and indirect emissions. Finally, the total carbon emissions at the stage of the distribution center depend on the type of packaging used, trade policy, and so on. So, total carbon footprint in the supply chain is the sum of all the stages.

This paper will use process analysis to calculate the carbon footprint in the whole manufacturing supply chain, so an end-to-end supply chain with nodes as shown in Fig. 85.1 will be considered.

85.3.3 Step of Process Analysis

The following assumptions pertaining to the supply chain were made:

- The type of the energy include coal, petrol, diesel, natural gas, kerosene, fuel oil, crude;
- Carbon emissions consist of CO_2, N_2O, CH_4, HFC, PFC and SF_6;
- Regard carbon dioxide as the standard and each type of greenhouse gas is converted to “Carbon equivalent”;
- Customer-side emissions are minimal when compared to emissions from suppliers, manufacturers, warehousing and transportation;

Our process analysis provides results for step 1, 2, 3. In detail these are:

Step 1: identification of selected key suppliers’ carbon footprint.

This article takes both direct and indirect emissions into account when calculating the carbon footprint. This is the first subjective phase of the application of process analysis. At this stage it is necessary to identify the objectives of the analysis and the system boundaries. So in this paper, an end-to-end supply chain with nodes as shown in Fig. 85.1 will be considered.

Step 2: development of a carbon process map.

Depending on the type of energy, the carbon footprint produced by energy consumption is divided into the direct carbon footprint, which focused on final energy consumption, and indirect carbon footprint, which generated by electricity consumption.

As a certain product enters the supply chain node, it will release greenhouse gases due to various processes. This increase depends on the performance of the product and process drivers of the supply chain. The processes consume energy and emit carbon and wastages. As shown in Fig. 85.2.

Step 3: calculation of product carbon footprint.

Firstly, we consider the carbon footprint of one node in the manufacturing supply chain.

$$CF = CF_d + CF_u$$

where

CF the total carbon footprint (including the direct carbon footprint and indirect carbon footprint)
CF_d the direct carbon footprint
CF_u indirect carbon footprint

$$CF_d = \sum_j K_j \cdot Q_j = \sum_j \frac{44}{12} \cdot C_j \cdot B_j \cdot Q_j \cdot V_j$$

j the type of the energy
Q_j energy consumption
K_j CO_2 emission factors of j energy
C_j Potential emission factors of j energy
B_j Carbon oxidation rate of j energy

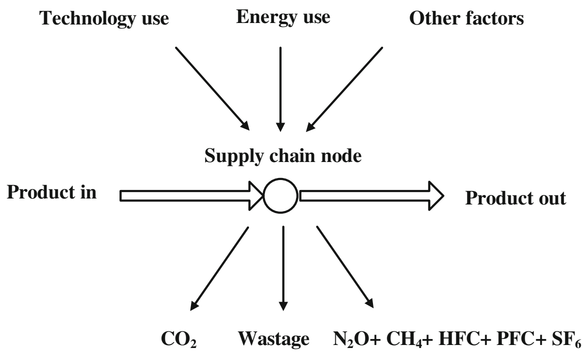

Fig. 85.2 Carbon process of a stage in an end-to end chain

V_j Lower calorific value of the energy of j energy

$$CF_u = CF_e = K_e \cdot Q_e$$

Q_e electricity consumption every year
K_e CO_2 emission factors of electricity

Secondly, the carbon footprint of all nodes in the whole manufacturing supply chain should be considered. It is noticed that there are five nodes in the supply chain as shown in Fig. 85.1, so the total carbon footprint is calculated by adding each scope of the five nodes.

$$\begin{aligned} CF &= CF_{supplier} + CF_{inbound} + CF_{manufacturer} + CF_{outbound} + CF_{distributor} \\ &= CF_1 + CF_2 + CF_3 + CF_4 + CF_5 = \sum_i CF_i \end{aligned}$$

$$CF = \sum_{ij} \frac{44}{12} \cdot C_{ij} \cdot B_{ij} \cdot Q_{ij} \cdot V_{ij} + \sum_i K_{ie} \cdot Q_{ie}$$

Potential emission factors of j energy, C_j, can be obtained from 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy. Carbon oxidation rate of j energy, B_j, and Lower calorific value of the energy of j energy, namely V_j, can be obtained from China Energy Statistical Yearbook. CO_2 emission factors of electricity, K_e, can be obtained from China Clean Development Mechanism Website. However, the difficulty of obtaining Q_j data for an end-to-end manufacturing supply chain has limited this study to preliminary results. So there is a limitation to data analysis in this paper.

85.4 Discussion

In order to identify and analyze impacts on climate change, this article undertook an inductive life cycle approach to investigate emerging topics of carbon footprint within the manufacturing supply chain management.

Identifying and measuring carbon footprint can be a useful source of carbon competitiveness. In particular, developing indicators for identification and measurement of carbon footprint can be critical for integrating carbon footprint into supply chain management.

By identifying the objectives of the analysis and the system boundaries and building a carbon process map, this article calculated of product carbon footprint across the supply chain, and identified carbon risks and mitigated carbon challenges across the supply chain. Carbon risks as well as new opportunities, and ultimately sustainability competitiveness in the whole supply chain will be identified by practicing this.

This study sheds some light on the issue of carbon footprint in the manufacturing supply chain management. This is an emerging discipline in an end-to-end supply chain management.

85.5 Conclusion

This article discusses the carbon footprint across the manufacturing supply chain and presents an initial method that measures carbon emissions from both direct and indirect aspects. Specifically, the carbon footprint across various stages in an end-to-end supply chain is measured. With the approach presented in this article, it can be seen what and where the areas of acceptable carbon emissions are.

The difficulty of obtaining energy consumption data for an end-to-end manufacturing supply chain has limited this study to preliminary results. And there is a limitation to manage the carbon footprint across the supply chain is another strategically important to reduce carbon emissions. Moreover, there is a limitation to a clear picture of traceable carbon emissions in order to make strategic decisions. So, it is necessary to collect data and to do data analysis for further study.

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Chapter 86
Research on Collaborative Pricing Decisions of Enterprises in Supply Chain Under Constraints of Carbon Emission

Qian Liu and Huiping Ding

Abstract For supply chain, enterprises' collaboration is necessary condition to meet carbon emission constraints. Pricing decisions influence the profit allocation and is the key factor influencing the stability of collaborative relationship. Based on the above opinion, this paper reviews literatures of studies on carbon emission constraints and enterprises' collaborative pricing decisions, then constructs collaborative pricing decision model. The model is nonlinear programming model with objective function of profits maximization and constraints of carbon emission. Kuhn-Tucker theorem is used as basic tool to analyze this model. In conditions of non-cooperation, the Stackelberg game theory is used. Through comparison of profits under conditions of cooperation and non-cooperation, Rubinstein bargaining game theory is used to analyze the coordination process. This paper provides framework for collaborative pricing decisions of enterprises in supply chain.

Keywords Constraints of carbon emission · Supply chain · Collaborative pricing decision · Nonlinear programming · Game

86.1 Introduction

The collaboration of member enterprises in supply chain is the key of determining whether the reduction behavior will last or not. Rational profits allocation which mainly influenced by the pricing decision is the basis of sustainable collaborative relationship. Problem this paper focused on is the collaborative pricing decision of

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enterprises in supply chain under carbon emission constraints, which has both theoretical and practical significance.

Academic studies related to carbon emission are abundant. For example, Wang and Ye (2012) studies China's industry total factor energy efficiency, pointing out that the structure of energy consumption and energy efficiency is negatively correlated. He and Ma (2011) establishes an optimization decision making model in production and storage under constraints of carbon emission. Webner and Neuhoff (2010) focused on carbon emission trading and its technology. Chaabane et al. (2012) researches design of supply chain under carbon emission constraints. So far, studies of carbon emission both in China and abroad is mainly focused on the macro level, studies of micro level is relatively lack. In the studies of supply chain's collaborative pricing decisions, game theory is used widely. For example, Ge and Huang (2008) use game theory as basic tool to analyze pricing decision under centralized and decentralized decision-making. Lots studies of low carbon and supply chain's collaboration pricing decision existed, but studies of collaborative pricing decision under carbon emission constraints are rare.

Based on the assumption of coordination in supply chain can reduce the carbon emission, this paper employs non-linear programming method to establish a collaborative pricing decision model then use Kuhn-Tucker theorem to analyze the model. In the analysis process, firstly, Stackelberg game theory is used to analyze the pricing decision under non-cooperation condition; secondly, according to the necessary conditions of profits under condition of cooperation should larger than non-cooperation, the pricing coordination is studied using Rubinstein game theory; lastly, proposes framework of collaborative pricing decision for Pareto optimal. The study provides framework for collaborative pricing decision of supply chain and is useful for member enterprises to improve cooperation and achieve maximized cooperative profit.

86.2 Collaborative Pricing Decision Model Under Carbon Emission Constraints

86.2.1 Model Assumption

Member enterprises have their own business goals, they eager to reduce carbon emission, but they don not want to jeopardize the profit. Thus, the coordination of both enterprises' individual interest and collaborative benefit is necessary for the sustainability of carbon emission reduction. The key of coordination is determining the price. To analyze the above problem, we assume as follows:

(1) Consider a two-level supply chain consists of one manufacturer and one supplier, manufacturer sells products to the market, supplier provides intermediate products to manufacturer. The manufacturer and supplier have

complete information, so, the production consistent with sales, the sales and price is related as follows: Q = a−bP.

(2) The demand is relative stable, the price of traditional price is P. After the implementation of carbon emission reduction, in order to make up the increased cost, the manufacturer prices the products with $P'(P' > P)$, can be described as $P' = (1 + \beta)p(\beta \geq 0)$.

(3) Governments set the constraints of carbon emission. The parameters are shown in Table 86.1

Ignoring the influence of tax and other factors, the profit of the manufacturer is:

$$\begin{aligned} R_m &= Q(P' - T - C_m) = (a - bP')(P' - T - C_m) \\ &= [a - b(1 + \beta)P][(1 + \beta)P - T - C_m] \end{aligned} \quad (86.1)$$

The profit of the supplier is:

$$R_s = Q(T - C_s) = (a - bP')(T - C_s) = [a - b(1 + \beta)P](T - C_s) \quad (86.2)$$

The profit of the supply chain is:

$$R = Q(P' - C_m - C_s) = [a - b(1 + \beta)P][(1 + \beta)P - C_m - C_s] \quad (86.3)$$

86.2.2 Model Building and Analysis

(1) Pricing decision under condition of non-cooperation

Under condition of non-cooperation, object of decision making is to maximize self profits. We assume that, the manufacturer and supplier bargain about the intermediate product price, then, the manufacturer decides the sales price. In the

Table 86.1 Parameters of the model

Parameter	Meaning
Y	Carbon emission constraints
Q	Production quantity
P	Price of traditional products
P'	Price of products after implementation of carbon emission reduction
β	Price increase rate (decision variable of manufacturer)
C_s	Cost of supplier
C_m	Cost of manufacturer
T	Price of intermediate products (decision variable of supplier)
W	Carbon emission by the supply chain producing one product

bargaining process, the supplier is dominant, and the manufacturer is subordinate. So, the two stage pricing process can be analyzed using the Stackelberg game theory. In the following, reverse recursive method is used.

Firstly, consider the manufacturer takes action after the supplier, with the information of intermediate price equals to T, the manufacturer decide the price increase rate β in order to maximize its profits under carbon emission constraints, the problem can be describes as formula (86.4):

$$\begin{aligned} &MaxR_m = [a - b(1+\beta)\mathrm{P}][(1+\beta)P - T - C_m] \\ &st.\mathrm{Q}W \le Y \end{aligned} \tag{86.4}$$

Standard forms of mathematical programming are shown in formula (86.5):

$$\begin{cases} \min f(\mathrm{x}) \\ \mathrm{g_i}(\mathrm{x}) \ge 0, \quad \mathrm{i} = 1, \ldots, \mathrm{m} \end{cases} \tag{86.5}$$

Model of pricing decision under constraints of carbon emission is different from the standard model, so we change (86.4) into the form of formula (86.5), shown in formula (86.6). The target function is nonlinear, so the programming problem is nonlinear programming.

$$\begin{aligned} &Min(-R_m) = -[a - b(1+\beta)\mathrm{P}][(1+\beta)P - T - C_m] \\ &st. - \mathrm{Q}W \ge -Y \end{aligned} \tag{86.6}$$

According to Kuhn-Tucker theorem, if $\beta*$ is the minimum point of formula (86.6) (that is when $\beta = \beta*$, the profits of manufacturer is maximum), and is non-relevant to the linear gradient of point $\beta*$'s active constraint, there must be $\lambda*$ which make formula (86.7) is set up.[1]

$$\begin{cases} \dfrac{\partial L}{\partial \beta} + \lambda(Y - QW) = 0 \\ \lambda \dfrac{\partial L}{\partial \lambda} = 0 \\ \lambda \ge 0 \end{cases} \tag{86.7}$$

Formula (86.7) are the Kuhn-Tucker conditions of this programming, λ is Lagrange multiplier. $\frac{\partial L}{\partial \beta} = 0$ is necessary condition, while $\lambda \frac{\partial L}{\partial \lambda} = 0$ is complementarily condition (if $\lambda > 0$, $\frac{\partial L}{\partial \lambda} = 0$; if $\lambda = 0$, $\frac{\partial L}{\partial \lambda} > 0$).

From formula (86.7), we get formula (86.8):

$$\begin{cases} aP - 2\mathrm{b}P^2(1+\beta) - bPC_m - bPC_s + \lambda b(1+\beta)PW = 0 \\ \lambda[aW - b(1+\beta)PW - Y] = 0 \end{cases} \tag{86.8}$$

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[1] Han(2007).

Economic mean of Lagrange multiplier λ is similar to shadow price,[2] here means marginal profits gets from increasing emission of unit carbon. When $\lambda = 0$, marginal profit gets is 0, and the constraints are inactive constraints, means when the price increase rate equals β, the carbon emission is lower than the constraints, when β has subtle change, the carbon emission is still lower than the constraints. When $\lambda > 0$, the constraints are active constraints, marginal profit gets is above 0, in this condition β located in the boundary of the feasible region, when β has subtle change, the carbon emission will higher than the constraints. Since there is externalities of behaviors taken by individual enterprises to reduce carbon emission, under condition of non-cooperation, both manufacturer and supplier has no activity to reduce carbon emission, the constraints is non-effective, so $\lambda = 0$. According to the complementarily conditions, the optimal price increase rate under non-cooperation is:

$$\beta^{*\prime} = \frac{bT + a + bC_m - 2bP}{2bP} \tag{86.9}$$

Secondly, consider the price decision of supplier which is dominant. When supplier offers, the price increase rate β can be forecasted. Fill formula (86.9) into formula (86.2), the decision problem of supplier under condition of non-cooperation can be shown in formula (86.10):

$$MaxR_s^* = [a - b(1 + \beta^{*\prime})\mathrm{P}](\mathrm{T} - \mathrm{C_s}) \tag{86.10}$$

First order condition for optimization is:

$$\frac{\partial R_s^*}{\partial T} = 0 \tag{86.11}$$

From formula (86.11), we can get the optimal intermediate price under condition of non-cooperation:

$$T^{*\prime} = \frac{\mathrm{a} + bC_s - bC_m}{2b} \tag{86.12}$$

Fill formula (86.9) and formula (86.12) to formula (86.1), (86.2) and (86.3), the profits of manufacturer, supplier and the supply chain can be shown as follows:

$$R_m^{*\prime} = \frac{(a - bCs - bC_m)^2}{16b} \tag{86.13}$$

$$R_s^{*\prime} = \frac{(a - bC_s - bC_m)^2}{8b} \tag{86.14}$$

$$R^{*\prime} = \frac{3(a - bCs - bC_m)^2}{16b} \tag{86.15}$$

[2] Wei (2010).

(2) Pricing decision under condition of cooperation

As shown in formula (86.3), the profit of supply chain is determined by the product sales price, more specifically, determined by price increase rate β. However, has no direct relationship with intermediate price T. T determines the allocation of profit between manufacturer and supplier. Under condition of cooperation, manufacturer and supplier has the contact to reduce carbon emission collaboratively, so the carbon emission constraint is active. According to K–T conditions and complementarily conditions, if the constraint is active, $\lambda > 0$ and $\frac{\partial L}{\partial \lambda} = 0$. The optimal price increase rate under condition of cooperation β^* is:

$$\beta^* = \frac{a}{bP} - \frac{Y}{bPW} - 1 \tag{86.16}$$

Fill formula (86.16) to formula (86.1), (86.2) and (86.3), the profits of manufacturer, supplier and supply chain under condition of cooperation are as follows:

$$R_m^* = \frac{aY}{bW} - \frac{Y^2}{bW^2} - \frac{YT}{W} - \frac{YC_m}{W} \tag{86.17}$$

$$R_s^* = \frac{Y}{W}(T - C_s) \tag{86.18}$$

$$R^* = \frac{aY}{bW} - \frac{Y^2}{bW^2} - \frac{YC_m}{W} - \frac{YC_s}{W} \tag{86.19}$$

If the cooperation of supplier and manufacturer can be lasted, the following conditions must be satisfied, $R_m^{*\prime} \geq R_m^*$ and $R_s^{*\prime} \geq R_s^*$. The satisfaction of the above conditions needs the coordination between manufacturer and supplier, the coordination process is the collaborative pricing decision processes.

The profit of supply chain is determined by price increase rate, under condition of cooperation. When the rate equals β^*, the profit of supply chain is maximum and equals R^*. When $R < R^*$, the manufacturer can modify β until $\beta = \beta^*$, β is the unique optimal rate. However, to satisfy the requirement of $R_m^{*\prime} > R_m^*$ and $R_s^{*\prime} > R_s^*$, the manufacturer and supplier must be coordinate the intermediate price T. The goal of the coordination is to realize the unification of both individual interest and collective benefits and finally achieving the condition of Pareto optimization. The coordination process is the allocation of profits between manufacturer and supplier, different contacts have different outcomes. In this paper, we employ profit distribution factor to analyze the collaborative pricing decision. The coordination process is bargain process, in indefinite bargain game with two participants, the unique sub game perfect Nash equilibrium is $x^* = \frac{1-\delta_2}{1-\delta_1\delta_2}$ (if $\delta_1 = \delta_2 = \delta$, $x^* = \frac{1}{1+\delta}$),[3] δ_1, δ_2 is the discount factor of participant respectively

[3] Zhang 2011a.

(discount rate is the patience degree of participants, can be seen as the cost of bargain $0 \le \delta \le 1$),[4] $x^*(0 \le x^* \le 1)$ indicates the suppliers' part of profits and $1 - x^*$ means the manufacturer's part.

Necessary conditions of coordination are $R_m^{*\prime} \ge R_m^*$ and $R_s^{*\prime} \ge R_s^*$, that is:

$$\begin{cases} \dfrac{(a - bCs - bC_m)^2}{16b} \ge \dfrac{aY}{bW} - \dfrac{Y^2}{bW^2} - \dfrac{YT}{W} - \dfrac{YC_m}{W} \\ \dfrac{(a - bC_s - bC_m)^2}{8b} \ge \dfrac{Y}{W}(T - C_s) \end{cases} \tag{86.20}$$

Calculated from formula (86.20), the feasible zone of T is as shown in formula (86.21)

$$\left[\frac{(a - bC_m - bC_s)^2 W}{8bY} + C_s,\ \frac{aW - Y - bWC_m}{bW} - \frac{(a - bCs - bC_m)^2 W}{16bY}\right] \tag{86.21}$$

When the intermediate price tends to the maximum, the supplier can get more profits; otherwise, the manufacturer will get more profit. As we can know from the above, the unique sub game perfect Nash equilibrium, namely the profit sharing factor of manufacturer is:

$$x^* = \frac{1 - \delta_2}{1 - \delta_1 \delta_2} \tag{86.22}$$

Then,

$$\frac{x^*}{1 - x^*} = \frac{1 - \delta_2}{\delta_2 - \delta_1 \delta_2} = \frac{T_{\max} - \mathrm{T}^*}{\mathrm{T}^* - T_{\min}} \tag{86.23}$$

Fill the maximum value and minimum value get form formula (86.21) into formula (86.23), the optimal intermediate price T* can be calculated, the outcome is shown in formula (86.24):

$$T^* = \frac{(\delta_2 - \delta_1 \delta_2) T_{\max} + (1 - \delta_2) T_{\min}}{1 - \delta_1 \delta_2} \tag{86.24}$$

Combine formula (86.16) and formula (86.24), the equilibrium outcome under conditions of cooperation to achieve Pareto optimization is formula (86.25):

$$(\beta^*,\ T^*) = \left[\frac{a}{bP} - \frac{Y}{bPW} - 1,\ \frac{(\delta_2 - \delta_1 \delta_2) T_{\max} + (1 - \delta_2) T_{\min}}{1 - \delta_1 \delta_2}\right] \tag{86.25}$$

In the process of cooperation, the manufacturer and supplier can bargain constantly until attain the equilibrium of $(\beta^*,\ T^*)$.

[4] Zhang 2011b.

Table 86.2 Profits comparison under conditions of cooperation and non-cooperation

	β	T	R_m	R_s	R
Non-cooperation	0.25	12.5	56.25	112.5	168.75
Cooperation	0.17	9.24	97.8	127.2	225

86.2.3 Numerical Analysis

Based on the above analysis, in this section we will provide a numerical analysis to test and support the model. We assume the traditional product price P = 15, the product price after implementation is P′(unknown), P' = (1 + β)P, the relationship between quantity and price is Q = 100−4P′. Cost of the manufacturer producing one product is $C_m = 5$, the intermediate price is T (unknown). Cost of the supplier producing one intermediate product is $C_s = 5$. The carbon emission constraints of the supply chain is 300 unit, Y = 300. Carbon emitted by supply chain producing one product is 10 unit, W = 10. The discount rate of supplier and manufacturer is respectively 0.15 and 0.1, $\delta_1 = 0.15$ and $\delta_2 = 0.1$.

Fill the above number to the above formula; we can get profit of manufacturer, supplier and supply chain under different conditions respectively. The outcome is shown in Table 86.2.

Seen from Table 86.2, under condition of cooperation, through collaborative pricing decision, the intermediate price is obviously lower than the price under non-cooperation. The reduction of intermediate price can reduce the cost of manufacturer, thus the manufacturer can decide a lower price increase rate. Lower price brings more sales quantity than non-cooperation, and the profit of supply chain is increased. So, collaborative pricing decision can not only increase the individual profits but also the whole profit of supply chain.

86.3 Conclusion

This paper establishes collaborative pricing decision model using nonlinear programming method to analyze the collaborative pricing decision under constraints of carbon emission. Through research, we found that, under conditions of non-cooperation, not only the carbon emission constraints can not be satisfied, but the individual profit and collective profit is not optimized either. The coordination process of manufacturer and supplier provides framework for the collaborative pricing decision. At last, the utility and effectiveness of this model is tested by numerical analysis.

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Chapter 87
Research on the Low Carbon District Development Mechanism of Beijing

Yingkui Zhang, Di Wu and Jia Liu

Abstract This paper analyses the importance to develop low carbon districts in Beijing; builds up Motivation Mechanism, International Competitive Mechanism and Cultural Mechanism for Beijing; and points out that districts in Beijing, in order to become low carbon ones, should improve themselves from the aspects of economy, energy, technology and society.

Keywords Low carbon · Low carbon district · Development mechanism

87.1 Introduction

87.1.1 The Importance to Build Low Carbon Districts in Beijing

With the rapid development of society and economy, problems about energy shortage and environmental pollution are ever worsening. Almost all the major countries and cities in the world are seeking for the way of low carbon development.

China, one of the biggest countries in the world, needs to build a low carbon development mechanism as well (Pan 2010). Nowadays, the energy consumption per unit product of industries (steel industry, nonferrous metal industry, electricity industry, etc.) in China consumes 40 % more energy than that in other advanced

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countries. Environmental production and low carbon development become more and more significant (Gill 2010).

Beijing is the capital of China, and the construction of low carbon districts in Beijing is basic for the construction of low carbon China.

87.1.2 The Content of Low Carbon District

A Low Carbon District is a district which conserves resources, keeps harmony with environment and develops sustainably. Generally speaking, a low carbon district has the following features:

1. Sustainable development: reduce carbon emission and satisfy people's increasing material and cultural needs at the same time.
2. Carbon emission needn't to link up with economy development. Less carbon supports more economy development.
3. From a global perspective, the district creates new low carbon technologies or productions, and contributes to the low carbon world.
4. Pay special attention to institutional innovation.

87.1.3 The Content of Low Carbon Development Mechanism

Low carbon development mechanism is a mechanism of an economic entity, which makes full use of all kinds of resources, and builds the following three mechanisms: low carbon economy motivation mechanism, forward-looking international competitive mechanism and low carbon awareness cultural mechanism.

For Beijing, the motivation mechanism aims at allocating and using all kinds of resources properly, and acts as an accelerator in building Beijing's low carbon districts; international competitive mechanism aims to emphasize Beijing's soft power, and acts an expander; cultural mechanism stresses moral education and knowledge sharing, acts as a flocculator.

87.2 Problems to Build Low Carbon Districts in Beijing

87.2.1 Lack of Planning and Construction Mode

Firstly, government and developers have some difficulties in positioning a certain new project. In practical terms, with no accurate planning, the responsibility of government and developers is unclear to some extent. So it is not easy for them to monitor the construction process.

Secondly, when facing a new low carbon project, the government and developers may not have enough knowledge and experiences to manage that. The construction of low carbon district is complicated and needs all the related parts to cooperate, including government, developers and consumers. It is of great importance to improve the construction mode of a low carbon district (Chen et al. 2010).

87.2.2 Lack of Advanced Technology

Firstly, research on the technology of low carbon districts is rare. In fact, researchers can't reach an agreement of what a low carbon district means. And most of ordinary people can't grasp the core content of low carbon district.

Secondly, the key technology of low carbon district doesn't form a complete system now. Lots of planning staffs overemphasize certain technology of energy or environment, but not pay enough attention to the comprehensive utilization of them.

Finally, the research and the practice of low carbon district come apart. The applying rate of the research achievements is quite low.

87.2.3 Lack of Proper Management System

Firstly, most of the developers pursuit short-term earnings, and utilize the idea of low carbon for hyping. In China, investment of low carbon projects returns slowly, so developers prefer commercial housing than low carbon housing. What is more, some so called eco-districts are not really environmentally friendly. Many developers, who hold the opinion that eco-district means to spend lots of expensive material, are unwilling to construct low carbon buildings.

Secondly, the lack of supporting measures is another obvious phenomenon which needs to change. The government could encourage low-carbon energy and environmentally friendly materials by legislation and tax. At present, China doesn't have a good motivation system for the developers in low carbon districts.

87.2.4 Lack of Social Consciousness of Low Carbon Life

Simple life styles are common in Beijing, but numerous people can't help themselves to buy much more things than their demand. Low carbon life is more like a slogan than an action.

87.3 Low Carbon District Development Mechanism in Beijing

87.3.1 Motivation Mechanism

87.3.1.1 Allocate Resources Properly

Low carbon district involves two levels: low carbon economy and low carbon society.

Low carbon economy emphasizes less greenhouse gases for faster economy development, and it is related to the development and utilization of low carbon energy, low carbon technology and low carbon production.

Low carbon society stresses on low carbon life and low carbon consumption. It aims to switch people's previous opinion about life and promote the coordinated development between the human society and nature (Yuan and Zhong 2010).

In the early stage of the construction of Beijing's low carbon districts, people think more about low carbon economy than low carbon society. In fact, the two parts are of the same importance.

87.3.1.2 The Motivation of Energy Saving

Beijing's construction of low carbon districts can't be separated from low carbon industry. The government should build the motivation mechanism of energy saving, and encourage the companies to reduce carbon dioxide emission and recover resources.

87.3.2 International Competitive Mechanism

87.3.2.1 Mechanism of Technology Innovation

Technology innovation is the main power for Beijing's development of low carbon districts, and it involves the innovation of technologies about electricity, transportation, construction, chemistry and so on.

Beijing should focus on technology innovation for strengthening its international competitiveness, and the following three factors can't be ignored.

Firstly, Beijing should make close connection among market, research, production, etc., in order to form a creative organizational system to support the operation of low carbon district. Especially, talents are the determinants.

Secondly, Beijing should pick up some key industries, like the industry of electricity, transportation, construction and chemistry, as major support objectives when building low carbon districts.

Thirdly, Beijing should take some measures to encourage companies to do low-carbon related research independently and take the research achievements into practice.

87.3.2.2 The Mechanism of International Cooperation

In the modern world, international situations have undergone numerous of new changes. The integration of Jingjinji Area keeps going further. The concept of "People's Beijing, High-tech Beijing and Green Beijing" calls for the construction of low carbon districts in Beijing.

Facing the accelerated pace of economic globalization and the enhancement of marketization and continuous increasing of China's economy, Beijing should make better use of its advantages of geographical position and the convenience in international communication, and finally take part in higher levels of international and inter-regional low carbon events (Gillingham et al. 2009).

87.3.3 Cultural Mechanism

87.3.3.1 The Mechanism of Carbon Emission Regulation

At the international level, Chinese government has made a solemn commitment to cut the CO_2 emission per unit of GDP by 40–45 % by year 2020 off the year 2005 level. At the same time, China is in the critical stage of realizing urbanization and industrialization. To achieve these goals, China should set up carbon emission regulation, referring to the international advanced practices of carbon reduction.

For the purpose of controlling emission of carbon dioxide and other greenhouse gases, The government should set the indicator and task of carbon reduction according to the situation of different districts. The government may also make carbon reduction agreements with environmental administration departments and related companies. The defaulters have to assume environmental responsibility. What is more, the government may absorb the suitable experience of foreign countries and bring in the concepts of carbon trading and carbon credit, which are efficient market methods in developing low carbon districts.

87.3.3.2 Ecological Compensation Mechanism

Ecological compensation mechanism is a sustainable mechanism, which means the theories and ways to making up for the ecological damage, in order to recover or protect ecological service function. Ecological compensation mechanism is an interest mechanism, which makes external costs internalized. It requires ecological destroyers to bear external costs essentially, and let eco-investors get reasonable return.

Ecological compensation mechanism is a necessary approach to offset market failure. Considering the ecosystem services value and the ecological protection cost, Beijing's government should take measures like fiscal, taxation and market, to create institutional arrangement to regulate the economic interest relationship among eco-protector, eco-beneficiary and eco-destroyer.

The government had better bring key rivers, key nature reserves, key ecological function areas and mineral resource areas into the range of ecological compensation. As for the principle of ecological compensation, the government should take fully account of the external costs from eco-destroyers and the deserved investment income for eco-investors, make clear the subjects of ecological compensation, and avoid free riding behavior effectively. Ecological compensation calls for the endeavor of the whole society, especially the government, which may create proper ecological compensation institution arrangement, set up dedicated funds or make key investments in ecological protection.

87.4 Basic Measures for Beijing to Develop Low Carbon Districts

87.4.1 Economic Low Carbonization

Economic structure decides energy consumption structure, and decides greenhouse gases emission to some extent. The energy intensity of secondary industry is much higher than primary industry and tertiary industry. In 2006, the energy intensity of primary industry is 0.34 ton per 10,000 yuan of value-added, the number for secondary industry is 1.73 and for tertiary industry is 0.41. The energy intensity of secondary industry is 5 times as much as primary industry, and 4 times as much as tertiary industry. Industrial structure has a huge effect on energy consumption and energy intensity. Beijing's government may take the following factors into consideration when building low carbon districts.

Firstly, optimize the industrial structure, and give priority to key industries; promote modern service industry, finance industry, cultural creative industry and hi-tech industry and optimize their internal structure; stress the importance to stimulate strategic emerging industries; speed up the new generation of information technology industry; encourage importance project construction like 3G projects; develop new biological medicine industry, etc.

Secondly, fully foster the complementary industries. For example, adjust the investment structure of real estate proactively; consolidate the advantages of traditional business service industries; develop urban modern agriculture; encourage the development of tourism.

Thirdly, enlarge consuming demands and promote investment; develop multi-level consumption style to meet consumers' changing demand; promote the upgrade of consumption structure; perfect the community commercial service.

87.4.2 Energy Low Carbonization

Beijing should change the energy supply from the energy basis and speed up the employ of low carbon energy. It is important, but difficult to realize. Data displays that, in 2005, the ratio of coal in demand of energy in China is 69.1 %, the ratio of petroleum is 21 %, and the total ratio of natural gas, hydropower, nuclear power and solar energy is about 9.9 %. But at the same time, globally, the ratio of coal in demand of energy is 27.8 %, the ratio of petroleum is 36.4 %, and the total ratio of natural gas, hydropower, nuclear power and solar energy is about 35.8 %. Therefore, China should quicken technology innovation in carbon neutral, carbon capture and so on, and to make clean, secure and efficient energy like water power, wind power, solar power, tidal power and nuclear power. What is more, raising the proportion of new energy in total energy gradually is another useful method.

87.4.3 Technology Low Carbonization

Low carbon technology means the technologies that can control greenhouse gases emission effectively, and involves fields of energy saving, coal efficiency, marine exploitation, and new energy development. To get low carbon technology, districts in Beijing may bring in advanced technology from abroad through CDM, or strengthen technological innovation, especially low carbon technology for basic industries, like chemistry industry.

A research about developed countries shows that, only by whole process of energy-saving reduction can organizations achieve initiative energy conservation. So, optimize energy structure by cleaner protection and employ science & technology to support energy conservation and environmental protection is a worthwhile endeavor.

87.4.4 Social Low Carbonization

The demand of materials grows simultaneously with the development of economy. In 2000, life energy consumption of China is 149.1183 million tons of standard coal; the number in 2006 is 253.8787 million, which is 1.7 times as many as in 2000. The main reason is the popularity of electronic products like refrigerators, televisions and computers (Gillingham et al. 2012). Mistakes in district planning lead to district sprawling, public transportation lagging, and living costs increasing. For the sake of low carbon districts' development, people should switch their high-consuming lifestyle to a simpler one.

87.5 Conclusion

Low carbon development is a necessary choice for Beijing, and Beijing has the responsibility and the ability to take actions as soon as possible to build up low carbon city in order to gain initiative in the fierce competition among cities. Low carbon district construction is achievable through applicable Motivation Mechanism, International Competitive Mechanism and Cultural Mechanism. More specifically, districts in Beijing, in order to become low carbon ones, should improve themselves by economic Low carbonization, energy low carbonization, technology low carbonization, and society low carbonization.

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Chapter 88
Current Trends for Development in the Aviation Industry World Integration Groups

Bo Wang and Shaolan Yang

Abstract Actual trends in corporate structures of modern globalization processes are searched. Process dynamics of interaction between actors in cooperation, integration and analysis of trends in capital funding-term business aviation industry is determined.

Keywords Group integration · Corporate structure · Consolidation capital · The aviation industry

88.1 Introduction

At the present stage of economic development, the companies' critical success factors in global markets and growing international competition are the increment of their market value, which is realized through integration and consolidation of capital. Business merger makes it more powerful, less regulated and controlled by national governments and the international economic organizations. Therefore, the research of trends and dynamics of these processes is of great importance.

On the basis of research, one could argue that the aviation industry of any technologically advanced country is considered to belong to the strategic one and plays a significant role in its economic development. One of the directions for improvement of the efficiency of market environment is to use the powerful integrated structures that are created with the help of certain successful

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organizations and enterprises to improve product competitiveness. That is why it has actively occurred in the process of consolidation (mergers/acquisitions) and global business in recent years in the aviation industry. The development of the global supply network, aircraft service and suppliers not only help to accelerate the formation of new markets, but also avoid researching and manufacturing the same products, particularly in manufacturing components and assemblies. In turn it can enhance and improve the specialization of production.

Modern scholars' questions concerning consolidation of capital have been widely represented. In particular, considerable attention is paid to the study of contemporary forms of group integration, analysis of merger conditions, as well as planning and organization processes of merger and acquisitions. But at the same time many aspects of these scientific problems remain unsolved. Further study at the theoretical basis of capital is required in the process of global environment unification. The research of current consolidation and restructuring trends still not been fully solved. The positive and negative aspects of identification of mergers and acquisitions are in need of major improvement of motivational concepts of business restructuring through mergers and acquisitions. Poor performance is also the quite relevant evidence about the issue of the activities in this fact. The results carried through the associations over the past decade. The question needs deep analysis, and then, to determine the best way to resolve it.

In modern industry, especially in aircraft manufacturing is considered to be one of the greatest economic problems of technological process. The enterprise of heavy machinery sector production such as aircraft manufacturing, powerful economic and resource supply are required to place on its territory. Because aircraft manufacturing requires enormous financial funding, highly-skilled employees, the possibility of the transportation of special fields' materials from other countries and special fields for new products testing and so on. The USA, Canada, UK, Germany, Spain, France, Russia, Switzerland possess such a potential. Among these countries, additional constructions for companies are produced in Italy, Ukraine, Greece, Bulgaria and other countries.

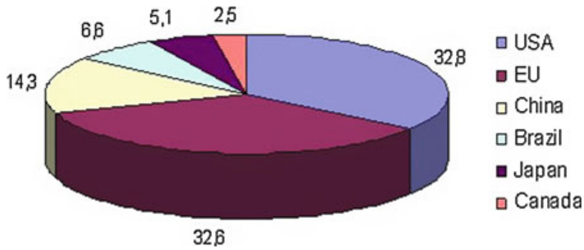
Nowadays, powerful positions in the aviation industry belong to Canada, USA, EU countries (France, Germany), Brazil, Japan. China (Table 88.1) is also gaining a rapid development in aviation industry (Matveev and Novykova 2009).

According to structural analysis of the world aircraft market, world leaders in this field are the U.S. and EU (Fig. 88.1) (Corokeyro 2002).

Table 88.1 The positions of the leading countries in the world aerospace products markets (% of total market)

Years	USA	Canada	EU	China	Brazil	Japan	The general amounts of market, bn. USD
1980	46.6	2.0	29.6	–	16.0	0.1	196.7
1990	51.7	2.3	28.4	0.1	9.1	0.2	261.3
2000	39.5	3.3	31.5	10.1	6.4	3.7	252.4
2009	32.8	2.5	32.6	14.3	6.6	5.1	273.7

Fig. 88.1 World aircraft market structure



Aviation industry, based on a scientific bases and highly skilled staffs, has developed only in countries with high economic level (Fig. 88.2).

The main competitive advantages that contribute to the formation of industrial clusters, increasing profitability and serial production, investment, development of technological base are: the establishment of international consortia, with leading corporations participation (Airbus, Eurfighter), organization of joint companies (Eurocopter), long-term cooperation (Boeing and Dassault Sistems, Snecma Moteurs and NPO Saturn), cross-border mergers and acquisition (Boeing, BAE Systems; Lockheed Martin; Aerospatiale Matra), aerospace industry state support. The main subjects of aerospace technology are diversified companies with high share of civil products, which are usually influenced by private capital and are widely involved in international integration (Table 88.2).

In such a way, the production potential which is served by tremendous current assets, intellectual and labor resources gives an opportunity to set and solve correspondent problems, accepting and running the competition. The greatest aviation industry global companies are: “Boeing”, “Lockheed Martin”, “EADS”, “British Aerospace”, “Raytheon-Hughes” and others. Thus, the main financial condition, which is formed by the global market for “passing” to the number of manufacturers which design and produce modern aircraft is consolidated capital, based on the production with an annual sales volume of at least several billion US dollars.

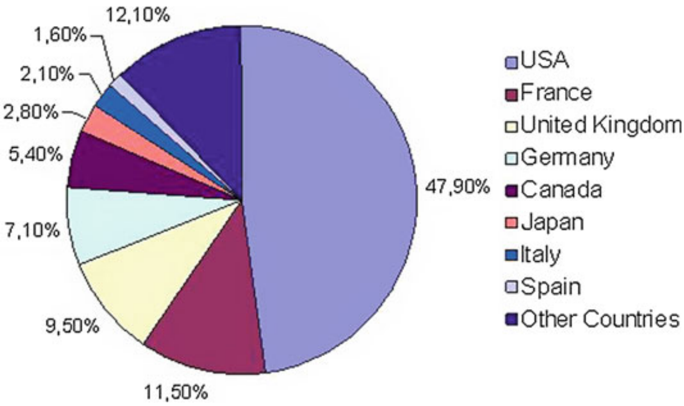


Fig. 88.2 Sales volume of world aviation industry products in the 2009

Table 88.2 Integration groups in the world aviation industry

Company name	Location of country	Form of ownership	Revenue in 2008 billions, USD	Companies involved in the integration group	Transaction cost, billions, USD	Year of merger
Boeing	USA	Private	52.4	Hughes space and communications activities	3.8	2000
				Conquest	–	2003
				Rockwell aerospace/defense	3.1	1996
				Frontier systems	–	2004
				McDonnell Douglas	16.3	1996
Lockheed Martin	USA	Private	35.5	Lockheed corp. > Martin Marietta corp.	10.0	1995
				Loral company	9.1	1996
				Titan corp.	2.5	2003
European aeronautic defence and space (EADS)	Netherlands	Private	43.4	Aerospatiale-Matra (France)	–	2000
				DaimlerChrysler aerospace AG (DASA) (Germany)	–	2000
				Construcciones aeronauticas SA (CASA) (Spain)	–	2000
Bombardier aerospace	Canada	Private	15.8	Canadair limited	–	1986
				de Havilland Canada	–	1992
				Learjet company	–	1990
				Short brothers (PLC)	–	1989
Embraer	Brazil	Private	3.4	–	–	–
Northrop–Grumman	USA	Private	29.9	TRW	11.9	2002
				Litton	2.6	2001
				Newport news	2.6	2001
BAE systems	Great Britain	Private	25.4	Marconi electronic SYSTEMS (USA) > the British aerospace	12.75	1999
				Tracor	1.4	1998
				Lockheed Martin control systems	2.2	2000
				United defense industries (UDI)	4.2	2005

As a result, according to the authors, to overcome the crisis in the aviation sector of Ukraine should create favourable conditions for domestic entity, using the world's experience to make aviation company's integration in a single system. The results of world leading aircraft manufacturers showed disappointing state of Ukrainian aircraft industry. But with the help of own mistakes and experience, some actions for a single aviation industry group creation have been performed since 2005. Thus, in 2007 state concern "Aviation of Ukraine" was established [8]. Which includes the following state enterprises: State Enterprise "Aviation Scientific-Technical Complex named after Antonov"; State enterprise Kyiv Aviation Plant "Aviant", State "Plant N 410 of Civil Aviation", Kharkiv State Aviation Production Enterprise, State Enterprise Research Institute, Buran, State Enterprise "Kharkiv aggregate Design Bureau", State Kharkiv enterprise of machine-building plant "FED", State Enterprise "Zaporuizhya Machine-Building Design Bureau "Progress" named after A.G. Ivchenko " State Enterprise "Novator", State-owned Enterprise "Radiovymiryuvach". But on October 30, 2008 the Cabinet of Ministers of Ukraine [9] excluded these groups from five sub-enterprises and then, it appeared a new name: the State Concern aircraft Antonov. Nowadays the State aircraft Concern "Antonov" includes: "State enterprise "Aircraft Scientific-Technical Complex named after Antonov" Kharkiv State Aviation Production Enterprise, state enterprise "Kyiv Aviation Plant "Aviant", State Company "Plant N 410 of Civil Aviation" (Lozhachevska et al. 2008).

Various reasons of integration, which is caused by the world cyclical economic development and the rate of technological changes, character of production changes, identified a wide range of different organizational forms of cooperation of business entities, are differently considered by theoreticians and practitioners because of the legal status, specification which is provided by civil and/or economic legislation in different countries.

In conclusion, according to the authors, we should apply the experience of aviation companies' integration into a single system to overcome the crisis in the aviation sector of Ukraine favorable conditions for domestic entity performance.

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Chapter 89
Shipping Enterprise Develop Strategies Based on Low-Carbon Integrated Logistics

Lei Yang, Guilu Tu and Xiaocui Xiao

Abstract With increasingly fierce competition, it is a trend for shipping enterprise to provide the integrated logistics service rather than just ocean transportation. Meanwhile, the hot topics of global warming, environment pollution, energy prices rise, and low carbon economy are taken more and more seriously, hence Chinese shipping industry faces a series of challenges. This paper constructs a developmental pattern of shipping enterprises based on low-carbon integrated logistics, calculates the carbon emission of the main low-carbon integrated logistics service activities and then concludes the major carbon emission influencing factors of shipping enterprise implementing low-carbon integrated logistics, offers several suggestions for implementing low-carbon integrated logistics strategy in the aspect of technology, operation, management and market. This research enriches the academic theories on low-carbon integrated logistics and provides a certain amount of inspiration and references for the shipping enterprises.

Keywords Low-carbon integrated logistics · Shipping enterprise · Path analysis · Develop strategies

89.1 Introduction

The world shipping industry faces increasingly fierce competition nowadays. The profit margins of shipping enterprises are getting lower and lower. Facing the various personal demands of shippers and customers, it is necessary to seek a new

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service pattern for sustainable development of enterprises. The traditional shipping enterprises could rely on their advantages in ocean transportation to get involved in integrated logistics services. Low-carbon economy that aims at addressing high energy consumption, high pollution and high emission is highly recommended as a new way for shipping industry. Shipping enterprises can effectively combine logistics services with low-carbon economy development. This paper proposes some development strategies for shipping enterprises based on low-carbon integrated logistics. The research results will have great practical value in expanding the scope of business, improving the competitiveness and logistics level, reducing logistics service costs of shipping enterprise, promoting the shipping industry transformation, energy conservation and emission reduction.

"Low-carbon economy" firstly appears in the British government's white paper (2003). In the report, the low carbon economy is regarded as a future direction and guide of the national energy development for England. The famous economist, Nicholas Stern, also highly recommend low-carbon economy (Stem 2006). He presents that the low-carbon economy has a great impact on the development of economy. 1 % of GDP investment can reduce the potential GDP loss for 5–20 % annually. Some foreign scholars argue the feasibility of low-carbon economy from an empirical perspective. For example, Kawase et al. (2006) show that the target of 60–80 % emission reductions can be achieved under certain conditions. Shimada et al. (2007) take Shiga, Japan as example, using a new scene description method to empirically analyze the urban long-term low-carbon development. They deeply study the impact of low-carbon on the development direction and operating mode of the whole logistics industry through further discussing low-carbon logistics. Li (2010) recognizes that green logistics contains low-carbon logistics according to the comparison of the origin, essential meaning and scope between them.

In terms of integrated logistics services of shipping enterprises, Luan and Hu (2008) find that integrated logistics is different from traditional logistics service mode. The integrated logistics relies on the integrated logistics service center to provide personalized value-added services for shippers and customers. Its service technology includes network technology, information processing technology, etc. As the development of integrated logistics services, some scholars go deep into study from the perspective of development of shipping enterprises, which implement integrated logistics services.

Some scholars deeply discuss the development strategy of the shipping enterprises mainly from the perspective of corporate strategy, performance, innovation, etc. Lorange (2001) studies the competitiveness of enterprises in terms of corporate strategy. Jenssen (2003) investigate the contribution of innovation factors to the performance of shipping enterprises through a sample survey on Norwegian shipping enterprises. Dragovic et al. (2006) conduct a performance evaluation of ship calling at the port.

From literatures above, the scholars mainly conduct research on low-carbon economy, low-carbon logistics, integrated logistics services and strategic assessment of shipping enterprises from different perspectives. However, the study on low-carbon integrated logistics services for shipping enterprises and specific ways of operations is scarcely found. The rest of this paper is organized as follows. In the next section, we construct a developmental pattern of shipping enterprises based on low-carbon integrated logistics. Section 3 calculates the carbon emission of the main low-carbon integrated logistics service activities of shipping enterprise and then analyzes the influencing factors. Section 4 proposes some strategic suggestions. Section 5 shows the conclusions and outlook of this paper.

89.2 Developmental Pattern of Low-carbon Integrated Logistics

89.2.1 Development Status of the Integrated Logistics

The total amount of China' social logistics grows rapidly, in which the total amount of industrial logistics takes the largest share. According to the data published by China Federation of Logistics and Purchasing, the total amount of social logistics in China was about 125 trillion RMB in 2010, which is 2.6 times of the amount in 2005, with an average annual growth rate of 21 %. The share of logistics industry added value was 7 % in GDP, 16 % in tertiary industry. In the composition of China's total amount of social logistics in 2010, the total amount of industrial logistics accounted for about 90 %, which played a crucial role. Chinese ports occupy six seats of the world's top ten ports and six seats of the top ten container ports respectively. There are 22 ports whose cargo throughput is more than one hundred million tons, including 16 coastal ports and 6 river ports. The scale of the shipping capacity of China's shipping enterprises is growing continuously.

89.2.2 Development Situation of the Low-Carbon Emission Reduction

More than 90% of the global total cargo transport is realized by shipping. However, even if the shipping industry is regarded as one of the most environmentally friendly mode of transport, it also constantly threats the environment. By the "Second IMO GHG Study 2009" (2009), CO_2 emission efficiency of the ocean transportation is the highest in all modes. Shipping transport is higher than road transport, but the gap between the shipping transport and rail transport is very small. The governments around the world reach a series of conventions and treaty through decades of research, including the United Nations Framework Convention on Climate, the Kyoto Protocol, the "Bali roadmap", the regulatory framework for international shipping low-carbon emission reduction by IMO.

89.2.3 Development Mode of Shipping Enterprises Based on Low-Carbon Integrated Logistics

The low-carbon integrated logistics of shipping enterprises is a combination of low-carbon logistics and integrated logistics services. Through advanced network and information processing technologies, shipping enterprises not only pursue low power, low emissions, low pollution, re-utilization in low-carbon logistics, but also stresses the importance to expand new logistics value-added services fields, and optimize operations such as transfer, storage, distribution, uncrating, multimodal transport, information processing, etc. Shipping enterprises that focus on energy-efficiency and low-carbon emission reduction can rely on current marine transport infrastructure and existing advantages in firm size, service market, business networks and logistics facilities, and develop new value-added logistics services, extending integrated logistics services.

89.3 Carbon Calculation on Shipping Enterprises Based on the Integrated Logistics

This section calculates carbon emissions from two major service activities of shipping enterprises implementing low-carbon integrated logistics: international maritime transport service and terminal logistics value-added service.

89.3.1 Carbon Calculation on International Shipping Services Activities

According to the Circular MEPC.1/Circ.684 released by IMO and literature (Takashima et al. 2008), this section calculates Energy Efficiency Operational Indicator (EEOI), which represents shipping carbon emissions of the international maritime transport services activities. Indicators are defined as follows:

$$A = \begin{bmatrix} \underset{nm}{A_1} & \underset{n(n-m)}{A_2} \end{bmatrix}_{m<n}, \tag{89.1}$$

where i denotes the type of fuel. Let FC_i be the total consumption of fuel i in a voyage, CF_i be the conversion coefficient between the amount of fuel and the amount of CO_2, and $m_{c\arg o}$ be the laden weight designed, R_i be the packing rate of the ship in a voyage, D_i be the actually sailing distance of the ships corresponding to the cargo.

Admiralty Coefficient denotes the relation of power, speed and displacement of ships. It is a method that often used for calculating the vessel resistance in the ship

Table 89.1 The linear relationship between F_M *(P)* and P

Engine model	$F_M(P)/(t{\cdot}h^{-1})$	R_2
12K98MC	$(172.37P + 136716) \times 10^{-6}$	0.9993
12K90MC	$(172.82P + 105830) \times 10^{-6}$	0.9993
8K90MC	$(172.82P + 70553) \times 10^{-6}$	0.9993

Then, EEOI* = 140.34, 225.05, 227.35, 245.41, 281.88, 297.39

design. Let $C = \Delta^{2/3} \cdot V^3/P$ denote the Admiralty Coefficient, where the power of the main engine of the single-ship (*P*) is influenced by the displacement (Δ) and speed (*V*). To facilitate the discussion, we use EEOI* estimation formula under the ideal conditions for operations in the literature:

$$Score = \sum_{j=1}^{m} D_j f_j = \sum_{j=1}^{m}\sum_{i=1}^{n} D_j b_{ij} x_i. \tag{89.2}$$

The ship's actual dwt (Δc) is the product between design dwt (Δd) and the packing rate (R), ignoring the influence of the quality of fuel consumption on the total displacement. In the equation (89.2), let $F_M(P)$ be the fuel consumption of the main engine per unit time, P be the power of the main engine, $P = \lambda \bullet \Delta^{2/3} \bullet V^3$, unit: kw ($\lambda$ is a constant of comprehensive factors), Δ be the displacement of the ship, which is the addition of the design weight of the ship (Δs) and the actual dwt (Δc), V be the speed of ship navigation (unit: kn (knots)), F_A be the average fuel consumption of the auxiliary engine per unit time, unit: t/h, F_B be the average fuel consumption of the boiler per unit time, unit: t/h, t_n be the sailing time, which can be obtained by $t_n = {}^{D}/_{V}$ (unit: h), t_s be the berth time (in port).

Selecting the sample data of 6 typical ocean-going container ships (S1-S6) studied in the literature (Ding 2011). Based on the working status of ship in full load and common continuous power, the speed of ship sailing can reach the design speed. According to the formula $P = \lambda \bullet \Delta^{2/3} \bullet V^3$, we can calculate integrated factor constant λ for each sample ship, $\lambda = 1.142 \times 10^{-3}$, 1.926×10^{-3}, 1.851×10^{-3}, 1.726×10^{-3}, 1.895×10^{-3}, 1.933×10^{-3}. Based on the data of specific fuel oil consumption [SFOC g/kW• h] and the corresponding power (P, kw) in the ISO standard conditions, we can conclude that the fuel consumption of the main engine $F_M(P)$ per unit time has a direct linear relationship with the power of the main engine P as shown in Table 89.1.

89.3.2 Carbon Calculation of Terminal Logistics Value-Added Service Activities

The fuel consumption during the ship berth is mainly generated by the main engine, auxiliary engine and boiler. For example, for the 180,000 tons of bulk carriers with a main engine model of MANB & W6 S70MC MKVI, the fuel

Table 89.2 CO_2 emission efficiency of highway freight transport presented by IMO

Mode of transport	CO_2 emission efficiency value (g CO_2/ton*km)	Data sources of research sample
Heavy truck	138	"National Road Traffic Survey" and "Continuing Survey of Road Goods Transport"
Highway freight transport	127	Statistical data based on the European area
Freight (>40t)	80	Sample survey of 109 freight car
Freight (<40t)	181	Sample survey of 44 freight car
Highway freight transport	156	The results of statistical analysis on the EU
Highway freight transport (2007)	144	The results of statistical analysis on Japan

Data resources Second IMO GHG study 2009

Table 89.3 CO_2 emission efficiency value of highway freight transport by the UK department for environment, food and rural affairs (light truck)

Truck fuel	Truck deadweight	Emission efficiency value (Unit: g CO_2/ton*km)			
		CO_2	CH_4	N_2O	Overall
Gasoline (I)	<1.305t	1173.5	1.45	5.05	1180.0
Gasoline (II)	1.305–1.740t	820.6	0.93	3.25	824.8
Gasoline (III)	>1.740t	496.0	0.50	3.55	500.1
Gasoline average	<3.5t	563.7	0.59	3.55	567.9
Diesel (I)	<1.305t	959.5	0.38	6.46	956.4
Diesel (II)	1.305–1.740t	873.9	0.24	5.94	880.0
Diesel (III)	>1.740t	522.0	0.12	3.55	525.6
Diesel average	<3.5t	588.0	0.15	4.00	592.2
Liquefied petroleum gas	<3.5t	617.4	1.21	4.54	623.2
Compressed natural Gas	<3.5t	588.6	2.95	4.54	566.1
Average	<3.5t	586.5	0.17	3.97	590.7

Data sources The UK Department for Environment, Food and Rural Affairs (www.defra.gov.uk).2010).2010 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors, 2010, 10

consumption of the ship is 3.5 t/d, the fuel consumption of loading and unloading is 7 t/d, the fuel consumption of the boiler is 5.16 t/d, and the fuel consumption of the ship berth is 15.66 t/d. The carbon emissions of land transport service activities are mainly produced from the fuel consumption of transport machineries. The calculation of carbon emissions of land transport service activities could refer to Table 89.2, 89.3 and 89.4.

Based on Table 89.3 and 89.4, influencing factors of the carbon emission of land transport service activities include fuel type, vehicle type, vehicle deadweight and vehicle loading rate. Selecting fuel type with low economic cost and high

Table 89.4 CO_2 emission efficiency of highway freight transport by the UK department for environment, food and rural affairs (heavy truck)

Motorcycle type	Total deadweight	Cargo load factor (%)	Deadweight of every vehicle in England	Emission efficiency value (Unit: g CO_2/ton*km)			
				CO_2	CH_4	N_2O	Overall
Van	>3.5–7.5t	41	0.86t	659.5	0.35	6.85	666.7
	>7.5–17t	41	1.82t	412.4	0.22	4.28	416.9
	>17t	53	4.91	200.3	0.11	2.08	202.5
	Average in England	52	3.30	251.2	0.13	2.61	253.9
Trailer	>3.5–33t	45	5.56	152.6	0.17	1.59	154.4
	>33t	61	11.31	86.8	0.10	0.90	87.8
	Average in England	60	10.93	88.7	0.10	0.92	89.7
The overall heavy truck	*Average in England*	58	7.20	124.3	0.13	1.91	126.3

Data sources: the UK Department for Environment, Food and Rural Affairs Department (www.defra.gov.uk).2010).2010 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors, 2010, 10

environmental benefits, trailer with big deadweight, and improving the average vehicle load ratio contribute to carbon emission reduction and operational efficiency of land transport service activities.

89.4 Recommendations for the Development Strategy of Shipping Enterprises

The implementation of low-carbon integrated logistics, reduction of shipping logistics cost and improvement of the low-carbon integrated logistics capability become very important. Some suggestions for Chinese shipping industry are provided as follows.

89.4.1 Promote the Innovation and Application of Low-Carbon Integrated Logistics

Chinese shipping enterprises should accelerate technological innovation to improve energy efficiency operational indicator of newly-built ships, recycle marine accessories and greenhouse gases, develop and utilize new energy and alternative fuels, and transform production facilities and equipment in fuel and power efficiency, to realize the low-carbon efficiency. Many research findings show that the replacement of anti-fouling paint on large container ships contributes to the reductions in ship hull resistance. Shipping enterprises could also consider recycling valuable ship accessories under the guarantee of normal shipping conditions. They can even determine quota of material consumption for each ship and conduct regular assessment to save raw materials.

89.4.2 Promote Low-Carbon Operations of Integrated Logistics Activities of Shipping Enterprises

Chinese shipping enterprises can calculate the carbon footprint through implementing low-carbon integrated logistics activities. They should design reasonable speed, strengthen low-carbon operations of fuel and power consumption, promote multimodal transport, develop drop and pull transport, and establish coordination mechanisms with upstream and downstream enterprises. The shipping enterprises should calculate the contents of carbon footprint from the whole supply chain. Reducing the speed of ship has a significantly effect on improving energy efficiency. Shipping enterprises should monitor and account records of fuel consumption and boat storage every day, keep control of daily fuel consumption within reasonable limits, implement normal management of ultra-low load operations. Multimodal transport can reduce the long-distance transfer costs, delivery time and road congestion to a large degree.

89.4.3 Explore Measures of Low-Carbon Integrated Logistics with Market Intervention

Chinese shipping enterprises should take advantage of energy management contracting, establishment of voluntary agreement framework, establishment and announcement of ship environment indicator system, to achieve integrated logistics service activities. The Energy Management Contracting is a new mechanism, which aims to save energy through the contract and customers' mutual agreement on energy-saving construction projects, provide customers with services such as audit, design, financing, construction, equipment procurement of energy-saving projects, confirmation and guarantee of installation, staff training and energy savings, etc. Chinese shipping enterprises can establish a voluntary commitment mechanism to make emission reductions commitment to the government, customers and the public relying on certificates or honors, to show their friendliness to the environment.

89.5 Conclusion

This paper firstly constructs a developmental pattern of shipping enterprise based on low-carbon integrated logistics, including service mode, service direction, service content and development path, and then calculates the carbon emissions of the main low-carbon integrated logistics service activities from international shipping services and terminal logistics value-added services. Finally, this paper proposes suggestions: vigorously promote innovation and application, low-carbon operations, explore measures of low-carbon integrated logistics of shipping enterprises with market intervention.

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Chapter 90
An Estimation Method of the Carbon Footprint in Manufacturing Logistics Systems

Xiaolong Qu and Bo Li

Abstract Production Logistics includes a series of processing activities in manufacturing systems. With following the trend of low carbon economics, the estimation and analysis of the carbon footprint in manufacturing logistics system concern the sustainable development of a company. In this paper, we first put forward a conception of carbon footprint from the manufacturing logistics system level, and further definite the boundary to estimate carbon footprint of the production logistics system. With the help of Kaya Identity, the four main factors are presented to describe the influence on the production logistics carbon footprint and a carbon footprint calculation method is provided. By the traditional factor analysis approach, the sensitivity of changes of each factor on the carbon footprint is discussed.

Keywords Production logistics · Carbon footprint · Kaya identity · Factor analysis approach

90.1 Introduction

Under the highly competitive business environment, customers and government pay more attention to the environment issues. Carbon footprint is the indicator used to measure the impact of human activities on the environment, the level of environmental stress, and the direct or indirect GHG emissions caused by certain activities.

The literature on carbon footprint calculating is growing these years. On the macroscopy, Larsen and Hertwich (2009) calculated carbon footprint in the United State by using input–output analysis. Sun et al. (2010) integrated the result of

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China's carbon emission calculation based on regional input–output model. Under the framework of Kaya identity, Xing and Shan (2011) analyzed how the indicators of carbon intensity of energy consumption, energy intensity of GDP, per capita income and population have impacted China's CO_2 emission from 1978 to 2009.

On the microscopy, Scipioni et al. (2010) aiming at GHG management issues, provided a life cycle approach used to identify the processes of an organization and its supply chain that had major impacted on climate change. Lee (2011) pointed that measurement of direct and indirect carbon footprint and identification of system boundary was critical for mitigating supply chain risks by studied the case of Hyundai Motor Company (HMC) in the automobile industry. Shen and Wang (2011) built a carbon emissions estimation method of the paper industry based on "Greenhouse Gas Protocol-Corporate Accounting and Reporting Standards". China National Institute of Standardization (2011) based on the ISO14064 series of international standards developed GHG accounting procedures and methods.

According the literature review, it comes out that Kaya identity is more popular and common at the macro level. However, for the activities of enterprises at the micro level, researchers tend to use process analysis methods such as life cycle approach and emission list set method. There are some shortcomings: the enormous data, the omission of indirect carbon source and the uncertainty of emission factors. Likely, the Kaya Identity could maintain the basic amount of information at the same time, simplify the complex calculation and provide strategic decision-making for companies. In view of the above, this paper uses the improved Kaya Identity to calculate the carbon footprint from the production logistics system in the manufacturing company, and then reveals how the changes of four factors (production inputs, output, energy intensity and carbon intensity of energy) affect the carbon footprint emissions.

90.2 Calculation the Carbon Footprint of Production Logistics System

90.2.1 Boundary of Production Logistics Carbon Footprint System

See (Fig. 90.1).

90.2.2 The Estimation Identity of the Carbon Footprint in Production Logistics

The Kaya identity was proposed by a Japanese scholar called Mao Yang (Yoichi Kaya) (also known as Mao Equation), it reveals the link between CO_2 emissions and economic, policy and population from the macro level. The equation can be

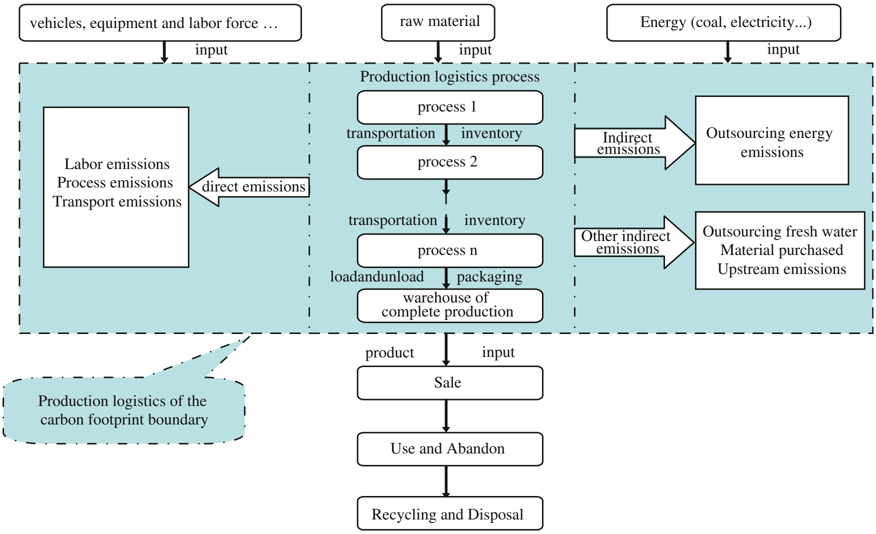

Fig. 90.1 Production logistics of the carbon footprint boundary

expressed as: Carbon emission = Population × Per capita GDP × Energy consumptions per GDP × Carbon emission of per unit energy consumption. From the micro level, if we change Kaya identity in a proper way, we could use the change of four factors: production inputs, output, energy consumption of unit output, and carbon intensity of energy to reflect the change of the carbon footprint from the production process, the accounting identity (model) is:

$$C = I \times \left({}^{P}\!/_{I}\right) \times \left({}^{E}\!/_{P}\right) \times \left({}^{C}\!/_{E}\right). \tag{90.1}$$

C production logistics systems carbon footprint during the reporting period(C_1 is defined as number during the reporting period, C_0 is number of base period), tCO_{2e};
P Quantity of output during the reporting period, million;
I Production input during the reporting period(i_1 number of reporting period, i_0 number of base period), million;
E Energy consumption during the reporting period, *tce*;
P/I input-output per unit during the reporting period(p_1 number of reporting period, p_0 number of base periods), million/million;
E/P energy intensity of output during the reporting period(e_1 number of reporting period, e_0 number of base period), *tce/*million;
C/E carbon intensity of energy during the reporting period(c_1 number of reporting period, c_0 number of base period), tCO_2/tce.

90.2.3 Factor Changes on the Carbon Footprint

During the reporting period, the variation of production logistics system carbon footprint is ΔC, according to the formula (90.1) we obtain the following formula:

$$\begin{aligned}\Delta C &= C_1 - C_0 = i_1 \mathrm{p}_1 \mathrm{e}_1 c_1 - i_0 p_0 e_0 c_0 \\ &= (i_0 + \Delta i)(p_0 + \Delta p)(e_0 + \Delta e)(c_0 + \Delta c) - i_0 p_0 e_0 c_0 \\ &= (i_0 p_0 e_0 \Delta c + i_0 p_0 c_0 \Delta e + i_0 e_0 c_0 \Delta p + p_0 e_0 c_0 \Delta i) \\ &\quad + (i_0 p_0 \Delta e \Delta c + i_0 e_0 \Delta p \Delta c + i_0 c_0 \Delta p \Delta e + p_0 e_0 \Delta i \Delta c + p_0 c_0 \Delta i \Delta e + e_0 c_0 \Delta i \Delta p) \\ &\quad + (i_0 \Delta p \Delta e \Delta c + p_0 \Delta i \Delta e \Delta c + e_0 \Delta i \Delta p \Delta c + c_0 \Delta i \Delta p \Delta e) + \Delta i \Delta p \Delta e \Delta c\end{aligned} \tag{90.2}$$

It can be seen from formula (90.2) that these factors could affect the carbon footprint separately and conjointly. So it is necessary to decompose the combined effect of several factors. As Δi, Δp, Δe and Δc are in different dimensions, it is necessary to use identical transformation method, turn the absolute value (which are Δi, Δp, Δe, Δc) into the amplitude of variation (which are $\frac{\Delta i}{i_0}, \frac{\Delta p}{p_0}, \frac{\Delta \mathrm{e}}{e_0}, \frac{\Delta c}{c_0}$). The rate is comparable according to the mathematical operation rules, besides it is well-found in the economic world. The derivation and discussion process are as follows:

Firstly, on the basis of formula (90.2)'s identical transformation, we could get:

$$\begin{aligned}\Delta C &= C_1 - C_0 \\ &\equiv \left[\frac{\Delta i}{i_0}\cdot\frac{p_0 e_0 c_0 \Delta i}{\frac{\Delta i}{i_0}} + \frac{\Delta p}{p_0}\cdot\frac{i_0 e_0 c_0 \Delta p}{\frac{\Delta p}{p_0}} + \frac{\Delta e}{e_0}\cdot\frac{i_0 p_0 c_0 \Delta e}{\frac{\Delta e}{e_0}} + \frac{\Delta c}{c_0}\cdot\frac{i_0 p_0 e_0 \Delta c}{\frac{\Delta c}{c_0}}\right] \\ &\quad + \left[\begin{aligned} &\left(\frac{\Delta i}{i_0}\cdot\frac{e_0 c_0 \Delta i \Delta p}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}} + \frac{\Delta p}{p_0}\cdot\frac{e_0 c_0 \Delta i \Delta p}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}}\right) + \left(\frac{\Delta i}{i_0}\cdot\frac{p_0 c_0 \Delta i \Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}} + \frac{\Delta e}{e_0}\cdot\frac{p_0 c_0 \Delta i \Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}}\right) \\ &+ \left(\frac{\Delta i}{i_0}\cdot\frac{p_0 e_0 \Delta i \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta c}{c_0}} + \frac{\Delta c}{c_0}\cdot\frac{p_0 e_0 \Delta i \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta c}{c_0}}\right) + \left(\frac{\Delta p}{p_0}\cdot\frac{i_0 c_0 \Delta p \Delta e}{\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}} + \frac{\Delta e}{e_0}\cdot\frac{i_0 c_0 \Delta p \Delta e}{\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}\right) \\ &+ \left(\frac{\Delta p}{p_0}\cdot\frac{i_0 e_0 \Delta p \Delta c}{\frac{\Delta p}{p_0}+\frac{\Delta c}{c_0}} + \frac{\Delta c}{c_0}\cdot\frac{i_0 e_0 \Delta p \Delta c}{\frac{\Delta p}{p_0}+\frac{\Delta c}{c_0}}\right) + \left(\frac{\Delta e}{e_0}\cdot\frac{i_0 p_0 \Delta e \Delta c}{\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}} + \frac{\Delta c}{c_0}\cdot\frac{i_0 p_0 \Delta e \Delta c}{\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}\right)\end{aligned}\right] \\ &\quad + \left[\begin{aligned} &\left(\frac{\Delta i}{i_0}\cdot\frac{c_0 \Delta i \Delta p \Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}} + \frac{\Delta p}{p_0}\cdot\frac{c_0 \Delta i \Delta p \Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}} + \frac{\Delta e}{e_0}\cdot\frac{c_0 \Delta i \Delta p \Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}\right) \\ &+ \left(\frac{\Delta i}{i_0}\cdot\frac{e_0 \Delta i \Delta p \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta c}{c_0}} + v\frac{\Delta p}{p_0}\cdot\frac{e_0 \Delta i \Delta p \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta c}{c_0}} + \frac{\Delta c}{c_0}\cdot\frac{e_0 \Delta i \Delta p \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta c}{c_0}}\right) \\ &+ \left(\frac{\Delta i}{i_0}\cdot\frac{p_0 \Delta i \Delta e \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}} + \frac{\Delta e}{e_0}\cdot\frac{p_0 \Delta i \Delta e \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}} + \frac{\Delta c}{c_0}\cdot\frac{p_0 \Delta i \Delta e \Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}\right) \\ &+ \left(\frac{\Delta p}{p_0}\cdot\frac{i_0 \Delta p \Delta e \Delta c}{\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}} + \frac{\Delta e}{e_0}\cdot\frac{i_0 \Delta p \Delta e \Delta c}{\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}} + \frac{\Delta c}{c_0}\cdot\frac{i_0 \Delta p \Delta e \Delta c}{\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}\right)\end{aligned}\right]\end{aligned}$$

$$+\left[\begin{array}{l}\frac{\Delta i}{i_0}\cdot\frac{\Delta i\Delta p\Delta e\Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}+\frac{\Delta p}{p_0}\cdot\frac{\Delta i\Delta p\Delta e\Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}\\+\frac{\Delta e}{e_0}\cdot\frac{\Delta i\Delta p\Delta e\Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}+\frac{\Delta c}{c_0}\cdot\frac{\Delta i\Delta p\Delta e\Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}\end{array}\right] \tag{90.3}$$

Then, we could get (D_i), the difference number of carbon footprint's change caused by i's change, by means of putting forward $\frac{\Delta i}{i_0}$ from formula (90.3). The expression is:

$$\begin{aligned}D_i = {} & \frac{\Delta i}{i_0}\cdot\frac{p_0e_0c_0\Delta i}{\frac{\Delta i}{i_0}}+\frac{\Delta i}{i_0}\cdot\left(\frac{e_0c_0\Delta i\Delta p}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}}+\frac{p_0c_0\Delta i\Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}}+\frac{p_0e_0\Delta i\Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta c}{c_0}}\right)\\ & +\frac{\Delta i}{i_0}\cdot\left(\frac{c_0\Delta i\Delta p\Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}+\frac{e_0\Delta i\Delta p\Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta c}{c_0}}+\frac{p_0\Delta i\Delta e\Delta c}{\frac{\Delta i}{i_0}\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}\right)\\ & +\frac{\Delta i}{i_0}\cdot\frac{\Delta i\Delta p\Delta e\Delta c}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}+\frac{\Delta c}{c_0}}\end{aligned} \tag{90.4}$$

By the use of this way, we could get D_p, D_e and D_c (the difference number of carbon footprint's change caused by the other three factors) either.

Finally, we discuss formula (90.3) from the following five kinds of cases:

Case i: when all Δi, Δp, Δe, Δc are not zero, all the factors affect the changes of carbon footprint. This kind of situation just has been discussed;

Case ii: when one of Δi, Δp, Δe, Δc is zero, assuming that $\Delta c = 0$, then the ΔC caused by three factors (i, p and e) can be obtained:

$$\begin{aligned}\Delta C = {} & C_1 - C_0\\ \equiv {} & \frac{\Delta i}{i_0}\cdot\frac{p_0e_0c_0\Delta i}{\frac{\Delta i}{i_0}}+\frac{\Delta p}{p_0}\cdot\frac{i_0e_0c_0\Delta p}{\frac{\Delta p}{p_0}}+\frac{\Delta e}{e_0}\cdot\frac{i_0p_0c_0\Delta e}{\frac{\Delta e}{e_0}}\\ & +\left(\begin{array}{r}\frac{\Delta i}{i_0}\cdot e\frac{e_0c_0\Delta i\Delta p}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}}+\frac{\Delta p}{p_0}\cdot\frac{e_0c_0\Delta i\Delta p}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}}+\frac{\Delta i}{i_0}\cdot\frac{p_0c_0\Delta i\Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}}+\frac{\Delta e}{e_0}\cdot\frac{p_0c_0\Delta i\Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta e}{e_0}}\\+\frac{\Delta p}{p_0}\cdot\frac{i_0c_0\Delta p\Delta e}{\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}+\frac{\Delta e}{e_0}\cdot\frac{i_0c_0\Delta p\Delta e}{\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}\end{array}\right)\\ & +\left(\frac{\Delta i}{i_0}\cdot\frac{c_0\Delta i\Delta p\Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}+\frac{\Delta p}{p_0}\cdot\frac{c_0\Delta i\Delta p\Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}+\frac{\Delta e}{e_0}\cdot\frac{c_0\Delta i\Delta p\Delta e}{\frac{\Delta i}{i_0}+\frac{\Delta p}{p_0}+\frac{\Delta e}{e_0}}\right)\end{aligned} \tag{90.5}$$

Accordingly, we could get D_i, D_p, and D_e in this case. Specific steps are the same as formula (90.4).

Case iii: when two of four factors are zero, assuming $\Delta e = 0$ and $\Delta c = 0$, then the ΔC caused by two factors (i and p) can be obtained by using the same method in case ii. By the same token, we also could get D_i and D_p in this situation.

Case iv: when three of four factors are zero, assuming $\Delta p = 0$, $\Delta e = 0$ and $\Delta c = 0$, then we could get the ΔC and D_i caused by single factor (i).

Case v: when all four factors are zero, that is $\Delta i = 0$, $\Delta p = 0$, $\Delta e = 0$ and $\Delta c = 0$, then carbon footprint of production logistics system does not change during the reporting period, thus $\Delta C = 0$.

90.3 Empirical Analyses

We select the year of 2004 as base period and the year of 2005 as reporting period. Specific data and calculation results are shown in Table 90.1 and Table 90.2.

According to the Case ii, we derive that $D_i = 278.4$, $D_p = -940.95$, $D_e = -1551.08$. Changes in production inputs I exacerbates the increase of the carbon footprint of company's production logistics, while the reduction of the input–output caused by the raising of cost and the reduction of energy intensity of products caused by the technological progress impact the carbon footprint reversely. And product energy intensity's reduction makes the most significant contribution to the reduction of carbon footprint. The combined effects of the three effects are as follows: $D_i + D_p + D_e = -2213.63$, which is approximate with the value of ΔC in Table 90.2 (the calculation errors can not be avoided). If we change the order of the changes of the three factors, the result is still the same, and the specific calculation in this article will not be described.

90.4 Conclusions

From the perspective of the company's carbon footprint theoretical system, carbon emissions calculation is only the primary study on the carbon footprint research; there is no mature evaluation methods and standard specification for the carbon footprint system. Basic data to support carbon footprint evaluation are not enough from practice yet, so it is necessary to strengthen the related research and the collection of the basic data. A lot of problems worth thoroughly investigate such as the carbon footprint compensation mechanism (carbon or carbon offsets), the

Table 90.1 Production and energy consumption data of the car manufacturers in 2004 and 2005

Years	2004	2005
Number	117	117
Total output value (million)	57627000	56404000
Enterprise average value (million)	492538.46	482085.47
Total Input (million)	53823618	54288850
Enterprise average investment (million)	460030.92	464007.27
Input–output ratio (million/million)	1.071	1.039
Production energy intensity (tce/million)	0.0846	0.0804
Carbon intensity of energy (tco_2e/tce)	0.7559	0.7559

Table 90.2 Influencing factors on average carbon footprint of the car manufacturer during the reporting period

Influencing factor	Base period (2004)	Reporting period (2005)	Variation(±)
Production input I (million)	$i_0 = 460030.92$	$i_1 = 1464007.27$	$\Delta i = 3976.35$
Input–output ratio $^P/_I$ (million/million)	$p_0 = 1.071$	$p_1 = 1.039$	$\Delta p = -0.032$
Production energy intensity $^E/_P(tce/\text{million})$	$e_0 = 0.0846$	$e_1 = 0.0804$	$\Delta e = -0.0042$
Carbon intensity of energy $^C/_E(tco_2e/tce)$	$c_0 = 0.7559$	$c_1 = 0.7559$	$\Delta c = 0$
Target: Carbon footprint $C(tCO_2e)$	$C_0 = 31507.3$	$C_1 = 29299.53$	$\Delta C = -2207.77$

carbon trading mechanism, and scientific utilization of the carbon footprint theory in practice.

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Chapter 91
The Optimization Model and Algorithm of Reverse Logistics Network for Resource Recovery

Wei Cao, Xi Zhang, Te-lang Li and Ying-hui Liang

Abstract Considering the location, storage, transportation and service in the reverse logistics network of resource recycling, this paper puts forward a multi-echelon reverse logistics network which includes customers, initial collection point, centralized recycling center and recovery processing factory. Based on the constraint of facility capacity and customer demand, this paper establishes the 0-1 mixed integer programming model. We use Lingo 8.0 to solve it and prove it is feasible, combined with the example and the simulation analysis of it.

Keywords Resource recovery · Reverse logistics · Network optimization · Multi-objective programming · Location

91.1 Introduction

There are three ways to design the network of reverse logistics: design the network of reverse logistics independently; design the network of reverse logistics and forward logistics comprehensively; design the network of reverse logistics based on the network of forward logistics. There are many papers on designing the structure or network of reverse logistics home and abroad. Fleihmann (2001) established a

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mixed integer nonlinear programming model and designed a mixed genetic algorithm to solve it through researching the optimization problem of manufacturing/remanufacturing in reverse logistics network; Hokey et al. (2006) put forward an mixed integer programming model to make sure the location and the number of recycling remanufacturing factory of electronic products; Considering stochastic demand, Jayaraman et al. (1999) established a mixed integer programming model and solved it through genetic algorithm. The references above only considered the problem of facility site selection and assignment in network design. But they didn't considered the impact on the network design made by the decision of inventory and transportation quantity. Considering the factors of site selection, storage, transportation and service in reverse logistics network, this paper establish an 0-1 mixed integer programming model and solve it through Lingo 8.0.

91.2 Problem Description

In this thesis, the reverse logistics network of resource recycling consists of client area, initial recycling points, centralized recycling center and recovery processing factories. Clients need send the recycling products to initial recycling points. Then centralized recycling center will dismantle, repair and remanufacture them after collecting. In order to bring convenience to the customers, the initial collection points are usually built near them. Based on the scale effect of transportation of the products client area return, recycling center collects every point's products regularly Ko and Evans (2007).

91.3 Model Building

91.3.1 Parameters and Variable Definition

The definition of the parameters and variable are as follows:

Define $i \in I$ as customer's subscript, $m \in M$ as initial collection point's subscript, $n \in N$ as centralized collection center's subscript, $f \in F$ as recovery processing factory's subscript, λ as the recycling resource's reusable ratio after handled by the initial collection point, η as the recycling resource's reusable ratio after handled by the centralized collection center. c_m as the cost when the initial collection point is built at m, a_m as the unit resource's operation cost of initial collection point a year, e_m as the unit resource's processing cost of initial collection point a year, b_m as the unit product's inventory cost of initial collection point a day, N_i as the number of daily recycling products of customer i, w as working days a year, p as the largest distance of the initial collection point m cover, r as the customer's unit resource's punishment cost when there is no initial collection point, T_m as the inventory cycle of the initial collection point m, R_m as the largest storage capacity of the initial collection point during inventory cycle, γ as the unit resource's punishment cost of the client area isn't covered.

$$\rho_{im} = \begin{cases} 1 & \text{The client area is not in the coving scop of initial collection point} \\ 0 & \text{else} \end{cases}$$

c_n as the cost of building centralized recovery center at n, a_n as the unit resource's operation cost of collection center a year, R_n as the biggest capacity of recovery center n, d_{mn}as the distance from initial collection point to centralized recovery center, e_n as the unit resource's processing cost of recovery center, b_n as the unit resource's inventory cost of recovery center, d_{nk} as the distance from centralized recovery center to recycling processing plant, T_n as the storage cost of recovery center.

Define decision variables as follows:

$$K_m = \begin{cases} 1 & \textit{If} \text{ choose m to establish the initial collection point} \\ 0 & \textit{else} \end{cases}$$

$$X_{im} = \begin{cases} 1 & \textit{If} \text{ the resourse of client area is transported to the initial collection point m} \\ 0 & \textit{else} \end{cases}$$

$$X_{mn} = \begin{cases} 1 & \textit{If} \text{ the resourse of point m is transported to collection center} \\ 0 & \textit{else} \end{cases}$$

$$X_{nf} = \begin{cases} 1 & \textit{If} \text{ the resource of collection center c is transported to f} \\ 0 & \textit{else} \end{cases}$$

Define freight function as follows:

$$f(\mathrm{u_j}, \mathrm{d_j}) = \mathrm{E}\alpha\beta.$$

Among them, u_j as the middle variable: the amount of resources shipped from the initial recovery point or centralized recycling centre to the next recycling resource processing place. $u_{mn} = \sum_i N_i(1-\lambda)X_{imn}T_m$ as the amount of resources which the initial collection point couldn't handled and shipped to the recycling center; $u_{nf} = \sum_m N_i(1-\lambda)1-\eta X_{mns}T_n$ as the amount of resources that the recovery center couldn't handled and shipped to processing factory.

E as freight rates for the unit;

α as scale effect factor caused by different transportation batch:

$$\alpha = \begin{cases} \alpha_1 & u_j \le N_1 \\ \alpha_2 & N_1 \le u_j \le N_2 \\ \alpha_3 & u_j \ge N_2 \end{cases}$$

β represents scale effect factor caused by different transportation distance:

$$\beta = \begin{cases} \beta_1 & d_j \le d_1 \\ \beta_2 & d_1 \le d_j \le d_2 \\ \beta_3 & d_j \ge d_2 \end{cases}$$

91.3.2 Model Building

The goal of building model is to make the total cost in reverse logistics network of recycling resource minimum.

$$\begin{aligned} \min\ C = & \sum_m K_m(c_m + a_m) + \sum_n Z_n(c_n + a_n) + \sum_i \sum_m \lambda N_i e_m w \\ & + \sum_i \sum_m (1-\lambda)\mathrm{N_i X_{im} b_m} \frac{T_m + 1}{2} \mathrm{w} \\ & + \sum_i \sum_m \mathrm{X_{mn}}(1-\lambda) N_i T_m f(\mathrm{N_{mn}, d_{mn}}) \frac{\mathrm{w}}{\mathrm{T_m}} \\ & + \sum_i \sum_m \sum_n \mathrm{X_{mn}}(1-\lambda)\eta N_i e_n w \\ & + \sum_i \sum_m \sum_n X_{mn}(1-\lambda)(1-\eta)\mathrm{N_i} b_n \frac{T_n + 1}{2} w \\ & + \sum_i \sum_m \sum_n X_{nf}(1-\lambda)(1-\eta)\mathrm{N_i} T_n f(\mathrm{N_{nf}, d_{nf}}) \frac{\mathrm{w}}{\mathrm{T_n}} \\ & + \gamma w \sum_i X_{im} \rho_{im} N_i \end{aligned} \tag{91.1}$$

$$\text{s .t.} \quad \sum_m X_{im} = 1 \tag{91.2}$$

$$\sum_i X_{im} \le MK_m \tag{91.3}$$

$$\sum_m X_{mn} \le MZ_n \tag{91.4}$$

$$\sum_i \sum_m X_{im} N_i (1-\lambda) T_m \le K_m R_m \tag{91.5}$$

$$\sum_i \sum_m \sum_n X_{mn}(1-\lambda)(1-\eta)\mathrm{N}_i T_n \le Z_n R_n \tag{91.6}$$

$$\sum_m K_m \leq Q_1 \tag{91.7}$$

$$\sum_n Z_n \leq Q_2 \tag{91.8}$$

$$K_m, Z_n, X_{im}, X_{mn}, X_{nf} = \{0, 1\} \tag{91.9}$$

$$T_m, \mathrm{T}_n = \{0, 1, 2, 3, 4, 5, 6, 7\} \tag{91.10}$$

$$\begin{array}{ll} i = 1, 2, \ldots \mathrm{h} & \mathrm{m} = 1, 2 \ldots \mathrm{r} \\ \mathrm{n} = 1,2,\ldots \mathrm{s} & \mathrm{f} = 1, 2, \ldots \ldots \mathrm{t} \end{array} \tag{91.11}$$

The objective function (91.1) is the minimum cost of the reverse logistics network, which includes the cost of building initial collection points and centralized collection centers, recycling resources' preliminary treatment fee of initial collection points, inventory fee of recycling resources which can't be handled, operation cost a year, freight fee of recycling resources which can't be handled to the centralized collection center, punishment cost of the client area isn't covered by initial collection points, cost of reprocessing of recovery center, storage cost of resources which can't be processed, operation cost a pear, freight fee of recycling resources which can't be handled to the processing factory.

Constraints (91.2) ensure that customer's recovery resources can be delivered to initial collection point; Constraints (91.3) and (91.4) prevent customers from being assigned to the initial collection points which are not open; Constraints (91.5) and (91.6) guarantee recycling resource is not more than the biggest inventory capacity of the initial collection point and several kinds of the recycling centre. Constraints (91.7) and (91.8) is the amount constraint of the initial collection point,and recycling centre, $M = \max\{I, M, N, F\}$; Constraints (91.9) and (91.10) and (91.11) set the scope of variables. Lingo8.0 is a kind of software for solving large-scale linear programming, integer programming and nonlinear programming. This paper use it to solve the model.

91.4 Example

In order to deal with more and more resources recovery, some company plans to establish a reverse logistics network. Build the initial collection point and centralized recycling center as far as possible to bring convenience to the customers (Rogers and Tibben 1998). The coordinates of potential initial collection point (6), centralized recycling centre (5) and recycling plant (2) are shown in Tables 91.1. The cost of building new initial collection point and new centralized recycling center are respectively shown in 91.2 and 91.3.

The initial collection point and the centralized recycling centre which are selected will serve 20 customer bases, the number of recycling resource of every

Table 91.1 Coordinates of the logistics facilities

Logistics facilities		Coordinates	
		x	y
Potential initial collection point	m_1	24.97	45.89
	m_2	43.57	45.65
	m_3	25.43	18.25
	m_4	42.04	20.97
	m_5	15.08	23.71
	m_6	34.28	16.91
Potential centralized recycling centre	n_1	9.47	29.14
	n_2	23.22	9.05
	n_3	40.01	60.11
	n_4	49.55	7.40
	n_5	51.22	38.23
Potential recycling plant	f_1	18.01	48.02
	f_2	35.11	46.24

Table 91.2 The cost of building new initial collection point

Collection point	1	2	3	4	5	6
c_m	2092	2211	2165	2088	2229	1954
b_m	1.2	1.3	1.1	0.9	0.8	0.9

Table 91.3 The cost of building new centralized recycling center

Collection point	1	2	3	4	5	6
c_n	11311	11254	12133	11924	28621	27154
R_n	1822	1688	2122	1814	2351	2354

customer base is shown in Table 91.4, other parameters are shown in Table 91.5. The total demand is 900, working days a year are 242d, $w = 242$.

Let N_m be the number of initial collection point built, N_n be the number of centralized collection center built, A_m be the total operation cost of initial collection point, A_n be the total operation cost of centralized collection center, B_m be the processing cost of initial collection point, B_n be the processing cost of centralized collection center, C_m, C_n be the inventory cost of initial collection point, centralized collection center respectively, F_m, F_n be the freight fee of initial collection point, centralized collection center respectively, R be the punishment cost of customer base which is covered.

Use Lingo 8.0 to solve the model. The results are as follows (Table 91.6):

Using the model and algorithm above, when making the total reverse logistics cost minimum, bringing more convenience to the customer and making the enterprise have their original forward logistics network, we can have the reverse logistics network be allocated optimally.

Table 91.4 The daily number of recycling resources of each customer base

Customer base	Coordinates		The daily number of recycling resources
	x	y	
1	29.45	36.45	60
2	20.66	15.42	30
3	32.10	43.92	18
4	52.80	40.82	44
5	38.87	16.01	46
6	25.93	46.69	17
7	38.21	62.01	40
8	52.14	24.57	70
9	37.02	11.79	60
10	13.02	52.29	65
11	12.27	70.32	23
12	22.33	39.72	50
13	36.78	14.12	14
14	55.90	70.55	55
15	32.45	70.72	64
16	43.22	32.21	32
17	55.46	40.01	42
18	22.01	26.24	32
19	45.23	27.01	60
20	43.21	26.69	40

Table 91.5 The related parameters input in the model

Parameter	a_m	e_m	a_n	e_n	E	α_1	α_2	α_3	β_1
Value	398	220	420	397	1	0.7	0.6	0.5	1.1
Parameter	β_2	β_3	r	λ	η	N_1	N_2	d_1	d_2
Value	1.3	1.0	0.7	0.1	0.3	300	200	50	20

Table 91.6 Calculation results

Variable	Result
qN_m	3
N_n	2
$(m{:}T_m)$	{(3:1),(4:1)(6:1)}
$(m{:}i)$	{(3:1,5,8,10,13,18,20),(4:2,4,9,12,14,17) (6:3,6,7,11,15,16,19)}
$(m{:}N_i)$	{(3:166),(4:88)(6:60)}
$(n{:}m)$	{(1:3,4),(3:6)}
$(n{:}T_n)$	{(1:3),(2:3)}
A_m	1398
A_n	6300
B_m	6441
B_n	3400
F_m	33200
F_n	25621
R	300
C	8086

91.5 Conclusion

The paper builds not only reverse logistics network for enterprise but collection points near the client area. Considering the convenience and economy of enterprise's recycling products, this paper builds three recycling facilities which are initial collection point, centralized recycling centre and recycling factory to realize the reverse logistics. This paper sets up a mixed integer programming model which can minimize the total cost of reverse logistics. Combined with the practical constraints, this paper solved the problem of site selection and assignment of reverse logistics facilities. This paper uses Lingo 8.0 to solve the model, analyzes it through example and proves it feasible.

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Chapter 92
Analysis of the Development of Low-Carbon Logistics Based on a Low-Carbon Economy

Xiu-Ying Liu

Abstract The low-carbon economy is a kind of Win–win economic development patterns of developing economic and protecting environment. The logistics industry occupies an important position in the low-carbon economy. The development of low-carbon economy relies on the support of low-carbon logistics. Firstly, this paper analyzes the relationship between low-carbon economy and low-carbon logistics. Secondly, it expounds the current development status of China's low-carbon logistics; Finally to focus, it raises the forward suggestions and countermeasures of China's development of low-carbon logistics.

Keywords Low-carbon economy · Low-carbon logistics · Low-carbon logistics systems

92.1 Introduction

Under the background of global warming, in order to prevent the continuing deterioration of the ecological environment, the development of low-carbon economy has become a hot spot of global concern. Therefore it has given birth to some new nouns, such as "low carbon economy", "low carbon technology", "low carbon development", "low carbon society", "low carbon city", and "low carbon world" etc.

The world will enter one era of low-carbon economy based on low energy consumption, low pollution, low emission, to change the traditional model of economic development, promote the adjustment and upgrading of industrial structure, carry out low-carbon economy and build a resource-saving and

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environment-friendly. It is a historical necessity which is realized with sustainable economic and social development.

92.2 The Relationship Between Low-Carbon Logistics and Low-Carbon Economy

92.2.1 The Development of Low-Carbon Economy Relies on the Low-Carbon Logistics Support

Logistics plays a decisive role in the low-carbon economy, according to the statistics of the world's energy consumption in 2005, the transportation accounted with 26 %. It fully shows that we must focus on "low carbon" running of the transport sector to promote the operation and development of low-carbon economy. "Logistics" is inseparable from the transportation. Logistics industry is the large energy consumption, and also emits a large amount of carbon dioxide gas. So, to develop the low-carbon economy, the logistics industry must lower the carbonation road (Yue 2010).

92.2.2 The Development of Low-Carbon Logistics is the Only Way to Achieve Low-Carbon Economy

The development of low carbon logistics is to reduce carbon dioxide emissions and energy consumption in the logistics process to a minimum or even zero emissions, fully recycle and recovery the logistics resources through low-carbon transport, low-carbon storage, low-carbon packaging, low-carbon loading and unloading, low-carbon distribution and low-carbon recovery, the formation of a low energy consumption, low carbon emissions and less environmental pollution, and economic costs of low-carbon industry. Therefore, it is necessary to strengthen the management and control of all aspects of the logistics, to reduce carbon dioxide emissions, and to make reasonable use of resources to achieve a "low-carbon logistics".

92.3 The Current Development Status of China's Low-Carbon Logistics

92.3.1 Road Transportation has a Large Proportion

There are many ways of logistics transportation, the ratio of carbon dioxide emissions in the various modes of transportation is: 31 % for road transportation, 6 % for shipping, 3 % for aviation, 3 % for railway. Among them, the carbon dioxide emissions by road are about ten times that of the railway, and its cost is also more than 10 times of the railway. From the Table 92.1, a mass of the main line transportation in our Country still mainly rely on road, and the total mileage of kilometers is increasing continuously, The tail gas and noise from vehicles is becoming one main pollution source in large cities and threatening the human beings health seriously.

92.3.2 The Lack of Unified Planning in Logistics System has Caused the High Energy Consumption and Low Effectiveness

The lack of unified planning in Logistics system results in serious waste of logistics resources. For example, an unreasonable freight network location and distribution center layout will cause goods circuitous transportation; the connection of all aspects of logistics is not close; the logistics equipment is not standard; the equipment standards between the various modes of transport are not uniformed etc. Due to all the problems above, It is more difficult to make low carbon logistics operation smoothly.

92.3.3 Logistics Infrastructure Layout is not Reasonable

Different departments are in charge of logistics infrastructure planning and construction, and lack the necessary communication and consultation with each other. Therefore, logistics infrastructure is short of compatibility, which made the whole

Table 92.1 Mode of transport freight volume and its growth rate statistics in 2011

Index	Absolute number	Increase number t han 2010
Total freight(hundred million tons)	368.5	13.7
Railway	39.3	8.0
Road	281.3	14.9
Water	42.3	11.7
Aviation	552.8	-1.8
Pipeline	5.4	9.0
The quantity of goods (ton-km)	159014.1	12.1
Railway	29465.8	6.6
Road	51333.2	18.3
Water	75196.2	9.9
Aviation	171.7	-4.0
Pipeline	2847.2	29.6

function of logistics system declined. At the same time, it is lack of effective consultation between different transport systems and different regions. The slow process of the construction of Logistics Park and Logistics Center seriously has impacted the rational flow of goods. The utilization ratio of equipment is low and the energy consumption increases, which has seriously hampered the development of low-carbon logistics.

92.3.4 The Government Policy and Regulation is not in Place

For a long time, our country logistics industry appears fragmentation, the phenomenon of multiple management is becoming more and more serious. Logistics activities relate to the different functional departments, all of these departments segment operation, each of them does things in their own way. The various functional departments to develop low-carbon logistics lack of a unified strategic conception and the overall planning. It has caused the low-carbon logistics development management not in place, and aggravated logistics waste of resources and energy consumption. In addition, China's policy and legal system about the development of low-carbon logistics are abnormally weak, there is little laws and regulations policy made to relate with carbon emissions.

92.4 Suggestions and Countermeasures to Develop Low Carbon Logistics

The implementation of low-carbon logistics is a huge logistics engineering, it relates to many different aspects of the logistics, and requires the establishment of a complete logistics system.

92.4.1 Government Should Release the Corresponding Laws and Regulations, and Strengthen the Supervision at the Same Time

The government should speed up to promote the structural reform of China's logistics management system, e, to establish one variety of low-carton subsidy policies, tax policies and loan offers policies through environmental legislation to implement the supervision and control.

On the one hand, you can take the policy of low-carbon subsidies to give encouragement and financial support to the logistics enterprises who achieved energy saving and carbon emissions reducing.

In addition, you can also use the tax measures and market mechanisms (carbon tax and carbon trading mechanisms) to restrict the packaging, e, to exhaust emission, e, to establish and perfect the low-carbon logistics certification and regulatory system, increase the penalties for high carbon emissions logistics companies, and restrict and monitor carbon emissions behavior of the logistics enterprises; Third, restrict some high energy consumption, resources wasting and inefficient logistics enterprises through macro-adjustment of the industrial and product policies. In short, the constraints of policy and regulations and the implementation of varieties of incentives will be the external driving force for the logistics enterprises to develop low-carbon logistics.

92.4.2 To Strengthen the Logistics Industry in Low-Carbon Awareness Training, and Build Low-Carbon Business Philosophy

To promote the healthy development of China's logistics industry, we must first conduct a civil quality education to popularize the universal concept of low-carbon life, enhance citizens' low-carbon awareness, so that the whole people will recognize the importance of low-carbon in the sustainable development, thus to create a corporate environment for the enterprises to develop low-carbon logistics; Second, cultivate business operators to establish a low-carbon business philosophy and social responsibility awareness so as to let them plan systematically in the entire logistics system to achieve the overall optimization, lessen the exhaust emission, noise pollution and traffic congestion problems actively, and to let them realize that achieving economic, social and ecological benefits at the same time is the only way to realize the sustainable development of enterprises (Wang and Li 2010).

92.4.3 Emphasis on the Construction of Logistics Information and to Lay the Foundation for the Realization of Low-Carbon Logistics

First, we must improve the logistics enterprises' IT construction. The information is the basis of modern logistics management, but also the premise to improve the logistics efficiency. The low-carbon logistics information is an effective way to serve the low-carbon society effectively. Through the promotion and application of bar code technology, radio frequency technology, EDI, GPS, GIS technology and so on in the logistics industry, it can effectually improve the efficiency of logistics operations.

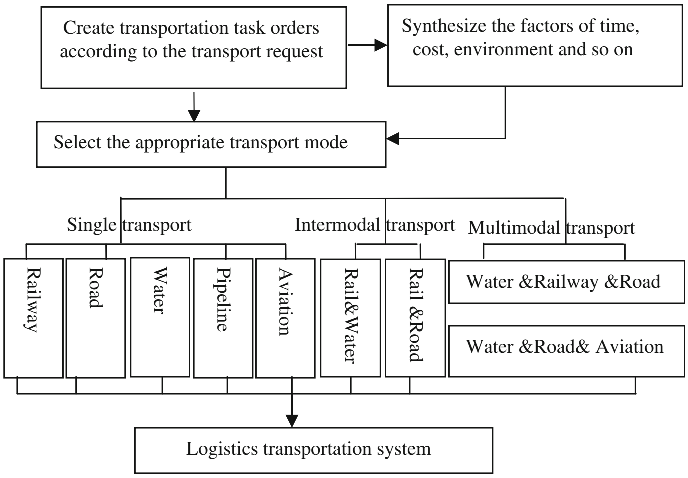

Fig. 92.1 Logistics transportation system

Secondly, establish an unified logistics information platform. It can achieve intensive allocation of logistics resources, reducing and lessening energy consumption base on the logistics information platform as well as modern logistics IT.

Finally, strengthen the R&D and utilize of new logistics technologies. Utilize the Internet of Things technology and cloud technology to promote the upgrade of modern logistics. Internet of Things can effectively achieve the intelligent scheduling of logistics management, it also plays a very positive role to integrate logistics core business processes, strengthen the rationalization of logistics management, consolidate communication among the various aspects, save energy, and reduce carbon emissions etc. The application of advanced technology such as the Internet, internet of Things, cloud technology speeds up the evolution of the traditional logistics to a low carbon logistics.

92.4.4 Overall Planning, Accelerate the Transformation of Logistics, Improve the Integrated Transport System

To improve the logistics and transport system, it is necessary to give full play to the advantages of various modes of transport. As the Fig. 92.1 shown, the way of transportation has single transport, intermodal and multimodal transport etc., strengthen the coordination of various departments, innovate transport organization mode, build a reasonable transport network, and tap its huge potential of energy saving and consumption reducing. To carry out the intermodal transportation among the railway, waterway and road transport as far as possible, and build a leaner, more efficient, more environmentally friendly low-carbon transport system (Dai 2008).

All in all, the development of low-carbon economy needs modern logistics' support. There is still a long way to go for China to develop the low-carbon logistics due to the large gap with many foreign countries. Therefore, the development of low-carbon logistics in the background of low-carbon economy is still a long-term and important research topic, and also has very important practical significance.

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Chapter 93
Eco-Efficient Based Logistics Network Design in Hybrid Manufacturing/ Remanufacturing System Under Low-Carbon Restriction

Yacan Wang, Xiaoxia Zhu and Tao Lu

Abstract In this paper the question of trading off the economic and environmental effects embodied in eco-efficiency in the hybrid manufacturing/remanufacturing logistics network design in the context of low-carbon economy is examined. A multi-objective mixed integer linear programming model to find the optimal facility locations and materials flow allocation is established. In the objective function, three minimum targets are set: economic cost, CO_2 emission and waste generation. Through an iterative algorithm, the Pareto Frontier of the problem is obtained. The results of numeric study show that in order to achieve a Pareto improvement over an original system, three of the critical rates should be increased. Also, to meet the need of low-carbon dioxide, an iso-CO_2 emission curve in which decision makers have a series of optimal choices with the same CO_2 emission but different cost and waste generation is plotted. Each choice may have different network design but all of these are Pareto optimal solutions, which provide a comprehensive evaluation of both economics and ecology for the decision making.

Keywords Hybrid manufacturing/remanufacturing system · Tradeoff · Pareto improvement · Logistic network design · Low-carbon economy · Eco-efficiency

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93.1 Introduction

Remanufacturing supply chain consists of not only the traditional forward logistics network for manufacturing and distribution but also the reverse logistics supply chain logistics network for remanufacturing, which is a typical closed-loop manufacturing/remanufacturing hybrid system. During the design of hybrid manufactured/remanufacturing logistics network (Krikke et al. 2003; Savaskan 2004; Mutha and Pokharel 2009), economic efficient and environmental efficiency have been treated as two separated goals for long, and they haven't been integrated with each other, which is against the interest of low-carbon economy. Low-carbon economy is the pursuit of eco-efficiency, which is a win–win situation between economic and environmental efficiency (Neto 2009).

Increasing attentions have been paid to examine the integrated logistics network design in hybrid remanufacturing system, but only adopts single objective, normally minimum cost (Francasa and Minner 2009; Easwarana and Üsterb 2010). This research associates carbon emission to our objective function and uses Pareto sets to analyze how to balance profitability and environmental impacts in designing remanufacturing closed-loop supply chain in the context of low-carbon economy.

Concerning the trade-off relationships among the objectives in this paper, pareto-optimal is adopted to search for the best solution to avoid negative influence on other solutions and all trade-offs between the logistic network cost and its environmental impact. This paper sets up a tri-objective mathematical programming and attempts to achieve Pareto boundary. In light of the need of low-carbon economy, this paper attempts to search for the solutions comprising business and the environment at a certain level of carbon emission.

93.2 Mathematic Model

93.2.1 Description of the Problem

The designed network consists of factory, distribution center, consumption area, recycling center, and solid waste disposal location. Among them, products collected can be divided into recoverable for remanufacturing and unrecoverable for disposal. This model contributes to determine the optimal locations, as well as the allocations of both forward and reverse material flows in the closed-loop supply chain.

We assume a sample manufacturing/remanufacturing logistics network: there are M potential factories, which can manufacture and remanufacture; J potential recycling center, which check and categorize the collected products. After checking and categorizing, the recoverable will be sent to factories for remanufacturing. After remanufacturing, the products will be sold in I potential distribution center and the unrecoverable products will be dealt in the disposal facility. The Logistics network topology structure is illustrated in Fig. 93.1.

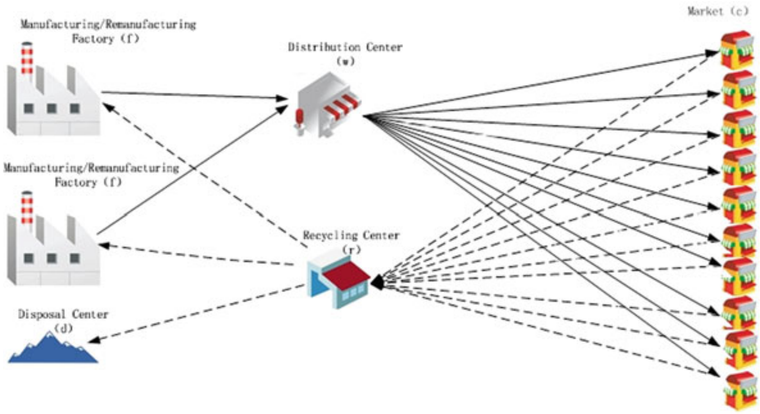

Fig. 93.1 Logistics network structure

Table 93.1 Assumed conditions of the model

No.	Assumptions
1	Factories can both manufacture and remanufacture and those products can all meet the market demand via distribution center.
2	Remanufacturing the collected products can save cost, and we believe the cost saved and products recycled are in positive relation.
3	Products collection is calculated by areas and is in positive relation to the particular consumption and return rate is certain and known. Products can be remanufactured in the factories after checking by the collection point.
4	We assume the ratio of remanufacturing to all collected products is exogenous.

93.2.2 Assumptions

First we concern the basic assumptions in this model, as those in Table 93.1.

93.2.3 Formulation

To answer the call of low-carbon economy, in this model, we set the optimization goals as: 1. Minimum total cost. This cost is the sum cost throughout one product's life cycle; 2. Minimum environmental impact. Considering the difficulty in fetching all LCA data of the products, it becomes regular practice to use simplified indicators instead of doing a full LCA to lower data requirements in mathematic modeling (Sasse et al. 1999; Umeda et al. 2000; Bloemhof-Ruwaard 1996). In this paper, we adopt waste generation and carbon-dioxide emission for an approximation to evaluate environmental impact. The optimization objectives are illustrated in Fig. 93.2.

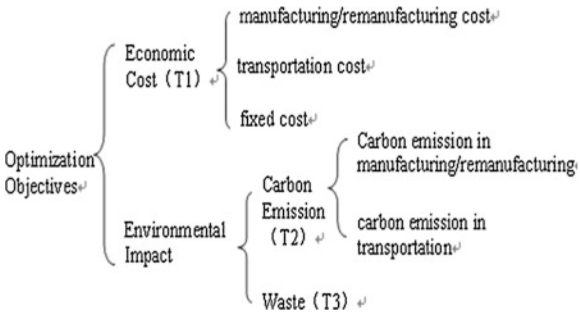

Fig. 93.2 Optimization objectives

Optimization Objective

The first optimization objective is minimum economic cost:

$$\min T_1 = FC + TC + MC \tag{93.1}$$

which includes the fixed costs of setting up factories, distribution centers and recycling center

$$FC = \sum_m F_m^f Y_m^f + \sum_i Y_i^w F_i^w + \sum_j Y_j^r F_j^r$$

Transportation cost consists of that in forward logistics (from factory to distribution center) and reverse logistics (from market to recycling center and then to factory and disposal facility).

$$\begin{aligned} TC = & \sum_i \sum_m C_{mi} X_{mi} + \sum_i \sum_c C_{ic} X_{ic} \\ & + \sum_c \sum_j C_{cj} X_{cj} + \sum_j \sum_m C_{jm} X_{jm} + \sum_j \sum_d C_{jd} X_{jd} \end{aligned}$$

Cost of manufacturing/remanufacturing: cost of manufacturing minuses cost saved by remanufacturing.

$$MC = \sum_m \sum_i E_p X_{mi} - \sum_j \sum_m C_r X_{jm}$$

The second optimization objective is minimum carbon emission

$$\min T_2 = TE + ME \tag{93.2}$$

The calculation of the carbon emission during transportation is similar to that in (93.1)

$$\begin{aligned} TE = & \sum_i \sum_m E_{mi} X_{mi} + \sum_i \sum_c E_{ic} X_{ic} \\ & + \sum_c \sum_j E_{cj} X_{cj} + \sum_j \sum_m E_{jm} X_{jm} + \sum_j \sum_d E_{jd} X_{jd} \end{aligned}$$

Carbon emission during manufacturing/remanufacturing: carbon emission of manufacturing minuses carbon emission saved by remanufacturing.

$$ME = \sum_m \sum_i E_p X_{mi} - \sum_j \sum_m E_r X_{jm}$$

The last objective is minimum waste discharge

$$\min\ T_3 = \sum_j \left[\sum_c X_{cj} - \left(\sum_m X_{jm} + \sum_d X_{jd} \right) \right] \tag{93.3}$$

According to WEEE, the quantity of waste equals to the quantity of the discarded products received by the collection point minuses the amount of products recovered (Neto 2009). In this paper, collection point includes the factory and disposal facility. The factory reproduces the end-of-life products and disposal facilities recycle the discarded ones.

Constraints

$$X_{mi}, X_{ic},\ X_{cj} \ldots \geq 0 \tag{93.4}$$

$$Y_m^f, Y_i^w,\ Y_j^r = 0, 1 \tag{93.5}$$

(93.4) represents the materials flow allocation of each route is nonnegative;(93.5) represents the location decision variable is constrained by 0–1. 1 represents the correspondent facility is under construction and 0 represents the opposite.

$$\sum_i X_{mi} \leq A_m^f Y_m^f, \forall m \tag{93.6}$$

$$\sum_c X_{ic} \leq A_i^w Y_i^w, \forall i \tag{93.7}$$

$$\sum_c X_{ic} \leq A_j^r Y_j^w, \forall c \tag{93.8}$$

(93.6)–(93.8) represent the capacity constraints of factory, distribution center and collection point respectively

$$\sum_i X_{ic} = D_c, \forall c \tag{93.9}$$

(93.9) represents products delivered from the distribution center to the market must meet its demand

$$\sum_m X_{mi} = \sum_c X_{ic}, \forall i \tag{93.10}$$

(93.10) represents the materials flow balance among the distribution centers

$$\delta_c \sum_i X_{ic} = \sum_j X_{cj}, \forall c \quad (93.11)$$

(93.11) represents the products collected from the market by the recycling center equals to the amount of products sold in the market times to return rate

$$(1-\beta)\sum_c X_{cj} \geq \sum_d X_{jd}, \forall j \quad (93.12)$$

$$\beta \sum_c X_{cj} = \sum_m X_{jm}, \forall j \quad (93.13)$$

(93.12) and (93.13) represent after checking and categorizing in the recycling center, products are delivered to disposal facility and factory for reproducing.

93.3 Algorithm and Numeric Study

We do the numeric study on an example of refrigerator industry. We randomly generated 5 potential factories, 6 potential distribution centers and recycling centers, 8 markets and the coordinates (km) of 4 disposal facilities. Take refrigerator as example, each refrigerator is about 65 kg and the transportation cost is 2 Yuan/ton each kilometer. Transportation consumes 0.015 L/ton each kilometer. The manufacturing cost per unit is 300 Yuan, and it consumes 1 kw. According to CO_2 emission index, 2.69 kg CO_2 emits for every liter of gasoline and 0.785 kg for each kilowatt. The fixed cost of facilities is illustrated in Table 93.2. There are 100 refrigerators demanded for each market, the capacity of each factory is 500 and the maximum capacity for distribution center and recycling center is 300 and 200 respectively.

In the following two sections, we give relevant algorithms and computational results from two aspects.

Table 93.2 The fixed cost of facilities

f1	f2	f3	f4	f5	
Fixed cost of factories (RMB)					
300000	400000	300000	300000	300000	
w1	w2	w3	w4	w5	w6
Fixed cost of distribution centres (RMB)					
30000	20000	20000	20000	20000	20000
r1	r2	r3	r4	r5	r6
Fixed cost of recycling centre(RMB)					
10000	10000	10000	10000	10000	10000

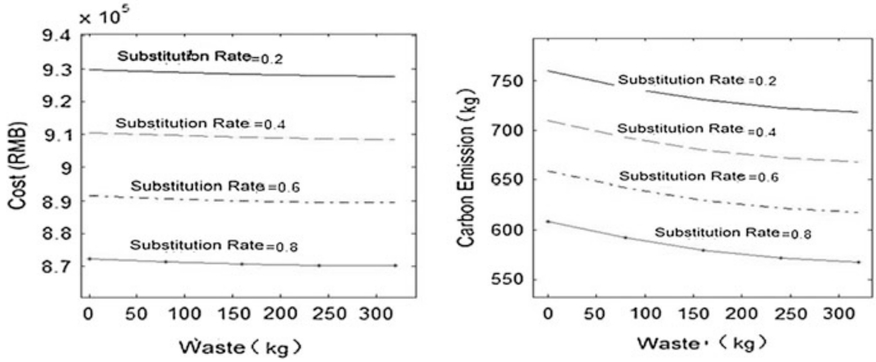

Fig. 93.3 The Pareto Frontiers with different cost substitute rates

93.3.1 Pareto Frontier in Different Parameter Conditions

The model in this paper is a mixed multi-objective integer programming. There are already comprehensive solvers for mixed integer programming, like cplex and Lingo. However, to achieve the Pareto sets of this model, a reasonable iterative algorithm should be designed. For there are clear upper and lower bounds for objective function (3), we will gradually relax objective function (3) and comprise that with objective (1) and (2) and finally work it out after weighting. The algorithm step is shown below:

The Pareto sets with different substitute rates worked out by the method above are showed in Fig. 93.3. Waste is in the trade-off relation with economic cost and carbon emission. (return rate = 0.8, recovery rate = 0.5). By examining the tendency of the boundaries we can have the following observations: (1) there is trade-off relation between carbon emission and waste generation; (2) there is also trade-off relation between economic cost and waste generation.

What's more, there is positive relation between carbon emission and cost. In setting up remanufacturing network, economic cost comes mostly from freight, fixed cost of facilities and operation cost of remanufacturing. As carbon emission generates mostly from transportation and remanufacturing, when they emit more carbon, the costs of freight and remanufacturing increase accordingly, and finally the total economic cost increases. With respect to the return rate and recovery rate, we can also get the similar results. In similar method, we can also analyze the return rate (recovery rate = 0.5, cost substitute rate = 0.8) and recovery rate (recovery rate = 0.8, substitute rate = 0.8).

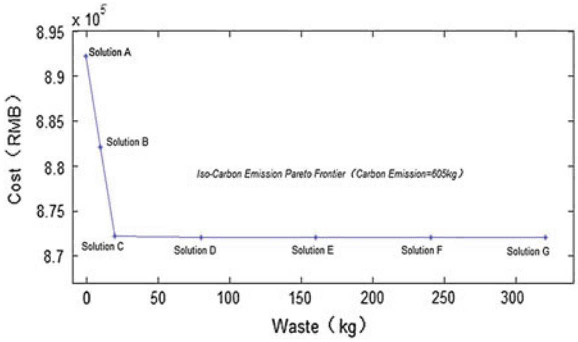

Fig. 93.4 The Iso-CO_2 emission Pareto Frontier

Table 93.3 Site-selection results in Pareto solution set

Solutions	A	B	C	D	E	F	G
Factory	1,3	1,3	1,3	1,3	3,5,	3,5	4,5
Distribution center	1,4,6	3,4,6	3,4,6	3,4,6	3,4,6	3,4,6	3,4,6
Recycling center	1,2,4,5,6	1,2,4,5,6,	1,2,4,5	1,2,4,5,	1,2,4,5,	1,2,4,5	1,2,4,5
Waste (kg)	0	10	20	80	160	240	320
Economic cost (RMB)	892020.5	882020.6	872220.4	872019.9	872019	872018.6	872018.4

93.3.2 The ISO-CO_2 Emission Pareto Frontier

To meet the need of low-carbon economy, enterprises are supposed to trade off profitability and environmental impact on the premise of controlling the carbon emission. We can achieve the basis for decision-making by solving the Pareto curve with equal carbon emission offered in this model. Similar to the first algorithm, we can set the carbon emission as T_2^C to be the constraint to get the following algorithm:

By adopting the method mentioned above, we can work out a similar Pareto Frontier (shown in Fig. 93.4). Table 93.3 is the location decision corresponded by each optimal solution on the Pareto Frontier.

In Fig. 93.4, we can find out, although the solutions all fit Pareto optimal, there are still different site options. These solutions explain when environmental impact is more important, the facilities will be close to disposal facility and away from market and factories. When cost concerns more, the facilities will be away from disposal facility and close to market and factories. In order to save cost, some of the discarded products will not be even delivered to the disposal facility.

93.4 Conclusion and Future Work

The objective of this study is to examine how to trade off the economic and ecological effects in the closed-loop logistics network design in the context of low-carbon economy. We establish a multi-objective mixed integer linear programming model to find out the optimal facility locations and materials flow allocation. In the objective function, we set three minimizing targets: economic cost, CO_2 emission and waste generation. The numeric study shows by increasing either of the three of the critical rates (i.e. return rate, recovery rate, cost substitute rate) can we achieve a Pareto improvement between economic and ecological efficiency.

The current study includes several limitations that offer opportunities for future research. First, in further research, we can consider the extension of this mode and fit it to multi-product and multi-loop situations. Second, during further research, we can discuss the design with variant parameters. Last but not least, researches on implications of remanufacturing closed-loop supply chain have just started up, few enterprises practice them. There is still possibility to study their real statistics to verify this model in further research.

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Chapter 94
Research on Household Electrical Appliances' Supply Chain Based on the LCA Method in the Situation of Low-Carbon Product Certification

Honghao Gao and Xianliang Shi

Abstract It is significant to studying the supply chain of household electrical appliances in low-carbon product certification. In the situation of low-carbon product certification, this paper used the LCA method to analyze the carbon emissions of household electrical appliances and to study how to optimize household electrical appliances' supply chain management in the situation of China's low-carbon product certification.

Keywords Low-carbon product certification · Life cycle assessment (LCA) · Household electrical appliances' supply chain

94.1 Introduction

In recent years, in order to better protect the natural environment and reduce carbon emissions in the atmosphere, more and more countries are beginning to carry out low-carbon product certification activities. The so-called low-carbon product certification means, based on the product's carbon footprint on products' all lifecycle, when a product's carbon footprint does not exceed predetermined limits, the product will be granted a low-carbon product marking and will be identified the carbon footprint or carbon levels (Hua et al. 2010).

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Life Cycle Assessment (LCA) method means collect and determinate environmental impact and input and output of material and energy which are directly related to the functionality of the product or service system throughout their whole life cycle. Household electrical appliances' supply chain management in low-carbon product certification puts low environmental pollution, low-carbon emissions, and low energy consumption as the purpose to improve the efficiency of using resource and saving costs (Zhu and Geng 2011). Therefore, in the situation of low-carbon product certification, the LCA method is an effective method to optimize household electrical appliances' supply chain management.

94.2 The Principles of Using the LCA Method

The LCA method can quantitatively analyze and qualitatively evaluate carbon emission from the initial raw material acquisition to final waste disposal, of which the purpose is to evaluate the consumption of energy and material and the influence of waste emissions on the environment. By defining household electrical appliances' goal and scoping, taking inventory analysis, evaluating impacts, and interpreting results, people can draw the greatest impact stages and influence types for carbon emissions in household electrical appliances' life cycle, and proposed improvement measures and methods, so that can provide a basis of analysis and decision-making for stakeholders in household electrical appliances' supply chain management (Valente et al. 2011).

What is more, it is known by analyzing household electrical appliances and their life cycle activities that they are composed by a number of components with certain functions, and their life cycle activities are just for realizing these functions or providing some services. In response to this common feature, people can through establishing a LCA model to optimize the supply chain management of household electrical appliances in the situation of low-carbon product certification, and enterprise can seek an opportunity to improve the environmental impact and take advantage of this opportunity (Schliephake et al. 2009).

94.3 Analysis and Optimization Process

94.3.1 Definition of Goal and Scoping

94.3.1.1 Definition of Goal

The main purpose of the life cycle assessment of household electrical appliances in low-carbon product certification is through qualitatively and quantitatively analyzing the impact of carbon emissions on the entire life cycle of household electrical appliances, find the link that carbon emissions in the life cycle of household electrical appliances cannot meet the low-carbon product certification and find out the location of these links in the supply chain, then use the theory of supply chain management to seek the starting points of changing production process and seek the ways of reducing products' carbon emissions.

94.3.1.2 Scoping

Composition Boundary

The composition boundary of household electrical appliances' life cycle assessment refers to the material compositions which are related to the household electrical appliances and have an important impact on the household electrical appliances systems (Li 2001). According to integrity rules, the composition boundary should contain all components of the products.

Process Boundary

In the situation of low-carbon products certification, household electrical appliances should be taken full account carbon emissions in the whole life cycle from raw material extraction, material processing, component manufacturing, product assembly, product packaging, product transportation, product use, recycling waste products, to reuse and process (Razmi and Pishvaee 2011). Therefore, the process of household electrical appliances' life cycle mainly includes: collection and transportation of raw materials; manufacturing and processing; distribution and transportation; use, maintenance, and repair; recycling and waste treatment.

94.3.2 Life Cycle Inventory Analysis

94.3.2.1 Data Collection

The main impact ways should be investigated where the greenhouse gas produced in the life cycle of the household electrical appliances, then collect the number of greenhouse gas which is produced directly or indirectly in all aspects. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) are the six kinds of main compositions of greenhouse gases, which are the main contents of calculating products' carbon footprint, so the greenhouse gas that we collect mainly refers to these six gases (Cellura et al. 2012). The main ways that influence carbon emissions are shown in Table 94.1.

Table 94.1 The main ways that influence carbon emissions in the life cycle of household electrical appliances

Life cycle	The main ways that produce greenhouse gas
Raw material	1. All inputs at any stage of the life cycle; 2. Texture of the raw materials (metal, wood, plastic, etc.); 3. Activities which are related to raw materials (pre-processing, packaging, storage, transportation, etc.)
Production and processing	1. All activities from purchasing raw material to selling products; 2. The energy consumption of all production equipments in the production process, 3. All products that produced in the process of production and processing (products, wastes, direct emissions of carbon dioxide, etc.);
Distribution and retail	1. All activities in the processes of transport and storage 2. The direct emissions of carbon dioxide in the process of retail, storage and display;
Consumers use	1. The energy consumption in stages of consumers' use 2. The direct emissions of carbon dioxide in the process of consumers' use
Recycle	1. All activities in the process of recycle such as transport, storage, and processing; 2. The energy required in the recycling process 3. The direct emissions of carbon dioxide in the recycling process

94.3.2.2 Data Calculation

People first should calculate the quantity of greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) which are produced in each unit process in various stages of the life cycle, then convert these greenhouse gas to an equivalent of carbon dioxide. Table 94.2 shows the carbon dioxide equivalent of various greenhouse gases (100 years) (Chaabane et al. 2012).

Formula,

$$Z = \sum\nolimits_{i=1}^{m} \sum\nolimits_{j=1}^{n} C_j Q_{ij} (i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n) \tag{94.1}$$

$$Q_{ij} = \sum\nolimits_{X=1}^{k} W_{ijx} (i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n;\ x = 1, 2, \ldots, k) \tag{94.2}$$

$$W_{ijx} = P'_{ix} * E'_{ijx} + P''_{ix} * E''_{ijx} + P'''_{ix} * E'''_{ijx} (i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n;\ x = 1, 2, \ldots, k) \tag{94.3}$$

Table 94.2 The global warming potential (GWP) of greenhouse gas (100 years)

Greenhouse gas	CO_2	CH_4	N_2O	HFCs	PFCs	SF
GWP	1	25	298	1430	10900	22800

$$Z = \sum_{i=1}^{5} \sum_{j=1}^{6} \sum_{X=1}^{m} C_j \left(P'_{ix} * E'_{ijx} + P''_{ix} * E''_{ijx} + P'''_{ix} * E'''_{ijx} \right) \tag{94.4}$$
$$(i = 1, 2, \ldots, m; j = 1, 2, \ldots, n; x = 1, 2, \ldots, k)$$

P'_{ix} = The input number of raw materials of the x influencing factors in the i stage;

P''_{ix} = The input number of recycled materials of the x influencing factors in the i stage;

P'''_{ix} = The number of waste that the x influencing factor disposes in the i stage at the end of products' life;

E'_{ijx} = The number of j greenhouse gas that is produced by the raw material input of x influencing factors in i stage;

E''_{ijx} = The number of j greenhouse gas that is produced by the renewable material input of x influencing factors in i stage;

E'''_{ijx} = The number of j greenhouse gas that is produced by the waste disposal of x influencing factors in I stage;

C_j = The global warming potential (GWP) of j greenhouse gas;

Z = The total carbon emissions in life cycle of the product;

Q_{ij} = The number of j greenhouse gas in i stage of the life cycle;

W_{ijx} = The number of j greenhouse gas that is produced by x influencing factors in i stage of the life cycle;

i = 1,2,…,m; Respectively represents the stage of raw materials, production and processing, distribution and retail, consumer use, and recycle in the life cycle (m = 5);

j = 1,2,…, n; Respectively represents CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6, (n = 6);

94.3.2.3 The Results of Inventory Analysis

The results of inventory analysis are usually expressed as a list of tables to confirm and explain the important information of inventory analysis. The results of inventory analysis for household electrical appliances' life cycle are shown in Table 94.3.

Table 94.3 The results of inventory analysis for household electrical appliances' life cycle

Life cycle	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Raw materials	Q_{11}	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{16}
Production and processing	Q_{21}	Q_{22}	Q_{23}	Q_{24}	Q_{25}	Q_{26}
Distribution and retail	Q_{31}	Q_{32}	Q_{33}	Q_{34}	Q_{35}	Q_{36}
Consumers use	Q_{41}	Q_{42}	Q_{43}	Q_{44}	Q_{45}	Q_{46}
Recycle	Q_{51}	Q_{52}	Q_{53}	Q_{54}	Q_{55}	Q_{56}
Total emissions of greenhouse gases	$\sum Q_{i1}$	$\sum Q_{i2}$	$\sum Q_{i3}$	$\sum Q_{i4}$	$\sum Q_{i5}$	$\sum Q_{i6}$
Carbon dioxide equivalent	$\sum C_1 Q_{i1}$	$\sum C_2 Q_{i2}$	$\sum C_3 Q_{i3}$	$\sum C_4 Q_{i4}$	$\sum C_5 Q_{i5}$	$\sum C_6 Q_{i6}$

94.3.3 Impact Assessment

94.3.3.1 Classification

According to the actual situation of household electrical appliances' supply chain management and the principle of selecting impact types for life cycle impact assessment, this paper mainly chooses resource consumption, global warming, and solid waste as the main impact types in the various stages of the life cycle of household electrical appliances.

94.3.3.2 Characterization

This requires calculating the potential contribution of a variety of carbon emissions on a variety of impact types. Expressed by the formula isaccording to the comparison of potential value

$$EP(j) = \sum EP(j)_i = \sum \left[H(j)_i * EF(j)_i\right] \quad (94.5)$$

EP (j) = The influence potential of j impact type of carbon emissions;

$EP(j)_i$ = The influence potential of i interference factor of carbon emissions on j impact type of carbon emissions;

$H(j)_i$ = The quantity of carbon emissions of i interference factor in j impact type of carbon emissions;

$EF(j)_i$ = The characterization factor of j impact type of carbon emissions in the situation of i interference factor of carbon emissions;

94.3.3.3 Quantization

The quantitative evaluation includes standardization and weighting:

Standardization

The potential impact and resource consumption can be expressed as the following formula

$$NP(j) = EP(j)/[T * R(j)] \quad (94.6)$$

T = The product's service period;

R (j) = The standard benchmark on j year;

EP (j) = The impact potential value of j product's carbon emissions;

Weighting

This process is known as the weighting, and the impact potential value after weighting can be expressed as the following formula

$$WP(j) = W(j) * NP(j) = W(j) * EP(j)/[T * R(j)] \quad (94.7)$$

W (j) = The weighting factor of j carbon emissions impact type;
NP (j) = The j impact potential value after standardizing;

94.3.4 Interpretation and Optimization

According to the previous calculation and analysis, the number of greenhouse gases generated by all aspects of the entire life cycle of household electrical appliances can be obtained, and convert these calculated values into carbon dioxide equivalent $\sum C_j Q_{ij}$, then compare these numerical values to the minimum value of corresponding gas emissions which are required by the corresponding low-carbon certification standards of household electrical appliances. If $\sum C_j Q_{ij} < R_j$, it indicates that the existing management of the household electrical appliances can meet the low-carbon certification requirements; If $\sum C_j Q_{ij} > R_j$, it indicates that the carbon emissions of this household electrical appliance product under the existing management style is higher than the stipulated minimum standards of low-carbon product certification, and it does not meet the requirements of low-carbon product certification. Different influencing factors that produce carbon emissions on various stages of the life cycle of household electrical appliances are corresponding to the corresponding positions in the supply chain, shown in Fig. 94.1. Therefore, it can be used to optimize the supply chain of household electrical appliances to achieve the purpose of reducing carbon emissions. In addition, according to the comparison of potential value W(j), we can give priority to make optimization on the position of supply chain which is corresponding to the impact type of carbon emissions that has the maximum W(j).

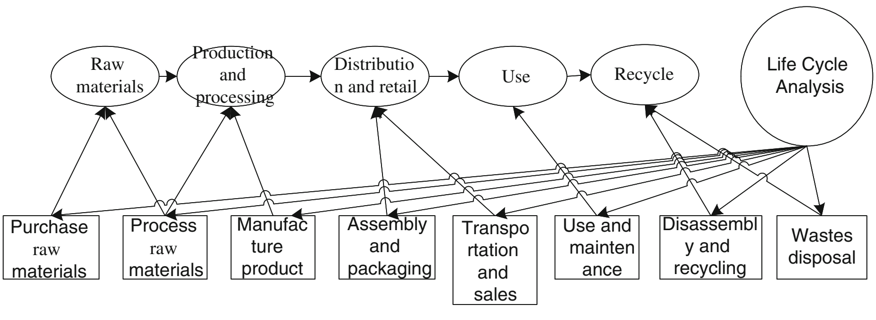

Fig. 94.1 The relationship between the LCA of household electrical appliances and supply chain positions

94.4 Conclusion

Based on life cycle assessment framework, this paper put forward the life cycle assessment model for low-carbon products certification of household electrical appliances and provided some theoretical basis for future specific case studies. Through analyzing products' types, the potential environmental impact factors, and the position that product life cycle process in the supply chain, this paper posted some targeted supply chain optimization methods. For enterprises which are in key aspects of environmental issues, through implementing some appropriate optimization measures of green supply chain management, not only can enhance their own competitive advantage in the industry, but also can restrict the upstream enterprises and make downstream enterprises complete the production of low-carbon products, so as to achieve winning results.

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Chapter 95
Comparative Research on the Environmental Cost of Replacement and Maintenance of the Computer

Jing Zhang and Yaoqiu Wang

Abstract With the rapid development of computer and its correlation techniques, the discarded computers are becoming a growing burden to the modern society. The Green IT advocate the green design, but the appropriate time you discard your computer isn't done in-depth research. This essay puts its effort on computer component update and maintenance work. Firstly we will calculate the environmental cost caused by each period of the life cycle of computers, then draw a contrast between the cost of reusing the computer after maintenance and of replacing a new one, in order to figure out the optimal time at which the life cycle of computer product ends. And Environmental cost reach the lowest.

Keywords Life cycle of computer · Environmental cost · Equipment maintenance · Equipment replacement · Cost comparison · Optimal time

95.1 Introduction

Nowadays, the calls of "GREEN IT" and "ENERGY SAVE" are prevalent and strong. The concept of "GREEN IT" focuses on how to improve IT product's structure and energy consumption during the course of fabrication so that minimize environmental pollution and energy consumption. But, is it true that if we replace the old one by the new, more environmental friendly, we can meet those requirements of environment protection and achieve sustainable development? Some experts say that the life of a professional designed computer can be twice

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compared with now, which is just about 3–5 years, so that, customers need not to replace computer during a short period. Computer component update and maintenance work is more economical (Li and Wen 2006).

Based on this situation, this essay puts its effort on computer component update and maintenance work. Firstly we will calculate the environmental cost caused by each period of the life cycle of computers, then draw a contrast between the cost of reusing the computer after maintenance and of replacing a new one, in order to figure out the optimal time at which the life cycle of computer product ends.

95.2 Calculations of the Computer Life Cycle Environmental Costs

The product life cycle refers to the process of a product from the beginning to the final disappearance in the market. In general, a produce will experience the following phase in its life cycle: raw materials purchase, materials manufacture and process, produce, consume, recycle or abandon. The environmental cost of a product includes the cost of resource, pollution control, pollution treatment, environment management and environmental disruption.

Consider the limitation of information and documents, the method this essay used to calculates the environmental cost of computers mainly based on its resource consumption, such as the consumption of raw material and utilities consumption. During the period of using, this essay focus on the consumption of utilities; when it was abandoned, this essay mainly focus on the influence of environment, including the influence of water, then use the charge of pollution as the pollution cost of environment (Research Institute of China 2009).

95.2.1 The Environmental Cost of Computer Manufacturing Process

The following table is the composition of a desktop computer, including a number of metallic and nonmetallic. Table 95.1 calculates the environmental costs of manufacturing a desktop computer. Table 95.2 shows the amount of materials consumption.

Then according to the average annual price list of means of production of 36 large and medium-sized cities in 2009 (China price year book 2010), we can calculate the material cost of a desktop computer (Average 10 kilograms). Preliminary estimate, manufacture of a micro-computer needs about 33,000 liters of water and the power consumption is 2315 w/h. According to the Beijing industrial

Table 95.1 The material composition and recovery rate of desktop computer

Material name	Mass fraction	Mass/ kg	Recovery rate/ %	The main application components	Pollution category
Dinas rock	24.88	6.80	0	Screen, CRT. PWB	General waste
Plastic	22.99	6.26	20	Case, base, bottom, cable skin	Fire retardant, dioxins and other toxic substances
Iron	20.47	5.58	80	PWB; Structure, support, magnet; CRT; PWB	Metais Comuns
Aluminum	14.17	3.86	80	PWB; Structure; conductor; support parts; connector; PWB	Metais Comuns
Copper	6.93	1.91	90	Conductor; connector; CRT PWB	Heavy metal
Lead	6.30	1.72	5	Metal weld structure; anti-radiation screen; CRT PWB	Pollution of groundwater, strictly control pollutants
Zinc	a2.20	0.60	60	Battery; phosphor	Heavy metal
Tin	1.01	0.27	70	Metal solder joints	Heavy metal
Nickel	0.85	0.23	80	Structure, support, magnet; CRT; PWB	Heavy metal
Barium	0.03	0.05	0	Vacuum tube (CRT)	Heavy metal
Manganese	0.03	0.05	0	PWB; Structure, support, magnet; CRT; PWB	Heavy metal
Silver	0.02	0.05	98	Conductor(PWB); connector	Heavy metal

Source Li and Wen (2006)

Table 95.2 The percentage content of *metal material*, *plastic*, *glass, circuit boards and other substances* in the computer (%)

	Iron	Copper	Aluminum	Plastic	Glass	Circuit board	Freon, foaming agents etc.	Wire and cable
CRT screen	9.0	6.3	0.3	17.9	64.1	2.0		0.3
LCD screen	18.6	–	0.3	52.8	22.5	4.8	0.4	0.6
Host computer	59.8	1.7	1.5	14.4		15.0		7.6

Source The research of computer dismantling and processing in China, Research Institute of China Household Electrical Appliances (2009)

water average price which is 2.94 yuan/ton and industrial electricity average price which is 0.6 yuan/kWh in 2009, we can get the environment cost table of a computer (Table 95.3). The total environmental cost of manufacturing process is 1385.34 yuan.

Table 95.3 Environmental cost of manufacturing process

Raw materials and utilities	Average price (yuan/ kg)	Environmental costs (yuan)
Silicon	80	644
Iron	3	16.74
Aluminum	20.36	78.59
Copper	63.4	121.1
Lead	19.92	34.26
Zinc	29.2	17.52
Tin	123.3	33.29
Nickel	336.4	77.37
Barium	400	20
Manganese	17.74	0.88
Silver	3445	172.2
Plastic	PS:11 PP:12.32	70.98
Water	0.00294	97.02
Electricity	0.6	1.389

95.2.2 The Environmental Cost of Computer Using Process

In this process, the environmental impact mainly in the energy consuming. The number of use days and the power consumption of a computer show in the Table 95.4 (Ge and Wang 2009).

According to the Table above, the cost of power consumption of desktop computer is 366 kWh multiplied by 0.4438 yuan/kWh (2009 average price of residential electricity), which is 162.4 yuan a year.

95.2.3 The Environmental Cost of Discarded Computer Dismantling

When dismantle computer, because we can recycle some raw material, so the cost of resources is negligible. Only estimate the influence of environment cause by poisonous and harmful metal. According to The sewage fee collection standards

Table 95.4 The daily power consumption and annual power consumption of DELL computer

Name	Power /w	Daily hours of work/ hr	Daily power consumption/ kW· h	Annual working days/d	Annual energy consumption/ kW· h
DELL desktop computer (Dimension 5150)	305	4	1.22	300	366

Source The research of computer dismantling and processing in China, Research Institute of China Household Electrical Appliances 2009 and methods of computation, we calculate the pollution equivalent caused by poisonous and harmful metal and the sewage fee.

$$\text{The pollution equivalent number of a pollutant} = \frac{\text{Emissions of pollutant (kg)}}{\text{The pollution equivalent value of a pollutant (kg)}}$$

If we recycle some of the main material and put the others to landfill, the cost of harmful metal is 1.9 kg, including lead, mercury, arsenic, chrome, cadmium. The charge of the pollution is 1.9 yuan. If we use wet broken method to deal with those wastes, so the charge of the pollution treatment is 191.66 yuan when the pollution equivalent number of lead is 68.8 yuan, of mercury, is 200 yuan, of arsenic is 5 yuan.

By calculating we can get two data, one is the influence to environment when buried the waste and the other is the influence of environment of effluent, especially wastewater. Using both together, we calculate an average, which is 96.78 yuan.

95.3 Contrast Between the Cost of Reusing the Computer After Maintenance and of Replacing a New One

First we should learn about the difference between new and used computers in terms of environmental costs. According to experts, the closest two generation computers will not have so fast material update. The new one just has better battery performance, about 15 %. So that, compared with the one that ready to throw away, which have been used for 5 years, the newest one can save 75 % power. Secondly, according to some large-scale enterprise's institution about computer scrap, enterprises required to scrap the computer after five years (on the basis of maintenance upgrade) to avoid wastage. Again, according to experts who are good at computer repair and maintenance, the environment cost of computer maintenance upgrade is negligible; Therefore, we can calculated the environment cost of discarding a computer and of reusing it after maintenance when the computer has been used for 5 years.

- It was used for anther N years after maintenance.

The environmental costs caused by manufacturing + The environmental costs caused by using × N + the environmental cost caused by abandoning.

- It was discarded after 5 years and replaced by a new one which can be used for N years.

The environmental costs caused by manufacturing + The environmental costs caused by using × 5 + the environmental cost caused by discarding + The environmental costs caused by manufacturing of the new one + The environmental costs caused by using the new one × N.

Table 95.5 Contrast between the environmental cost of the same performance computer

Environmental cost year	Environmental costs of maintenance of the computer (yuan)	Environmental costs of replacement of computer (yuan)
6th	2456.52	3751.51
7th	2618.92	3823.57
8th	2781.32	3895.63
9th	2943.72	3967.68
10th	3106.12	4039.74
11th	3268.52	4111.80
12th	3430.92	4183.85
13th	3593.32	4255.91
14th	3755.72	4327.97
15th	3918.12	4400.03

Then we can get Table 95.5, which show the environmental cost of every year.

From the Table 95.5 we can know that in its using year of 6th–9th, recycling computer can save about 1,100 yuan, and in its year of 9th–15th, the environmental cost of recycling computer after maintenance is close to the environmental cost of replacing computer. Considering that the components of computer need to be maintained and repaired have been less and less in the following years, so we can get the conclusion that when a computer is going to be abandoned at its 5th year, we can do maintenance and repair work so that we can abandon it at its 9th or 10th year finally.

95.4 Conclusion

To conclude, in its whole life cycle, computers actually do a lot of harm to the environment. Therefore, based on the principle that “first use, then recycle”, we can upgrade and repair the ole computer appropriately so as to extend its working life and reduce carbon emissions (Yu and Zhou 2010). At the same time we can reduce unnecessary production of new products and decrease excessive scraps, which will also relieve environment pollution. In addition, we should strengthen the whole process of computer waste management, establish a good computer waste recycling system to prevent the pollution caused by waste transfer, storage, and crude recovered.

The calculation and research of computer environmental costs is a new issue. It is hard to collect some of the information in practice (Zhou and Zhou 2010). So in this essay, it is only a estimate of environmental cost. The date this essay rely on, such as user fees of the raw materials, electricity, sewage charges are relatively lower than actual data. We believe the near future, the calculation and application of environmental costs can be spread in the enterprise, and thus play an important role in the control of the environmental load of the entire cycle of the product.

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Chapter 96
Hoteling Price Competition Model Under the Carbon Emissions Constraints

Bin Zhang and Wenliang Bian

Abstract Nowadays, industry development with low-carbon has become a trend. How a energy-intensive company can get an advantages to adapt to the requirements of the carbon emissions policy? Because of the ignoring the carbon emissions factors, the original Hoteling model does not apply to the new circumstance easily. In order to provide a reference to the management of energy-intensive industries under this new challenge, we add the carbon emissions constraints to the Hoteling model in this paper. We confirm that the unit cost of carbon and carbon emissions quotas are directly related to the profits of enterprises. For the enterprise, one of the best way to increase the profit is to decrease the unit cost of carbon emissions of enterprises with advanced low-carbon technologies in the production process and to gain more carbon emission quotas rationally.

Keywords Hoteling model · Low-carbon · Carbon emission · Equilibrium price · Equilibrium profits

96.1 Introduction

For the high energy consumption enterprises' own development under the influence of social low-carbon policies, how they can get the advantages to adapt to the requirements of the carbon emissions policy? They should take the carbon

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emission factors to consider as an important factor in the production processes. In order to provide a reference to the high energy consumption enterprises under the new circumstances, I add the carbon emission constraints in the original Hoteling model in this paper.

96.2 Literature Review

Low-Carbon Economy means that under the guidance of sustainable development ideology, which by means of technological innovation, industrial transformation and new energy development; to change the energy structure, reduce as much consumption of coal, oil and other high-carbon energy as possible, as well as greenhouse gas emissions. And to achieve a win–win economic development form for both social-economy development and environmental protection, which highlights the development model of low energy consumption, low pollution and low-emission, and its essence lies in improving energy efficiency and creating a clean energy structure.

Hua et al. (2011) add the carbon emissions factors to the classical EOQ model and compare the new model with the classical EOQ model. They analytically and numerically examine the impacts of carbon emissions trading, carbon price, and carbon cap on order decisions, carbon emissions, and total cost. They make interesting observations and provide managerial insights from the research findings.

96.3 Model Framework

In order to provide reasonable suggestions for enterprise development, I analyze the equilibrium price and equilibrium profits under the carbon emissions influence or no carbon emissions influence based on the Hoteling model in this paper.

In the model assumptions, the enterprise products are homogeneous, but there are differences in the spatial position between them. Product is no longer entirely replacement because of the consumer transportation costs is different.

The basic assumption of the Hoteling model is: (1) The decision variable is price between the two enterprises; (2) The game is static, assuming that the enterprise is simultaneous action; (3) Enterprises' products are different in spatial position.

Enterprise 1 and 2 is respectively located at both ends of the linear city of length 1 (Fig. 96.1).

Fig. 96.1 Enterprise position schemes

96.3.1 Model Definition

c: Unit cost of the homogeneous product produced by the enterprise; e_i : Unit carbon emissions of the homogeneous product produced by the enterprise $i; v$: Unit transportation cost of consumer, assume that unit consumer is uniformly distributed on interval [0, 1]; m_i : Carbon emissions quotas of enterprise $i; n_i$: Carbon emissions trading volume of enterprise $i; k$: Social average carbon price; p_i : Strategic choice of the price for the enterprise i to maximize enterprise profits; π_i : Profits of enterprise $i; D_i(p_1, p_2)$: Needs of enterprise i Here, we let $i = 1, 2$.

96.3.2 Model Analysis

When there are differences in the spatial location of the product, price is no longer the only factor to decide to purchase for consumers. Rational consumers will choose the smaller sum of price and transportation cost. Because consumers are uniformly distributed on the line and each consumer's unit transportation cost is the same, the consumers located at left of x will purchase from enterprise 1 if the consumer located at x purchase from enterprise 1. Similarly, the consumers located at right of x will purchase from enterprise 2 if the consumer located at x purchase from enterprise 2. Assumed that x is the point in the interval [0,1]: Products for consumers located at enterprise 1 and 2 is no difference, the cost of consumer located at x purchasing products from enterprise 1 or 2 is the same.

Therefore, x meets the following conditions,

$$p_1 + vx = p_2 + v(1 - x)$$

When x satisfies the above conditions, Needs of enterprise 1 is the number of consumers located at left of x,

$$D_1(p_1, p_2) = x$$

Needs of enterprise 2 is the number of consumers located at right of x,

$$D_2(p_1, p_2) = 1 - x$$

In this paper, carbon emissions constraints defined as follows based on the study of literature, we assume that carbon emissions quotas for enterprise i is m_i, carbon emissions trading volume of enterprise i is n_i. The relationship among m_i, n_i, e_i, $D_i(p_1, p_2)$ is as follows,

$$\begin{cases} m_1 = n_1 + e_1 D_1(p_1, p_2) \\ m_2 = n_2 + e_2 D_2(p_1, p_2) \end{cases}$$

n_i can be positive or negative, when n_i is positive, it indicates that the carbon emissions generated by the production of products are less than its carbon emissions quotas. This positive part of carbon emissions trading volume is as the profits of the enterprise. When n_i is negative, this negative part of carbon emissions trading volume is as the cost of the enterprise.

Simultaneously solved the above equations,

$$\begin{cases} D_1(p_1, p_2) = \dfrac{p_2 - p_1 + v}{2v} \\ D_2(p_1, p_2) = \dfrac{p_1 - p_2 + v}{2v} \end{cases}$$

So, taking the carbon emission constrains consider, the enterprises' profits function are:

$$\begin{cases} \pi_1 = (p_1 - c)D_1(p_1, p_2) + kn_1 \\ \pi_2 = (p_2 - c)D_2(p_1, p_2) + kn_2 \end{cases}$$

Take the needs formula into the profit function,

$$\begin{cases} \pi_1 = (p_1 - c)\dfrac{p_2 - p_1 + v}{2v} + k\left(m_1 - e_1\dfrac{p_2 - p_1 + v}{2v}\right) \\ \pi_2 = (p_2 - c)\dfrac{p_1 - p_2 + v}{2v} + k\left(m_2 - e_2\dfrac{p_1 - p_2 + v}{2v}\right) \end{cases}$$

Due to π_i is differentiable, the partial derivative of above equations are,

$$\begin{cases} \dfrac{\partial \pi_1}{\partial p_1} = \dfrac{p_2 - 2p_1 + v + c}{2v} + \dfrac{ke_1}{2v} = 0 \\ \dfrac{\partial \pi_2}{\partial p_2} = \dfrac{p_1 - 2p_2 + v + c}{2v} + \dfrac{ke_2}{2v} = 0 \end{cases}$$

Simultaneously solved the above equations, the equilibrium price of two enterprises is,

$$\begin{cases} p_1^* = c + v + \dfrac{k(2e_1 + e_2)}{3} \\ p_2^* = c + v + \dfrac{k(2e_2 + e_1)}{3} \end{cases}$$

The equilibrium profit of two enterprises is,

$$\begin{cases} \pi_1^* = \dfrac{k(e_2 - e_1) + 3v}{6v}\left[v + \dfrac{k(2e_1 + e_2)}{3} - ke_1\right] + km_1 \\ \pi_2^* = \dfrac{k(e_1 - e_2) + 3v}{6v}\left[v + \dfrac{k(2e_2 + e_1)}{3} - ke_2\right] + km_2 \end{cases}$$

The needs of the two enterprises are,

$$\begin{cases} D_1(p_1, p_2) = \dfrac{1}{2} + \dfrac{k(e_2 - e_1)}{6v} \\ D_2(p_1, p_2) = \dfrac{1}{2} + \dfrac{k(e_1 - e_2)}{6v} \end{cases}$$

From the above conclusion we can see that because of the spatial location of the product is different, the equilibrium profits of two enterprises is not zero any more, the enterprise's pricing is also greater than the marginal cost of the product. In equilibrium, the equilibrium price is the sum of unit cost of product, unit transportation cost of consumers and the average unit carbon value of the enterprise. The higher unit transportation cost, the higher equilibrium price and equilibrium profit. The reason is that difference in the spatial location of the impact of product differentiation is reflected by the consumer's unit transportation cost in the Hoteling model. The higher unit transportation cost, the greater the product differentiation under the same spatial location. Therefore, with the rise of the consumer's unit transportation cost, product alternative abate between the two enterprises and the competition among enterprises is weakened. Each enterprise's monopoly power is strengthen for its consumers nearby. Equilibrium price and profits will rise too.

Similarly, the higher the social average carbon price, consumer's share of the cost of carbon emissions will rise. Enterprises will be able to get more profits from carbon trading, so the equilibrium price and profits will rise up. With the rise up of the carbon emissions quotas, product alternative abate between the two enterprises and the competition among enterprises is weakened. Each enterprise's monopoly power is strengthen for its consumers nearby. Equilibrium price and profits will rise too.

We also noted from the conclusions above, equilibrium profit of the enterprise is only related to the unit transportation cost of consumers, social average carbon price, carbon emissions quotas and unit carbon emissions of the enterprise, equilibrium profit of the enterprise has nothing to do with the unit cost etc. The two enterprise's unit carbon cost is the same, so the product alternative is unchanged between the two enterprises in the case of other factors constant. The factor changes will not affect competition among enterprises, so the factor has nothing to do with the equilibrium profits. The carbon emissions quotas of enterprise are direct related to the carbon emissions trading volume of enterprise, so that the difference between carbon emissions quotas and carbon emissions of production is carbon emissions trading volume.

96.4 Conclusion

The profit is one of the most concerned factors for enterprises. The unit cost of carbon and carbon emissions quotas are directly related to the profits of enterprises. If the carbon emissions quotas cannot be changed for enterprises, one of the best way to increase the profits is to decrease the unit cost of carbon emissions of enterprises with advanced low-carbon technologies in the production process.

We analyze the influencing factors of enterprise equilibrium profits in the case of considering carbon emissions based on the Hoteling model in this paper. Finally, we found that the higher unit transportation cost of consumers, the higher equilibrium price and profits of enterprises; the higher social average carbon price, the higher equilibrium price and profits of enterprises; the higher carbon emissions quotas, the higher equilibrium profits of enterprises. The equilibrium price is only related to the unit cost of product, unit transportation cost of consumers and the average unit carbon value of the society. The equilibrium profits are only related to the unit transportation cost of consumers and carbon emissions quotas of enterprises.

We have some suggestions to improve the model in future research. First, the profits of the unit carbon emissions are different between the two enterprises. Second, we can take the carbon emissions of logistics activity into consideration when modifying the Hoteling model. So factors, such as inventory, inside and inbound and outbound logistics, which can make correlative links with carbon emission. Third, we can take other carbon policies into account in Hoteling model to analyze the influence of equilibrium profits. Finally, setting a reservation price (the highest price that consumers can accept) into the model can be another perspective. If the equilibrium price is higher than the reservation price, the consumers will not buy the products from the enterprises.

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Chapter 97
Reverse Logistics Practices: A Survey in Electronic Industry in Guangdong Province of China

Yacan Wang, Junjun Yu and Yakun Wang

Abstract This survey investigates reverse logistics practices related to electronics industry firms-from the producer's perspective-with the objective of identifying the status of reverse logistics practices. Site visits were conducted to develop a survey instrument. The survey provides detailed information about types and reasons of returns, reverse logistics channels, final disposition options involving 150 different companies in Guangdong in electronic industry. Results indicate that reverse logistics do bring added value to companies. However, there are some problems in returns: warranty returns are predominating type of returns, defective causes most returns among all reasons for return and 3PSP doesn't take use of its advantages, finally some suggestions are proposed to overcome these problems.

Keywords Reverse logistics · Empirical research · Survey · Electronics industry

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97.1 Introduction

Guangdong is the principal production and export base and ranks first in output of electronic products in China for eighteen consecutive years (Ma 2010). Although RL have been introduced into Guangdong industry nowadays, for short lifecycle and fast upgrading of electronic products, as a relatively new area involving over one company, it seems complicated and requires holistic approaches. Thus, it's necessary to investigate the status of RL systems properly.

Research on RL practice has predominantly relied on normative quantitative research (Fleischmann and Bloemhof-Ruwaard 1997), case studies (Brito and Dekker 2003). and theoretical frameworks (Thierry et al. 1995). Empirical studies during 1995–2005 based on survey totaled barely 5 % (Rubio et al. 2008). And empirical studies about RL practice focus on channels and disposition of returns, leaving reasons, types and disposition time unaddressed.

Because empirical studies on RL practices and added value in electronic industry in China even still lies blank. This paper aims at answering the question: What is the status of types, channels, disposition options and disposition time of RL practices in electronic industry in Guangdong?

The reminder of the paper is as follows. Section 97.2 introduces the research methodology; Sect. 97.3 analyzes the data results; Sect. 97.4 summarizes the research findings, then the paper ends with the limitation of the paper and puts forward the potential topics for future research.

97.2 Methodology

The survey was conducted in three phases from April to May, 2012. First, series of site visits and interview in TCL, Skyworth and Desay was conducted to facilitate development of survey instrument. Second, the questionnaire was refined based on suggestions from survey development experts. Then 20 electronic enterprises drawn randomly from the Guangdong Electronic Industrial Association (GDEIA) membership list were asked to respond to the survey before formal test to improve it with respect to relevance, clarity, and comprehensiveness. At last, a final instrument was developed and contained three sections: basic information; RL practice; awareness of RL. As GDEIA includes most electronic enterprises in Guangdong and these enterprises are typical, each one of 345 firms who stated their specific address and email address in their profile was sent a questionnaire. 45 firms completed the survey through face-to-face interview, others were sent questionnaire through emails.

Table 97.1 Sample demographics

	Manufacturer	Wholesalers	Retailer	3PSP
%	84	5.4	2.7	7.4
Plant sizes	Less than 100	101–30	501–1000	Over 1000
%	11.33	30	11.34	47.33
Annual sales	Blow 10	10–50	50–100	Over 100
%	7.33	20	30	42.67

97.3 Results

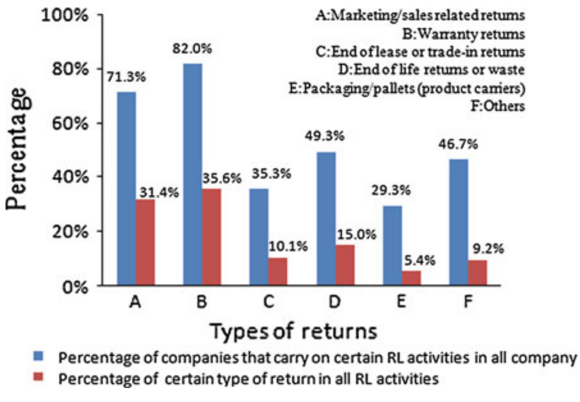
Besides 26 incomplete questionnaires, the survey yielded a sample size of 150 companies, with the response rate 69 %. Only one enterprise hasn't practiced any RL activity, while the remaining 149 enterprises have already practiced RL activities; and except one company acts as manufacturer, retailer and 3PSP simultaneously; the other 149 companies only play one role in supply chain. The basic information about surveyed enterprises is shown in Table 97.1. The unit of annual sales is CNY million.

97.3.1 Types of Return

As shown in Fig. 97.1, Warranty returns are the most commonly-practiced type by 82 % of respondents, followed by marketing/sales returns by 71.33 % of respondents. These two types of RL activities have taken the highest proportions among all of the RL activities, with the average proportion respectively reaching 35.6 % and 31.4 % (Fig. 97.1).

As regard to the reason for returns (shown in Table 97.2), defective quality is listed as the primary reason, existing in 78.52 % of respondents' return activities.

Fig. 97.1 Illustration of RL activities



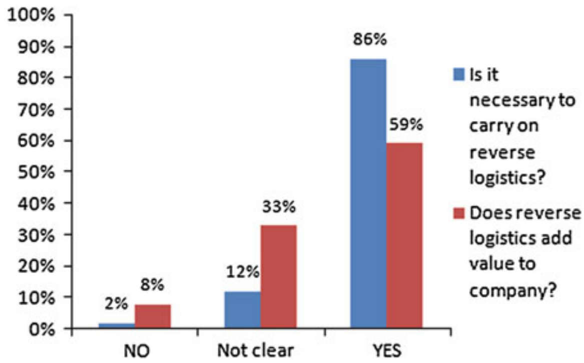


Fig. 97.2 Influencing factors of RL

Damage in shipment comes next, with a proportion approximately going to 50 %. Returns resulted by stock adjustment took the smallest proportion of 12.75 %.

In term of the stimulating factors of RL activities, 34 % of respondents consider cost as the most concerned item, followed by social responsibility. Requirement of law is the least heeded factor. Regarding barrier factors, four factors have yielded equal influence on hampering the development of RL. Relatively, the strongest influence was the high operation cost, which coincides with the fact that development cost is the primary concern of carrying out RL activities. The least factor is non-standard operation of RL (Fig. 97.2).

97.3.2 Channels of Returns

With regard to channels of returns, 24 enterprises adopted two channels, 4 enterprises adopted three channels. The rest 121 enterprises adopted one return channel (shown in Table 97.2). No matter seen from the entire 149 enterprises or from the 121 enterprises chose single channel, equal amount of enterprises have chosen each channel, despite of the low cost and low demands on enterprises for technology of third party channel.

97.3.3 Disposition of Return Products

As to the disposition of returns (Table 97.2), the most common options are repairing/refurbishing/remanufacturing and cleaning the defect-free products or reusing directly, with the proportion of 49.7 and 46.98 % respectively. As in the time-consuming of waste disposition (Fig. 97.3), 77.85 % of enterprises would treat the returned products within a time span of 4–30 days. Only 3.36 % enterprises would treat the returned products over 60 days, and none of the enterprises spent less than 3 days.

Table 97.2 Reasons for return, Channels of returns and the disposition methods of returns

Reasons for return	Damage during shipment	Customers' dissatisfaction	Errors or delays in delivery	Defective	Cancellation of sale orders	Stock adjustment
Percentage	48.99	36.91	28.86	78.52	20.13	12.75
Channels	A:Forward channel meant for sales		B:Separate reverse channel, under our company's responsibility		C:3PSP	D:Others
121 companies	28		31		39	2
All companies	35.6		32.9		42.95	9.4
Disposition options	Clean or reuse	Repair, refurbish, remanufacture	Harvest for parts/ components reuse	Recycle for material reuse	Landfill or incinerate	Others
Percentage	46.98	49.7	30.9	31.5	19.5	9.4

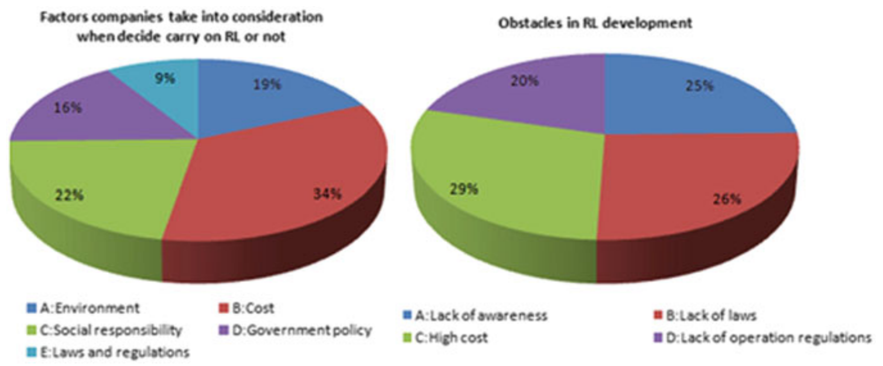
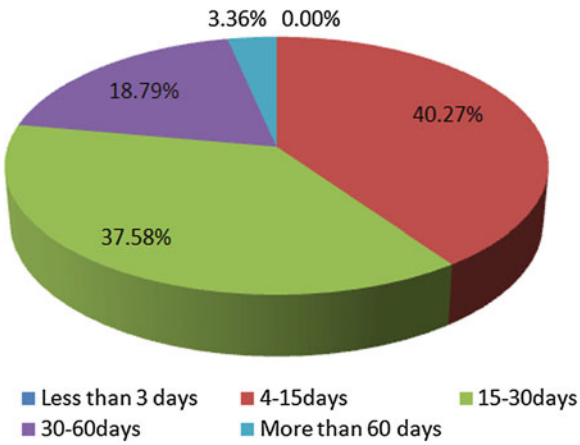


Fig. 97.3 Disposition time of returns

Fig. 97.4 Awareness of RL



97.3.4 Awareness Status of RL and its Added Value Effect

Only one of the surveyed enterprises has not taken up RL activities. However, as can be seen from Fig. 97.4, only as 86 % of the enterprises believe it is rather necessary to practice RL, among which 20.16 % of the enterprises are not certain if RL could bring added value to enterprise, and one of which even thinks RL could not possibly bring added value to the enterprise and does not carry out RL activities, other 40.3 % enterprises carry out RL not in pursuit of added-value.

97.4 Discussion of the Results and Implications

97.4.1 Discussion of the Results

Several insights can be summarized from the results as follows.

Firstly, regarding the goals of practicing RL, enterprises' positive acknowledgement of RL is far from sufficient. Figure 97.2 indicates 13.4 % of the enterprises have no definite goals in practicing RL, 18.12 % of the enterprises practice RL not for pursuing added value to enterprises. They might obliged by national policy, tough requirements by laws and regulations, or, blindly follow partners with the industry or rivals.

Secondly, the majority two types of return practice are warranty returns and sales/marketing related returns, which are the two most popular ways of returns by the real-life consumers. As to reasons for returns, 78.5 % of the enterprises experience returns for quality deficiency reason, it indicates that most enterprises practice RL not to recycle the available resource positively, but are forced to do it for quality reasons to save the image and the customers' confidence. Besides, 48.99 % of enterprises practice recycling for transportation damages, indicating logistics transportation process in China is still non-standardized and with lower-tech.

Thirdly, advise for the disposition options. The shares of every channel of recycling products are close, with the third-party channel slightly outnumbering other options. The most popular disposition options are to clean or reuse directly the flawless products and to repair/refurbish/remanufacture products.

97.4.2 Managerial Implication

The above insights of RL practices help the enterprise to develop RL strategy and government to make industry policy.

First, it is important for Chinese government to enhance publicity of RL and normalize legislation. On one hand, the government should not only highlight the importance but also to enhance publicity so that to make the decision-makers of enterprises better realize the value brought in by RL. On the other hand, it is very urgent for the government to make EPR system to be implanted effectively to impel enterprises to take the full responsibility of the whole life-cycle of their products.

Second, enterprises should establish reasonable and efficient RL channel. Most enterprises insisted in focusing on forward logistics, even though they have realized the economic value of RL (Guide et al. 2005). Actually, it is not that many wasted materials cannot be recycled, just that there are no low-cost, convenient and efficient way of recycling. Therefore, enterprises should invest more on developing new recycling system and take full account into the integration of forward and RL (Fleischmann et al. 2000). At the same time, minor enterprises with limited funds should use 3PSP with advantages in technology, management and information to implement RL management.

97.5 Conclusion and Future Work

Through a survey in 150 electronics enterprises of Guangdong province, this paper analyzes the RL practices in Guangdong province, China. Some suggestions on how to promote the development of the RL are proposed.

The current study has several limitations that offer opportunities for future research. Care should be taken when generalizing the results of this study for two reasons. First, this survey was conducted using a face-to-face questionnaire in electronic industry in Guangdong, findings may differ in other industries, cities and countries. Besides, this survey took a relatively small sampling of only 150 enterprises. Generalizability could be enhanced if future research is systematically sampled from a more dispersed sample by using some random sampling methods.

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Chapter 98
Study on the Legal System Development and Countermeasures of Low-Carbon Logistics in China

Chen Wang and Jia Jiang

Abstract Low-carbon logistics, as a new trend of the logistics development, requires advanced technology and perfect legal system. Due to the lack of systematicness and practical effect in the existing logistics laws and regulations in china, it is difficult to provide effective legal guarantee and support for the healthy development of logistics industry and logistics international competitiveness. This paper put forward constructive countermeasures of building and improving the logistics legal system based on the experience of logistics legal system construction in the developed countries and the problems existing in the related law system design of China's low-carbon logistics development.

Keywords Legal system · Logistics · Low-carbon logistics

98.1 Introduction

In the past thirty years after China's reform and opening-up, with the continuous rapid development of economy, concomitant problems of environmental pollution and wasting of resources are becoming increasingly serious. Low-carbon economy featuring low energy consumption, low material consumption, low emission and low pollution has become the new choice for our future economic development. As one of China's ten key industries, logistics plays an important role in low-

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carbon economy. However, the lack of systematicness and pragmaticality in logistics legislation makes it hard to provide effective legal protection and support for the health development of logistics industry and the increase of international competitiveness of logistics. In this context, the completion of China's logistics legal system is practically significant for the construction and development of our low-carbon logistics.

98.2 Content and Features of Low-Carbon Logistics

All elements of modern logistics activity cause environmental pollution to varying degrees because of the existence of non-environmentally-friendly factors. In order to reduce environmental pollution and increase the harmonious and sustainable development of economy and society, low-carbon logistics has become a tendency for logistics development at present. So far, there is no specific definition for the content of low-carbon logistics and existing understandings of low-carbon logistics mostly come from the extension of low-carbon economy. Based on the experience of low-carbon economic development of various countries, the key to promote low-carbon economic development is technological progress and energy restructuring. The former refers to revolutionary technological breakthroughs including the exploitation and utilization of new energy sources and renewable energy sources, carbon storage, cleaner production and waste recycling as well as environmental protection, while the latter refers to the popularization of energy conservation technology as well as the large-scale development and utilization of renewable energy sources (Ma and Huang 2008). In the author's opinion, low-carbon logistics is one that reduces its damage to the environment through energy efficiency technology, renewable energy sources technology and greenhouse gases emission reduction technology while it improves logistics management level, realizes the purification of logistics environment and makes the best of logistics resources so as to boost the sustainable development of economy. Low-carbon logistics has the following features: (1) Bidirectionality (Xu 2011); (2) Dependence on advanced technology; (3) Targeting sustainable development.

98.3 Status Quo of Legal System for Modern Logistics in China

Logistics was introduced into China from Japan at the end of the 1970s and it's still in the primary phase of development with a history of only more than 30 years. Existing logistics laws and regulations in China can basically maintain the economic order of logistics industry at present, but they are still insufficient for the rapid development of logistics. The more and more prominent environmental issues define the urgency of low-carbon logistics development while they put forward new requirements for system design. The disadvantages of existing legal system have become the bottle-neck to restrain logistics development and major problems are as follows: (1) A lack of systematic special legal rules for logistics industry. (2) Insufficient value orientation function of legal rules. (3) The development of logistics laws lags behind international development.

China's logistics enterprises start developing relatively late, and now they are still in the phase of providing traditional transportation and storage services, failing to reach the management and technology standards of modern logistics enterprises. Due to the influence of planned economic system and the restriction of historical conditions, logistics legislation is backward in China. In December, 2007, the United Nations Climate Change Conference drew up "Bali Roadmap" to reply to climate change, requiring developed countries to reduce their greenhouse gases emission by 25–40 % by 2020. Before Copenhagen Conference, Chinese government promised to reduce its national carbon dioxide emission per unit of GDP by 40–45 % comparing to that of 2005, fully exhibiting our determination in vigorously promoting energy conservation and emission reduction, speeding up the development of low-carbon economy and transforming the development model. However, China is extremely weak in the construction of policies and legal system for the development of low-carbon logistics and fails to formulate laws and regulations relating to carbon emission.

98.4 To Complete China's Logistics Legal System and Develop Sinicized Low-Carbon Logistics

98.4.1 To Formulate Special Logistics Laws

The publication of basic law of logistics can not be accomplished at one action for the complexity, universality and technicality define it a comprehensive and systematic legislation program. Logistics enterprises in western countries start developing early and they have mature experience. They have no uniform logistics law, either; still, their logistics policies and regulations have gone through years of practical test and have formed a complete system. The formulation of China's Logistics Law should start from the current situation of China's logistics industry with full reference to the advanced ideas and experience of logistics legislation in western developed countries. To avoid repeated labor and wasting of resources and improve efficiency in legislation, relevant departments are required to conduct systematic legal clear-up including supplement, modification and completion of existing legal norms so as to gain a clear understanding and gear them to international conventions and WTO rules to formulate a Logistics Law corresponding to China's actual conditions. We can start with the following aspects:

(1) To adjust legal relations in logistics comprehensively and systematically

Logistics legal system should be a unified whole with organic connections formed by various legal norms taking logistics subjects and actions as the subject according to certain rules on the basis of logistics law, and it should cover the following aspects: logistics subject law, logistics behavior law, logistics market management law and logistics standard law. The completion of China's modern logistics legal system requires not the urgent formulation of independent logistics law but the constant formulation and modification of logistics related legal system based on existing legal system.

(2) To reflect sustainable development in the legislative intent

To include sustainable development in legal normative documents as one of the legal values can not only bring the orientation function of legal values into play, but also declare the significance of sustainable development for China's social and economic development. For example, relevant administrative rules can be set to institutionalize the requirement of resource saving and environmental protection, such as regulations on exhaust emission and noise of vehicles.

(3) To use foreign advanced logistics systems for reference and formulate laws and regulations complying with international development requirements

Logistics internationalization has become the trend of modern logistics development and its significance is generally accepted and admitted by governments and logistics enterprises of various countries. Comparing to domestic logistics, internationalized logistics is more complex. In recent years, in order to adapt to its access to WTO China has improved some logistics related laws and systems which are still backward comparing to the requirements for the internationalization of modern logistics.

98.4.2 To Formulate Uniform Logistics Technical Standard and Scientific Evaluation System

There is a long distance between China's logistics infrastructure and equipments and the development requirements of modern logistics industry considering the small overall scale of transportation infrastructure, limited logistics distribution, storage and transportation facilities and low level of development in China; the unreasonable structure of logistics infrastructure and equipments and the low level of standardization prevent the full play of existing logistics facilities. At present, the United States and Europe have basically adopted unified standard of logistics tools and facilities, examples including 1000*1200mm standard of trays, several uniform specifications of containers and barcode technology, greatly reducing the operation difficulty of the system. As for logistics message-switching technique, European countries have realized not only the standardization inside enterprises, but also the standardization among enterprises and that of Europe's uniform market.

To meet the requirements for logistics modernization and improve the efficiency and level of China's logistics, uniform logistics technical standards must be formulated macroscopically and a scientific low-carbon logistics evaluation system should be built to speed up the modernization process of logistics legal system.

98.4.3 To Match Legislation with Social Development Requirements and Enhance Legal System Construction for Returned Logistics

In China, returned logistics has aroused the attention of the industry; still, existing legal regulations such as Administrative Measures for the Recycling of Scrapped Vehicles, Technical Policies on Pollution Prevention Caused by Used Batteries, Administrative Measures for Pollution Prevention Caused by Electronic Information Products and Law on Prevention of Environmental Pollution Caused by Solid Waste are too theoretical without specific implementing measures and reasonable maneuverability, thus hinder the development of China's returned logistics. Meantime, in the background of economic globalization, developing countries easily become the site for developed countries to dump backward and garbage goods. Therefore, China is in urgent need to enhance its legal system construction for returned logistics so as to facilitate the realization of low-carbonization of logistics behaviors and the exploration of new approaches for green economic development.

To sum up, there is a long way to go for China to develop its low-carbon economy. As one of the key industries of the country, logistics burdens compelling obligations for the development of low-carbon economy. In such background, it possesses a greater practical significance to construct and complete China's logistics legal system with research and reference to that of developed countries.

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Chapter 99
Analysis of Warehouse Location in Low-Carbon Supply Chain Based on the Cost

Zongxu Liu and Hongjie Lan

Abstract Since the 21st century, due to accelerating the process of industrialization with the footsteps of human, it brings the increasingly serious problem about the environment and energy. Direction to low-carbon development has become the common choice in various countries. In this paper, with the research status of low-carbon supply chain, we explore the warehouse location problem under the low carbon supply chain, make the analysis of transportation costs, renting costs in warehousing, put forward cost analysis method in the warehouse location selection, with the target of cost optimized, combined with the center of gravity method, derived the optimal warehouse location.

Keywords Low-carbon supply chain · Cost analysis · Warehouse location

99.1 Concept of Low-Carbon Supply Chain

According to the meaning of the supply chain and low-carbon, the basic concept of low-carbon supply chain can be: put the low carbon, environmental protection consciousness into the entire supply chain construction and operation, from the raw materials, such as resource planning, purchasing, manufacturing, material distribution, marketing, delivery and use and recycling the integrated operation process, the comprehensive consideration of the chain of enterprise resource integration to the influence of the environment. Low-carbon supply chain

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operation requests the member enterprises in the supply chain operation to deal with its negative influence on the environment as small as possible, and resource utilization high as far as possible, in order to achieve supply chain overall economic benefit and social benefit coordination optimization. Supply chain management including planning, purchasing, manufacturing, delivery and recovery these five basic flows, and low-carbon supply chain put environmental protection concept and technology into the supply chain link in, it formed a low carbon supply chain (Akkermans 2003).

99.2 Low-Carbon Storage

Low carbon storage in product warehousing links that take full account of environmental and energy efficiency, and to improve the efficiency of energy use on the one hand, a reasonable choice warehouse location needs to arrange vehicle transport, reduce inventory, and use information inventory instead of food materials inventory; the other hand the layout of warehouse facilities needs a reasonable planning and more space-saving resource.

99.3 Analysis of Warehouse Location

Under the conditions of low-carbon environmental protection, the core objective of the warehouse location is in the distribution of goods under the premise of high customer satisfaction, optimize path to reduce vehicle kilometers traveled legitimately, while reducing costs to achieve the low-carbon effect, there by the optimization of economic and social benefits (Beamon 2005). Based on this consideration, this paper analyzes the cost of warehouse location in low carbon supply chain, logistics companies can take the analysis for reference, which combined with the situation of the enterprise.

Optimize the design of the transportation links to occupy an important position in the low carbon supply chain operations of the entire enterprise, and also the implementation of the primary optimization object of the low carbon supply chain operations, while consider the company's warehouse site as an important factor. According to the characteristics of operating materials in logistics enterprises, the proportion of unstable traffic must be high, so paper analyzes the increase in costs of some sudden changes in traffic. Different storage methods may also cause the change in the cost of the warehouse location. To choose the strategy of warehouse location from the point of view of cost optimization, both optimize the vehicle route to reduce costs (Ding and Chen 2008), but also reduce carbon emissions effectively in the way of reducing the distance, so as to achieve requirements of a low carbon environmental protection. Overall, the warehouse site selection strategy needs to consider the following four points:

(1) Transportation cost W_1: fuel consumption by vehicle loading during transportation, and carbon emissions equivalent to the cost caused by vehicle transportation (Fisher 1997);
(2) Probability cost W_2: the increasing cost of transportation and warehousing caused by the sudden demand change from suppliers and customers;
(3) Inventory cost W_3: the cost compare from different method of warehousing and the carbon emission costs from warehouses electricity;
(4) Point Q: points of impact factors by specific environmental conditions of the warehouse around.

99.3.1 To Determine Transportation Cost W_1

Based on the actual location coordinates, various suppliers can be given as (X_{si}, Y_{si}), and delivery destination coordinates (X_{dj}, Y_{dj}). Based on the cost optimal function in the operation research, cost objective function equation can be given as following:

$$W_1 = \sum_i V_{si} \cdot R_{si} \cdot D_{si} + \sum_j V_{dj} \cdot R_{dj} \cdot D_{dj} + \sum_i E_{dj} \cdot Ta \cdot D_{si} + \sum_j E_{sj} \cdot Ta \cdot D_{sj} \tag{99.1}$$

where:

V_{si}, V_{dj} Denote the transport volume from the ith supplier to the warehouse, and the transport volume from the warehouse to the jth delivery destination;

R_{si}, R_{dj} Denote the transport rates from the ith supplier to the warehouse, and the transport rates from the warehouse to the jth delivery destination;

D_{si}, D_{dj} Denote the distance from the warehouse to the ith supplier or jth delivery destination;

Ta Represents the carbon tax;

E_{si}, E_{sj} Denote the carbon emissions generated from the ith supplier to the warehouse and that from the warehouse to the jth delivery destination;

Transport rate R should be decided by bridge tolls due to specific tonnage vehicle $f_1(V)$, every axiom oil fee S, fee of driver employment F, fee of rent the vehicle K in some situation:

$$R = \left[\sum f_1(V) + F + K\right] / D + S \tag{99.2}$$

which D is for the delivery of distance.

Distance can be taken as $D = \sqrt{(X - X_0)^2 + (Y - Y_0)^2}$, where (X, Y) represent the supplier or distribution destination.

99.3.2 To Determine Probability Cost W_2

Due to unexpected events happened, we can only give a rough statistical quantitative analysis. Based on recent years' data, we can statistics incident occurrence frequency of each supply and customer as P_{si} and P_{dj}, this situation can be saved by the safe stock S and contacting new suppliers, but more storage will increase warehouse maintenance expenses f_2 cost of carbon emissions E_s with warehouse electricity, human resource cost of contacting new suppliers a, cost of transportation f_3 and cost of carbon emissions $E_t$in this processing, the frequency P is determined by the average number of occurrences of incidents between every two suppliers' delivery in a period of time. Changes in transport volume can be determined by the absolute value of the average change in each emergencies (Xuhua 2007). On the condition of ensuring customer satisfaction, we can determine the safe stock S.

where:

Carbon emissions with warehouse electricity (E_s) = safe stock (S)* electricity consumption in every stock (P)* carbon emissions in every industrial electricity consumption (F).

Carbon emissions in transportation (E_t) = distance * oil consumption in every kilometer (L)* fuel conversion factor (cf)

$$W_2 = P_{si} \cdot (a + f_3 + E_t \cdot Ta) + P_{dj} \cdot (f_2 + E_s \cdot Ta) \tag{99.3}$$

99.3.3 To Determine Inventory Cost W_3

Based on the past experience, general warehouse is divided into two types: the warehouse of the customer owned, rented warehouse. In this paper, we put forward the mathematical model to calculate the costs of different storage, logistics manufacturers can apply their real situation to choose appropriate storage strategy.

We set W_{3a} as the cost of warehouse customer owned, W_{3b} as the cost of the warehouse rented, carbon emissions costs with warehouse electricity generated associated with carbon emissions E_s and carbon tax Ta.

For the warehouse that customer owned, cost of warehouse usually includes maintenance fees, but because that kind of warehouse may not be able to meet in the center of gravity of the supply and delivery destination, so it always bring a relatively higher cost of transportation.

$$W_{3a} = c_0 + (S + T_0)/M \cdot b_0 + E_s \cdot Ta \tag{99.4}$$

where:

S represents safe stock in W_2; T_0 represents the total number of transportation; M represents stock in unit area; c_1 represents maintenance fees; b_0 represents using rate of warehouse; Ta represents carbon tax; E_s represents carbon emissions with warehouse electricity;

For rented warehouse, we often have the lowest transportation costs, while there is a relatively high rent cost.

$$W_{3b} = c_1 + (S + T_0)/M \cdot b_1 + E_s \cdot Ta \tag{99.5}$$

where:

S represents safe stock in $W_2; T_0$ represents the total number of transportation; M represents stock in unit area; c_1 represents unexpected expenses; b_1 represents fee rate of warehouse rented; Ta represents carbon tax;E_s represents carbon emissions with warehouse electricity.

99.3.4 To Determine Point Q

That point often contains fuzzy factors, for example: five-year government plan; distance from the main road entrance; distance from the highway; distance away from the city center and so on. For such factors, we should take the analysis of fuzzy mathematics. Specific methods are as follows:

First, according to the sum of three costs, we can choose the address which has the lowest cost to be the candidate address. Then we determine the detail judge index according to the actual situation of each candidate address, while on the basis of importance degree of index, we can endow marks to three different addresses such as 1 point, 0.8 point, 0.5 point, 0.2 point and so on. Assigned to each index weights, we analyze the elected address by step, at last calculate environmental factors score of the address to be selected.

99.4 Method of Calculation

Based on actual experience, W_1 accounts for the largest proportion of the full cost accounting, based on the traditional center of gravity method, for the convenience of calculation, we can determine an approximate warehouse location, which the cost of carbon emissions in the transport process constraints excluded. On the basis of that, with the comparison of other location factors, thus reducing the complexity of the procedures for the preparation and expansion.

We use the two-dimensional coordinates in the actual calibration as the method of the coordinate position of the calibration, the specific method is as follows:

Note: In order to represent the actual situation objectively, coordinate (X, Y) can calibration the actual location of the space, and can also be calibrated that point X represent distance from the junction of the core, the point Y represent that point located on the Y street through the intersection of the core street, the first method for actual road which is orthogonal grid-based can be taken, the second calibration method for the actual road which is radiation type can be taken. Two different calibration methods may appear different transport distance algorithm, due to the grid type road prevalent, while analyzing warehouse location strategy, we can take the former calibration mode; for logistics line that is based on this algorithm which is used to be the core radiation highway in the city, we can take the latter calibration mode (Zhang 2009).

The warehouse located in the coordinate plane coordinates as (X_0, Y_0)

$$X_0 = \left(\sum V_i \cdot R_i \cdot X_i/D_i\right) / \left(\sum V_i \cdot R_i/D_i\right)$$
$$Y_0 = \left(\sum V_i \cdot R_i \cdot Y_i/D_i\right) / \left(\sum V_i \cdot R_i/D_i\right) \quad (99.6)$$

which can formula $D_i = \sqrt{(X_i - X_0)^2 + (Y_i - Y_0)^2}$

(1) Determine the coordinates of the destination point, while to determine the various points cargo traffic and a straight distance freight;
(2) Do not consider the distance factor, we use the center of gravity of the formula for estimating the initial location point:

$$X_0 = \left(\sum V_i \cdot R_i \cdot X_i\right) / \left(\sum V_i \cdot R_i\right) Y_0 = \left(\sum V_i \cdot R_i \cdot Y_i\right) / \left(\sum V_i \cdot R_i\right) \quad (99.7)$$

(3) According to formula (99.2), with the calculation obtained D_i in step (2);
(4) Put D_i to be substituted into the formula (99.1), to obtain the modified coordinates (X_0, Y_0);
(5) According to the corrected coordinates(X_0, Y_0), and then re-calculate D_i; Repeat steps (4) and (5) until the coordinates (X_0, Y_0) are in the process of successive iterations and no longer changes or changes within the required error.

Based on the above analysis, you can give the total cost of the warehouse $W = W_1 + W_2 + W_3$, as well as environmental factors score. While using the application model of the location, in accordance with the following procedures: under the premise of maintaining customer satisfaction, it will increase the cost. W_2 for the prevention of the occurrence of the incident, according to the analysis of cost W_2, you can get the amount of safe stock s; Put S into the cost W_3 and then sub the situation discussion of the customers' existing warehouse or renting warehouse, in both cases and to calculate W, and then select the lower cost that can be adopted by reference to various environmental factors score, weigh the costs and requirements of low-carbon, we can select the optimal solution.

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Chapter 100
Research on Multi-Facility Weber Problem to Reduce Carbon Emissions

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Abstract In this paper, cost of carbon emissions is integrated into multi-facility Weber problem. In order to deal with this problem well, an improved alternative location-allocation algorithm is developed. And impact of carbon emissions on location and allocation is taken into account in the algorithm. Then thus not only the cost of carbon emissions but also the total cost including the cost of both transportation and carbon emissions can be optimized. Finally, numerical analysis shows the superior quality of the algorithm. And positive significance of parameter k to improve the solution continuously is revealed.

Keywords Carbon emissions · Facility location and allocation · Weber problem

100.1 Introduction

Multi-Facility Weber problem (MFWP) is also known as uncapacitated multi-facility location-allocation problem. The problem concerns with how to locate m new facilities and how to allocate n existing customers to each facility in order to minimize the total cost.

So far multi-facility Weber problem has gained great attention. Sherali and Nordai (1988) proved that the problem is NP-hard. Cooper (1964) proposed a heuristic method known as Alternative Location-Allocation (ALA) to solve this

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problem, which can help to achieve a promising solution quickly. Furthermore, based on the Alternative Location-Allocation algorithm, Iyigun and Ben-Israel (2010) developed a generalized Weiszfeld's method to renew the location of facilities so that the problem can be solved more effectively.

In recent years, environmental problems have attracted great attention and thus the cost of carbon emissions has been integrated into the MFWP in many papers. However, in approaches used for MFWP considering carbon emissions, Elhedhli and Merrick (2012) used a Lagrangian heuristic to decompose the new problem into several subproblems to be settled one by one. And Wang et al. (2011) tackled this problem by proposing a multi-objective optimization model. For an overview about facility location to reduce carbon emissions, we refer to Dekker (2012). Notably, no matter which approach is selected, it is difficult to optimize the carbon emission cost and total cost including the cost of transportation and carbon emissions together. In order to bridge this gap, an improved ALA algorithm is developed in this paper. The algorithm can realize the optimization of total cost and carbon emissions cost.

The remainder of the paper is organized as follows: In the next section the problem is described and a mixed integer programming model is put forward to formulate it. An improved ALA algorithm is developed in Sect. 100.3. Numerical analysis is provided in Sect. 100.4. Finally we conclude the paper and provide some research avenues in Sect. 100.5.

100.2 Problem Formulation

We define the indices $i = 1,\ldots, m$ and $j = 1,\ldots, n$ corresponding to facility locations and customers locations respectively. w_{ij} and w_{ij}^T denote the transportation cost per unit distance and carbon emissions cost per unit distance between the ith facility and the jth customer respectively. p_i and q_j are the ith facility coordinate and the jth customer coordinate respectively. And $d(p_i, q_j)$ is distance between the ith facility and the jth customer. The problem can be formulated as:

$$\min \sum\nolimits_{i=1}^{m} \sum\nolimits_{j=1}^{n} t_{ij}(w_{ij} + w_{ij}^T) d(p_i, q_j) \tag{100.1}$$

s.t.

$$\sum\nolimits_{i=1}^{m} t_{ij} = 1, \quad i = 1, 2, 3, \ldots, m \tag{100.2}$$

$$t_{ij} \in \{0, 1\}, \quad i = 1, 2, 3, \ldots, m, \quad j = 1, 2, 3, \ldots, n \tag{100.3}$$

$$p_i \in R \tag{100.4}$$

The objective function is to minimize the total cost including transportation cost and carbon emissions cost. Equation (100.2) denotes that each customer's need must be satisfied by only one facility. Equation (100.3) indicates the binary property of allocation and location variables. And (100.4) show that every point in a continuous space can be selected as the location of a facility.

100.3 Solution Framework

In this section, an improved ALA algorithm is developed. The classical ALA algorithm will be described first as it will be the foundation of the improved ALA algorithm. And then the details of the improved ALA algorithm will be shown.

100.3.1 Alternating Location: Allocation Algorithm

The ALA algorithm was introduced by Cooper (1964) to help cope with the MFWP firstly. And because it can quickly give a promising solution, now it's widely used to tackle the problems about facility location. ALA algorithm contains two phases including the location and allocation. Firstly, m facilities are generated randomly in a continuous space. And then each existing customer is assigned to its nearest facility through Eq. (100.5). Then the location of each facility is renewed by the classical Weiszfeld's method given by Eq. (100.6). Repeat alternatively the two phases until the stopping condition is satisfied. In addition, about the research on the convergence of the classical Weiszfeld's method, we refer to Plastria and Elosmani (2008).

$$d = w_{ij} d\left(p_i, q_j\right) \tag{100.5}$$

$$a_i^r = \frac{\sum_{j \in T_i} \frac{w_{ij} x_j}{d(p_i^{r-1}, q_j) t_{ij}}}{\sum_{j \in T_i} \frac{w_{ij}}{d(p_i^{r-1}, q_j) t_{ij}}}, \quad b_i^r = \frac{\sum_{j \in T_i} \frac{w_{ij} y_j}{d(p_i^{r-1}, q_j) t_{ij}}}{\sum_{j \in T_i} \frac{w_{ij}}{d(p_i^{r-1}, q_j) t_{ij}}} \tag{100.6}$$

100.3.2 Improved ALA Algorithm

In the section, in order to optimize the total cost and the carbon emissions cost together, two measures are taken to modify the classic ALA algorithm.

The first measure is taken in the location phase. Notably, the location found by classic Weiszfeld's method is influenced only by the transportation cost and cannot reflect the effect made by the carbon emissions. Considering the impact of carbon emissions on the location, a parameter k ($k \geq 0$) is added to modify the weights w_{ij} in Eq. (100.6). And the new weights can be computed as:

$$C_{ij} = w_{ij} + k w_{ij}^T$$

Then Eq. (100.6) can be reformulated as

$$a_i^r = \frac{\sum_{j\in T_i} \frac{w_{ij}x_j}{d(p_i^{r-1},q_j)t_{ij}}}{\sum_{j\in T_i} \frac{w_{ij}}{d(p_i^{r-1},q_j)t_{ij}}}, \quad b_i^r = \frac{\sum_{j\in T_i} \frac{w_{ij}y_j}{d(p_i^{r-1},q_j)t_{ij}}}{\sum_{j\in T_i} \frac{w_{ij}}{d(p_i^{r-1},q_j)t_{ij}}} \tag{100.7}$$

Because the sole difference between Eqs. (100.6) and (100.7) lies in the weights where w_{ij} is replaced by C_{ij}, the convergence of the improved Weiszfeld's method is without any changes. In addition, the correlation between C_{ij} and w_{ij}^T is positive.

The second measure lies in the allocation phase. In the allocation phase, we still assign each customer to its nearest facility. But the allocation phase is improved by modifying the method to compute the distance between a facility and a customer. And then Eq. (100.5) is substituted by Eq. (100.8).

$$d = C_{ij} d\left(p_i, q_j\right) \tag{100.8}$$

Finally, the improved ALA algorithm can be summarized as follows. Firstly, in order to gain an initial solution, m facilities are generated randomly in the feasible region. Then according to the distances computed by improved distance formula, Eq. (100.8), each customer is assigned to its nearest facility. Next, location of each facility is renewed by improved Weiszfeld's method given by Eq. (100.7). Repeat the two phases of location and allocation until the stopping condition is satisfied. In the location phase, if the coordinate of facility is the same as the one of customer, the facility will be located where the customer stands. And if a facility has not been assigned to any customers, then relocate it in a Weiszfeld's point by assuming the demand of all customers. In addition, in order to avoid tangling in a local minima, different initial solutions should be generated randomly and the best result will be selected. Two different termination criteria can be used. (1) Before the number of iterations reaches the predefined maximum, the value of objective function has no improvement. (2) The predefined maximum number of iterations has reached.

100.4 Computational Results

In this section, the efficiency of the improved ALA algorithm is shown and the algorithm has been implemented in Matlab. Example data used in Bischoff et al. (2009) is selected in this paper. And the coordinates of the existing customers are shown in Table 100.1.

In the example problem, 6 facilities will be located and assignments of 18 existing customer also have values of W_{ij} and W_{ij}^T are generated randomly where

Table 100.1 Coordinates of customers from Bischoff et al. (2009)

q_1(1,2)	q_2(2,8)	q_3(3,12)	q_4(5,5)	q_5(6,1)	q_6(6,11)
q_7(7,4)	q_8(8,8)	q_9(9,1)	q_{10}(9,5)	q_{11}(9,10)	q_{12}(10,12)
q_{13}(14,2)	q_{14}(14,4)	q_{15}(16,8)	q_{16}(17,4)	q_{17}(17,10)	q_{18}(19,13)

$W_{ij}, W_{ij}^T \in [0,1]$. And we define $W_{ij} = \{w_{ij}, i = 1,2,3,\ldots6,\ j = 1,2,3,\ldots,18\}$ and $W_{ij}^T = \left\{w_{ij}^T, i = 1,2,3,\ldots6,\ j = 1,2,3,\ldots,18\right\}$.

Table 100.2 shows the computational results when $k = 1$. In Table 100.2, seven different W_{ij} and W_{ij}^T are selected respectively. And case1 is the result achieved by improved Weiszfeld's method and improved distance formula. Case2 denotes the result achieved by classical Weiszfeld's method and classical distance formula. Case3 shows the result achieved by improved Weiszfeld's method and classical distance formula. Case4 represents the result achieved by classical Weiszfeld's method and improved distance formula. And C_{total} denotes the total cost including transportation cost and carbon emissions cost. C_{carbon} represents the cost of carbon emissions of the final solution.

From Table 100.2, it's easy to find that both C_{total} and C_{carbon} in case1 have great advantage over case2 and case4, although its total cost of the first example (N = 1) is a little higher than case2 and case4. It means that to a great extent, the quality of case1 is better than case2 and case4, and case1 optimizes both the total cost and the carbon emissions cost. However, in contrast to case3, case1 has no too much advantage. It shows that improved Weiszfeld's method predominates in the case1 and the superiority of improved distance formula is not obvious.

Figure 100.1 shows an exploratory study about the impact of parameter k. In the section, only the values of W_{ij} and W_{ij}^T used in the first example of Table 100.2 are still used here. CC_1 denotes the cost of carbon emissions in case1 and TC_1 is the total cost. And CC_2 is the cost of carbon emissions in case2 and TC_2 denotes the total cost. Meanwhile, CC_1, TC_1, CC_2, TC_2 are computed respectively according to the value of $k = 0, 1, 2, 4, 6, 8, 10, 12, 14$. And $r1$ is the increase rate of carbon emissions in case1 and $r2$ represents the one of total cost:

$$r1 = \frac{CC_1 - CC_2}{CC_2}, \quad r2 = \frac{TC_1 - TC_2}{TC_2}$$

According to Fig. 100.1, with the increase of k, in case1, $r1$ decrease continuously and the $r2$ tend to increase. However, the maximum of *r1* can attain to 10 % and the maximum of *r2* 2 %. It means that the total cost in case1 can be kept

Table 100.2 Computational results

N	Case1		Case2		Case3		Case4	
	C_{total}	C_{carbon}	C_{total}	C_{carbon}	C_{total}	C_{carbon}	C_{total}	C_{carbon}
1	32.6536	16.6688	32.5979	18.0498	32.6536	16.6691	32.5981	18.0523
2	28.1227	11.2434	28.5076	12.3431	28.1229	11.2437	28.5076	12.3431
3	29.8829	16.2443	33.6152	22.1530	29.8829	16.2443	37.0763	25.5292
4	28.0337	14.4798	28.8448	19.4326	28.0377	14.4798	28.8460	19.4330
5	26.5094	11.3361	28.3729	14.0588	26.5094	11.3361	14.0592	14.0592
6	36.0830	13.6976	36.5328	14.3084	36.0830	13.6976	14.3082	14.3082
7	27.9776	12.7786	28.4094	13.4110	27.9776	12.7786	13.4102	13.4102

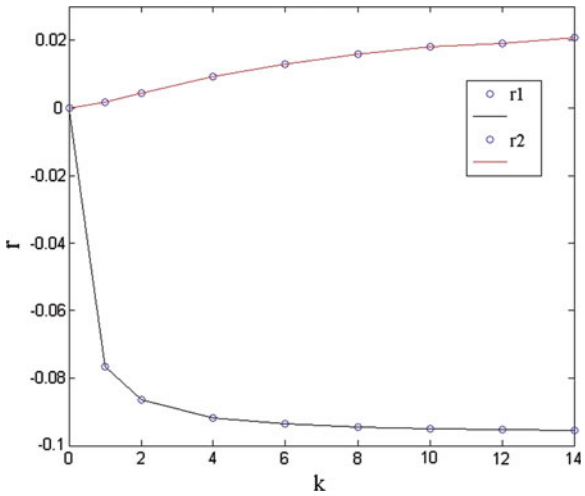

Fig. 100.1 Changes of total cost and carbon emissions cost for various values of parameter *k* in case1

in control effectively. So when the total cost in case1 is higher than the one in case2, it's considerable to continuously improve carbon emissions cost by adjusting the value of *k*. Then a reasonable solution in which both the total cost and carbon emission are promising can be achieved.

100.5 Conclusion

In this paper, the cost of carbon emissions is integrated into the multi-facility Weber problem. In order to achieve a solution which can optimize carbon emissions cost and total cost including the cost of transportation and carbon emissions together, an improved ALA algorithm is proposed. The algorithm can effectively reduce the carbon emissions and keep the total cost in control. Besides, solution gained can be also improved continuously by adjusting the value of *k*. Some future research avenues can also be underlined. Considering the limitation of capacity to the problem is a positive research direction and research on better algorithm is also promising.

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Chapter 101
Impact of Carbon Emission Control Policies on Food Logistics Chain Speed and Cost Performance

Zurina Hanafi and Dong Li

Abstract This research investigates impact of carbon emissions policies on multimodal transportation planning in a fresh produce transportation case. Optimised multimodal transportation has the potential to reduce negative impact on environment. Multimodal transport uses a combination of at least two modes of transportation in a single transport chain, without a change of container for the goods, with most of routes travelled by road, rail, inland waterway or shipping. An optimization analysis is carried out with different carbon charges to identify impact of carbon policies on the transportation mode selection and the logistics performance. This research shows that, with different carbon emission charges, optimal logistics chain speed with lowest transportation and carbon emission costs can be identified.

Keywords Transportation · Optimisation · Carbon emissions policies

101.1 Introduction

To protect environment, various policies for greenhouse gases have been set up at different levels from the global agreement, nationwide policies to local government regulations (UNFCCC 1998). Transportation industry is a main contributor of greenhouse gases. Among transportation modes, road transportation shares

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more than half of carbon emissions in transportation (IEA 2011). This research analyse logistics network performance in a UK food supply chain case.

In most of research, it is usually assumed that product quality is not influenced by supply chain design. "Clearly, this is not true for food supply chains, as quality change is intrinsic to the industry" (Van der Vorst et al. 2009). This research will therefore investigate a performance indicator, food logistics chain speed (FLCS) in particularly, measured by average time spent in a food transportation process.

101.2 Relevant Research

Green supply chain and eco-logistic strategies have attracted greater attentions in academic research and industrial practice (Schaper 2002). Kim and Van Wee (2009) developed research to compare intermodal freight system and truck-only freight system. In multimodal transportation, road still plays an important role in transferring goods to final destinations. Many studies have investigated the cost structure and associated performance in logistics networks (Janic 2007; Banomyong and Beresford 2001). The above research on cost performance of logistics services have not considered impact of carbon emission and associated costs. With increasing concerns over business and environment sustainability, emphasis in research and practice should be given to designing processes reduce carbon gas emissions and energy consumption. Linton et al. (2007). Potential policies as legislation with the aim to achieve effective environmental control will exert cost pressure on logistics operations and potentially drive strategic changes in transportation planning (Li et al. 2010). There are two popular environmental policies with the main objective to slow down the global warming, carbon emissions trading (CET) and carbon tax. The policy enforcement would play a significant role in controlling carbon emission and transportation performance. The existing research has not presented sufficient evidence quantitatively of such impacts of the policies on industrial. This research therefore focuses on food logistics service performance in the context of multimodal transportation and application of carbon control policies.

101.3 Multimodal Transportation Planning in Fresh Produce Industry

An optimisation modeling is proposed for analysis of the food logistics network. Mixed integer programming (MIP) is formulated in order to get optimal solutions of quantity, destinations and environmental impacts. The objective of the model is to minimise the total cost and identify performance in time or speed. The cost covers transportation cost and carbon emission cost with the consideration of two policies, carbon emissions trading and carbon tax.

$$Min\,C = \sum_{k=1}^{p}\sum_{j=1}^{n}\sum_{i=1}^{m}\left(TC_{i,j} + YT_{i,j,k} + X_{i,j,k}\right) + \sum_{k=1}^{p}\sum_{j=1}^{n}\sum_{i=1}^{m}\left(\left(CE_{i,j} * YT_{i,j,k} * YP_{i,j,k}\right)^{+} - CL\right) * CC + \sum_{k=1}^{p}\sum_{j=1}^{n}\sum_{i=1}^{m}\left(TT_{i,j} * YT_{i,j,k}\right) + \left(HT_{i,j} * YT_{i,j,k} * X_{i,j,k}\right)$$

Subject to:

$$\sum_{j=1}^{n} TT_{1,j} * YT_{i,j} \le RT_i \tag{101.1}$$

$$\sum_{k=1}^{p}\sum_{j=1}^{n}\sum_{i=1}^{m} X_{i,j,k} = D_i \tag{101.2}$$

$$X_{i,j,k} \ge 0 \tag{101.3}$$

$$YT_{i,j,k} \in \{0, 1\} \tag{101.4}$$

$$YP_{i,j,k} \in \{0, 1\} \tag{101.5}$$

Parameters:

i—Cluster index; j—Transportation mode; k—Carbon emissions policies;

$X_{i,j,k}$—Quantity sent to cluster i using transportation mode j at the time t;

$TC_{i,j}$—Transportation cost to cluster i with transportation mode j; $TT_{i,j}$—Travel time to cluster i with transportation mode j; $HT_{i,j}$—Handling time to cluster i with transportation mode j; $CC_{i,j,k}$—Carbon emissions cost to cluster i with transportation mode j and carbon policy k; RT_i—Required time for sending to cluster i; CE—Carbon emission; CC—Carbon charge; D_i—Demand at cluster i.

$$YT_{i,j,k} = \begin{cases} 1, & \text{if transportation mode } j \text{ is used} \\ 0, & \text{otherwise} \end{cases}$$

$$YP_{i,j,k} = \begin{cases} 1, & \text{if policy } k \text{ is chosen} \\ 0, & \text{otherwise} \end{cases}$$

Constraint (101.1) is about travel time to each cluster that must not exceed required time so that the quality of food will still at least be acceptable by retailers. Constraint (101.2) refers to demand at RDCs that must be fulfilled. Constraint (101.3) is a non-negativity constraint, while constraints (101.4) and (101.5) are binary constraints referring to transportation modes and types of carbon emission control policies. RDCS are located throughout the UK. The RDCs that are located next to each other are grouped into a cluster in this study for the purpose of analysis simplification. In the UK market case, the country is divided into sixteen clusters according to the locations of RDCs in practice of logistics services.

Table 101.1 Road carbon emission for delivering fresh produce from ports to Cluster 7

Cluster 7 from port	Road emission factor (kg CO_2/tkm)	Road distance (km)	Road emission (kg CO_2/tkm)	Weight of goods (per container)	Total emission (kg)
Southampton	0.0455	315	14.33	24	343.98
Felixstowe	0.0455	350	15.93	24	382.2
Tilbury	0.0455	315	14.33	24	343.98
Bristol	0.0455	191	8.69	24	208.57
Immingham	0.0455	226	10.28	24	246.79
Liverpool	0.0455	82	3.73	24	89.54

Six main ports are analysed as distribution hubs for the UK market. A virtual location is created based on locations of all RDCs in each cluster. This location is calculated using the concept of the gravity model. The concept is applied to calculation of the short road distance in transportation as well as the time average for both road and multimodal options. The calculation of total carbon emission per container for Cluster 7 as an example is shown in Table 101.1.

The rail emission factor is ranging from 13.9 to 49 g CO_2/tkm (Li et al. 2010). The emission factor used in this study takes the midpoint of the range which is 32 g CO_2/tkm.

101.4 Analysis Result and Discussions

The analytical model minimizes the main factors: transportation cost, carbon emissions and overall time taken in food supplies (including travel time and any other time spent in the delivery process) for weekly food supply through the logistics supply network (as average weekly demand is used in the analysis).In order to present impacts of the carbon emissions charges on selection of transportation modes in the logistics network configuration, impacts of carbon charges are analysed and the result is shown in Table 101.2.

As carbon charge increases, more routes by multimodal transportation are selected. With current carbon charge, the impact is not sufficient to drive changes of transportation modes from road to multimodal. However, when carbon charge increases, the percentage of multimodal choice and the overall supply time increase in the logistics network. This may be explained by the fact that increase in the cost associated with carbon emission has overridden the operation cost difference between transportation modes. From Fig. 101.1, it can be seen that there are potential optimal logistics chain speed solutions which is associated with minimum overall cost in the logistics network. This implies that, within food shelf-life constraint, the supply time or FLCS can be optimised to achieve cost efficiency in the food logistics network operations. In Fig. 101.1, more than one optimal supply time solutions is presented. When carbon charge is low, most of the routes

Table 101.2 Transportation cost, carbon emissions cost and supply time interactions

Carbon charge	Transportation cost (£)	Carbon emission cost (tax) (£)	Carbon emission cost (CET) (£)	Time (h)	Multimodal (%)	Distance to switch mode (km)
0	415,877	–	–	106	0.16	–
17/14	415,877	3,845	1,767	106	0.16	–
239	367,225	50,107	26,207	141	8.07	375
438	349,784	89,329	45,529	170	8.47	243
513	320,173	99,308	48,008	239	9.50	217
751	289,053	136,835	61,735	352	28.99	139

would select road transportation. This leads to fast increase in carbon emission cost in the logistics network as in the early part of the carbon emission cost variations. When multimodal transportation is selected for more routes in the network, the increase of carbon emission cost slows down as the supply time increase.

With the case in this research, there is an inflection point with emission cost variations as the consequence of a sudden change of proportion of multimodal transportation in the network. The inflection point divides the supply time into two sections which reflect two carbon charge regions, low and high carbon charge regions. In both regions, a minimum cost can be achieved at an optimal supply time or optimal ratio of multimodal to road only transportation under a given carbon charge.

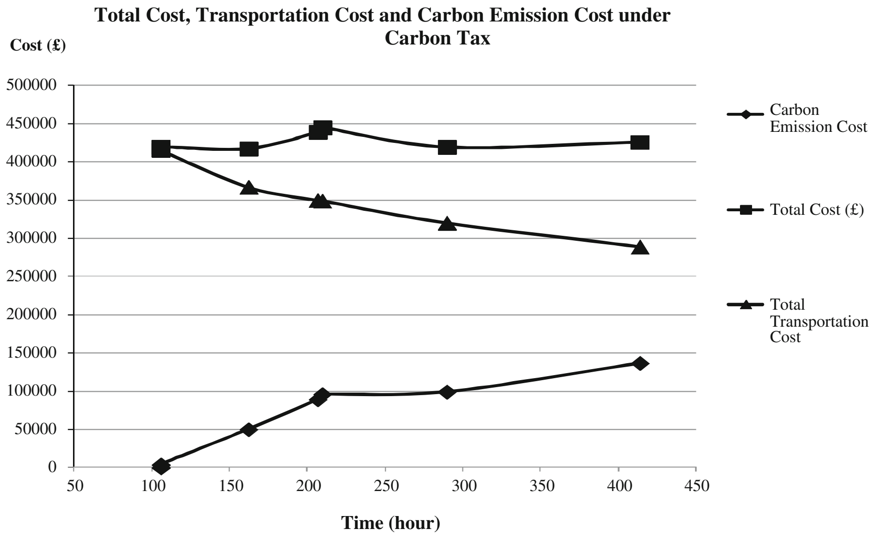

Fig. 101.1 Supply time and cost performance with given carbon control policy

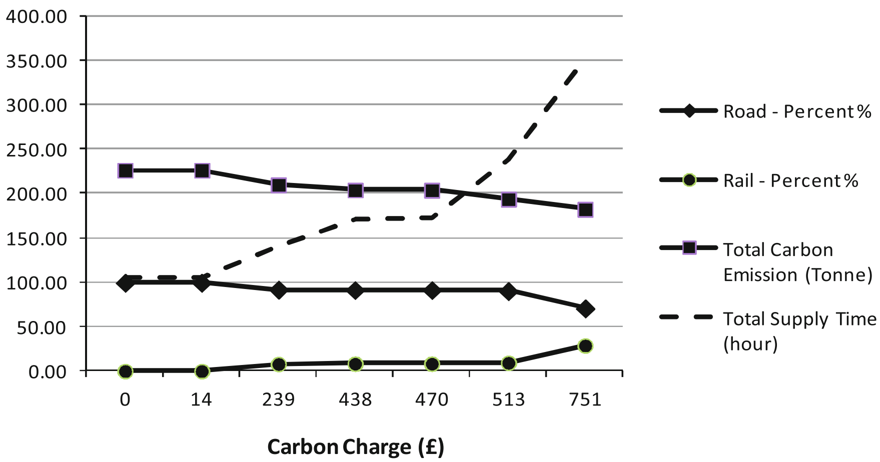

Fig. 101.2 Interactions of transportation mode shift and carbon emissions with carbon charge

It is apparent that the mapping between the cost inflection point and supply time or carbon charge depends on infrastructure of a network, i.e. demands in distribution areas, numbers of and distance to the RDCs, etc. This implies that more than one cost inflection point may exist in a logistics network and the carbon charge variations can be subsequently divided into several sections in each of which a minimum total cost can be achieved. The finding will benefit carbon control policy makers to understand the impact of carbon control policies on transportation cost and supply time, and develop effective carbon control policies for logistics service networks.

Figure 101.2 illustrates variations in transportation mode selection and carbon emissions associated with carbon charge (price or tax). It can be seen that, as the carbon charge increases, carbon emission is reduced slowly in the logistics operations due to shift between transportation modes. However, the supply time increase significantly.

As seen in Fig. 101.2, it is important to manage the logistics chain speed for food quality assurance. At different carbon charges, optimal supply speed should be the pursuit for minimizing costs of the logistics operations and environment impacts while meeting perishable food shelf-life requirement.

101.5 Conclusions

This research investigates impacts of two popular carbon emission policies on transportation operations in the food logistics service industry with a case in the UK. An optimal network design approach for food logistics service under carbon emission control is developed. When carbon charge is low, the road only option is the preferred mode. As the carbon charge increases, multimodal transportation planning can reduce carbon emission and overall cost. However, supply time or logistics chain speed is sacrificed when multimodal transportation is selected. This research has revealed that optimal logistics chain speed can be achieved at different carbon charge regions. Logistics service providers would be benefited from the logistics network design approach through developing optimal transportation operations with given carbon charge. The research can also significantly contribute to government policy making for carbon emission control.

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Chapter 102
The Research on Driver Model of Sustainable Supply Chain Management

Xiaohua Tang

Abstract Sustainable supply chain management (SSCM) has become a potentially valuable way of securing competitive advantage and improving organizational performance since competition is no longer between organizations, but among supply chains. The paper reviewed the definition research in sustainable supply chain management and discussed the drive model of SSCM. We aim to provide managers and industry practitioners with a better understanding about why and how to implement SSCM.

Keywords Sustainability · Supply chain · Driving factor

102.1 Introduction

There is a growing need for integrating environmental influence into supply chain management research and practice. Because the world faces severe changes with an expected 2–4 °C rise in global average temperature by the year 2100: 30–40 % of the species could be extinct, close to a third of global coastal wetlands are in danger of being submerged, millions of people will likely face food and water shortages, and many densely populated areas of the world, including many parts of Asia, will face higher rates of morbidity and mortality from heat waves, floods and droughts (IPCC 2007; Gupt and Palsule-Desai 2011).

A large part of the blame has been attributed to the greenhouse gases (GHGs). As measurements have shown, concentrations of GHGs in the earth's atmosphere

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have been relatively stable over the last 10,000 years (at between 250 and 300 parts per million). However, in the last 150 years or so, since the beginning of industrial revolution, concentrations of carbon dioxide in the atmosphere have shot up by more than 30 % (from less than 300 ppm to close to 400 ppm), and concentrations of methane have almost doubled (IPCC 2007; Gupta and Palsule-Desai 2011).

Sustainability is increasingly discussed by policy makers. Contradictions between economic development and environmental protection in China are intense. China will allocate RMB 3 trillion (US $460 billion) to the various green-related programs during the 12th Five Year Plan ("the plan or FYP"). The spending in the 12th Five Year Plan for the period 2011 through 2015 represents 60 % of the investment capital allocated for the decade.

The need for environmental protection and increasing demands for natural resources are forcing companies to reconsider their business models and restructure their supply chain operations. Scholars and proactive companies have begun to create more sustainable supply chains. However, it is not just about being environment friendly; it is about good business sense and higher profits. In fact, it is a business value driver and not a cost centre. The interaction between sustainability and supply chains is the critical next step for recent examinations of operations and the environment (Corbett and Kleindorfer 2003).

102.2 Definition of Sustainable Supply Chain Management

SSCM has its roots in both sustainability and supply chain management literature. Adding the "sustainability" component to supply chain management involves addressing the influence and relationships between supply chain management and sustainability.

Mentzer et al. (2001) defined supply chain management as "the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole". Lambert et al. (2006) state that it refers to "the integration of key business processes from end-user through original suppliers, that provides products, services, and information that add value for customers and other stakeholders".

The common standard to decide the function of traditional SCM is to achieve a profit through cost reduction. However, there have been various changes about customer demand and increase of environmental cost according to the trends of changing business. Therefore, the importance of sustainability has been highlighted as a standard of performance evaluation.

The concept of sustainability can be traced back to the book Our Common Future, also known as the Brundtland Report (WCED 1987). “Sustainable development (SD) is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” There is sufficient activity and ongoing development in the area of sustainability.

Sustainability has become a significant concern for companies that integrate environmental and social issues in their strategy (Srivastava 2007). Procter & Gamble (P&G) define sustainability as “ensuring a better quality of life for everyone, now and for generations to come” (P&G Sustainability Report 2010). During the last two decades, the focus on optimizing operations has moved to the entire supply chain. The focus on supply chains is a step to the broader adoption and development of sustainability, since the supply chain considers the product from initial processing of raw materials to delivery to the customer. And firms are aware of the importance of their partners’ sustainable responsibility in their own development (Dyllick and Hockerts 2002; Bai and Sarkis 2010). Sustainability of any organization is impossible without incorporating SSCM practices and environmental benefits diminish if downstream and upstream partners are not integrated in sustainable practices as well (Preuss 2005; Bai and Sarkis 2010).

There is a lot of and consistent body of literature dealing with sustainability in supply chain. Norman and MacDonald’s (2004) state that the definition of sustainable chain management is while creating financial benefits and attending to stakeholder’s preferences, supply chains must also care to shield the environment from the detrimental effects of their policies and actions. Company realizes development by acknowledging the social, economic and environmental aspects of its policies and actions. Elkington (1997) is credited with popularizing the latter three dimensions, which he called the triple bottom line (TBL) principle (also known as the three pillars: profit, planet, and people). From this perspective, Seuring and Muller (2008) point out the need to take into account the three bottom line approach in the management of sustainable supply chain.

According to the triple bottom line (TBL) principle, we define sustainable supply chain management as “integrating sustainability thinking into supply chain management which should coordinate resources, information, and operations through supply chain, in order to maximize the company profitability while at the same time minimizing the environmental impacts and maximizing the social well-being”. Social development refers how the supply chain treats people including employees, customers and the community at large. That means the objective of SSCM includes three dimension (see Fig. 102.1): Economic dimension, environmental dimension, and social dimension. It is different from the traditional supply chain management which just focus on economic dimension.

Similar to the concept of supply chain management, the boundary of SSCM is dependent on the goal of the investigator.

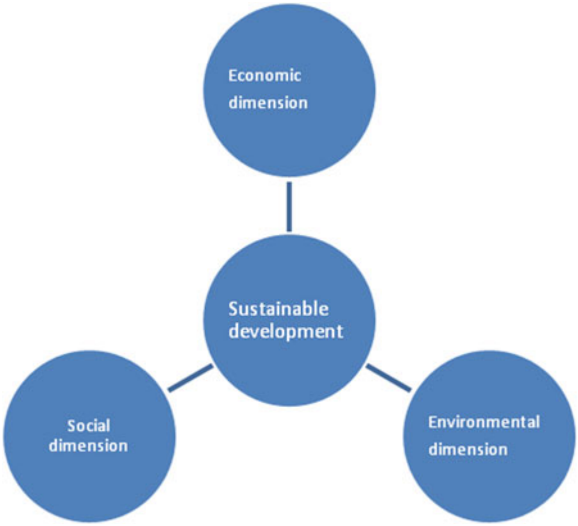

Fig. 102.1 The triple bottom line

102.3 Driver Model of Sustainable Supply Chain Management

There are various factors that drive companies to pursue sustainable supply chain management (see Fig. 102.2). In a 2008 survey of CEOs of large 3PL firms, five most important reasons for establishing their firms' sustainability programs identified are: desire to do the right thing, pressure from customers, desire to enhance company image, desire to attract green customers and competitive pressures (Lieb and Lieb 2011). These factors can be classified as either external or internal. The external factors include regulatory requirements, the nature of the business, competitor, and stakeholder actions (such as NGOs) and internal factors include top management vision, customer demand and suppliers' sustainable initiatives (Ageron et al. 2012).

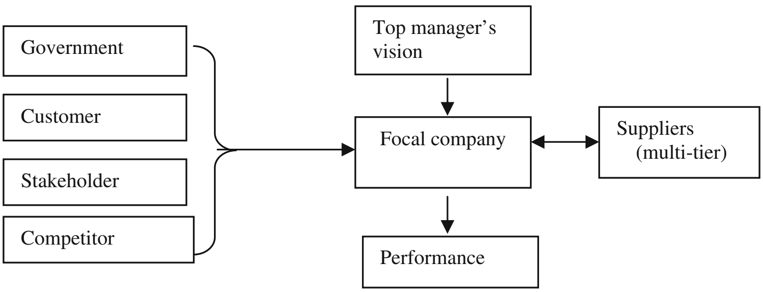

Fig. 102.2 Driver model of SSCM

102.3.1 Government

The advent of extreme climate change and global warming has spurred governments to enact laws or regulations requiring that companies adhere to certain environmental standards. The aim is to effectively control pollution and reduce the resultant environmental damages (Sathiendrakumar 2003). Regulatory pressures play a major role in this process. They can negatively impact performance via penalties and fines in those firms that do not respect the regulations.

In addition, industry standards (such ISO 14001) require suppliers to carry audits and certifications. Since 2003, Ford Motor Company requires its suppliers to have ISO 14001 certification and more than 5000 collaborators have been effected by this decision. Klassen and Vachon (2003) found that adoption of ISO 4001 is significantly related to companies' efforts to invest more in environmental management practices.

Proactive approaches to legal compliance with climate-related legislations seem to be more economically beneficial to companies and societies than reactive approaches. This is due to better mitigation strategies against environmental, social and financial risks (Beamon 1999; Green et al. 1996; Handfield et al. 1997; Walton et al. 1998; Zhu et al. 2005; Min and Galle 2001).

102.3.2 Customer

The pressure of environmental protection does not come solely from the demands of regulations; consumers and clients also exert pressure on companies (Hall 2000). More and more customers are aware of their personal environmental impact and in the name of being environmentally friendly they accept to pay more for green products. By doing this, they encourage and influence companies to adopt more SSCM practices and they ask in return companies to inform them on their sustainable decisions and actions (Ageron et al. 2012).

A study of Fortune 100 firms across several industries finds that almost 60 percent of firms adopt sustainable practices to strengthen brand names or differentiate their products to their consumers. In the U.S.A., an estimated 75 % of consumers claim that their purchasing decisions are influenced by a company's environmental reputation, and 80 % would be willing to pay more for environmentally friendly goods (Lamming and Hampson 1996). Walker et al. (2008) state that customer pressures on organisations vary depending on the size of the organisation. The more reputed the organisation is, the more sensitive the company becomes to customer pressure, since customer attitude does directly impact the company's bottom line.

102.3.3 Stakeholder

Environmental regulations and external stakeholders are considered the major factors affecting GSCM practices according to Zhu and Sarkis (2006), Hall (2000), Sarkis (1998) and other experts. It has been shown that community stakeholders have the ability to influence society's perception of a firm (Henriques and Sadorsky 1996). Various organisations build reputation and brand image by organising charity fundraisers and giving donations in the best interest of the less-privileged people. Some companies voluntarily undertake these activities to increase competitive advantage (Jones et al. 2005).

The society has recently become more aware of environmentally and socially sustainable production and distribution (Drumwright 1994). This has motivated companies to introduce new business practices with respect to sustainability (Delmas 2001; Sharma and Vredenburg 1998; Trowbridge 2001; Gabriel et al. 2000).

102.3.4 Competitor

Competitors equally have the ability to regulate standards and norm, thereby directly encouraging sustainable innovation (Henriques and Sadorsky 1999). Organisations may not have the proactive intention to be environmentally friendly but may do so to gain competitive advantage, such as financial benefits and reputation (Gonzalez-Benito and Gonzalez-Benito 2005). For example, competitive advantage can gain by means of energy efficiency, waste recycling, competent use and reuse of raw materials and resources, creating highest standards of workplace culture and improvement in safety standards.

102.3.5 Suppliers

Suppliers are not considered a key driver to sustainability but the integration and cooperation with them through information dissemination can result in competitive advantage and environmental abidance (Klassen and Vachon 2003; Theyel 2001; Vachon and Klassen 2006).

The relationship between suppliers and focal companies is a key factor to implement SSCM. A healthy supply relationship can result in operational efficiency, positive environmental impacts, cost reduction, flexibility in adapting to ever changing demands, technological innovations, energy efficiency and reduction in carbon emissions (Simpson and Power 2005).

Helping suppliers recognize the importance of resolving environmental issues and supporting them in installing their own improvement initiatives is a major issue that companies have to address today. Rajesh (2008) suggest that before implementing sustainable strategies in the supply chain, the various players must ensure the following, which act as influencing factors during the implementation of sustainability: (a) Understand the concept of sustainability, government and social policies and legislations. (b) Ensure they have the potential to implement sustainability in terms of cost, quality and culture. (c) Financial capabilities, since social/green production methods are expensive at adoption. (d) Appropriate organisational culture and avoidance of resistance to change. (e) Find key sustainable suppliers who support the principle of environmentally and socially friendly systems.

102.3.6 Top Manager's Vision

A company's mission statements and values along with appropriate management involvement are highly essential (New et al. 2000; Wycherley 1999). Sustainability as an important component of a company's strategy results mainly from the CEO's attitude (Klassen 2001). SSCM is a decision that has to be encouraged and supported internally at the corporate level.

Management takes on many different forms based on the decision making processes of suppliers or partnering firms. It can be active, reactive, pro-active, collaborative or individual. An active management approach involves being continually alert and keeping up with developments in sustainability strategies and techniques. This requires ongoing strategic plan and performance outcomes monitoring. Based on shared vision, systems, resources and actions, this approach seems well suited for sustainable supply management, but alignment of strategies is a challenging issue. The managerial approach adopted by suppliers and focal companies strongly influences the potential success of sustainable supply management (Ageron et al. 2012).

102.4 Conclusion

Sustainable supply chain management is fairly new in China. There are few reported studies on it. Therefore, it is necessary for us to find the critical drive factors and conditions of SSCM in China. According to the above driver model of SSCM, there are following critical success factors to implement sustainable supply management in China. Firstly, the government should strengthen legislation and enforcement, which are hard constraints for enterprises. Secondly, increase national awareness of sustainable development, which is the soft constraint for firms. Thirdly, focal company should enhance coordination and cooperation between enterprise and suppliers.

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Part VI
Green Buildings

Chapter 103
The Construction of Green Shipbuilding System

Hong-zhi Wang and Yang Zhao

Abstract As the supported industry of the whole national economy, shipbuilding industry, on the one hand creates abundant substance fortune, on the other hand it resumes a lot of resources and energy, and leads to environmental pollution at the same time. Therefore, how to make a harmonious development beside environmental protect and shipbuilding supply chain, are becoming the essential and key factors to the success, when shipyard pursuitting high returns. So, the paper research on the construction of green shipbuilding system systematically.

Keywords Green · Shipbuilding · Environment

103.1 Introduction

As the supported industry of the whole national economy, shipbuilding industry, occupies an important proportion of the national economy. Meanwhile, shipbuilding industry is a complex and systematic project. It belongs to labor-intensive industries, which inevitably causes some environmental pollution and destruction in the production process. Environmental issues bring a new challenge to shipbuilding enterprises. Therefore, to bring in the "green" concept into the shipbuilding industry is imperative.

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Currently, studies on Green Shipbuilding is still in initial stage, while, a variety of regulations and conventions grow increasingly stringent. IMO and IACS has introduced new standard in recent years and enhanced the protection of marine and atmospheric environment in the form of mandatory convention and regulations (Liu et al. 2000). For example, IMO PSPC became efficient in December, 2006. And BIMCO add new articles concerning environmental protection to its Standard Shipbuilding Contract, which clearly proposes new environmental requirements to the shipyards. It is sure to say that the international "green barrier" will become more and more serious in the future. Green shipbuilding management is an important means of enhancing environmental performance for those shipbuilding enterprises. Therefore, research on green shipbuilding has very important value on increasing international competitiveness for shipbuilding enterprises.

103.1.1 Green Manufacturing and Green Shipbuilding

Green Manufacturing is also known as Environmentally Conscious Manufacturing or Manufacturing For Environment. Studies on Green manufacturing can be traced back to 1980s (Zhu 2004). However, the systematic proposal for its concept and contents occurred in the Blue Book named Green Manufacturing published by SME in 1996. Thereafter, SME released Trends of Green Manufacturing on the website in 1998, in which a further presentation of the importance of green manufacturing and related issues has been made. Green manufacturing leads an important direction for manufacturing technology and mode in its future development.

The root causes for implementing Green Manufacturing is to solve the environmental, social, and ecological issues caused by the development of manufacturing industry (Li 2007). Its ultimate goal is to achieve the harmonious development among human, nature and society, and its essence is to embed the green manufacturing thinking into manufacturing activities.

To combine with the concept of Green Manufacturing and the characteristics of shipbuilding industry, we can figure out that green shipbuilding is a modern management model considering the environmental impact and resource efficiency. It is based upon green manufacturing theory and management technology, involving manufacturers, suppliers, shipyards, ships and other related departments. It aims to minimize the negative effects upon environment and maximize resources efficiency during the process, in which ship products from raw materials, ship equipment acquisition, processing into a variety of ship components, parts, and the total of all sub-paragraph, and ultimately into a complete closure of ship, are finally sent to the owners' hands. In the shipbuilding process, it is crucial to attach importance to every aspect of environmental problems, to increase environmental protection awareness and to run "green" "environmental protection" and "sustainable development throughout the operation of shipbuilding production. Only in this way, the systematic optimization of society, ecology, and overall economic benefits can be achieved, the sustainable development of environment and society can be promoted and therefore the competitiveness of enterprises and the whole industry can be enhanced.

103.2 System of Green Shipbuilding

System of Green shipbuilding covers all the nods associated with shipbuilding industry chain, which includes green procurement, green shipbuilding, green marketing and green recycling, etc.

103.2.1 Green Procurement

Green procurement is to consider whether the marine products are environmentally friendly materials and products at the beginning of procurement. It refers to source control, through which the awareness of environmental protection and resource conservation are implemented into the supply chain. Green procurement can not only meet the public demands for environmental products, but also reduce overall cost, thus finally bring economic benefits and competitive advantage for shipping enterprises.

Green procurement includes ship outfitting, whether the material is environment-friendly coating material, recycling and reusing of materials, removal of waste by sound measures of crushing, burning and degradation, whether the emission standards for marine machinery meet the minimum requirements of atmosphere and oceanic pollution. The selection of suppliers and the maintenance of relationship with suppliers compose an important part of green procurement. As to the specific implementation, we can consult the Table 103.1, which summarized by Hamner and Rosario in 1998 (Ofrid 2000).

Table 103.1 Green procurement activities

Product standard	Procurement environment-friendly products, such as recyclable materials and materials with eco-labels
Behavior standard	Require suppliers to publish the information concerning environment practice and pollution disposal
	Audit suppliers so as to evaluate their environment performance
	Require suppliers to implement environmental management system
	Require suppliers to acquire ISO14000 certification
Cooperation	Reduce the impact upon environment by changing product design and use of material through the cooperation with suppliers
Development	Training suppliers to increase awareness of potential environment issues and practical activities of their own business
	Timely deliver technology information related to the operation of suppliers

103.2.2 Green Shipbuilding

Green shipbuilding is placed at the core of green shipbuilding supply chain (Dao and Yan 2008). The extent of its impact on environment will determine the entire "green" extent of the supply chain. Ship manufacturing industry is a complicated system, which involves in not only strategic management, tactical planning and field implementation, but also construction process setting out from drawings of ship to berth close to the sub-assembly in water. Shipbuilding are composed of five modules: green enterprises management, green hull design, green hull construction, green monitor test and advanced shipbuilding technology.

(1) Green Business Management

Shipbuilding enterprises should build their development strategies and objectives under the guideline of sustainable development theory. They are required to comply with the requirements of sustainable development strategy, focus on ecological and environmental protection in their production, operation and management activities in order to achieve harmonious development of enterprise interests, consumer interests, social interests and ecological environment interests. The adaptability to the environment must be considered both in the adoption of newly-developed technology and shelling-outfitting-smearing integration production.

(2) Green Ship Designing

During the ship building, we must integrate the green, environmentally idea and considering the ship the product performance and quality, natural resource conservation and protection of ecological environment (Zhu and Geng 2004). The green design of the ship contains optimization design ship lines etc.; ship main and auxiliary power environmental design which including selection of the host of efficient and environmentally friendly fuel, diesel exhaust recycling etc.; The ship's automated and intelligent design, including automation room, no one cabin, intelligent monitoring room etc.

(3) Green Ship Building

All aspects of shipbuilding, ship manufacturing companies strive to impact on the environment with minimum waste and harmful emissions at least, in order to reduce the pollution of air, water and land. Lofting from the molded line of sheet material, assembled from components to the segmented manufacturing, from the total segment close to the slipway into the water should take environmental protection measures and means. For example, in the sandblasting of the steel pretreatment stage, in order to prevent the effects of dust and noise, we can install the dust silencer, and during the welding process, choosing efficient welding technology and low toxicity, low smoke, no welding material of the arc of dust pollution.

(4) Green Ship verification

Ship verification is an important aspect of the shipbuilding, throughout all stages of ship construction, so environmental indicators is particularly important as indicators to judge the various stages of the product.

(5) Advanced Shipbuilding Technology

Advanced shipbuilding technology not only can enhance the efficiency and level of shipbuilding, but also can reduce the consumption of raw materials and energy, and play a protective effect on the environment. Including the integrated system of computer-aided shipbuilding technology, lean manufacturing, precision control technology etc. Extensive application of these technologies will enhance the productivity of the shipbuilding enterprise, assembly levels, reduce wastage of resources, and reduce production costs.

103.2.3 Green Marketing

Green marketing is a shipbuilding enterprise to meet the ship market and the owner of a demand management process through developing ships products, in order to promote sustainable development, achieving shipyard and ship-owners economic interests, and receiving environmental benefits (Bowen et al. 2001). Therefore, shipbuilding enterprises should maintain natural ecological balance and conservation of natural resources to promote sustainable economic development whether in strategic management or in the tactical management.

Green marketing is a long-term strategy for the shipyards, in particular, how to attract more orders in the environment of the latter financial crisis period, how to get the favor of the owner, personally believe that green marketing is more important.

103.2.4 Green Recycling

Green recycling is an important branch of the circular economy, and plays an important role in the circular economy (Russel 1998). Green Recycling includes waste logistics and recycling logistics. Waste logistics is aimed primarily generated waste, scrap and other recycling in the shipbuilding process. Such as waste generated in the process of blank nesting, scrap generated in pre-outfitting stage etc. Recycling logistics is the defective products in the shipbuilding return to the supplier.

No matter what kind of green recovery, the ultimate goal is to dispose of these wastes and defective products as soon as possible, to reduce the retention time in the shipyard, and reduce the pollution to the surrounding environment. In order to make these items to reuse, recycle as much as possible (Dowatshali 2000).

103.3 Conclusion

The impact of shipbuilding industry on environment has been more and more attention, the shipbuilding industry shift from traditional manufacturing to green shipbuilding has become inevitable. The management of green shipbuilding system can bring huge economic benefits to the shipbuilding enterprise and the node enterprises. The more important is which can bring priceless environmental and social benefits to society, and thus promote and facilitate the development of China's shipbuilding industry.

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Chapter 104
Research on the Mahoney Tables Used in Shanghai Building Energy Efficiency Design

Bo Xia

Abstract The Mahoney tables are a set of reference tables used in architecture, used as a guide to climate-appropriate design. In order to research the Shanghai building energy saving design strategy, the paper studies the Shanghai building with the method of Mahoney tables combined with Shanghai meteorological data, and puts forward a series of building energy efficiency design strategies for Shanghai climate characteristics. Finally, according to the climatic characteristics of Shanghai and the residents' living characteristics, the limitations of strategies proposed by the Mahoney tables were analyzed.

Keywords Mahoney tables · Shanghai · Design strategies

104.1 Introduction

The Department of Development and Tropical Studies of the Architectural Association in London developed a methodology for building design in accordance to climate. In order to research the relationship between the Shanghai climate and building energy efficiency design and determine the most appropriate building energy efficiency design strategies in Shanghai, the paper adopts the Mahoney tables to Shanghai analyzing the design strategies according to the Shanghai meteorological data.

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Table 104.1 Mean relative humidity and Humidity group

Mean relative humidity (%)	Humidity group
Below 30	1
30–50	2
50–70	3
Above 70	4

104.2 Climatic Data

Using the meteorological data provided by the Shanghai Municipal Meteorological Observatory, the paper completed the analysis of the Shanghai outdoor climatic conditions described in Tables 104.1 and 104.2.

104.3 The Comfort Limits

The Mahoney tables divide the comfort zone into three temperature ranges in accordance with the level of the annual mean temperature (AMT): $\geq$20, 15–20 and <15 °C. Furthermore the Mahoney tables take into account people difference dressing habits and activities in the day and night, and limit difference thermal comfort range on the day and night the two time periods, which is shown in Table 104.3.

104.4 The Analysis of Each Month Comfort Limit

Similarly the monthly mean maxima and minima of the site in question are compared to the day and night comfort limits for each individual month, according to the annual mean ranges given in Table 104.3 respectively (i.e., maxima with the day comfort limit and minima with the night comfort limits). The classification is established as follows:

Above comfort limit H
Within comfort limit N
Below comfort limit C

The humidity and comfort classifications are compared for each month to establish humidity and arid indicators.

104.4.1 Humidity Indicators

H1 Indicates that air movement is essential.
H2 Indicates that air movement is desirable.
H3 indicates that precautions again strain penetration are needed.

Table 104.2 Shanghai climatic data

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Monthly mean max. (°C)	7.7	9.7	13.7	19.0	24.5	27.4	30.7[a]	29.8	27.2	22.4	17.0	11.0	
Monthly mean min. (°C)	1.6[b]	3.7	6.6	12	17.4	21.7	25.3	24.6	21.9	15.9	10.5	4.3	
Monthly mean range (°C)	6.1	6	7.1	7	7.1	5.7	5.4	5.2	5.3	6.5	6.5	6.7	
RH	76	71	78	73	76	82	81	82	76	73	67	66	
HG	4	4	4	4	4	4	4	4	4	4	3	3	
Rainfall (mm)	75	44	118	63	85	212	142	230	76	64	43	34	1186

AMR = Annual mean range = Highest − Lowest = 16.9, *AMT* = Annual mean temperature = (Highest + Lowest)/2 = 29.1, *RH* relative humidity, *HG* humidity group

[a] Highest monthly mean

[b] Lowest monthly mean

Table 104.3 Comfort limits

Average RH (%)	HG	AMT over 20 °C		AMT 15–20 °C		AMT under 15 °C	
		Days	Night	Days	Night	Days	Night
0–30	1	26–34	27–34	23–32	14–23	21–30	12–21
30–50	2	25–31	17–24	22–30	14–22	20–27	12–20
50–70	3	23–29	17–23	21–28	14–21	19–26	12–19
>70	4	22–27	17–21	20–25	14–20	18–24	12–18

RH relative humidity, *HG* humidity group, *AMT* annual mean temperature

Table 104.4 Diagnosis of Shanghai climatic data

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Thermal stress: Day	C	C	C	C	N	H	H	H	H	N	C	C
Thermal stress: Night	C	C	C	C	N	H	H	H	H	N	C	C

HG humidity group, *H* above comfort limit, *N* within comfort limit, *C* below comfort limit

Table 104.5 Indicators

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Humid													
H1 Air movement						X	X	X	X				4
H2 Air movement					X					X			2
H3 Rain protection						X		X					2
Arid													
A1 Thermal storage													0
A2 Outdoor sleeping													0
A3 Cold-season	X	X	X	X							X	X	6

104.4.2 Arid Indicators

A1 Need for thermal storage.
A2 Indicates the desirability of outdoor sleeping space.
A3 Indicates winter or cold-season problem.

The climatic data of Shanghai is tabulated in Mahoney's Tables 104.4 and 104.5.

104.5 Application of Mahoney Tables in Shanghai

There commendations of the climatic analysis for Shanghai building design are summarized in Table 104.6.

Table 104.6 Design recommendations (★ in the table is appropriate building design strategies for Shanghai)

Indicator total from Table (104.5)							Recommendations
Humid			Arid				
H1	H2	H3	A1	A2	A3		
4	2	2	0	0	6		
							Layout
			0–10			★	1 Building oriented on east to west axis to reduce exposure to sun
			11, 12		5–12		
					0–4		2 Compact courtyard planning
							Spacing
11, 12							3 Open spacing for breeze penetration
2–10						★	4 As 3, but protect from cold/hot wind
0,1							5 Compact planning
							Air movement
3–12						★	6 Rooms single banked. Permanent provision for air movement
1, 2				0–5			
				6–12			7 Double banked rooms with temporary provision for air movement
0	2–12						
	0, 1						8 No air movement required
							Openings
			0, 1		0		9 Large openings, 40–80 % of N and S walls
			11, 12		0, 1		10 Very small openings, 10–20 %
Any other conditions						★	11 Medium openings, 20–40 %
							Walls
			0–2			★	12 Light walls; short time lag
			3–12				13 Heavy external and internal walls
							Roofs
			0–5			★	14 Light insulated roofs
			6–12				15 Heavy roofs; over 8 h' time lag
							Outdoor sleeping
				2–12			16 Space for outdoor sleeping required
							Rain protection
		3–12					17 Protection from heavy rain needed

104.6 Conclusions

Through the above analysis, it can be found that the Shanghai natural environment is not very ideal. However, the Mahoney tables have some limitations. Shanghai climate is hot in summer and cold in winter, and Shanghai residents live for so long time in such climate that they not only have a certain degree of adaptation and tolerance of summer heat, but also have a greater tolerance in the winter cold environment than people living in the tropics. Therefore there may be some errors for the evaluation of the Shanghai winter environment that the actual below comfort limit situation should be less than 50 %. Shanghai residents have a better tolerance to cold environment, but the essence of building is to offer people a comfortable indoor environment, so it is also important to pay attention to the passive heating strategy used in Shanghai building energy efficiency design.

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Chapter 105
Healthy Development of Green Real Estate a Report on Current Status and Prospect of China's Green Real Estate Development in 2012

Xianming Huang, Junpeng Huang, Tao Li and Wei Gao

Abstract This paper probed the current status and prospect of China's green real estate development from the perspective of concepts, markets, industries, policies and human resources. Through the probation, the authors give their understanding on the latest trends in this field.

Keywords Green real estate · Concept · Technology · System

As the regulation and control of China's real estate market is intensified, the value of product character and quality has become increasingly outstanding in the cut-throat market competition. The environmental protection and low carbon concept and technology advocated by green real estate have become the key factors of enterprises' core competitiveness. Through in-depth survey in the current green real estate marketing environment, this research aimed to understand the latest trends of this field.

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105.1 What's "Green Real Estate"

"Green Real Estate" refers to the developers' for-profit development of residences and commercial real estates. On the premises of conforming to the building aesthetic principles, such development shall also ensure the virtuous cycle of natural ecosystems, cyclic economy based, harmonious society connoted, energy conservation and environmental protection technologies supported.

The "Green real estate" is an epitome of three sustainable development principles (People, Planet, Profit) in market development.

People-orientation refers to the "green real estate" being required to provide healthy, comfortable, safe and human-friendly human settlements to consumers.

Environment refers to integrating human into nature in the project design concept.

Profit refers to advocating comprehensive and sustainable "green profit", which means rather than merely profit-seeking, the enterprises shall also seek suitable approaches to balance the contradictions between efficiency and safety, short-term and long-term.

105.2 Research Method

The research data come from the following methods: Orientated questionaire, In-depth interview, Small symposiums, Network surveys, Street interview and Bibliodiagramic data acquisition.

105.3 Research Conclusions

105.3.1 Current Status of China's Green Real Estate Development

(1) Green building concept

- "Nature and Man in One with a Harmonious Coexistence" is the core concept of China's green buildings, and is being accepted as consensus by even more people.
- Among all the key elements of green buildings, consumers ranked "a healthy and comfortable working and living environment" above all, while "saving resources", which was deemed as the most important element by experts, was lower-ranked. This phenomenon suggested that the demand-oriented green real estate industry can not simply apply indiscriminately the green building models described in professional academic books.

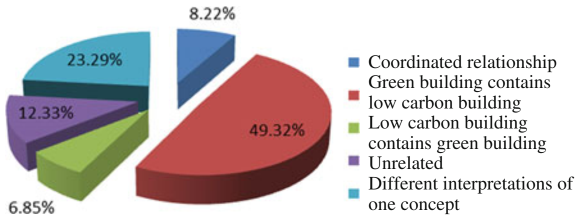

Fig. 105.1 Diagram showing perception of relationship between green buildings and low carbon buildings

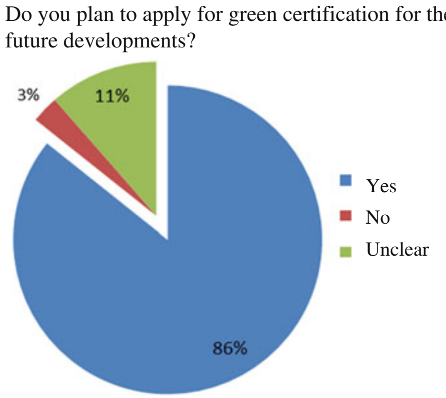

Fig. 105.2 Diagram showing interviewed developers' green participation willingness

- Big divergences exist in recognizing the relationships between "green buildings" and "low carbon buildings", and this is even true of the specialists. Therefore, in the current stage, an overheated speculation on the concept of "low carbon buildings" does no good (Fig. 105.1).

(2) Real estate market

- Research showed that ordinary consumers knew little about green buildings, and their inner duty-awarenesses were far from becoming the first cause of green real estate (Shaobin 2010).
- More and more real estate enterprises started to think about the "transition" problems as a result of the Macro-economic Control pressure and the drive of progressively matured technologies (incremental costs decreasing progressively) (Fig. 105.2). The cost rather than concept hindered the real estate developers from more rapid green transitions.
- The "Chinese Green Building Evaluation Label" has been soaring year by year. LEED, DGNB, OPL "One Planet Living" and BREEAM are applied in China besides Chinese rating system. Green buildings' influence on the market has been gradually growing.

(3) Industrial chain

- The pulling effect of the "Chinese Green Building Evaluation Label" towards green industrial chains remains to be strengthened.

- Green Building Evaluation and Consultation industries are springing up.
- Rankings of green real estate will support the development of green technologies.

(4) Policies and systems

- Currently, the Chinese consumers' green demands have yet to be fostered, which can not form active market forces, and the direct market profits brought by green buildings are not obvious. Thus, appropriate incentive policies are needed to guide the consumers and put the market in gear.
- The survey showed that the majority of practitioner's recommendations about the improvement of the "Evaluation Standard for Green Building" focused on four aspects, which include a transition from evaluation based on the number of items to performance evaluation, stressing multidisciplinary integration, emphasizing acting according to the actual conditions and providing more technical support.
- Due to the fierce market competition, the emerging green enterprises and technical products vary greatly, and need uniform normative guidances in this field urgently.
- There are still insufficient public participation means in green real estate area.

(5) Human resources

- Professional green building talents are increasingly becoming a part of the core competitiveness of enterprises.
- Training and certification systems need to be established for green building personnel.

105.3.2 Prospect of China's Green Real Estate Development

(1) Green building concept

- In terms of the green building concept and connotations development, domestic experts think that three tendencies are most likely to present, namely, urbanization (eco-cities and low carbon communities), which accounted for 46 %, life cycle assessment LCA, which accounted for 43 %, and carbon accounting, which accounted for 23 %; while the most unlikely tendencies are zero energy consumption, which accounted for 5 % and zero carbon, which accounted for 5 %. However, in the eyes of foreign experts, the most likely tendencies are Energy Efficiency in Existing Buildings, which accounted for 44 %, urbanization, which accounted for 33 % and old city reconstruction, which accounted for 30 % (Ling 2011).
- In the past decade of green building development, China's green building development mainly targeted to enhance the building greening from the perspective of machine and electricity and devices. As the research and practice went deeper, we fundamentally lowered the demand for building

energy and resources through well-planned structures, reasonable layout, effective design and operation & management, which became a new hot spot for building concepts, technologies and system studies.

(2) Real estate market

- Green "label" plays an important role in the enterprises' green transition. But as the practical experiences accumulated, those mature enterprises will establish their own operation specifications and construction standards based on their own development needs.
- An increasing number of real estate enterprises have come to realize that only by establishing technology systems with technologies and items clearly defined, can the green concept be followed and progressively improved, thereby becoming the enterprises' core competitiveness.
- The "standardization" advocated by green real estate refers to which varies with the climate, building types and economic, social and cultural conditions. The value of green concepts, such as passive priority, active optimization and proceeding from local conditions, will be realized by more and more enterprises.
- Policy-based houses and old buildings reconstruction & renovation will become a new hot spot for green real estate.

(3) Industrial chain

- Design and consultation will displace evaluation & consultation. Integrated design will become mainstream in this area.
- As the low carbon concept is rapidly popularizing, it will progressively become the new core to integrate various green technologies. This new core will be conductive to enhancing the operability of green concept and a useful outreach for energy-saving technologies.
- Enhancing the reliability of green energy-saving technologies will become the main trend in technology development.
- The BIM-centered (Building Information Model) design integration and optimization platform is very helpful to simplify simulation and optimization process and reduce time for design optimization and financial cost. The survey shows that application of design optimization softwares will be more popular.

(4) Policies and systems

- In anticipating the green real estate policy environment, the survey showed that the most likely scenarios to present are "integrating energy efficiency and environmental protection into development-related system construction", which accounted for 50 %; "being integrated into unified planning of energy conservation and emissions reduction", which accounted for 42 %, and "from incentive to enforcement", which accounted for 37 %. While comparatively the less likely scenarios are "green credit financing support", which accounted for 28 % and "tax relief", which accounted for 31 %.

- In 2011, China launched its revision procedure of "evaluation standard for green building". This revision is under the guiding ideology that revise and improve the existing standard based on the past four years' practical experiences; extend the scope of application of the standard and put forward implementing rules in response to different types of buildings; further improve the evaluation process and documentation requirements.
- New industrial norms will be introduced progressively. The new policies and norms might include price signal-oriented mechanisms for energy, resources environment-related products and services; extended mechanism for accountabilities of "polluter pays"; standard systems of energy and resources consumption and pollutant discharge as well as third party supervision mechanism; emission limit system and emissions trading scheme; technology access permit system; professionalized operating mechanism for enterprises who are specialized in providing energy-conservation and environmental protection services.

(5) Human resources

The green building development brought about industrial upgrading, which also brought all-dimensional requirements for green talents to this industry, which includes the government administration departments, developers, research and design institutes, product and technology R&D organizations, financial service firms, etc.

105.4 Postscript

This research will continue for a period of 3–5 years, the survey carried out in 2011 can be deemed as a preliminary investigation and grope process for the whole research, and its conclusions will be used as a basis and reference for deepening the research in the near future.

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Chapter 106
Research of Chinese Ancient Urban Morphologies Based on Climate Adaptability

Zhongzhong Zeng, Haishan Xia and Haoxia Chen

Abstract Ancient Chinese cities have a history of thousands of years. Different historical dynasties recorded different urban planning philosophy. Many of these ancient practices on urban planning and design can be used as references for today's urban planning. A study of the climate adaptability of ancient Chinese urban form is theoretically significant. It helps to guide the modern city design, to create and build a modern city with Chinese characteristics and to inherit and carry forward the local traditional culture. Moreover, such studies can enrich the current deficient knowledge in ancient city construction history.

Keywords Climate adaptability · Ancient Chinese urban form · Site selection · Urban water system · City layout

106.1 Introduction

The current researches in ancient Chinese urban form mainly focus on historical geography, archeology and architecture. Morphology of ancient Chinese cities, considering the object, can be divided into three levels: research in the individual

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case of urban morphology; research in typological, regional and urban form in different historical periods; comprehensive study of Ancient Chinese urban morphology from a macro perspective. Most scholars mainly focus on city history while more or less neglect the climate adaptation of ancient urban form.

106.2 Climate Adaptation in Feng Shui

Feng Shui is an ancient Chinese theory on environment selection. It is reasonable in ecological and climatic perspectives, especially when it is applied in site selection and layout design. An urban site selection guided by Feng Shui is of simple dialectic view and harmonious concept of nature.

In Ancient China, the civilization of agriculture is depended on sunshine, water and soil. Therefore, many principles and modes in Feing Shui theory are based on geology, such as southern exposure principle is due to the fact that northern mountains can block cold wind in winter.

Guiding environment selection, Feng Shui Theory is reasonable in terms of ecology and climate when it comes to site selection and layout design. The rationality is displayed in four aspects as specified below (Fig. 106.1). First aspect is orientation. Basically, the ideal orientation is sitting north and facing south, which is due to the solar exposure in the Northern Hemisphere. The ancients regard a good orientation principal in improving microclimate, which is scientifically rational. Second is about negative Yin-Yang and protection against unfavorable wind. The dominant wind direction has greatly impacted Feng Shui Theory. In winter, the cold and dry northerly wind prevails. Thus forming the environmental mode in Feng Shui Theory where three sides, north, west and east, are surrounded by mountains and southern side is slightly open. The third aspect is about wind management and micro-ventilation utilization. Through study wind typology, direction and corresponding influence, Feng Shui theory helps to promote the beneficial and abolish the harmful, therefore achieve a good wind environment in settlements. Specific measurements include using geological conditions to block western and northern wind, keeping the southern part open to bring in cool southern wind, as well as not setting up residential buildings on particularly windy spots, and etc. Last point is about city site selection and water. It is climatically reasonable that Feng Shui emphasized the significance about setting up a city that faces water. Large scale of water can cause breeze in summer due to temperature difference, which is termed as ‘Land and sea wind’. The breeze is very beneficial for cooling down and moistening settlements in summer.

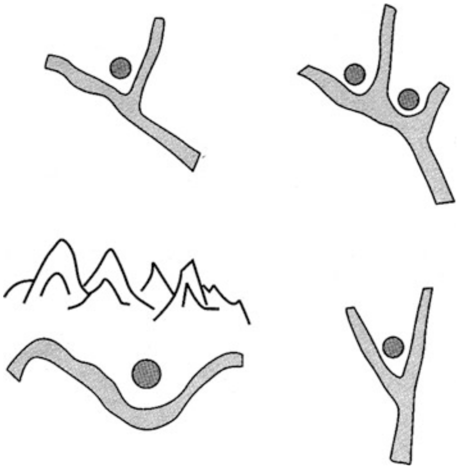

Fig. 106.1 Site selection and layout design in ancient China

106.3 Historical Urban Site Selection Based on Climate Adaptability

China is dominated by continental monsoon climate since it is located in Northern hemisphere. Through observation, the ancients discovered that southern exposure of buildings favored lighting, heating and ventilation. And it slowly became a routine. Later it evolved to the city construction rule in Western Zhou Dynasty as recorded In 'Kao Gong Ji Zhou Craftsman'. The emphasis on north–south orientation has substantial influence on city orientations in later ages. To sum up, the emphasis on ancient city orientation is rooted in their climate adaptability.

The spring and autumn period was a turbulent era and cities were developing rapidly at that time. In the realm of urban planning, the planning principles from Western Zhou dynasty were broken through and improved. Urban morphology emerged to be diverse instead of sticking to one pattern. One typical example is the ideology proposed by Guan Zi (Dwight 1969), that is to pay attention to local geological and climatic conditions and to adjust planning measurements according to local conditions.

The site selections of many ancient cities prove people's profound understanding in local situations. For instance, literature legibly recorded that back mountains can help prevent cold western and northern wind from entering cities in winter time, besides, it can also block sand from the north. Historical literatures show that the ancient gave priority to local microclimate when they chose city sites in order to distinguish cities' further development. As the ancient Chinese urban civilization was emerged in Loess Plateau and under the special monsoon climate, it is very enlightening for today's city site selection.

106.4 Ancient Urban Water System Based on Climate Adaptability

Ancient urban water systems were mostly developed from individual project such as water supplicant system, suburban farmland irrigation system and shipping. With the changing of social conditions and urban development, water system were transformed and extended, together with their quality perfected and changed.

Although there was no clear conception about climate adaptability of urban water system in ancient times, Chinese people, through long term experience, learned how to bring water into urban areas via water conservancy projects or transform natural water areas to be promising city site. These suburban and urban water areas can improve urban microclimate and beautify cityscape. It is an important issue in urban water conservancy projects. In the history, large cities such as Chang'an, Luoyang, Kaifeng, Hangzhou, Nanjing and Beijing set up corresponding water projects in order to deal with urban water consumption.

In Sui Dynasty and Tang Dynasty, because of climatic fluctuation together with human's influence, ecological environment started changing. Vegetation on Loess Plateau disappeared step by step, and large amount of urban water conservancy projects became emerging in cities. For instance, the water systems in Chang'an and Luoyang had positive influence on the urban microclimate. In later historical literatures, it is recorded that bringing water into cities through water conservancy projects can help improving urban microclimate and beautifying urban environment.

106.5 Ancient City Layout and Urban Microclimate

The ancient did not follow the ideal model described in 'Kao Gong Ji Zhou Craftsman' exactly. Instead, before they plan for new cities, they would study each site's special location and climatic characteristics or they would make modifications according to old city's layout, climate, location or other factors. Typical examples include Luoyang city in East Han Dynasty and Da Du in Yuan Dynasty (Gaubatz 1996; Rowe 1984); both of them have more northern gates than southern gates. Other examples include Ying Du in Chu Kingdom, Han Gu Cheng in Zheng Kingdom, Xia Du in Yan, Gu Cheng in Lu, they placed palaces in southeast according to the dominant wind, and arranged handicraft industry and ceramic craft in downwind direction. In many cities, the roads were designed parallel to the dominant wind direction because it is beneficial for heat exchange. Chai Rong, an emperor of the later Zhou Dynasty, issued imperial letters to propose using water system and greenery to improve urban environment. Old city of Chengdu, Wenzhou and Xiangyang utilized river ways and streets as wind passages, so that the street and neighborhoods could obtain satisfactory lighting and ventilation qualities. And in order to protect the city against dry and cold air current from

Northwest as well as sand from the north, Luoyang in East Han Dynasty applied some climate adaptable methods such as reducing the amount of city gates (Rozman 1973).

106.6 Conclusion

The paper aims to set up a new framework for ancient urban morphology based on climate adaptability. In order to conduct a thorough study in the climatic rationality of ancient cities, the paper applies interpretation and other research methodologies to research and analyze abundant ancient literature, within which many are still inspiring for today's low-carbon urban planning practice.

There are some research achievements in ancient Chinese urban morphology recently. However, because of research methods, basically no breakthrough progress has been achieved. And further study on ancient Chinese urban morphology will be carried out in the following perspectives:

To excavate and systemize historical data. For studying ancient urban morphology, local history is the first-hand material, whose value is irreplaceable. A research in local history is the foundation of morphological study, therefore can lead to more reliable conclusions;

To strengthen analyzing abilities. The main reason that resulted in multiple problems in the previous studies is the lack of logical training as well as ability in analyzing historical data.

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Chapter 107
Case Study of BIM-Based Building Energy Evaluation

Runmei Zhang, Changcheng Liu and Tao Xu

Abstract Building energy consumption is increasing great over time so that we need to take measures to reduce it. Building energy analysis and evaluation is the premise to realize building energy-saving. Calculating the heating or cooling load by static algorithm is a traditional method to do building energy analysis. This method ignores the delay and attenuation of heat transfer so that it's not accurate as well as unsustainable. According to BIM's completeness of information, good visualization and sustainability, a method to evaluate building energy based on BIM is presented in this paper. Firstly, BIM technology and it's research status are introduced. Secondly, a framework to explain how to analyze and assess building energy by BIM software is presented. Then, a teaching building in Hefei is taken as an example, and it's building energy evaluation is done with Ecotect. Some energy-saving measures are put forward finally. This article provides some ideas and methods for evaluating building energy in hot summer and cold winter region.

Keywords Building energy-saving · Energy evaluation · Thermal performance · BIM · Ecotect

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107.1 Introduction

Every year, energy consumption of buildings forms 30–40 % of global energy. Building emissions of greenhouse gas account for one-third of total global emissions. The building sector accounts for about 40 % of the total energy consumption and 38 % of the CO_2 emission in the U.S. (DOE 2009). High building energy consumption has become an energy problem to be solved. And in China, the problem is more prominent. The total national building energy consumption is 16 billion tons standard coal which accounts for 20.7 % of the total end energy consumption in the year 2004. For the past 20 years, building energy consumption in China has been increased by more than 10 % a year (Cai et al. 2009; Jiang and Yang 2006). Reducing building energy consumption and improving building energy efficiency has become the top priority of the construction industry.

Building energy consumption receives the restriction of the local climatic conditions, indoor air quality standards, thermal performance, efficiency of HVAC facilities and many other aspects. Analysis and evaluation of building energy is the premise of reducing building energy consumption. Traditionally, there are two main building energy analysis methods. One method is calculate building thermal/cold load by using static algorithm. This method ignores the building heat transfer delay and attenuation effects, which will results in large deviation of calculated load compared with actual load. The other is doing energy analysis by manually inputting the relevant data of building to dynamic simulation software. This method often requires lots of manual input, and the operation of these softwares usually requires complex professional knowledge about energy analysis and computer science (Laine and Karola 2007; Zeng and Zhao 2006).

BIM (Building Information Modeling) contains all the information related to the building. With many advantages, BIM has developed rapidly in the construction industry in United States and European countries in recent years. BIM technology has been applied in building design, building performance simulation, energy-saving design and the whole life cycle management. The BIM model provides an effective platform to overcome the difficulties of acquiring the necessary building data in life cycle assessment (LCA). And thus, it provides great potential for conducting whole building LCA in the design stage (Wang et al. 2011). The application of BIM theory in building energy consumption assessment and energy analysis can be an effective solution to the deficiencies of traditional methods, and can greatly improve the efficiency of building energy consumption assessment and energy analysis. Some scholars have begun research in this area. Saad Dawood et al. present a framework that will facilitate the integration of Environmental Impact Assessment (EIA), Whole Life Cycle Assessment (WLCCA) and Life Cycle Assessment (LCA) using 3D and BIM technologies (Dawood et al. 2009). Yan Yuan et al. present a methodology which could realize synergy between building design and energy-saving technology with BIM's powerful ability on information processing and quantitative analysis (Yuan and Yuan 2011). Kevin Tantisevi and others proposed to calculate the Overall Thermal Transfer Value (OTTV) of the building by BIM technology in order to assess the building energy consumption (Tantisev and Sornsuriya 2010). Salman Azhar and others proposed a conceptual framework to explain how the construction companies to use BIM for sustainability and LEED rating (Azhar et al. 2009). Besides, the interaction between BIM and building performance simulation (BPS) tools was explores by some researchers (Sanguinetti et al. 2009; Bazjanac 2008; Attia et al. 2009).

Most of the studies, however, lay particular stress on the theoretical framework discussion of BIM applications or comparison of BIM sustainable analysis software and specific case analysis for the assessment of building energy consumption is lack. This paper took a college classroom building in Hefei, China as an example, and did performance simulation and energy assessments by BIM sustainable analysis software, simultaneously proposed the corresponding energy-saving strategy.

107.2 BIM and Its Characteristics

BIM is based on three-dimensional digital technology, integrating data model of the relevant information of construction projects. It is the digital expression of the building entity and features. BIM is a process of producing and managing project data of the whole building life cycle from planning, design, construction, operation, and until demolition (Xu and Lu 2011).

BIM contains information about all aspects of construction projects, and all this information is interrelated. BIM also have good properties such as visualization, simulation and coordination. Using BIM can improve the efficiency of the building design, optimize the process of building design and construction, reduce the cost of construction and operation in the building life cycle. Most important of all is that building energy consumption and environmental impact can be reduced (Azhar et al. 2008).

107.3 BIM-Based Building Energy Evaluation

107.3.1 Feasibility Analysis

A major feature of BIM is the comprehensive level of information. The information which is needed in building energy evaluation and analysis such as design drawings, materials and personnel can be obtained from BIM. This makes BIM technology usage for building energy evaluation a possibility.

There is a special sustainability analysis software in the various types of BIM software which can analyze the energy consumption, resource consumption and environmental impact of building. Using these softwares, energy consumption of building can be simulated by computer conveniently. The intuitive graphical results gained from this process can provide convenience for improving the design scheme. The Ecotect Analysis 2010 (Ecotect for short in the following) is an excellent and practical sustainable analysis software. It can analyze thermal, acoustic, optical, cost control, environmental impacts of building. The energy consumption analysis described in this article is achieved by this software.

107.3.2 Process of the Method

In this article, the design information of the building is assumed complete. Figure 107.1 is the flow chart about how to use Ecotect to do building energy evaluation.

107.4 Case Study

We take a teaching building of a university in Hefei as an example, with BIM sustainable software (Ecotect) we model it and simulate its energy consumption. Then we analysis its thermal performance and energy consumption status, inquire into its existence of energy conservation potential. It is confirmed that use BIM technology to do building energy evaluation is feasible and the convenience.

107.4.1 Project Overview

This 5-floor teaching building is a portal frame construction. The standard building store height is 4.2 m, floor space is 19,959 m^2 and shape coefficient is 0.297. It has 51 classrooms that can hold 120 people, 20 classrooms that can hold 160 people and 20 offices. The classrooms are all multimedia classrooms without air condition and heating equipment.

The building envelope is constructed mainly with reinforced concrete and gangue hollow brick masonry. Powder particles of polystyrene is used in the external walls to keep thermal insulation while extruded polystyrene board used in the roof. The windows are made with double layer glass and aluminum alloy frame. And some windows are handled with fixed exterior shading. The window to wall ratio of east, west, south, north orientations respectively is 0.07, 0.25, 0.05, 0.25.

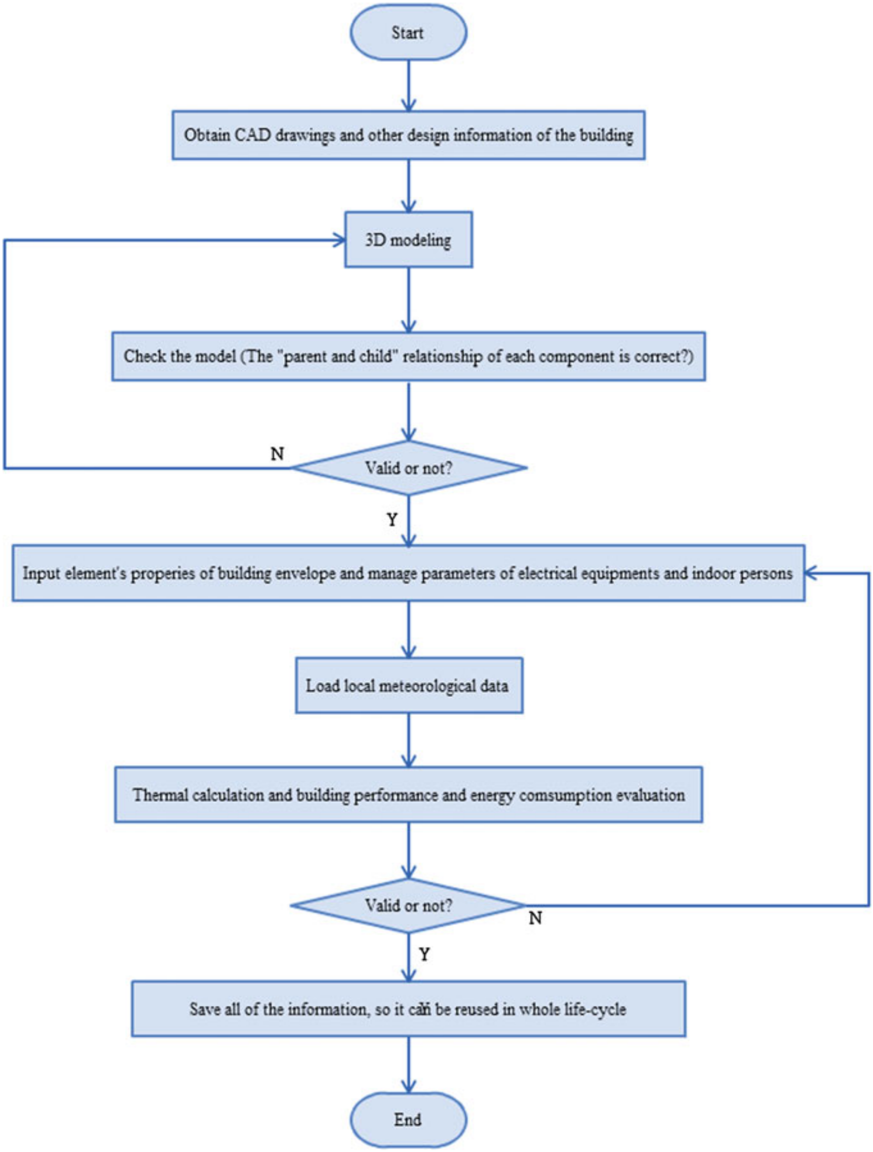

Fig. 107.1 The flow chart of building energy evaluation

107.4.2 Modeling Process

According to the 2D CAD drawings, the building is modeled under the Ecotect operating environment. The visualization of the geometric model is shown in

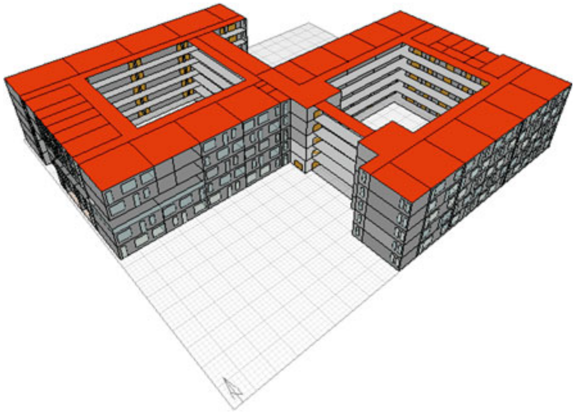

Fig. 107.2 Geometric model of the building

Fig. 107.2. Some treatments were simplified in modeling process, such as omittance of the stairs, thermal bridge and exterior shadings, etc.

Then set the parameters like building material's thickness, density, specific heat capacity, thermal conductivity and the power of electrical equipment, the rate people in the room, indoor temperature, relative humidity, ventilation frequency, meteorological data. The software will quickly calculate the thermal properties of the building envelope, such as U-value, Solar Heat Gain Coefficient, etc. The formation of building envelope material was shown in Table 107.1 and indoor environment parameters were shown in Table 107.2.

Table 107.1 The structure of building envelope and their heat transfer coefficient

Structure	The formation (mm) or type of the structure	Heat transfer coefficient(W/m^2.K)
External wall	Facing layer 5 + fiber glass mesh and special mortar protective layer 5 + powder particles of polystrene thermal insulation 40 + polymer cement mortar 5 + coal gangue hollow block 200 + cement mortar 20	0.75
Roof	Protective layer 5 + waterproofing membrane 5 + cement mortar 20 + extruded polystyrene board 40 + cement expanded perlite 30 + cement mortar 20 + reinforced concrete 120	0.62
Overhead floor	Cement mortar 20 + reinforced concrete 120 + powder particles of polystyrene thermal insulation 30 + cement mortar 20	1.09
Ground	Floor tile 10 + cement mortar 25 + reinforced concrete 80 + gravel concrete 100 + compacted clay 400	2.04
Windows	Off ordinary insulating glass of hot aluminum alloy 6 + 9A + 6	3.4
External doors	Energy-efficient doors	2.47

Table 107.2 The parameters of indoor thermal environmental

The use of room	Indoor temperature (summer)	Indoor temperature (winter)	Per capita zoon (m^2/person)	Lighting power (W/m^2)	Electrical equipment power (W/m^2)	Flesh air (m^3/hp)
Corridor	26	18	5	5	5	5
Classroom	26	20	4	11	20	30

107.4.3 Building Energy Analysis

As an important channel for both inside and outside environmental heat exchange of building, building envelope has a great impact on the overall energy consumption of the building (Wang and Wan 2011). The thermal insulation property of building envelope will directly affect the cooling load of room in summer and heating load in winter. Its heat gain amount reflects the load level of the room to a certain extent (Li and Zhu 2012). With good thermal insulation performance of building envelope, interior and exterior of the building should have obvious difference in temperature, and the effect that indoor temperature gets from outdoor temperature should be small. Therefore, according to the hourly temperature curve, envelope heat gain and other simulation results of building models, we can judge whether the thermal performance of building envelope is good or bad and learn, and then provide some references and ideas to achieve building energy efficiency.

This paper respectively calculated hourly temperature, hourly heat gain, hourly heat loss, annual temperature distribution and proportion of all kinds of heat gain (heat loss) of the model in two conditions: one with HVAC and the other without. Moreover, we did energy consumption evaluation and energy saving potential exploration of the model by analyzing of calculating results.

Hourly Temperature Profile. Figure 107.3 is the hourly temperature curve of the model without air conditioning in the coldest day (January 18) of Hefei. Figure 107.4 is the hourly temperature curve of the model without air conditioning in the hottest (August 23) day of Hefei.

The intensive curves represent the temperature of various regions of the building. It can be seen from the above two graphics that no matter it is summer or winter, day or night, indoor temperature did not change significantly. In winter, the indoor temperature is 2–5 °C higher than the outdoor. In summer, the indoor temperature is slightly lower than the outdoor during the day while 2–5 °C higher than outdoor during the night. In addition, the temperature of corridors affected by outdoor air temperature is much than other indoor areas. This shows that good thermal insulation performance of the building envelope is helpful to realize building energy conservation. However, the indoor and outdoor heat exchanger should be increased in the summer evenings so that the indoor temperature will reduce at night. And then the cooling load during the day will also decrease.

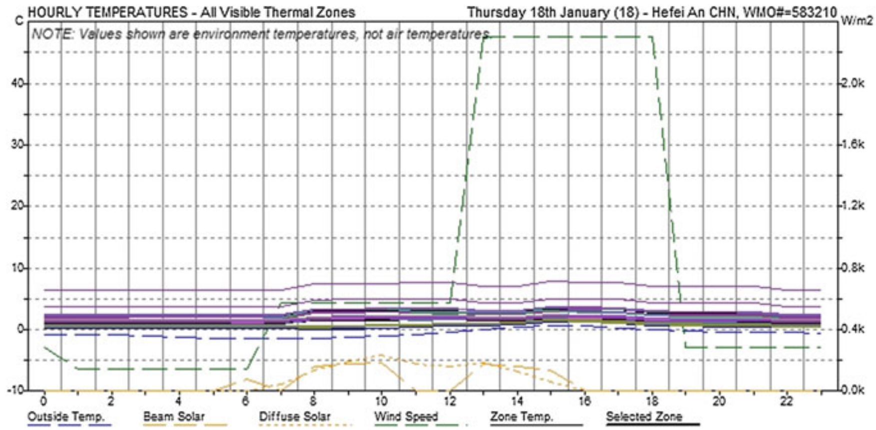

Fig. 107.3 Hourly temperature curve in the coldest day

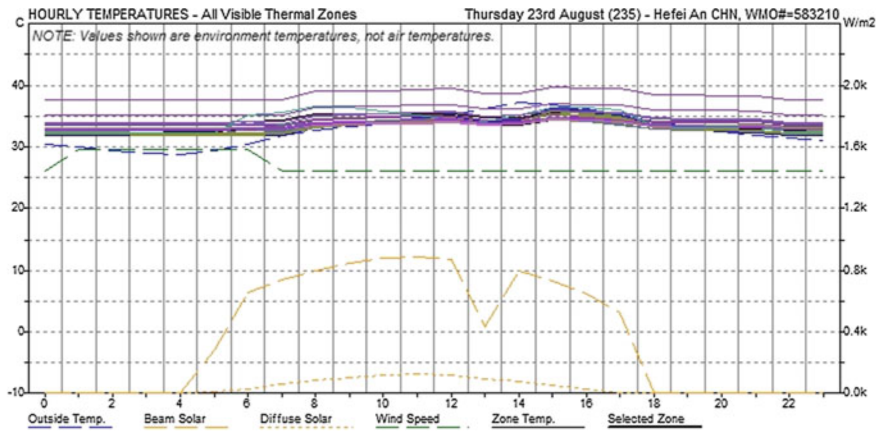

Fig. 107.4 Hourly temperature curve in the hottest day

Hourly Heat Gains/Losses. Figures 107.5 and 107.6 are the hourly heat gains or losses curves of the model with air conditioning in the coldest and hottest day of Hefei City.

It can be seen from the two graphics that whether in winter or summer, the indoor heat gains or losses through the building envelope thermal conduction is relatively small. It is indicated that the thermal performance of building envelope is good, but heat gains and losses through ventilation is very large. It could be considered appropriately to reduce the frequency of ventilation during winter and summer. In addition, as can be seen from the diagram that cooling load in summer is higher than heating load in winter. This is because the building is a teaching building which often has a great deal of using personnel. The large internal gains in winter cause the reduction of heating load.

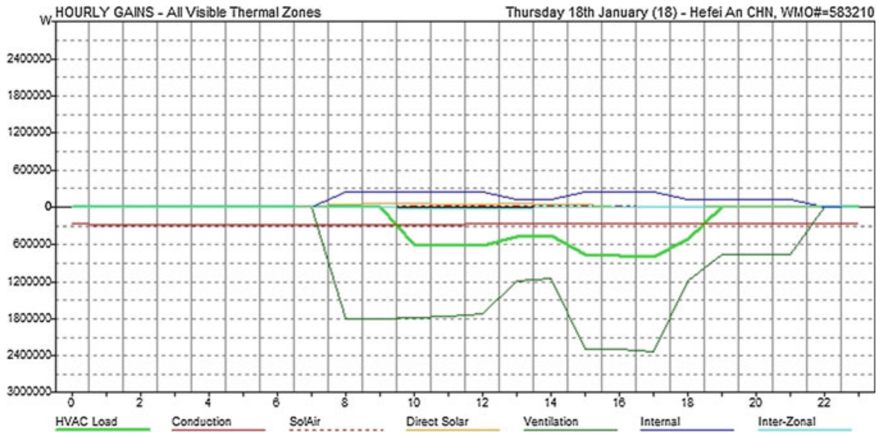

Fig. 107.5 Hourly heat gains or losses curves in the coldest day

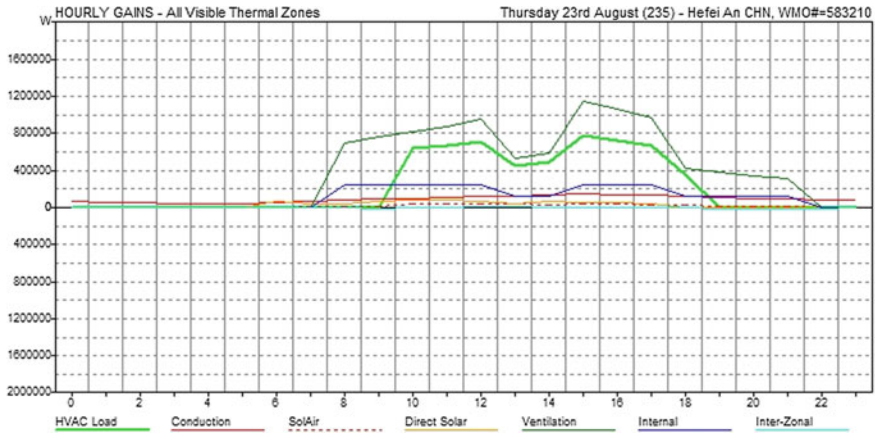

Fig. 107.6 Hourly heat gains or losses curves in the hottest day

Passive Gains Breakdown and Monthly Loads. Figure 107.7 is the passive heat gains breakdown throughout the year of the building model without air conditioning. The positive direction of Y-axis represents heat gains while the negative direction represents heat losses. Figure 107.8 is the monthly cooling and heating load of the building model with air conditioning.

As shown in Fig. 107.7, it is almost all heat gains during May to September while the heat losses are much larger than heat gains during November to March. When in April and October, the heat gains are almost the same with heat losses. Figure 107.8 shows that there are large cooling load during May to September and large heating load during November to March while there are very small loads in

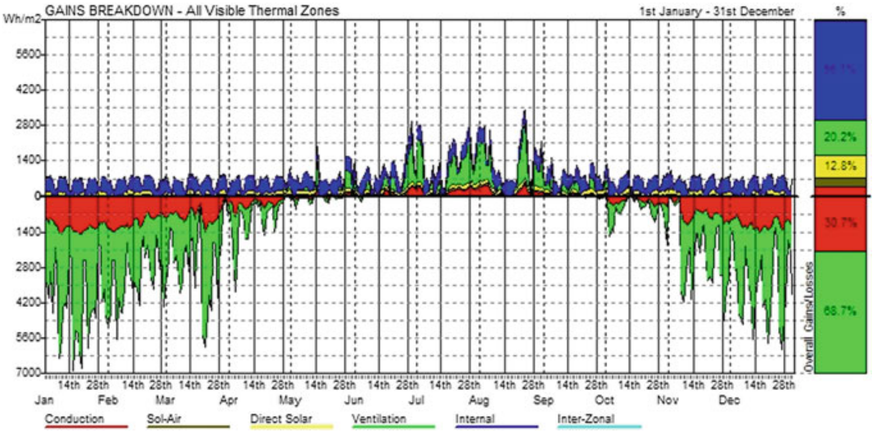

Fig. 107.7 Passive heat gains breakdown without air conditioning

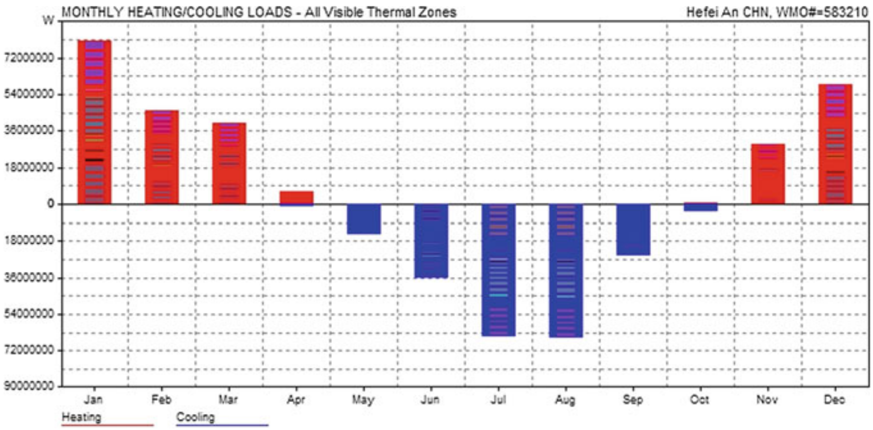

Fig. 107.8 Monthly cooling and heating load with air conditioning

April and October. This is also in accordance with the climate characteristics of hot summer and cold winter regions which are long in summer and winter while short in spring and autumn.

107.4.4 Results

Through above analysis, the building's thermal performance and energy status are obtained qualitatively, a number of energy-saving measures can be put forward.

(1) The thermal performance of this building's external wall is good, but the roof's insulation measures are not good enough. Generally speaking, thermal performance of building envelope is good because the heat gain and loss which transfers through building envelope is not significant. It is appropriately to make the roof light-colored or increase thickness of the roof insulation.
(2) The ventilation heat gain and loss of the building is too much, resulting in a substantial increase of the cooling and heating load. On the one hand, the set of the model has a high air exchange rates, on the other hand, the building itself has two chambers and high bare corridor area. We should consider reducing the air exchange frequency in summer and winter, strengthening seal or setting shelter for avoid wind at the entrance appropriately. In addition, outdoor temperature is lower than indoor in the summer night, so we can open more windows at night to reduce daytime cooling load appropriately.
(3) External shading has been used on the south and north windows of the building, which is beneficial to reduce direct solar heat gain and envelope heat gain, but meanwhile it also increase lighting energy consumption. Therefore we can consider removing the external shading on the north of the building, in order to strengthen the natural lighting of the room.

107.5 Conclusion and Outlook

Taking the defects of the traditional building energy analysis methods and the advantages of BIM in building design into account, a method to evaluate building energy based on BIM thinking is presented in this paper. Take a teaching building in Hefei as a case, we evaluate it's performance and energy consumption with Ecotect and then put forward some energy-saving measures. Relevant information appear in the analysis process can be saved for the whole life cycle. The actual case proved that it is feasible and sustainable to evaluate building energy consumption based on BIM. This method, good as it is, still has some shortcomings, such as it's difficult to modeling complex building with Ecotect and the simulation results is only qualitative rather than quantitative. How to solve these problems will be the key point of our future work.

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Chapter 108
High Green Value with Low Resource Cost: Case Study of Pearl Region Delta Greenway in China

Huibin Zhu

Abstract High cost is core puzzle that affects effect of low-carbon city and green architecture construction. Greenway is an important linear landscape sector in connection with open space, marsh, drainage system and abandoned railways as green infrastructure to form a regional green space system. The paper notices greenway's important role with low resource cost and high green value in creating sustainable green value in Pearl River Delta (PRD) and tries to figure out the successful cooperation pattern of PRD greenway in China.

Keywords Cost · Ecology city · Green architecture · Greenway

108.1 Introduction

Pearl River Delta region have special characters as unique planning method that merge architecture with landscape to be accustomed to specific climate; period floating population that part of people stay in rural and others go out to make profits, when they are old they come back to enlarge their house; history and culture relics without appropriate protection produce more potential for regional development growth.

Different kinds of infrastructure have great influence in different periods of PRD development. Road and highway inspired the first economy development in 1980s. Track transport inspired the second economy development in 2000s. However, they all brought great difficulty as high cost and difficult coordination with different

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levels of government. Greenway as new kind of infrastructure creates new development possibility for PRD with relatively low resource cost and high green value.

108.2 Emergent Demand for Pearl River Delta Greenway

PRD was formed by long-period sea erosion and slowly became a nature port for commercial trade. Due to unique advantages, PRD became the commercial and logistics hub in southern China with political pole in Guangzhou. Same as other countries in the world, governments mostly have strong power in ancient times. The urbanization and industrialization surrounds Guangzhou to create new urban areas to form Foshan and Dongguan.

In 1980s, China held a "Reform and opening-up" policy to set up four coastal cities to make new economy growth pole and produce high-level extroversion modernization. Shenzhen as one of the four coastal cities in PRD make burgeoning development in last decades. Shenzhen appeals enormous international investment and makes lots of reform in finance and other regulation because of its individual location near Hong Kong. PRD have two urban cores as Guangzhou and Shenzhen in these years.

Hong Kong plays a vital role in urbanization of PRD especially for the east coast of PRD. Hong Kong as one of four major economic engines in Asia had demand of transferring its low-end industry and made more space for high-end industry to develop. Export processing is the typical industry requires land and cheap manpower without high threshold. PRD had fluent and low-cost land as well as low-cost manpower to load the industry. At the same time, PRD had strong will for more economy production in the new era to improve the living condition of citizens. Hong Kong and PRD make close relationship in coordination. XU Xueqiang (1991) called the situation with Hong Kong as the shop and store in the front while PRD as the factory in the rear.

Import of industry improves the economy production as well as the living condition of PRD. The low-end industry occupies much land and produces lots of production. PRD becomes the world factory and changes its role where was once habitable and sustainable for people to live. PRD environment was seriously affected by the urbanization and modernization, the government notices the live and habitable demand of people and decides to change development mode by improving the development quality and environment of PRD. PRD Greenway is an important measure (Fig. 108.1).

108.3 Coordination in Greenway Between Governments

In most counties, conflicts between different levels of government as upper and local levels occur occasionally because of the ambiguous rights they have. Governments tend to boost the regulation and construction that benefit them. When

Fig. 108.1 Location of Pearl Delta River Region

setting up a policy or regulation like greenway construction, government of different levels conflict to make difficult to go on. In PRD Greenway construction, the three different levels of government are the province-level, city-level and town-level.

Greenway planning is not a legal planning that doesn't have law influences on related government. The low-level could choose not to follow the planning. In former situations, quite a lot of negotiations are used in execution of the planning despite the province government leader highly approved the planning. However, curious situation occurred. Different levels of government approve the planning without any difficulties.

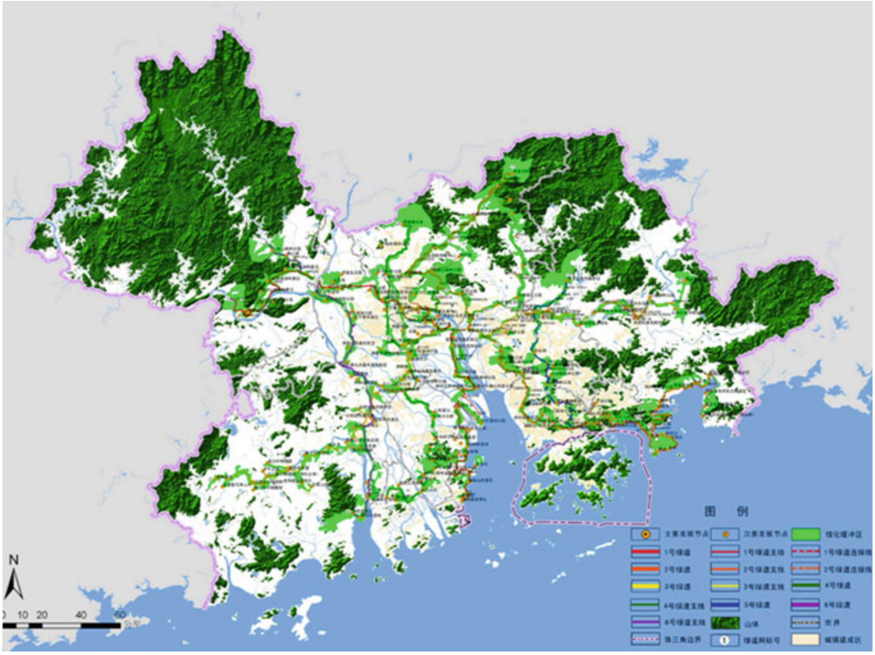

Fig. 108.2 Greenway Master Planning of Pearl Delta River Region

For local governments, improvement of urban areas and revitalization of rural areas are common demands. Though rural areas are not equal to poor areas, people in rural areas mostly live in poverty. At the same time, rural areas don't have resources like fund. They have to choose a special path to develop with low cost and good quality. Greenway is one of the best planning paths to improve the regional living condition land value in surrounding areas. More development opportunities occur in rural areas to find new pattern to be sustainable (Fig. 108.2).

108.4 Greenway Externality and Effect

108.4.1 Space Externality

Greenway supplies new space for sustainable development and reduces the urban sprawl phenomena. Ecology greenway mainly creates a buffer zone surrounded by river, valley, coastal and crest line for protection, creation, connection, management of ecology environment in PRD. Country greenway mainly creates a buffer zone surrounded by open space, water, coastal and field for creation of green natural space. New space pattern as boardwalk occurs that as a new kind of ecology space and induce new kinds of ecology economy like ecology agriculture.

Table 108.1 Average Construction Cost

Type	Average cost/(thousand RMB/km)
Highway (four road)	50000 ~ 100000
2008 ~ 2011 greenway	1000 ~ 1500

108.4.2 Population Externality

City-group organization has great advantages as balance between residence and work. Greenway has influence on creating rural-group in rural areas that inspire the balance of between residence and work. Greenway connect between rural and city to improve rural employment and attract manpower for ecology economy. Point-pollution and area-pollution both exist in rural areas of PRD. Greenway as important way shows great potential to improve basic public infrastructure. Greenway shortens distance between city and rural to induce more activities between city and rural areas.

108.4.3 Economy Externality

For rural areas especially in poor areas, sustainable economy development pattern is the most important. Based on regional characters, rural areas should utilize the greenway to emerge culture and education industry as new tourism economy style. Tourism has several development stages like natural and ecology economy, theme economy, culture economy that merges culture, education and tourism to create high added value. Most individual rural areas have specific symbols. As in Zhaoqing (PRD CITY), bamboo is main symbol of the city. Zhangqing creates an ecology corridor surrounded by bamboo for special economy (Table 108.1).

108.5 Conclusion

Greenway makes great influences as new green infrastructure to promote multiplied effects on low carbon city and ecology city planning. The core issue of sustainable management is the balance between cost and value. PRD Greenway

Fig. 108.3 Picture of Pearl Delta River Greenway

makes good coordination with cost and value to satisfy the demand of region. With high coordination between governments, PRD Greenway as a perfect planning example has space, population and economy positive externality for people (Fig. 108.3).

Chapter 109
Research on Economic Incentive Policy to Promote the Development of Green Buildings in China

Lei Fan, Dao-zhai Zhu and Yuan-feng Wang

Abstract Due to the externality of green building, it's necessary to establish a government leading comprehensive system consisting of law and policy. Chinese green building is still in a primary stage and the law and policy system is imperfect. Based on the analysis of current status and deficiency in economic incentive policies on Chinese green building, this paper puts forward some suggestions on economic incentive policies such as special funds, tax incentives and financial subsidy, etc., to promote the development of green building.

Keywords Green building · Economic incentive policy · Tax

109.1 Introduction

The world is facing the challenge of global energy resources and environmental problems. In the building sector, the development of green building has become an inevitable demand of sustainable development. Its development is conducive to our country to build the resource-saving and environment-friendly society and push forward the healthy urbanization. It is also an important factor to realize the national development mode transformation. The development of green building cannot only rely on the market, government policies and regulations can also play an important role. Carrying out appropriate and reasonable economic incentive

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policy, enacting laws and regulations which match the economic incentive mechanism best, the green building can be developed well and promoted in low-cost and high-efficiency.

109.2 Policies and Regulations' Strategic Position in Promoting the Development of Chinese Green Building

Under the guidance of Chinese sustainable development strategy and scientific outlook on development, the development of green building is facing an unprecedented opportunity. Architectural energy efficiency and green building are set as priority goals in the key areas of urbanization and urban development in the "National Medium and Long-term Science and Technology Development Plan" (2006–2020). It indicates that the Chinese government has paid much attention to the development of green building and has carried out actual action at the national level. Now, Chinese green building development strategy is composed of technological innovation,architectural practice, policies and regulations, as shown in Fig. 109.1 (Wu and Deng 2008).

Scientific and technological innovation strategy, i.e. supporting the green building with adaptive key technologies research and development. The technological innovation strategy of green building consists of two parts. One is the R&D of green building design technology, architectural energy-saving technology and

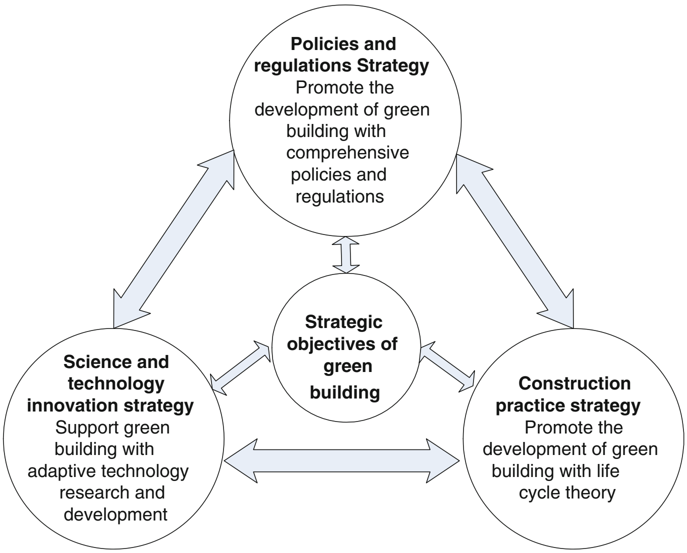

Fig. 109.1 China's green building development strategy

equipment, renewable energy installations, architectural integrated application technology, architectural energy-saving materials and green building materials technology and the R&D of other crucial green building technology. The other is the R&D of the natural ventilation, shading measures, the rational utilization of energy, rainwater collection, etc., reasonable means and the portfolio of new technology products, and low-skilled and high-tech adaptive technology of green building.

Construction practice strategy, i.e. promoting the development of green building based on the theory of life cycle. According to the life cycle theory, six phases shall be studied: (1) the plan phase; (2) the design phase; (3) the construction phase; (4) operation and management; (5) repair and maintenance; (6) reuse after the demolishment. The six phases above include various types of architectural enterprises, such as the planning enterprises, survey and design enterprises, manufacturers of building materials, construction companies, engineering installation companies, property management enterprises. All these enterprises will participate in the construction of green building and shall be responsible for promoting the practice of green building.

Policies and regulations strategy, i.e. utilizing full range of policies and regulations to promote green building, which is the most important strategy to promote the development of green building currently in China. In recent years, the Chinese government has been formulating related laws and regulations to promote the development of green building. The legal system consists of four levels: law, administrative rules and regulations, department regulations and other normative documents. The policy system includes the incentive policy, mandatory policy and achievement assessment policy. Chinese policies and regulations system of green building is gradually forming a complete three-dimensional framework, the first dimension is the lateral system which includes the trunk law and the related law; the second dimension is the vertical system which consists of four levels: law, administrative rules and regulations, department regulations and other normative documents; the third dimension is made up with incentive policy, mandatory policy and achievement assessment policy, as shown in Fig. 109.2 (Wu and Deng 2008). The implementation of these incentives and punishment of policies and regulations is a long-term process, requiring the cooperation between the trunk law and the related law as well as different departments.

109.3 The Status and Deficiencies of Economic Incentive Policies on Green Building in China

Although the green building in China started relatively late, some useful explorations in economic incentive policies have been done. At present, formulated economic incentive policies in China are mainly on the following aspects:

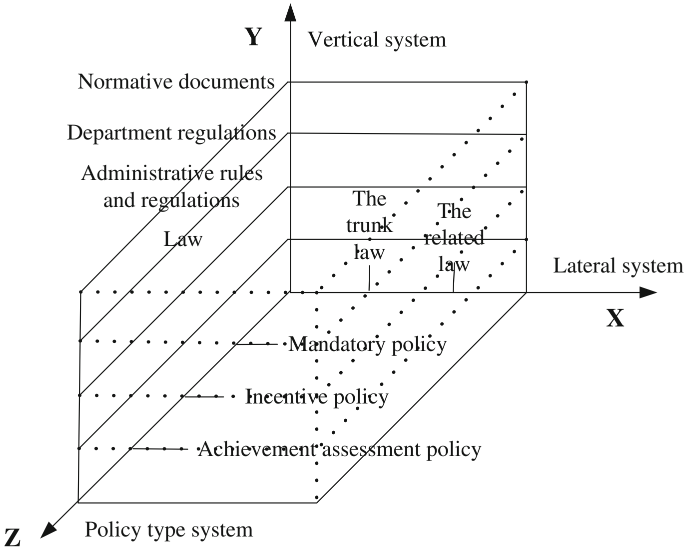

Fig. 109.2 Green building policy and regulation system

109.3.1 The Status of Economic Incentive Policies on Green Building in China

109.3.1.1 Tax Preference

Tax Preference on green building in China mainly includes three aspects currently.

(1) Tax on fixed assets investment (Wu and Liu 2007)

Fixed assets investment orientation regulation tax is a tax levied on investment in fixed assets of various funds of units and individuals in China. "The People's Republic of China fixed asset investment orientation regulation tax Provisional Regulations" issued by the State Council in 1991, provided that tax on fixed assets investment of "northern energy efficiency house" (the house meets the provisions of the energy efficiency design standard) is zero. The incentive effect disappeared with the stop of this tax policy in 2000. But there is still some positive impact on guiding the direction of investment and improving energy efficiency in buildings.

(2) Enterprise income tax preference

The enterprise income tax is a tax levied on profit and other income of the production of domestic-funded enterprises and business units. "Notice on some preferential policies of the enterprise income tax" was issued in 1994. This incentive policy had played a significant role in promoting the development of new wall materials and restrictions on the use of solid clay brick in building energy efficiency. In addition, 10 percent of the enterprises' investment in purchasing the equipment of environmental protection, energy and water conservation, production safety can credits from their current year tax payable; if the 10 percent of the investment is more than the tax payable, the credit can be carried forward in the following five tax year.

(3) Value-added tax preference

Value-Added Tax (VAT) is a tax levied on the value added of sale goods or manufacture, repairs and replacement services and the importation of goods of units and individuals. Ministry of Finance and State Administration of Taxation issued a number of value-added tax preference policies to effectively motivate the production and use of new energy-saving materials. For example in the following notices: "Notice on speed up the wall materials innovation and the promotion of energy efficient building views" in 1992, "Notice on some products of the resources utilization exempt from VAT" in 1995, "Notice on VAT policy issues about some resources comprehensive utilization products and other products", there are relevant provisions of the VAT discount for new wall materials in all of them.

109.3.1.2 Financial subsidy

The ministry of Finance and the Ministry of Construction formulated "Interim administrative measures of the special funds for renewable energy buildings" in 2006, which provided the supporting for special funds in the form of free allowance. Projects like renewable energy buildings apply key common technology integration and demonstration promotion, energy efficiency test and identification, validation and perfection of specifications and so on, will be supported by total subsidy according to the approved project funds.

The financial subsides on green building are mainly used for efficient lighting products. "The administrative measures of the financial subside for efficient lighting product" (2007) (Kang 2008) and related promotion program provided the financial subsidies used for replacing 50 million incandescent lamps with efficient lighting production each year in the next 3 years. In order to speed up the application of the solar energy technology in architectural areas, "The Administrative Measures of The Financial Subside for Solar Architecture" (2009) makes some regulations on the supported projects and using range of subsidy funds.

109.3.1.3 Preferential Loans

The Chinese government has issued some relevant discount and preferential loans policies to encourage enterprises to utilize new energy-saving materials. For example, "Building energy efficiency management regulations in Beijing" issued in 2001 provided that the utilization of industrial waste residues, urban waste residue and crops straw to produce new wall materials, as well as other exploitation and reconstruction projects of applied technology on materials and equipment related with promoting the development of architectural energy saving can enjoy preferential loans policy.

109.3.1.4 Funds and Special Funds

(1) Special funds for new wall materials. This fund is designed to limit the production and application of solid clay bricks and promote the new wall materials for saving the land and improving the residential environment. The main relevant provisions include "the notice of the opinions on speeding up the wall material innovation and promoting energy conservation construction" (1992), "the management measure of special funds collection and use on new wall materials" (2007) and "the directory of new wall materials". Those measures above will promote the development of building materials.
(2) Funds for demonstration project of renewable energy building. The Ministry of Finance and the Ministry of Construction formulated "administrative measures of demonstration project funds for renewable energy building" and "the implementation opinions of promoting renewable energy's applications in the building" in 2006. In order to encourage the application of solar energy, geothermal energy and other renewable energy in the construction field, the Ministry of Finance and the Ministry of Construction formulated "The notice of strengthening the management of demonstration projects of the renewable energy building" in 2007.
(3) Other measures. Local governments have formulated series of special plans and project management measures about special funds for energy saving and energy-saving reconstruction of the existing building.

109.3.2 The Deficiency of Economic Incentive Policy Promoting the Development of Chinese Green Building

Although the Chinese government has issued some economic incentive policies on green building in recent years, the improvement of the economic incentives policy and laws still needs long-term construction. The deficiency of economic incentive policy for green building can be concludes as following:

109.3.2.1 The Shortage of Tax Preference

At present, the tax policy for promoting the architectural energy efficiency is imperfect and there are some problems. Firstly, the tax preference for green building is very fragmented and most of them have not done enough. For example, the regulating tax on the fixed assets investment is most preferential but has been suspended, and its rate is only 5 %. After the suspension of the tax, other taxes have not been issued to fill in the policy gap. Secondly, the tax preference policies for green building are not perfect in China. Environmental Taxation in developed countries has played an important role in promoting the development of green building. But there is still no Environmental Taxation in our country.

i. **The Shortage of Financial Subsidy**

The financial subsidies are rarely used for architectural energy efficiency and renewable energy in building in China, and mainly paid by the government. As a developing country, China has limited finance incomes; however, there are so many business need subsidies, so it is not a good idea to depend on the government financial support for a long time. At present, China is in the primary stage to promote green building and the utilization of effective financial subsidies will promote it enormously.

ii. **Other Deficiencies of Economic Incentive Policy**

The developed countries started earlier in economic incentives of green building. For example, in addition to cash subsidies, fund support, mortgage loan, America has accelerated depreciation system, low-income families plan, “carbon tax system” to encourage the development of green building. However, green building started late in China, there are not enough research on the economic incentive policy.

109.4 Recommendations on Economic Incentive Policies for Promoting Green Building Development in China

Compared with the mandatory policies for promoting green building development, the most significant characteristics of economic incentive policies is low-cost and high-efficiency; besides, the economic incentive policies can encourage the innovations and generalization of green building technologies. In theory, proper designed and implemented economic incentive policies can achieve the goal of promoting the green building in a lower social cost. In this paper some relevant recommendations will be proposed in the following aspects.

109.4.1 Special Funds for Green Building

At present, special funds for green building have not been established in China, which makes the green building developed without stable funding.

In the aspect of the capital source of green building, we should give priority to the finance investment, and treat other funds as an auxiliary source. Special funds for building energy efficiency established by the central and local governments should mainly rely on the financial investment. Green building should be included in the national and local budget and expensed from the fiscal budget, allocated to special funds for green building as a stable source of special funds according to the annual Green Building work plan. In addition, it is considerable to set up energy saving investment funds and attract the social capital to promote the development of green building. For example, part of government bonds can be put into the special funds for green building, and the funds levied on wall materials renovation funds can be partly used for green building.

In the aspect of the application of special funds for green building, the use of the funds should reflect the purpose of the government's macroeconomic control. Besides, special funds should be used primarily to promote the key and difficult areas of green building, to support green buildings important action plan and major model projects, support the economic incentives for green building investment, to increase the efforts to the advocacy, education and training work of green building, to guide the promotion of advanced and applicable technologies, processes and equipment, to increase the intensity of support for the project on energy audit, as well as areas with urgent need of financial support or lack of financing channels. The use of special funds can be direct payments, and the funds can be supported by tax preference, preferential loans and financial subsidies.

109.4.2 Tax Preference for Green Building

Chinese tax policies have its own distinct characteristic, for example, its contents and types are plentiful, and its implementation is flexible, etc. Therefore it is reasonable to design suitable tax incentives for Green building by utilization of those existing tax policies in the promotion of the development of green building.

In accordance with the different types of buildings, i.e. the new green buildings and green reconstruction of existing buildings, different tax incentives should be implemented for different incentive targets. The business tax, urban maintenance and construction tax, land appreciation tax, urban land use tax, corporate income tax and other tax incentives can be used for property developers; business tax and enterprise income tax can be used for construction enterprises and the property tax and deed tax, etc. can be used for buyer. Parts of the tax policies recommendations of green building shown in Table 109.1 (Wu and Liu 2007).

Table 109.1 Some recommendations on preferential tax policies green building

Incentive target	Tax incentives type	The specific content of the policy
Property developers	Business tax	50 % relief on the business tax
	Urban maintenance and construction tax	Enjoy a 1 % tax rate benefit for the urban area; enjoy a zero tax rate benefit for the county and the town.
	Land value increment tax	VAT does not exceed 50 % of the amount of deductions shall be exempted from land value increment tax.
	Urban land use tax	Before sale, buildings shall be exempted from urban land use tax.
	Corporate income tax	Fixed assets adopt accelerated depreciation, and exempt from capital gains tax, such as the application for this project to a separate income tax accounting, and enjoy 15 % tax preference policy.
Construction enterprises	Business tax	Reduce 50 % of payable tax
	Corporate income tax	Fixed assets adopt accelerated depreciation, and exempt from capital gains tax, such as the application for this project to a separate income tax accounting, and enjoy a 15 % tax preference.
Buyers	Real estate tax	Individuals at market prices lease this type of building residential houses, so the rate of rent zero tax rate property tax may be reduced.
	Deed	Consumers towards this type of construction or its second-hand transactions, adopt zero percent preferential deed tax rate.

109.4.3 Green Building Financial Subsidy Policy

Financial subsidies with the characteristic of simple method and apparent effect, is one of the most direct and effective way to promote building energy efficiency. According to the basic operation of the existing financial subsidy policies, it is suitable to design green building fiscal policies to meet the requirements of different objects in different stages.

It is an admissible suggestion to give different levels of financial subsidies to the real estate developers, construction companies, consumers who satisfied the green building standards. The financial subsidies should encourage the development, construction and purchase of green energy-saving buildings. However, the buildings that do not meet a certain level of energy saving can receive no subsidy. For example, 1) give the real estate development companies who build green building a 50 % subsidy of its calculated incremental cost, and special investment subsidies of building energy efficiency based on actual energy savings of green building; 2) give the green building purchasers 300 Yuan per square meter monetary subsidy.

109.4.4 Other Economic Incentive Policies on Green Building

Other green building incentives mainly include: increasing the number of green building purchased by the government, enlarging the green building demonstration and enhance the incentive, etc. If the proportion of government procurement of green building is enlarged, it will play an effective role in boosting the development of Chinese new wall materials and green building market. The exhibition of engineering to green building owners, designers, constructors, and energy-saving materials suppliers, etc., will have strong incentive effect in expanding the popularity of green building (Shi 2010).

109.5 Conclusions

The development of green buildings requires substantial support of the legal system and policy system. After summarizing the shortage of China's current economic incentive policies and considering Chinese national conditions, we put forward some recommendations in this paper, such as setting up special funds for green building, providing preferential tax, strengthening the financial subsidy intensity and formulating preferential policy on loan, to take full advantage of economic and effective incentive policies to promote the healthy and rapid development of China green building.

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Chapter 110
A Study on the Measures in Multi-Angles for Developing Green Building in Beijing

Nana Zhang and Jing Liu

Abstract Beijing is the first city to develop green building in China. It has achieved a certain degree of effectiveness by developing green building in these years and has made new construction targets in "12th five-year", in order to expand the percent of green building. Though the rapid development it has, Beijing green building's current situation has a big gap with many developed countries as well as some first-tier cities in China. This article analyses the questions and difficulties in Beijing green building development from diffident angles and makes some measures and ways to promote the development of green building in Beijing.

Keywords Green building · Multi-angles analysis · Development measures

110.1 Introduction

Since England published the first Green Building Evaluation Standard in 1990, green building has flourish development all over the world. Resource conservation and eco-friendly green building concept has been firmly established in people's mind. Green building has become the power source and direction of the construction industry innovation and development. In recent years, Beijing attaches

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great importance to energy efficiency and green building, and has achieved excellent achievement. In the "11th five-year", Beijing finished 14 projects of green building and energy efficiency building which in total 1.62 million square meters. Among them, 11 projects have got national green building evaluation marks. Though Beijing has such improvement in green building, there are gap with many cities whose green building develops quickly such as Shanghai, Shenzhen, and so on. Development of green building still has many problems to be solved and many challenges to face. Green building' development not only needs government's strong promotion, but also needs the attention and support from all the participants in the social.

110.2 Development Status Quo and Problems of Beijing Green Building

110.2.1 Development Status Quo of Beijing Green Building

Beijing's green building started from energy efficiency building. Since 1988, Beijing has published the energy efficiency standards of 30 %, 50 % and 65 % of "residential building energy efficiency design standards", in 2005, issued "public building energy efficiency design standards". Through three stages of improving energy efficiency standards, Beijing building energy efficiency has apparent developed change. Since 1988 years, there are accumulated 277 million square meters of residential energy conservation.

On the basis of development of building energy efficiency, Beijing's "Green Building" project further extended to the whole process like resource conservation, improved indoor air quality, improve the living comfort and safety of the construction. During the "11th five-year", Beijing finished 14 projects of green building and energy efficiency building which in total 1.62 million square meters.

110.2.2 Development Problems of Beijing Green Building

110.2.2.1 Government Guidance

Beijing has made some effect to develop green building. Beijing has released relevant policies and regulations and is the first city to make green building evaluation standard, but Beijing has not form a complete system of incentive policies and guidance mechanisms, relevant policies and regulations is not perfect, making green building cannot be comprehensive and effective development.

110.2.2.2 Market Supply

Up to now, there are few projects which reach the green building standard; the percent of new green building projects is also very low. The supply of green building is serious shortage. There are a lot of reasons of it, such as the shortage of advanced equipment and materials, the higher price of the materials, the immaturity of technology of green building. As this, many real estate developers would not like develop green building or the green building project is far from the standard.

110.2.2.3 Market Demand

Now Beijing is lack of demand of green building, there are two mainly reasons which lead to it:

On the one hand, the most consumers mainly consider the location, the traffic condition, environment beside the building and the infrastructure of the property when face the high house price. On the other hand, many consumers have no explicit idea of green building. Meanwhile, developers mislead the concept to the consumers when sell the houses, let them regard the green in the district as the symbols of green building which make the consumers have big losses after buying the buildings. From the analysis, we can see there are many questions no matter from the government aspect or from the market. These questions are the obstacles to develop green building, so it needs to take measures from different angles to accelerate the development of green building, let it get into more people's life.

110.3 The Thinking Framework for Beijing's Green Building Development in Multi-Angles

110.3.1 The Total Thinking of Analysis in Multi-Angle

This article analyzes from three angles: first, green building's development needs all the participants' active support. The main participants include government, construction units and consumers. Second, full life cycle is an important feature of green building, so we should pay attention to all the phases of it which contain pre-decision phase, construction phase and use phase. Last, stage of development of green building is a gradual process from the initial stage, development stage, and finally reached a mature stage, the content and focus of each phase's work is also different.

Through analyze two angles that full life cycle and different development stages, make clear the participants' responsibility and the focus work and then propose measures to solve the problems to accelerate the development of green building.

110.3.2 The Basic Framework of Multi-Angles Analysis

Let different participants as main line, to analyze the full life cycle, different stages of development. The basic framework is as follows: (Fig. 110.1)

110.3.2.1 Analysis of Different Participants

The main participants in the development of green building are the government, the construction unit and consumers. Government plays a major role to guide and regulate the development of green building by establish a perfect legal norm as well as a series of incentive policies. The construction units are the main perpetrators of the green building construction. The construction unit here mainly refers to real estate developers, with associated units including the provider of green materials, green building design contractors, contractors and supervision units. Consumers are the main users of green building, how to increase consumers' need for green building is the fundament of green building development.

110.3.2.2 Analysis of Full Life Cycle

The main difference between green building and normal building is that green building can achieve efficient utilization of resources and minimum environmental

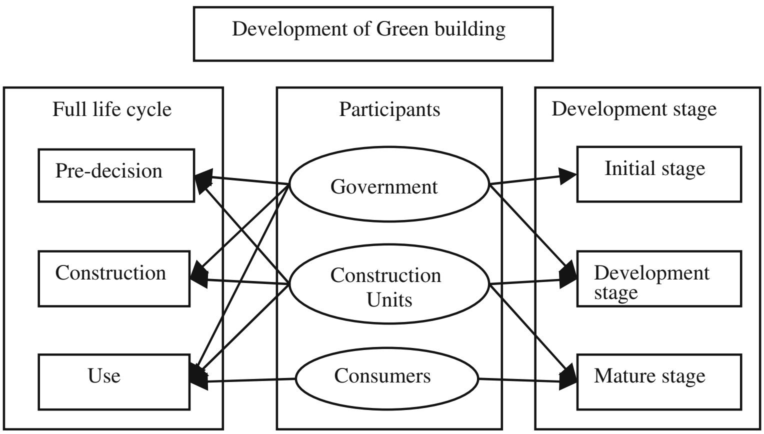

Fig. 110.1 Framework of multi-angles analysis

impact buildings in its full life cycle. The investment in construction stage is higher than normal building but the operation and maintenance cost in the use phase is low. Therefore, according to the questions in the different phases in full life cycle, analyzes the participants' responsibility and make relevant measures. During the pre-decision phase, the development of green building is mainly rely on the government's legal force and policy incentives to promote green building development, and the developers' positive response to the construction of green buildings. In the construction phase, the government plays a supervisory role, the quality of the projects need all the construction units' active control and positive response. During the use phase, it is mainly the cooperation between the construction side and the consumer. Strengthening consumer preferences for green building through the actual advantages of green building, so as to promote the acceptance of green building.

110.3.2.3 Analysis of Different Development Phases

The development of green building is relatively short in China than other countries, so it is still in the initial stage (Liu 2012).

The modes and measures are different according to the different development stages. In the initial stage, as the developers and consumers' consciousness of green building is not strong, and is lack of awareness of it, therefore, the government needs to play a major role. During the development stage, government and real estate developers both need play an important role by establishing incentives policies and increasing the supply of green building. When the green building develops to the mature stage, with the perfection of the laws and regulations, the establishment of incentive policies, the government can withdraw from the main role, the development can led by the market, rely on real estate agency and consumer pull of supply and demand balance, and promote the further development of green buildings.

110.4 The Analysis in Multi-Angles to Promote the Development of Green Building in Beijing

110.4.1 Studies on the Measures Focus on Full Life Cycle

110.4.1.1 Pre-decision Phase

In order to strengthen the developers to develop green building, the government should play a leading role. First, the Government should establish Beijing building energy efficiency regulations based on analysis of building energy consumption statistics, mandatory limit on the highest energy consumption of buildings. Secondly, the Government should provide the appropriate incentive policies, such as reducing land premium, to reduce the purchase cost of land, giving the appropriate financial and tax incentives and credit incentives, lower construction costs, and encourage more real estate agency on the development of green building (Zhengyou 2009). Real estate developers should keep up with the national policy in countries actively promote green building period, and vigorously develop green buildings. On the other side, the design of the green building has a key role in the pre-decision phase. The design must be based on the original intention of the green building for energy saving and environmental protection goals, not simply using the overlay of green technology which in fact a waste of resources and a departure from green building's original purpose.

110.4.1.2 Construction Phase

In this stage, the owner should always supervise the construction of the building; inspect the construction materials are reasonable use and whether to meet the design requirements, to ensure the quality of green building. The construction unit should enhance their own professional competence and technology to ensure that new technologies can play the desired effect.

Materials and equipments suppliers should actively research new materials; new technologies to understand the foreign green materials research and develop suited materials to China's building to ensure that green building can be built according to the standard (Li 2009).The contractor is the main perpetrators to transfer green design into the physical. The contractor should raise the professional standards of the construction team, and establish and improve the supervision mechanism to ensure that green building design can be completed as required.

110.4.1.3 Use Phase

The use phase of green building is the time to reflect the function of energy saving and environmental protection. The developers should regular inspect the use situation of green building, such as solar energy systems, energy efficient wall weather make energy savings to consumers. As green building technology in China is relatively weak, a lot of building materials are not advanced enough, the government should strengthen the supervision and investigation of the use of green building has been built.

Consumers are the main users of green building and have an important relationship in the use stage; the development of green buildings cannot do without the support of consumers. Therefore, consumers had better enhance their own green awareness, to learn more about the green building features as well as the practical interests and benefits. In the living process, the consumer should reflect the actual usage of the green building. Report the questions and problems in time in order to avoid the same problem.

110.4.2 Studies on the Measures Focus on Different Development Stage

110.4.2.1 Initial Stage

At the initial stage, many of the policy systems are not perfect, the guide mechanism is not established, and people's concept of green building is still awareness. Therefore, the mode that "Government incentives and norms-based, market independent regulation subsidiary" should be used at this stage. The government improves the laws and regulations, establish incentive policies and guidance mechanisms, and strength promotion so that more real estate agency focused on green building and more consumers to choose green building.

110.4.2.2 Development Stage

With the further development of green building; the improvement of Government' laws and regulations; the establishment of the policy of the relevant incentives, the attention on the market for green building greatly increased, green building concept is slowly gained recognition and deeply rooted. At this stage, "market regulation and government guidance synchronization" mode can be adopted. The Government continued to strengthen the management and promotion of green building. The market can though real estate agency increase supply and consumers expand demand to further promote the development of green building.

110.4.2.3 Mature Stage

With Beijing's development of green building policies and regulations, technical standards and market service system are constantly improved, developers and consumers will become increasingly strong preference for green building, market's incentives function for green building will continue to enhance, punishment role of high-energy buildings will also continue to strengthen. Therefore, in the mature stage of the green building, the "market adjustment-based, Government control and regulation subsidiary" mode can be implement. Let the developers and consumers increase the supply and demand of green buildings independently, green building technology through market competition gradually strengthen and the Government just play an assist management role.

110.5 Conclusion

Through the above analysis to study the different participants' measures to be taken in the development of green building and which role should play at different stages in the life cycle, different periods of the development of green building, to makes clear the responsibility of government, developers, consumer in the development of green building allocation and to provide appropriate measures and proposals. Only participants actively involved, can green building in Beijing have better development.

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Chapter 111
A Study on the Connotation and Evaluation System of Green Railway Station

Gaiping Zhang and Chaohe Rong

Abstract First, this paper introduces the process of the green concept in recent years, summarizes the green concept, focuses on the meaning of the "Green Railway Station", and shows that it has public good attributes. Based on this, the paper establishes the Evaluation Index System of the Green Railway Station. Furthermore, this paper designs the supply mechanism to promote the development of the green railway passenger station.

Keywords Green railway passenger station · Basic meaning · Public good attributes

111.1 Introduction

After the reform and opening up, there are many problems during the development of China's economic, such as maintaining the coordination of development and the natural environment. In view of this, some concepts such as "green", "low carbon" emerge. The "Green Railway" came to being as a result of the financial crisis and the medium and long-term railway network planning. It emphasized that in the whole production process, it is necessary to conserve resources, protect the environment, and make the implementation of sustainable development. Some scholars have analyzed the value of the ecological environment and green

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technology and the connotation and evaluation system of the "Green Railway" (Feng et al. 2009).

As an important component of the railway transport system, railway station can stimulate the commercial development of the city, raise the city's image and taste, and bring new opportunities for the development of the city, therefore, it has a typical public good attribute (Fu and Xu 2009). As a result, how to effectively carry out the construction of green railway station will give the green rail transport a great impact. Now the railway station must meet the requirements such as "functional, systematic, advanced, culture, economy" (Meng 2008).

Some studies show that some elements should be noted when designing the railway station, while there has been lack of systematic analysis which is compatible with the "green railway", as well as a reasonable meaning and evaluation of the "Green Railway Station". This paper will focus on the connotation of "Green Railway Station", and sum up a scientific and rational evaluation to establish a complete evaluation system and the corresponding supply mechanism.

111.2 The Basic Meaning of the Green Railway Station

The more specific meaning of "Green railways" includes: (1) internalize the negative externalization of the railway industry; (2) railway construction, operation and management meet for China's green GDP accounting requirements (Fu and Xu 2009); (3) reduce the negative impact of the ecological environment; (4) save energy and resources; (5) railway is in harmony with nature; (6) own a perfect security system; (7) have a higher speed and greater capacity (Liu et al. 2007).

From the point of view of the meaning of "railway", "Green Railway Station" also should ensure that the construction, operation and management of" green" so as to meet the basic requirements of the green economic development. With the requirements of the development of green cities, "Green Railway Station", will need to be able to support the green buildings. Compared with the green building," Green Railway Station "has all the characteristics of the green building as well as the railway station features: not only has the function as the basic building, but also fulfill important environmental features and cultural functions.

In summary, the basic connotation of the Green Railway Station, stated as follows: First, the green railway station must include a waiting room, the entrance the station, wicket, a station and so on; Second, Green Railway Station can make full use of green technology techniques to maximize the protection of the environment, reduce pollution; Third, Green Railway Station focuses on energy efficiency, energy conservation and low-input, high output; Forth, Green Railway Station must be market oriented, and implement the concept of "people-oriented", give full consideration to the needs of consumers; Fifth, Green Railway Station as a city building needs to reflect the cultural and ecological characteristics of the city. Therefore, Green Railway Station has a positive externality, so it has a certain public good attributes.

111.3 The Design of Evaluation Index of Green Railway Station

Green Railway Station evaluation index should involve environment, energy, economic, cultural and other factors. The index should give the structure, function, efficiency, and ecological benefits a reasonable evaluation, also it should make a complete and accurately reflect of the Green Railway Station. At the same time it should ensure that the concept of clear indicators, and evaluation indicators to be measurable, easy to measure and get. Table 111.1 show the evaluation index based on the above analysis of the evaluation:

111.4 The Design of the Supply Mechanism

Green railway station has the public good attributes, so it is important to design an effective supply mechanism to meet the society needs.

Set the Tokyo Station, Japan as an example, the superstructure achieved good development which made Tokyo Station a "Railway Station City". The station has hotels, office buildings, movie theater, exhibitions, shops and other facilities. All of these make it not only convenient for passengers going shopping, but also through multiple operating it will make much profit to cover the station daily expenses. Another good example is Metro Group in Hong Kong, which followed the "prudent commercial principle", with the development of land along, and operate multi-business in subway stations, the Hong Kong subway can be one of the few self-financing in the world, and it can make the recovery of the investment business entities (Sheng et al. 2009).

If only using a single model of government financial subsidies, the Green railway station can not operate normally, for it made the excessive dependence on government finance; While, due to its less profit, few company wants to operate it. Therefore, this paper presents the main view as follows: Government-led resource allocation should be used, as well as the introduction of market competition mechanism. The concrete form can be a special corporate or franchise.

111.5 Conclusions

This paper has analyzed the connotation of "Green Railway Station", and emphasized on the environmental protection and resource conservation, application of green technology and gestation of cultural connotation and its public good attributes. Then the author builds the evaluation index of the green railway station from the following four areas: environmental protection, resource use, convenient and comfortable, humanistic value. Through learning from the successful

Table 111.1 Comprehensive evaluation index system

Evaluate index system of green railway passenger station	First level index	Second level index	
		Topic	Quantitative indicators
	P_1 environmental protection	P_{11} solid pollution	Solid waste emissions of unit turnover
		P_{12} air pollution	Exhaust emissions of unit turnover
		P_{13} wastewater pollution	Wastewater emissions of unit turnover
		P_{14} noise pollution	The utilization of sound insulation and soundproofing
	P_2 the use of resources	P_{21} land resources	Covers of unit turnover
		P_{22} electric resources	Consumption of power resources per unit turnover
		P_{23} water resources	Consumption of water resources of the unit turnover
		P_{24} weather resources	Solar, wind and other utilization of unit turnover
	P_3 convenient and comfortable	P_{31} the waiting crowd	Per capita area of the waiting room
		P_{32} inbound poured	Per capita time required from the waiting room to the boarding
		P_{33} outbound flow	Per capita time required to get off to the outbound
		P_{34} baggage flow	The average time of luggage delivery
	P_4 humanistic value	P_{41} building structure	Building constructed with the degree of manifestation of the local culture
		P_{42} propaganda facilities	Publicize the number of facilities of the local culture
		P_{43} cultural facilities	The number of magazines and other cultural facilities within the unit area

experience both home and abroad, this paper builds its supply mechanism to protect the later Green Railway Station, and make sure that it will continue to be improved, thus the construction of green transportation system will be promoted.

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Chapter 112
Investigation of Application of Evaluation Standard for Green Building

Ling Ye, Zhijun Cheng and Qingqin Wang

Abstract For the purpose of more extensive application and revision in the future of current national standard, *Evaluation Standard for Green Building* (GB/T50378-2006), its application status is investigated by two methods. One is counting compliance ratio of each provision in 57 green building projects. Another is comparing it with 13 local standards. It's concluded that technical difficulties among provisions differ sharply, some provisions are restricted in specific building stage, function and region, and changes on evaluating provision and evaluating method in local standards could be helpful to the improvement and revision on GB/T50378-2006.

Keywords Green building · Evaluation · National standard · Local standard

112.1 Introduction

Green building is encouraged by Chinese government, according to an official document (Ministry of Finance, Ministry of Housing and Urban-Rural Development 2012) jointly issued by the Ministry of Finance (MOF) and the Ministry of Housing and Urban–Rural Development (MOHURD) in April, 2012. In China, green building should be distinguished from ordinary buildings by evaluation. Current national standard, *Evaluation Standard for Green Building* GB/T50378-2006 (Evaluation standard on green building GB/T50378- 2006), has been enacted from June, 2006. In accordance with its method and provisions, about 350 green

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Table 112.1 Evaluating provision quantity in GB/T50378

Section	Prerequisite provision	Optional provision	Optimal provision	All
Land saving and outdoor environment	8/5	8/6	2/3	18/14
Energy saving and energy utilization	3/5	6/10	2/4	11/19
Water saving and water resource utilization	5/5	6/6	1/1	12/12
Material saving and material resource utilization	2/2	7/8	2/2	11/12
Indoor environmental quality	5/6	6/6	1/3	12/15
Operation and management	4/3	7/7	1/1	12/11
Sum	27/26	40/43	9/14	76/83

Note "a/b" represents provision quantity through "a" for dwelling and "b" for public building respectively

building projects had been evaluated by the end of 2011. And on its basis, more than 20 local standards on green building evaluation have been developed. GB/T50378 is the most important standard on green building evaluation in China.

In GB/T50378-2006, evaluating provisions are set separately for two building types, dwelling and public building. As shown in Table 112.1, they are divided into six sections, namely land saving and outdoor environment, energy saving and energy utilization, water saving and water resource utilization, material saving and material resource utilization, indoor environmental quality, and operation and management. Each section includes three provision categories, namely prerequisite provisions, optional provisions and optimal provisions. All prerequisite provisions must be complied by all green building projects, whereas optional ones and optimal ones could be chosen by projects. Green building levels of one-star ★, two-star ★★ or three-star ★★★, are determined by compliance quantity of optional provisions and optimal provisions.

For the purpose of its more extensive application and revision in the future, application of GB/T50378-2006 is investigated and analyzed. One method is counting compliance ratio of each provision in it. Investigation sample here is all 57 green building projects evaluated by Chinese Society for Urban Studies (CSUS) by the end of 2010. Among them, 32 are dwellings, and the other 25 are public buildings. Another method is comparing it with 13 local standards on green building evaluation. Local standards in Beijing, Tianjin, Hebei, Shanxi, Shanghai, Jiangsu, Zhejiang, Hubei, Hunan, Chongqing, Fujian, Guangdong and Guangxi are investigated.

112.2 Provision Compliance Ratio

Considering its own appropriate condition, each provision is not participated by all green building projects. Not to mention its compliance of all projects. Therefore, participation ratio of all optional and optimal provisions should be counted as well

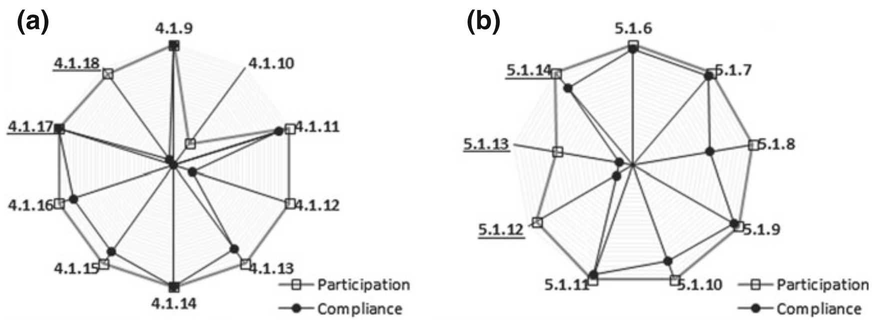

Fig. 112.1 Participation and compliance ratio of provisions in section of land saving and outdoor environment. **a** Dwelling, **b** public building

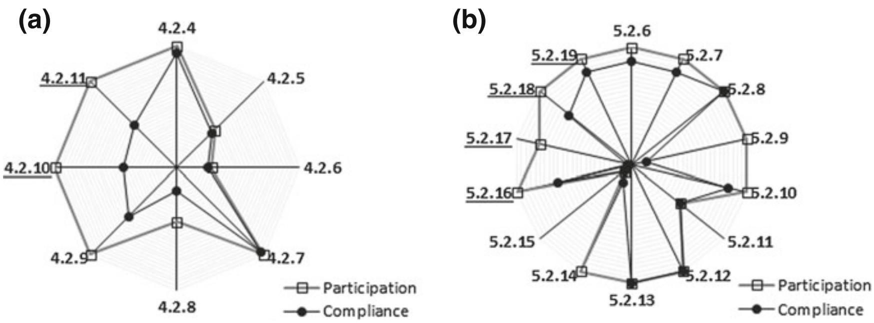

Fig. 112.2 Participation and compliance ratio of provisions in section of energy saving and energy utilization. **a** Dwelling, **b** public building

as the compliance ratio. Prerequisite provisions are not counted any more, since they must be complied with for all green building projects once participating.

The ratios of those provisions in six sections are given in Figs. 112.1, 112.2, 112.3, 112.4, 112.5, 112.6, respectively. In these radar graphs, center represents the ratio of 0, and the longer the radius, the higher the ratio. The numbers of optimal provisions are underlined, as distinguished from optional ones. Detailed analysis on each section is as follows:

(1) Participation ratios of almost all optional and optimal provisions are high, except No. 4.1.10 and No. 5.1.13 with the topic of reuse of existing building. Compliance ratios of No. 4.1.10 and No. 5.1.13 with the topic of reuse of existing building, No. 4.1.12 with the topic of heat island effect and No. 4.1.18 and No. 5.1.12 with the topic of brownfield redevelopment are close to 0. That means, both of brownfield redevelopment and heat island effect simulation are difficult or unpractical for current projects. In addition, No. 4.1.17 with the topic of underground development as an optimal provision for dwellings, participation and compliance ratios are both 100 %.

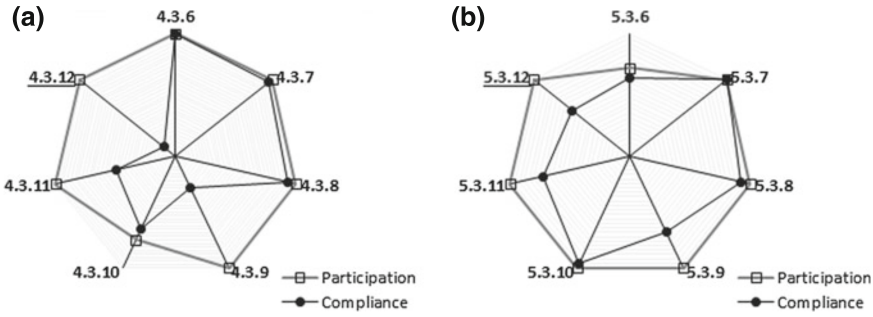

Fig. 112.3 Participation and compliance ratio of provisions in section of water saving and water resource utilization. **a** Dwelling, **b** public building

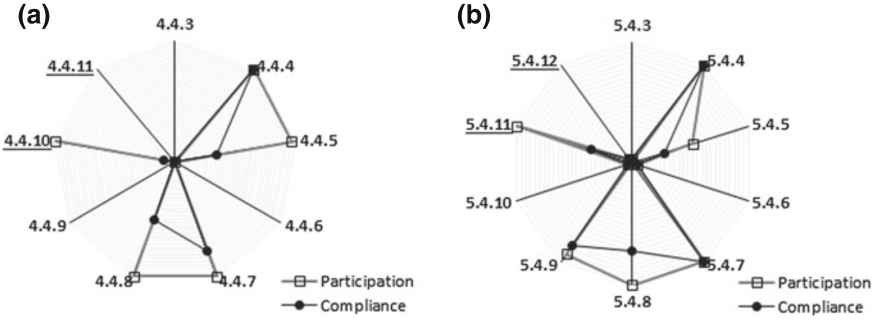

Fig. 112.4 Participation and compliance ratio of provisions in section of material saving and material resource utilization. **a** Dwelling, **b** public building

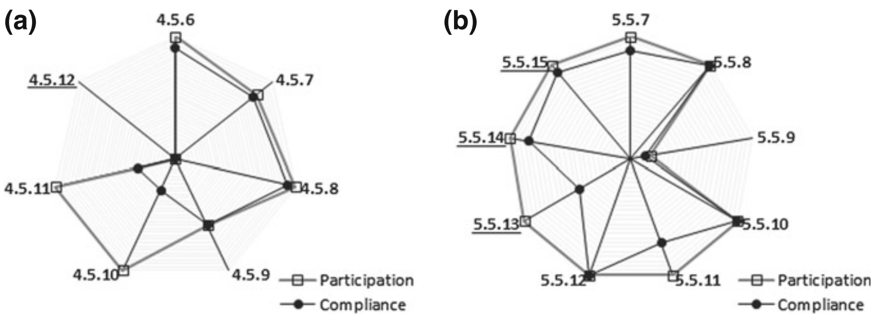

Fig. 112.5 Participation and compliance ratio of provisions in section of indoor environmental quality. **a** Dwelling, **b** public building

(2) Provisions with low participation ratio include No. 4.2.5 with the topic of distribution system efficiency, No. 4.2.6 with the topic of heating and cooling equipment efficiency, No. 4.2.8 with the topic of heat recovery in dwelling

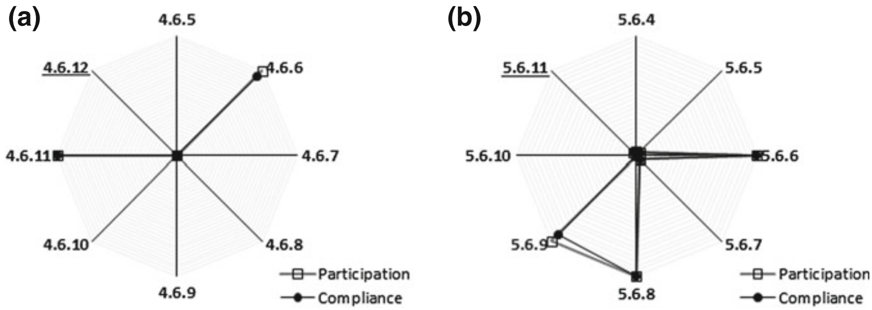

Fig. 112.6 Participation and compliance ratio of provisions in section of operation and management. **a** Dwelling, **b** public building

part, and No.5.2.15 with the topic of energy sub-metering for refurbishment in public building part. In dwelling part, only two provisions, No .4.2.4 with the topic of architectural layout and No. 4.2.7 with the topic of efficient lighting, are usually complied with. Besides No. 5.2.15 with the topic of energy sub-metering for refurbishment, compliance ratios of No. 5.2.9 with the topic of thermal storage, No. 5.2.14 with the topic of heat recovery and No. 5.2.17 with the topic of distributed CCHP are extremely low.

(3) Generally, provisions with low participation ratio are No. 4.3.10 and No. 5.3.6 with the topic of rainwater utilization, whereas provisions with low compliance ratio are No. 4.3.12 and No. 5.3.12 with the topic of non-traditional water source ratio (optimal provisions). Although No. 4.3.10 and No. 5.3.6 with the topic of rainwater utilization is participated not so frequently, their relative compliance ratios are high. The reason is that rainwater utilization is not a difficult technology, but is only suitable for wetter regions. Compare to public buildings, lower compliance ratio of No. 4.3.12 with the topic of non-traditional water source ratio in dwelling projects (optimal provision), indicates its technical difficulty of index value of 30 %. It's found that compliance dwelling projects all have centralized reclaimed water system.

(4) Due to most projects investigated did not finish their construction during evaluating, provisions only suitable for building operation stage, including No. 4.4.3 and No. 5.4.3 with the topic of local materials, No. 4.4.6 and No. 5.4.6 with the topic of construction and demolition waste sorting, No. 4.4.9 and No. 5.4.10 with the topic of recycled material and No. 4.4.11 and No. 5.4.12 with the topic of reusable material, are seldom participated. What's more, compliance ratios of No. 4.4.5 and No. 5.4.5 with the topic of high performance structure material and No. 4.4.10 and No. 5.4.11 with the topic of structure system optimization are pretty low as well. There actually is no obvious difference on technical difficulty between optional provisions (No. 4.4.5 and No. 5.4.5 with the topic of high performance structure material) and optimal provisions (No. 4.4.10 and No. 5.4.11 with the topic of structure system optimization).

(5) For dwellings and public buildings, there is one provision with low participation ratio respectively, namely No. 4.5.12 with the topic of functional material and No. 5.5.9 with the topic of sound insulation performance. The excuse for No. 4.5.12 with the topic of functional material is its appropriate stage of building operation. And the reason for No. 5.5.9 with the topic of sound insulation performance is its appropriate building type is hotel only. As far as dwellings were concerned, compliance ratios of No. 4.5.10 with the topic of adjustable sun shading and No. 4.5.11 with the topic of IAQ monitoring are low. On the other side, their compliance ratios for public buildings (No. 5.5.13 and No. 5.5.14) are much higher, even as optimal provisions. Their compliance ratios contrast with each other.
(6) For the same reason mentioned above, provisions in the section of operation and management are participated not so many. However, five provisions participated are complied with by most of projects, including No. 4.6.6 and No. 5.6.8 with the topic of Building automation, No. 4.6.11 and No. 5.6.6 with the topic of replaceable equipment and fittings and No. 5.6.9 with the topic of equipment monitoring and control.

112.3 Local Standard Comparison

Thirteen local standards are compared to GB/T50378-2006, from two aspects of evaluating method and evaluating provision. Comparison results are summarized as follows:

(1) Evaluation method in local standards completely or basically follows that in the GB/T50378-2006. Compared to GB/T50378-2006, little changes in local standards include: adding innovation provision in the standards of Beijing and Hunan, scoring green building in the standards of Zhejiang and Hunan, adjusting green building levels in the standards of Guangdong and Chongqing, and adjusting evaluation index system in the standards of Fujian.
(2) Most of provisions in local standards are quoted directly from GB/T50378-2006, while some provisions in local standards are different with those in GB/T50378-2006. Considering that local conditions of climate, resources, economy, society, policies and customs differ sharply among provinces, some provisions have been changed, by means of supplementing, simplifying, modifying, establishing, removing, splitting, incorporating, adjusting section or attribute, etc. For instance, provisions with the topic of nature ventilation, efficient air-conditioner, efficient elevator, efficient white goods and power supply and distribution system, are supplemented in section of energy saving and energy utilization in local standards.

112.4 Discussion and Conclusions

Based on investigation results above on application of GB/T50378-2006, some discussion and conclusions are derived as follows:

(1) Technical difficulties among evaluating provisions in GB/T50378-2006 differ sharply. Some are seldom complied with, and some can be made without cost. Every provision should have clear topic, specific requirement, reasonable value, and careful wording. Technical review and experimental evaluation could be helpful.
(2) Some provisions are restricted in specific building stage, function, region, etc. Provisions in section of material saving and material resource utilization should be considered more for building design, those in section of energy saving and energy utilization should be suitable for those dwellings without centralized heating/cooling system as well.
(3) Local standards are great complement to GB/T50378, especially on evaluating provisions. However, their evaluating methods should keep unanimous with GB/T50378. After all, further improvement or revision on GB/T50378-2006 should take these changes in local standards into consideration, in both aspects of evaluating provisions and evaluating method.

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Chapter 113
Study and Application on China Railway Construction Project Scheduling Model Based on Resource Leveling

Yuanjie Tang, Rengkui Liu and Quanxin Sun

Abstract As China's railway is undergoing a period of massive construction, scheduling more reasonablely and levelingly means lot to railway construction project management. At this stage, China's railway construction projects mainly adopt the traditional network planning methods or Gantt chart methods in its management, which has its limits for the typical linear project of railway construction. This paper uses the linear scheduling method to solve the resource-leveling-based railway construction project scheduling problem of China, proposes the China railway construction project scheduling model and employs the constraint programming technique for the searching of the solution. On basis of this, the actual data of Urumqi-Junggar railway in Urumqi Railway Bureau is used to verify the model and algorithm.

Keywords China railway · Linear project · Linear scheduling method · Resource leveling · Constraint programming

113.1 Introduction

Currently, China is carrying on the world's largest railway construction; according to the twelfth five-year plan, by the end of 2015, China's total mileage of railways opened to traffic will have risen from 91,000 to 120,000 km. Scheduling is one of

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the most fundamental functions of construction project management (Georgy 2008, The Ministry of Railways of the People's Republic of China 2010).

The railway construction is a typical linear project, which is characterized by composition of a series of repetitive activities, such as railways, highways, pipelines, tunnels and so on. Scheduling often relies on the CPM and other network planning methods in the construction field. However, the traditional network planning methods are not suitable for the linear project, and LSM by virtue of maintaining the continuity of resources, visual and other advantages is applied in the linear project scheduling as a new method (Harris and Ioannou 1998; Reda 1990; Yamín and Harmelink 2001; Johnston 1981; Harmelink and Rowings 1998).

In order to guarantee the completion of the construction on a predetermined duration and budget, resources need to be well managed, and the major challenge is to achieve leveling management of resources for construction projects with a fixed duration (Georgy 2008; Halpin and Woodhead 1998).

This paper mainly studies the use of LSM for China railway construction project scheduling and resource leveling optimization problems under the constraint of a fixed duration, established China's railway construction project scheduling model, and the model was constructed by constraint programming technique. Finally, this paper used the actual data of Urumqi-Junggar railway in Urumqi Railway Bureau to verify the model and algorithm.

113.2 Literature Review

113.2.1 Linear Scheduling Method and Resource Leveling

There have been many researches on linear scheduling method (LSM), however, until present, the studies on how to use LSM to schedule automatically are not much. Kallantzis and Lambropoulos (2004) discussed the scheduling problem, but did not take into account the fixed duration constraint; furthermore, the resources usage of the activities and the buffer between activities are fixed, and the schedule was developed on the basis of merely satisfying the buffer constraints. The model proposed by Georgy (2008) has the function of scheduling, and considered the satisfaction of the fixed duration constraint and resource variability, but the schedules meeting the constraints had to be obtained in a random way, and the efficiency is relatively low.

In addition, some scholars have conducted researches on resource leveling problems based on LSM. Mattila and Abraham (1998) used integer programming method to solve the modeling and resource leveling problems of LSM, but the process relies on an existing schedule, and only consider the adjustment of the resources of the non-critical activities, which is not flexible enough (Georgy 2008). Georgy (2008) considered the adjustment of the activities of the overall resources, but the model built on genetic algorithm can not guarantee the quality of the solution; moreover, the model which artificially added the maximum buffer constraints would also affect the optimization results.

Construction project resource-leveling problem belongs to the combinatorial optimization problem; in addition to the mathematical methods and heuristic methods, CP technique has been employed as a new approach to handle this kind of problem (Brailsford et al. 1999; Lottaz et al. 1999; Chan and Hu 2002; Liu and Wang 2007).

113.2.2 Requirements and Status of China Railway Construction Project Scheduling

China railway construction project scheduling mainly adopts the Gantt chart method, progress visual graph and network planning method; the related management specification of railway construction have explicit representations (The Ministry of Railways of the People's Republic of China 2010; Ministry of Housing and Urban-Rural Development of the People's Republic of China 2006); because of the characteristics of these planning methods, the quality of the schedule is largely dependent on personal experience of the planner, and the rationality of the schedule cannot be guaranteed and the unsuitability of traditional methods such as network planning method for railway construction project which is a kind of linear project had already been discoursed (Harris and Ioannou 1998; Reda 1990; Yamín and Harmelink 2001; Johnston 1981).

Moreover, the scheduling of China railway construction project and the allocation of resource do not proceed at the same time, resource allocation plan subordinate to the schedule, the leveling allocation of resources can only be realized through local adjustments of the schedule after the completion of the it, this way of scheduling is not conducive to the levelly allocation of resources, and may even lead to problems such as insufficient supply of resources, which will affect the progress.

113.3 The Constructing of China Railway Construction Project Scheduling Model

The proposed model conducts the scheduling and resource leveling of railway construction based on LSM. On the basis of the LSM, such as activity, rate, buffer and other elements, the scheduling problem is abstracted into a constraint satisfaction problem (CSP), whose objective is to realize the human resource leveling allocation, then a CSP-based optimization model is based and the constraint programming technique is used to get an optimal solution. In order to enhance the practicality and flexibility of the model, the commencement date of activity is

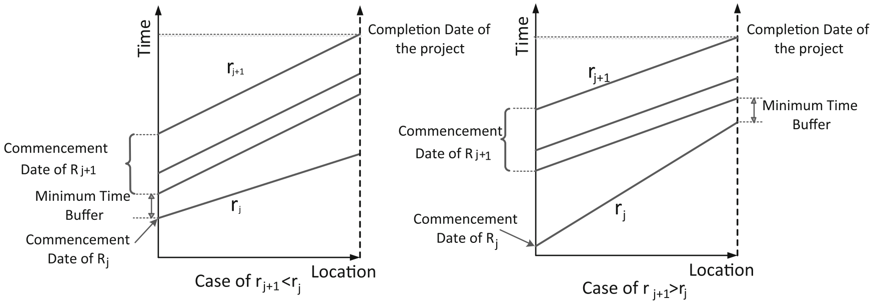


Fig. 113.1 Criterion of the determination of commencement date based on minimum time buffer

treated as a decision variable, and the domain is determined according to the method shows by Fig. 113.1.

Compared with the existing research results, the proposed CSP-based model for the scheduling based on LSM has the following innovations:

- The proposed model could realize the scheduling and resource leveling for linear projects automatically while satisfying the fixed duration constraint;
- On the basis of meeting the minimum buffer constraints between activities, the commencement date of the activity was treated as a variable, which improved the flexibility of the model;
- The CSP-based model was combined with the CP technique, the optimal solution could be obtained with efficiency.

113.4 Constraint Programming

Constraint programming (CP) is a computer implementation integrated mathematics, artificial intelligence and operations research techniques, and is designed to solve constraint satisfaction problems (CSPs) and combinatorial problems (Chan and Hu 2002; Liu and Wang 2008).

Compared with heuristic methods and mathematical methods, CP can search for solutions more simply depending on the algorithm chosen by users, and it is not restricted by any particular model formulation, such as linear equations (Heipcke 1999), the quality of the solutions could also be ensured.

In this study, the CP is choose to find the optimal solution of the proposed model and the ILOG OPL language (Hentenryck 2002) is adopted as the model formulation language. The variables are initialized in the following order: (1) resource usage (r_i); (2) the commencement date of the activity (ST_i). The solution searching of the starts from the smallest value in each variable's domain.

113.5 Scheduling Model

The variables, constraints and objective as follows are adopted to construct of the CSP-based model.

113.5.1 Constants

The constants including:

fa the first activity of the project;
la the last activity of the project;
u_i the resource production rate of activity i;
SD_i the start location of activity i;
ED_i the end location of activity i;
q_i the total mileage of activity i;

$$q_i = ED_i - SD_i. \tag{113.1}$$

$minr_i$ the minimum resource usage of activity i;
$maxr_i$ the maximum resource usage of activity i;
$minb_{i,j}$ the minimum buffer between activity i and activity j (only the time buffer is considered in the proposed model);
C_i the type of activity i (bar type is treated as a kind of block type); $C_i \in \{block, line\}$
D the total duration of the project;

113.5.2 Decision Variables

The value of the decision variables is determined during the searching process. The decision variables including:

r_i the resource usage of activity i, $r_i \in [minr_i, maxr_i]$ (fixed for the block-type activity);
ST_i the commencement date of activity i, $ST_i \in [0, D]$

113.5.3 Decision Expressions

pu_i the production rate of activity i:

$$pu_i = r_i * u_i. \tag{113.2}$$

d_i the duration of activity i:

$$d_i = q_i/pu_i.(\text{fixed for the block-type activity}) \quad (113.3)$$

ET_i the completion date of activity i:

$$ET_i = ST_i + d_i. \quad (113.4)$$

R_i the total resource usage of the project on day i:

$$R_i = \sum_{j=1}^{n} r_j * W_{i,j}. \quad (113.5)$$

$W_{i,j}$ boolean variable that identifies whether activity j is being executed on day i or not:

$$W_{i,j} \in \{0, 1\}.$$

113.5.4 Constraints

(1) On the basis of the minimum time buffer between activities, the commencement date of activity i is constrained by its predecessor as follows:

When $C_i = line, C_h = line$

$$ST_i \geq minb_{i,h} + ST_h. \quad (113.6)$$

$$ET_i \geq minb_{i,h} + ET_h. \quad (113.7)$$

When $C_i = block, C_h = line$,

$$ST_i \geq T_{h,ED_i} + minb_{i,h} + ST_h. \quad (113.8)$$

When $C_i = line, C_h = block$:

$$ST_i \geq minb_{i,h} + ET_h - T_{i,SD_h}. \quad (113.9)$$

(2) The constraints of the fixed project duration constrain the commencement date and completion date of activity as follows:

$$ST_i \geq 0. \quad (113.10)$$

$$ET_i \leq D. \quad (113.11)$$

$$ET_{fa} = D. \quad (113.12)$$

$$ST_{la} = 0. \quad (113.13)$$

113.5.5 Objective Function

The objective function used to perform the resource leveling of linear schedules in this study is established as follows:

$$\text{Min} \sum_{i=1}^{D-1} |R_{i+1} - R_i| \tag{113.14}$$

113.6 Model Validation

To verify the model, the actual data from Subgrade Project DK45 + 750–DK53 + 000 in Xiaohuangshan—Wucaiwan section of Urumqi-Junggar railway is used. The total construction period was fixed to 137 days.

The schedule given by the planner according to his experience when the project was constructed is shown by Fig. 113.2 and has a corresponding objective function value of 145(people) while the solution given by the proposed model is shown by Fig. 113.3 and has a corresponding objective function value of 65(people).

The case study illustrates the ability of proposed model to generate linear schedule automatically based on linear scheduling method, which greatly improves the efficiency of scheduling; through comparison, it could be seen that

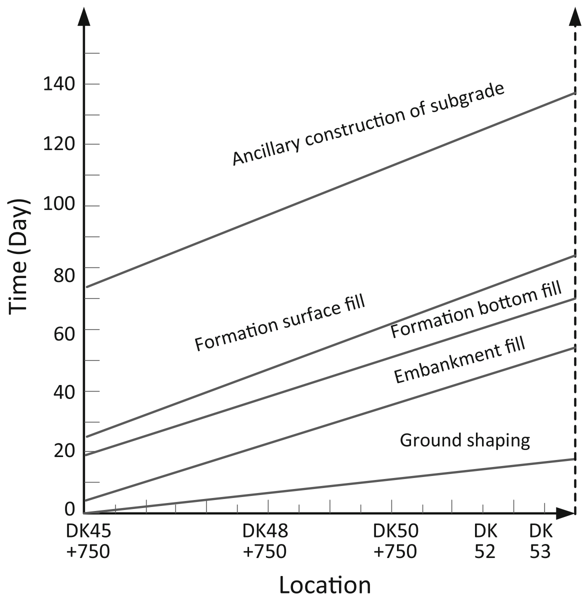
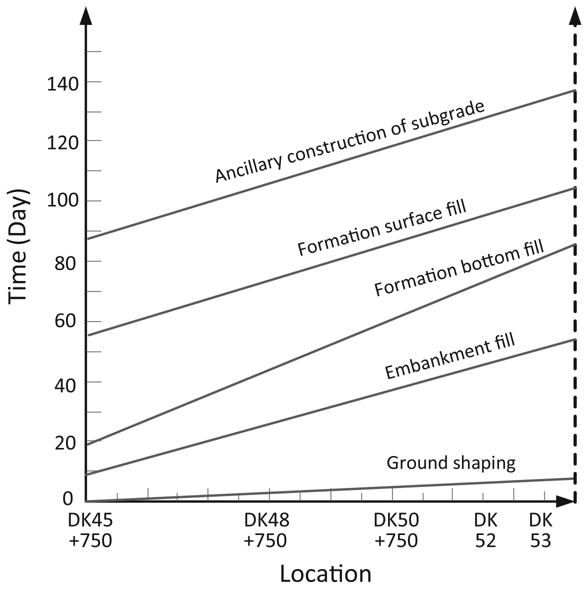


Fig. 113.2 LSM diagram when the project was constructed

Fig. 113.3 LSM diagram according to the scheduling model proposed by this paper



the schedule generated by the proposed model has obvious advantages over the schedule given by the planner.

113.7 Conclusions

This paper studies the LSM-based scheduling and resource leveling optimization problems of China railway construction under the constraint of a fixed duration, and proposed a CSP-based scheduling model. The model could realize scheduling and resource leveling simultaneously based on the concept of rate of linear activity, and has a strong flexibility by setting the resource usage of activity and the buffer between activities as variables. The proposed model was constructed by constraint programming (CP) techniques, and due to the effectiveness of the CP techniques, planners can get an optimal solution in a short time. The model was verified by the actual data from a Subgrade Project in Xiaohuangshan-Wucaiwan section of Urumqi-Junggar railway.

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Chapter 114
Study on Comprehensive Evaluation of External Thermal Insulation Composite Systems Based on Total Life Cycle of Building

Yisheng Liu and Xiaowen Wang

Abstract External thermal insulation composite systems' structure and feature are analysed, and the technology system is summarized. Then, an evaluating system of external thermal insulation composite systems is designed, composed of safety, economy, energy efficiency, environmental conversation and applicability, based on total life cycle of building. Fuzzy evaluation mode is applied to the evaluating system, while confirming weight with AHP and getting fuzzy membership degree with different methods between qualitative and quantitative indexes. The evaluating system is comprehensive, objective, and operational and provides a good guide.

Keywords External thermal insulation composite systems · Evaluating system · AHP · Fuzzy comprehensive evaluation

114.1 Introduction

Energy shortage and environment deterioration is the huge challenge for Global social economy development today. As a big construction country, China's building energy consumption is 1/4 as the same as Social total energy consumption, so building energy saving has come to a critical state (Qiu 2010). Now, external thermal insulation composite system becomes the most popular heat preservation practice in developed countries and is also promoted heavily in China. But the market is not mature enough to ensure quality or realize the survival of the fittest. With the development of external thermal insulation composite systems, a whole evaluating system is urgently needed. Now, there are still not relevant guidance documents, and

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researches in this field are also relatively scattered and unilateral. So, designing a comprehensive and systematic evaluating system becomes a popular question.

114.2 External Thermal Insulation Composite Systems' Feature

114.2.1 Structure of External Thermal Insulation Composite System

The fundamental of external thermal insulation composite systems is that thermal insulation material is covered on the external wall to cut off the energy passing. Different kinds of external thermal insulation composite system has different structure, material, part function and generally speaking, it consists of four parts, bonding layer, thermal insulation layer, render coat and finish coat. Bonding layer is used to bond external wall and the system with adhesive or mechanical fastener; thermal insulation layer is used to cut off energy delivering between indoor and outdoor; rendering coat is put on thermal insulation layer or screed-coat, with reinforced mesh in the middle, and it can protect thermal insulation layer or screed-coat from cracking, water and impact. Finish coat is the external layer and mainly plays the role of ornament. In addition, there are some other auxiliary parts, for example, fireproofing tectonic (Ministry of Construction 2004).

114.2.2 Character of External Thermal Insulation Composite System

Comparing with other building wall insulation methods, external thermal insulation method has irreplaceable advantages and now has grown as the main form of building wall insulation methods. It is the orientation of energy efficiency building and get rapid development in energy saving field. Its advantages mainly include the following aspects: It can be applied in wide field; it can improve main body's durability; it can improve residing environment; it can avoid 'thermal bridge'; it can lighten the wall's moisture, and improve water prevention and gas tightness; it doesn't occupy using space of the building. It is very suitable for energy efficiency rehabilitation of existing buildings; its comprehensive economic benefit is high.

114.3 Technology System of External Thermal Insulation Composite Systems

Since the 1990s, China began to develop external thermal insulation technology. After years' independent research, introduction, digestion, absorption and secondary innovation, China has achieved great success and formed a market, where various technologies contest and promote each other.

Technical specification for external insulation on walls, which was published in 2004 put forward 5 kinds of external thermal insulation composite systems: external thermal insulation composite systems based on EPS panel, insulating mortar consisting of gelatinous powder and expanded polystyrene pellets, external thermal insulation composite systems based on EPS panel in cast-in-place concrete form, external thermal insulation composite systems based on EPS panel with steel mesh in cast-in-place concrete form, external thermal insulation composite systems based on insulation panel with steel mesh in cast-in-place concrete form (Qiu 2010).

For promoting the implement of *technical specification for external insulation on walls* and conducting engineers and managers to follow the standards, MOC published *technical guide of external thermal insulation of building*, which added four kinds of external thermal insulation composite system: external thermal insulation composite systems based on spraying polyurethane rigid foam; external thermal insulation composite systems based on rock wool; external thermal insulation composite systems based on insulation panel affixing and bricklaying with mineral binder and expanded polystyrene granule material for adhesion and making level; external thermal insulation composite systems based on XPS panel (Standard Quota Research Institute of MOC 2006). All of above supplied more solutions to engineering practices.

Along with the development of external thermal insulation technology and the growing demands from market, *technical specification for external insulation on walls* has been modified since 2006. Seven kinds of external thermal insulation composite system were mentioned, with four kinds mentioned before. External thermal insulation composite systems based on insulation panel added rigid polyurethane foam board and rigid extruded polystyrene foam board on the basis of expanded polystyrene board; external thermal insulation composite systems based on insulation panel affixing and bricklaying with mineral binder and expanded polystyrene granule material for adhesion and making level, external thermal insulation composite systems based on spraying polyurethane rigid foam and external thermal insulation composite systems based on composite panels with insulation and decoration were mentioned first.

Additionally, there are many other external thermal insulation composite systems and materials, for example, inorganic thermal insulation materials. These technologies will play important roles as long as they are applied reasonable.

114.4 Evaluation Contents of External Thermal Insulation Composite Systems

114.4.1 Safety

Safety is one of the most important indexes in evaluating external thermal insulation composite systems. Safety includes fire resistance, construction safety and connection reliability. Fire resistance mainly depends on combustibility of insulation material and composite systems, and mean while, considers the setting of fire belt. Construction safety means good stability, good compatibility and suitable self-weight. Connection reliability depends on bonding strength, fixation strength, and wind load resistance (Song et al. 2008).

114.4.2 Economy

Economy is represented by Life Cycle Cost (LCC). LCC covers the construction and installation costs of the system, renewal fee, operation maintenance fee, demolition of building and residual value. Suppose that renewal transformation frequency does not consider technical progress and demolition of building is equal to residual value. LCC can be described as:

$$LCC = I_0 + \sum_{i=1}^{n} I_i + \sum_{j=1}^{T} I_j$$

where T is the total life of the building, I_0 the construction and installation costs of the system, I_{i} the present value of renewal fees, n the renewal transformation frequency, I_{j} the present value of maintenance fee.

114.4.3 Energy Efficiency

Energy efficiency is the core function of external thermal insulation composite systems, which indicates heat preservation, thermal insulation and energy saving stability. Heat preservation is used to be showed by heat resistance. Thermal insulation is used to be showed by the maximum temperature of exterior wall inside surface under the condition of outdoor calculated temperature in summer (Ma 2008). Additionally, energy saving stability can not be ignored because of construction error and different environments. It is used to be showed by correction coefficient of thermal conductivity.

114.4.4 Environmental Conversation

Environmental conversation should be considered as a binding index and it can guide the sustainable development of external thermal insulation composite systems. Environmental conversation raises demands on material recycling and harmful material emissions.

114.4.5 Applicability

According to 'Civil building thermal design standard', different climate regions of building and building types have different demands on technology, structure and function of external thermal insulation composite systems. Therefore, applicability is showed in two aspects, one is the conformance to standard in corresponding climate regions of building, and the other is the conformance to building types, which includes the height, the facing type of exterior wall and the base course wall.

114.5 Evaluation Indexes System

Evaluation indexes system of external thermal insulation composite systems, which is shown in Table 114.1, should follow the principals below: getting an overall perspective, giving prominence to the key points, defining scientifically, having a modern idea.

114.6 Multilayer Fuzzy Comprehensive Evaluation

Fuzzy comprehensive evaluation method is used to evaluate external thermal insulation composite systems because there are both quantitative indexes and qualitative indexes. Before this, every index should be set corresponding qualified standards and the system evaluated will be obsoleted if one of its indexes does not fit the qualified standards.

(1) Weight of indexes. The evaluating system consists of three-grade indexes. The weight of every index will vary with different positions, aims and conditions. So, the weight should be confirmed combining with practical. Here, AHP is applied and the result will be checked comparing with practice (Du et al. 2008).
(2) Evaluation grade. Evaluation grade V is built, which contains excellent, good, improved, poor, and the grade can make the influence of every index clear.
(3) Fuzzy membership degree of every index. How to confirm the fuzzy membership degree of every index is a key step of fuzzy comprehensive evaluation method. Here, we select fuzzy statistic method to quantitative indexes and fuzzy distribution function to qualitative indexes (Fei et al. 2012).
(4) Multilayer fuzzy comprehensive evaluation. The evaluation result of factor gather U_{ij} can be obtained by

Table 114.1 Evaluation indexes system of external thermal insulation composite systems

First grade indexes	Second grade indexes	Third grade indexes
*U*1 safety	*U*11 fire prevention level	*U*111 classification for burning behavior of Thermal insulation material
		*U*112 classification for burning behavior of system
		*U*113 settings of fire belt
	*U*12 safety level of system construction	*U*121 displacement of system's deformation/mm
		*U*122 compatibility among materials
		*U*123 self-weight of system/(kg·m^{-2})
	*U*13 connection reliability	*U*131 bonding strength between layers/MPa
		*U*132 fixation strength(MPa or kN)
		*U*133 wind load resistance/kPa
*U*2 economy		*U*211 LCC/¥
*U*3 energy efficiency		*U*311 heat resistance (m^2·K)/W
		*U*312 the maximum temperature of exterior wall inside surface/°C
		*U*313 correction coefficient of thermal conductivity
*U*4 environmental conversation		*U*411 harmful material emissions
		*U*412 rate of materials recycling
*U*5 applicability	*U*51 conformance to building t climate	*U*511 the conformance to standard in corresponding climate regions of building
	*U*52 conformance to building types	*U*521 the conformance to the base course wall
		*U*522 conformance to the height
		*U*523 conformance to the facing type of exterior wall

$$B_{\mathrm{ij}} = A_{\mathrm{ij}} \cdot R_{\mathrm{ij}} = \left(b_{\mathrm{ij}1}, b_{\mathrm{ij}2}, b_{\mathrm{ij}3}, b_{\mathrm{ij}4}\right),$$

where A_{ij} is the weight of indexes in U_{ij}, R_{ij} the corresponding degree of membership to grade V.

In a similar way, the evaluation result of external thermal insulation comprehensive systems B can be obtained by

$$B = A \cdot R = (b_1, b_2, b_3, b_4)$$

According to the principle of maximum membership degree, the final evaluation result can be sure.

114.7 Conclusion

The evaluation system this paper proposed is scientifically established on the basis of surveying and collecting relative materials. With the development of external thermal insulation composite systems, the evaluation system will be improved in practice, and as a result, it will provide valuable reference to the optimization and selection of external thermal insulation composite systems in China.

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Chapter 115
Analysis on Green Building's Technological Development and Economic Feasibility in China

Jie Li

Abstract With the recognition to the concept of sustainable development around the world, the idea of green construction has been increasingly valued in China. China has already achieved a lot in this field. But owing to its large population, lack of resources and poor bearing capacity of environment, green construction's further development and popularization has been restrained. Thus, from the perspective of technology level and content, this paper explores the economic feasibility of many techniques in the popularization of green construction. Perhaps China can adopt a gradual approach which is suitable to its domestic situation.

Keywords Green building · Technology development · Economic feasibility · China

115.1 Introduction

With the recognition to the concept of sustainable development around the world, the idea of green construction has been increasingly valued in China. China has made a lot of achievements in this field and proceeded to conduct the research involved with key technology. Since June 2006, the mainland of China issued the "Evaluation Standard for Green Building (GB/T50378-2006)". The current green building industry mainly abides by that standard.

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Though green construction has developed step by step, there are still many factors restricting its rapid development. Among other things, failure to understand incremental cost of green building seems to the biggest barrier. Taking the fabrication cost of cities' high-grade building at the level of 1500–3000 Yuan per square meter as a radix, the extra incremental cost which is 6 % of the total is only 90–180 Yuan. The current cost of the pilot green building project in our country is several times, even dozens of times more than this number (Ye et al. 2006).

Owing to its large population, lack of resources and poor bearing capacity of environment, China can neither indiscriminately imitate developed countries, nor simply introduce the expensive green technologies and products, nor proceed to reckon with energy conservation and green construction till its economy has advanced to a high level (Ye et al. 2006). The solution to this problem is involved with green construction's technological development and application. Thus, from the perspective of technology level and content, this paper explores the economic feasibility of many techniques in the popularization of green construction. Perhaps China can adopt a gradual approach which is suitable to its domestic situation.

115.2 Analysis of Green Building's Technological Level

In order to discuss the technical level of green building, it is necessary for us to make a comprehensive investigation over the main technical types of green building in terms of arrival time, development level, the technical complexity, the possible use of additional equipment, benefit, cost, prospect and so on (more details in Table 115.1). At present, green building technologies are not mature in China. Therefore, during the process of transforming from traditional architecture to sustainable architecture, firstly we should choose the low-cost technology that needs not additional equipment, such as passive structural energy-saving technology, green technology, passive solar energy technology and so forth; secondly we should adopt highly efficient and mature technology, like solar water heating technology, mechanical homothermal ventilative technology, energy-saving lighting technology, green building materials technology; finally we can select highly complicated technology that has a bright future, for example, solar photovoltaic power technology, waste recycling technology, intelligent control technology, etc (Wang 1998). Only in this way can China adopt a gradual approach which is suitable to its domestic situation in the application of green building.

115.3 Analysis of Green Building's Technological Content

As is shown in Table 115.1, green building's practical technology can be broadly divided into three levels: regional technology, intermediate technology and innovative high-tech. Regional and intermediate technologies belong to general technology,

Table 115.1 Analysis of technical level of green building

Main type of technology	Produce time	Developing level	Complex degree	Efficiency benefit	Additional equipment	Cost level	Developing outlook
Passive construction techniques	Early	Mature	Simple	Higher		Low	Better
Greening technology	Early	Mature	More mature	Higher		Lower	Good
Passive utilization of solar energy technology	Earlier	Mature	More mature	Higher		Low	Better
Solar water heating technology	Latter	Mature	More complex	High	Yes	Higher	Good
Other clean energy technology	Late	Immature	Complex	Higher	Yes	High	Better
Mechanical thermostats ventilation technology	Latter	More mature	More complex	High	Yes	Higher	Better
Energy-saving lighting technology	Late	Mature	More complex	High	Yes	Lower	Better
Water-saving technologies	Late	Mature	Relatively simple	Higher		Lower	Better
Resource-based use of the building technology	Late	More mature	More complex	Higher		Lower	Better
Waste disposal and recycling technology	Late	More mature	More complex	Higher		High	Good
Recycling technology of water treatment	Late	More mature	More complex	Higher	Yes	Higher	Better
Noise processing technology	Latter	Immature	More complex	Not high		Higher	General
Green building materials	Late	More mature	Complex	High		High	Good
Intelligent technology	Late	Immature	More complex	Higher	Yes	High	Good

high-tech is research technology. Regional technology refers to the natural, primitive ecological technology which is based upon regional climates, environment conditions. Its feature lies in its skillful use of the law in nature, such as passive structural technology, passive solar energy technology. Intermediate technology is the mechanical or manual one that doesn't need high investment and is relatively mature. It widely ranges from solar water heating technology, green technology, water-saving technology, intermediate water recycling technology, energy-saving lighting technology, green building material technology, mechanical thermostat ventilation technology, to resource-dependent building's utilization technology. New high-tech is based on the latest scientific achievements. It is the integration of artificial intelligence and technology to a high degree. Its application in green construction is mainly comprised of high-tech material technology, intelligence control technology, solar power technology, waste disposal and recycle technology (Wang 1999).

The principle of technology selection in green construction is: popularizing regional technology, recommending intermediate technology and conditionally adopting high-tech. We should not only ensure people's basic needs in life, but also avoid the damage to environment; that is, we should take both survival and development into account, and try to achieve the great balance between them. If so, we are likely to achieve sustainable development in green construction.

For example, the ordinary house in China can take the opportunity of home decoration to make it energy-saving, which may not just improve its comfortability, but also save heating and air-conditioning charges. First, the former ordinary single glazing should be replaced by the hollow energy-saving glazing. Meanwhile, movable external sunshade should be installed on the window facing the west and the east. Secondly, residents should try to use renewable energy so as to satisfy the family's need for boiling water and lighting, such as install the solar water heater. These innovative measures with lower cost can effectively improve the whole building's energy-saving effect. So it really fits well the domestic energy-saving innovations in existing house (Hu et al. 2010).

For new buildings, first priority should be given to passive energy-saving technology. Then many other green building technologies can be reasonably selected to use. The main content of saving technology includes: (1) choose the proper orientation of the building; (2) reduce shape coefficient of building, and improve the thermal insulation property of building envelope; (3) improve the building envelope's heat insulation performance, and take reasonable sunshade measures; (4) at the planning phase of construction, perform the simulation of wind environment for construction so as to improve the building ventilation effect; (5) use permeable bricks abundantly so that rainwater can seep into the ground; (6) provide hot water for residents by means of solar water heating system; (7) Make full use of natural light so as to reduce energy consumption in lighting. As for the selection of other green building technologies, comprehensively considering the factors, such as environment protection, energy conservation, emission reduction and financial ability, appropriate technologies can reasonably be adopted in terms of the construction project's features, like climate, meteorology, geology and other aspects (Sun 2010; Qiu 2005).

115.4 Economic Feasibility of the Ecological Green Building

In order to study the economic feasibility of green building, first of all, analysis should be made on principal green building technologies' capital operation conditions. Table 115.2 shows the comparisons between green building technologies' capital operation conditions and general building technologies' from many different perspectives. According to the comparisons a conclusion can be reached: the green eco-building's technologies need higher investment in the prophase and lower maintenance cost in the anaphase, therefore they are conducive to conservation of energy and resources, pollution reduction, for this reason their funds recovery period is relatively shorter.

Compared with general construction, green building has technological advantages which grant itself more comprehensive benefits. Firstly, the economic benefits of green building are higher than that of general construction. Though green building needs higher investment and fabrication cost in the prophase, it saves more investment and maintenance cost in the anaphase owing to its efficient and cyclic utilization of resources, which shorten the economic payback period. Secondly, green building focuses on the geographical features and provides more comfortable living environment, which probably enables habitants to enjoy spiritual pleasure and physical health. Thus those habitants' life quality and work efficiency will be greatly improved, and accordingly enormous social benefits may be generated. Especially, environmental benefits of green building are incomparable. They mainly lie in the fact that green building has no or less pollution and trash. Certainly environmental benefits belong to recessive ones which may not directly yield economic value, but ensure it sustainable. Therefore, they deserve our more attention.

Even though green building has such high potential benefits, in reality, it is not widely applicable as it should be, owing to Chinese traditional outlook about economy and value. Conventional research on architecture's economic feasibility encourages the emphasis on developers' economic interests. Priority is given to the assessment about the sum of investment, cost recovery period, and revenue generating period, irrespective of architecture's social and environmental benefits. Undoubtedly this kind of research is one-sided and outdated. With the advent of the green era, we should, in the time span of architecture's total life cycle, achieve lower consumption of the green, and seek for more comprehensive benefits that are overall rather than partial, sustainably long-term rather than short-term. As for a construction project, total life cycle control means the conformity to a lower consumption concept during the whole process from planning the project, setting its location, designing it, carrying it out, maintaining its operation, till finally dismantling it (Fig. 115.1). Such outlook on economy and value includes not only the direct calculation of economic benefits, but also the recessive social and environmental benefits as an important part of economic value. It takes green building's comprehensive benefits as an assessment standard. Therefore, in every

Table 115.2 Comparisons about green building technologies' capital operation conditions

Main technologies	Upfront input	Maintenance cost	Energy conservation	Conservation of resources	Reduce pollution	Economic payback period
Passive construction techniques	Low	Low	Better		Good	Short
Greenery	Lower	Lower	Ordinary	General	Good	Shorter
Passive utilization of solar energy technology	Low	Low	Better		Better	Short
Solar water heating	Higher	Lower	Good		Good	Longer
Solar power technology	Extremely high	Higher	Superb		Superb	Long
Other clean energy utilization	High	Higher	Good		Good	Long
Mechanical thermostats ventilation technology	Higher	Higher	Better		Better	Longer
Energy-saving lighting technology	Lower	Low	Good		Better	Short
Water-saving technologies	Higher	Higher	General	Good	General	Short
Resource-based use of the building technology	Lower	Lower	General	Better	Better	Shorter
Waste disposal recycling use of technology	High	Higher	General	Better	Superb	Long
Recycling technology of water treatment	Higher	Higher	General	Better	Superb	Longer
Noise processing technology	Lower	Lower			Good	Longer
Green building materials	High	Low	Better	Better	Superb	Longer
Intelligent technology	Extremely high	High	Better		Good	Extremely long
General building and technology	Low	Extremely high				Extremely long

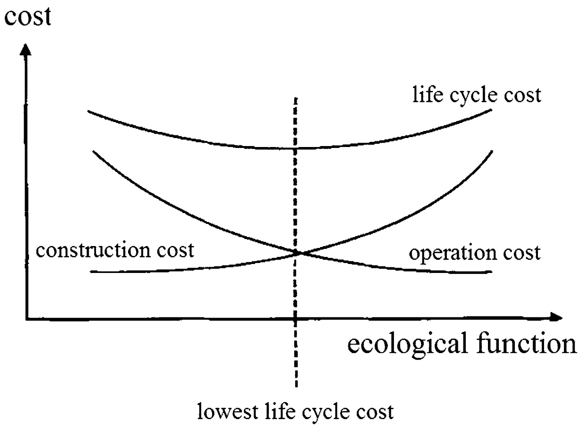

Fig. 115.1 Building life cycle cost factors (http://topenergy.org/show.php?newsid=250)

aspect, green building's economic feasibility has an incomparable advantage over that of general building.

115.5 Conclusion

The development of green building in China is in the ascendant. The task facing our times is how to persistently look for the right direction of development appropriate to the fundamental reality in China, and how to energetically popularize green building. Nowadays the strategy China has adopted is to lower the cost by means of industrialization. According to statistical survey the production cost of some green buildings is within the bearing capacity of the market owing to the adoption of some efficient and ripe techniques. Several kinds of those buildings can be duplicated and popularized on a large scale according to different systems' requirements. Prior analysis on economic feasibility of green construction should be conducted, thus the extra construction cost can be cut down to a great extent. It is recommended that a National Scheme of Green Construction should be formulated so as to carry it out unanimously, congruously and orderly. Effective accomplishments can be achieved only when different measures, such as science, economy, law, administration, and ethics are taken simultaneously.

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Chapter 116
Durability of Green Reactive Powder Concrete

Yue Wang, Ming-zhe An, Zi-ruo Yu and Xin-tuo Hou

Abstract In marine environment, due to the effect of chloride ion, sulfate, magnesium ions, dry-wet cycle, and freeze-thaw cycle, the damage of reinforced concrete bridge pier is extremely serious. Reactive powder concrete, which is considered as a kind of green high performance concrete, has high durability, high strength and presents good environmental protection performance. It is especially suitable for using as protection structure of reinforced concrete bridge pier in marine environment. Through the simulation of the actual service environment, dry-wet and freeze-thaw cycles are applied in durability experiments. The mass and relative dynamic elastic modulus variation of reactive powder concrete is investigated, and the rules are also discussed. The results indicate that the seawater corrosion resistance of reactive powder concrete is satisfactory, which provides design reference for reactive powder concrete pier protection in marine environment. Reactive powder concrete is suitable for marine engineering concrete protection structure as permanent template or maintenance component.

Keywords Green · Marine environment · Durability · Freeze-thaw cycle · Dry-wet cycle

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116.1 Introduction

Concrete is a large building engineering materials, and it occupies utmost important position in modern architecture. With the increase of cement and concrete annual production, it has a huge impact on the resources, energy and environment. Facing the increasingly serious environmental pollution, green concrete has been put forward in the "1997 high strength and high performance concrete" conference first (Liu and Song 2011). Reactive powder concrete which is considered as a kind of green high performance concrete has high durability, high strength and presents good environmental protection performance (Zhang et al. 2005; Yu and An 2010), especially suitable for using in complicated environment as main body structure materials and protection structure.

The current marine environment which reinforced concrete structure services is more complex, due to the influence of chloride ion, sulfate, dry-wet cycle, freeze-thaw cycle, the corrosion and damage of concrete pier is severe. Therefore the protection and restoration of concrete pier have become the focus of engineering.

The current researches are focused on the regular durability test of reactive powder concrete which is under the single factor (Li and Huang 2005; Ehab and Shrive Nigel 2006; Song and Wei 2006; Lee et al. 2005). In this article reactive powder concrete dry-wet cycle and the freeze-thaw cycle test has been carried out through the simulation of seawater environment. Moreover its mass and relative dynamic elastic modulus variation has been determined, which provides the theory basis for reactive powder concrete structure design based on life-time.

116.2 Materials and Methods

42.5 ordinary Portland cement, silica fume, quartz sand, super plasticizer, steel fiber, water and PVC plastic piece are used in the preparation of reactive powder concrete. Anhydrous magnesium sulfate, anhydrous sodium chloride and anhydrous sodium sulfate are used for simulating the marine environment. Considered the damage caused by collision, two mix proportions used for reactive powder concrete are present in Table 116.1, and R-D represents for damaged concrete proportion, R represents for non-damaged concrete proportion. High performance concrete proportion is given at Table 116.2 for comparative test.

Table 116.1 Mix proportion of reactive powder concrete (kg/m^3)

Mixture code	Cement	Silica fume	Quartz sand	Steel fiber	Super plasticizer	Water	Plastic piece
R	706	160	1249	160	74	122	–
R-D	704.6	159.7	1246.7	159.7	73.9	121.8	4.76

*The volume fraction of plastic piece is 2.5 % in proportion R-D

Table 116.2 Mix proportion of high performance concrete (kg/m^3)

Mixture code	Cement	Gravel		Sand	Fly ash	Mineral powder	Water	Admixture
		Coarse	Fine					
C50	308	565	565	693	88	44	132	5.3

According to the investigation results of seawater samples, the solution ratio is anhydrous sodium chloride 28.8 g/kg, anhydrous magnesium sulfate 3.39 g/kg, anhydrous magnesium chloride 2.42 g/kg, with the actual ion content expands 5 times.

The reactive powder concrete are prepared as 100 × 100 × 400 mm prism specimens and 50 × 400 × 400 mm thin plate specimens. The thin plate specimens are used for simulate protection structure. High performance concrete test is made on 100 × 100 × 400 mm prism specimens. Sea water freeze-thaw cycles test is based on GB/T50082 (Test Method for Rapid Freezing and Thawing), which sulfate solution is replaced by the laboratory seawater. The dynamic elastic modulus and mass are measured in every freeze-thaw cycle 50 times. And the specimens are soaked in the prepared solution for 12 ± 0.5 h and then natural drying for 12 ± 0.5 h. The dynamic elastic modulus and mass are tested every 10 times. In this paper dry-wet cycle times are beginning with the letter G, freeze-thaw cycle times are beginning with D.

116.3 Results and Discussions

116.3.1 Damaged Prism Specimen Dry-Wet and Freeze-Thaw Cycle Test

According to prophase test results, the times of dry-wet cycles and freeze-thaw cycles are magnified to 50 and 300 respectively. Moreover, the damaged specimens are used. The relative dynamic elastic modulus and mass of damaged prism specimens (R-D) under the action of dry-wet and freeze-thaw cycles are given at Table 116.3. The results of C50 high performance concrete seawater freeze-thaw cycle comparison test are discussed at Table 116.4. And the relative dynamic elastic modulus variation curve of damaged prism specimens and C50 specimens are shown in Fig. 116.1.

Through general analysis of Table 116.3, it is known that the relative dynamic elastic modulus of damaged specimens is less than 100 % only at 30 times during

Table 116.3 The results of damaged prism specimens dry-wet and freeze-thaw cycle test

D-W and F-T	G10	G20	G30	G40	G50	D50	D100	D150	D200	D250	D300
RDEM (%)	100.0	100.2	99.5	100.9	101.2	90.9	93.9	93.8	92.4	93.1	91.7
Mass (kg)	10.01	10.01	10.02	10.02	10.02	10.00	10.01	10.02	10.01	10.02	10.01

Table 116.4 The results of C50 high performance concrete freeze-thaw cycle test

F-T	D50	D100	D150	D200	D250	D300
RDEM (%)	100.0	101.6	101.6	96.1	76.8	40.9
Mass (kg)	10.02	10.05	10.03	9.92	10.05	10.07

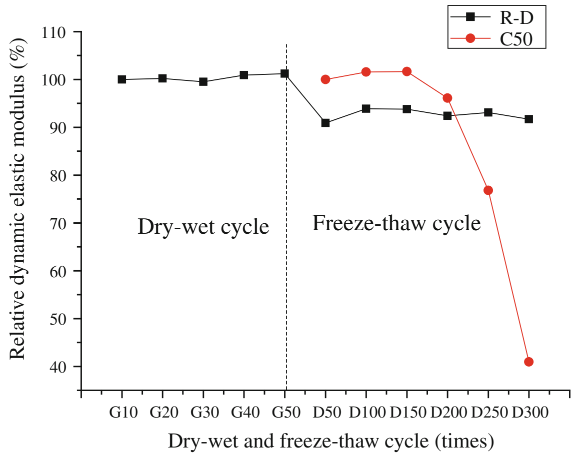

Fig. 116.1 The relative dynamic elastic modulus of damaged prism specimens and C50

dry-wet cycle 50 times, and it reduces only 0.5 %. The relative dynamic elastic modulus is 101.2 % at dry-wet cycle 50 times. The relative dynamic elastic modulus of damaged specimen decreases sharply during seawater freeze-thaw cycle 0–50 times and it has fallen by 10.3 % after 50 times. After that the relative dynamic elastic modulus slightly increases with the increase of freeze-thaw cycle times, then decreases, and 300 times is 91.7 %. But the relative dynamic elastic modulus of C50 high performance concrete slightly increases at the early stage of freeze-thaw cycles, both freeze-thaw cycle 100 times and 150 times are 101.6 %. Then relative dynamic elastic modulus falls sharply, 200 times, 250 times, 300 times is 96.1, 76.8 and 40.9 % respectively. The C50 specimens have been damaged after freeze-thaw cycle 300 times, the surface has obvious cracks, as shown in Fig. 116.2.

The crystal substance produced at the early stage of dry-wet cycles fills the surface initial damage and defect of reactive powder concrete, the relative

Fig. 116.2 The surface morphology of specimens after freeze-thaw cycles

dynamic elastic modulus slightly increases, and it changes little during 0–50 times. Seawater freeze-thaw cycle 0–50 times relative dynamic elastic modulus reduces sharply, this is mainly because the interaction between crystal substance and concrete by freeze-thaw cycle makes the concrete destructed. The expansion pressure produced by freeze-thaw cycle is extremely small, the relative dynamic elastic modulus changes little during 50–300 freeze-thaw times.

The relative dynamic elastic modulus of damaged specimens is slightly lower than non-damaged specimens in the same conditions, this is because the interface bonding is very poor between PVC plastic piece and concrete. And the relative dynamic elastic modulus is 91.7 % after dry-wet cycle 50 times and freeze–thaw cycle 300 times. However, the relative dynamic elastic modulus of C50 high performance concrete specimens is 40.9 % after sea-water freeze-thaw cycle 300 times. The specimens have already broke, it can be concluded that the reactive powder concrete has a good durability performance under the action of seawater freeze-thaw cycle.

116.3.2 Damaged Thin Plate Dry-Wet Cycle Test

The relative dynamic elastic modulus and mass results of damaged thin plate specimens (R-D) under the action of seawater dry-wet cycle are presented in Table 116.5. And the relative dynamic elastic modulus variation curve according to Table 116.5 is shown in Fig. 116.3.

Table 116.5 The results of damaged thin plate specimens seawater dry-wet cycle test

D-W	10	20	30	40	50	60	70
RDEM (%)	100.0	100.5	100.2	100.6	99.9	99.1	99.6
Mass (kg)	19.52	19.52	19.52	19.51	19.52	19.50	19.51

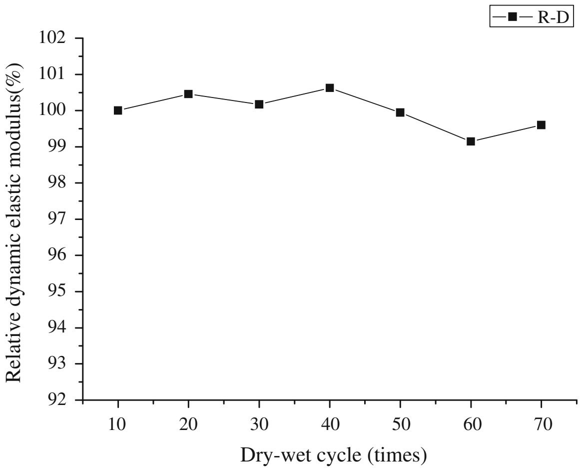

Fig. 116.3 The relative dynamic elastic modulus of damaged thin plate specimens

It is shown in Fig. 116.3 that reactive powder concrete damaged thin plate specimen has a good seawater erosion resistance performance under the action of dry-wet cycle. The maximum of relative dynamic elastic modulus is 100.6 % and the minimum is 99.1 % during dry-wet cycle 70 times, it fluctuates in a very small range. The initial damage caused by adding PVC plastic piece almost has no influence on reactive powder concrete seawater corrosion resistance performance. This is mainly because of the compact structure of reactive powder concrete, high strength of matrix, and steel fiber significantly makes up the weak defects of PVC and matrix interface bonding ability.

116.3.3 Non-Damaged Thin Plate Specimen Freeze-Thaw and Dry-Wet Cycle Test

The results of non-damaged thin plate specimens under freeze-thaw 200 times and dry-wet 30 times are displayed in Table 116.6, its relative dynamic elastic modulus variation curve is shown in Fig. 116.4.

Through general analysis of Table 116.6 and Fig. 116.4, it is known that reactive powder concrete with compact structure and high matrix strength, its surface pore ice crystal inflation is limited during freeze-thaw processes, the relative dynamic elastic modulus change little during freeze-thaw cycle 200 times. But the influence on reactive powder concrete will naturally produce by freeze-thaw cycle 200 times, especially the surface pore of concrete will slightly change by expansion effect. The crystal substance quickly fills the initial defect with dry-wet cycle 0–10 times, the relative dynamic elastic modulus obviously increases. The crystallization pressure begins to affect the concrete with the accumulation of crystal substance, the relative dynamic elastic modulus falls sharply dry-wet cycle 10–20 times, and it continues to drop during dry-wet cycle 20–30 times. But the relative dynamic elastic modulus decreases slowly due to its matrix strength.

With comprehensive analysis of the mass results given in Tables 11.3, 11.4, 11.5 and 11.6, which are under different experiment conditions, the mass of reactive powder concrete samples changes a little. The mass increases in Table 116.3, mass loss maximum is 0.1 % in Table 116.5, and it is the same with Table 116.6. However, the mass loss of C50 high performance concrete is −0.5 % after freeze-thaw cycle 300 times, while specimens have already broke. Therefore, the mass loss of high performance concrete should not be considered as an evaluation index of the durability individually.

Table 116.6 The results of non-damaged thin plate freeze-thaw and dry-wet cycle test

F-T&D-W	D50	D100	D150	D200	G10	G20	G30
RDEM (%)	100.0	101.4	101.5	103.9	121.5	102.9	101.6
Mass (kg)	20.22	20.23	20.24	20.27	20.20	20.21	20.20

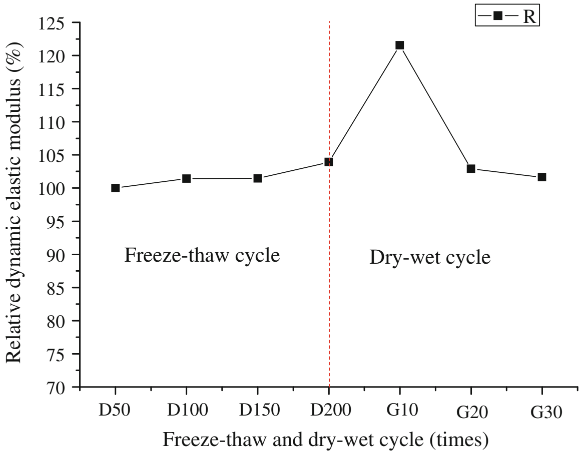

Fig. 116.4 The relative dynamic elastic modulus of non-damaged thin plate specimen

116.4 Conclusions

Through the simulation of actual seawater condition with damage, dry-wet cycle, freeze-thaw cycle considered, reactive powder concrete tests are carried out. There-fore the relative dynamic elastic modulus and mass of prism and thin plate specimens are presented. The results indicate that the reactive powder concrete has a good performance of seawater corrosion resistance.

The mass of reactive powder concrete changes little by dry-wet and freeze-thaw cycles. However, the mass loss of C50 high performance concrete is −0.5 % when it is failure. Therefore, the mass loss of high performance concrete should not be considered as an evaluation index of the durability individually.

Reactive powder concrete is suitable for marine engineering concrete protection structure as permanent templates or assembled in the form of maintenance component, and it will play an important role in the maintenance of concrete bridge pier.

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Chapter 117
Study on the Strategy of Green Buildings Development in China

Yisheng Liu and Mengyuan Hua

Abstract At present, the industry, construction and transportation are three main energy consumption areas. According to the data of the report of energy conservation and emission reduction in 2009, building energy consumption accounts for about 30–35 % of the total energy consumption. In this situation, the affect of main stakeholders of green buildings, and the dynamic mechanism of large-scale development on green buildings in China are analyzed in this paper. Meanwhile, this paper also learnt some experience from other countries and explored the strategy path of large-scale development on green buildings. The results of the study show that large-scale development on green buildings is related to the whole construction field of energy conservation and emission reduction effect directly and help to achieve the goals on low-carbon economy development.

Keywords Green buildings · Main stakeholders · Large-scale development

117.1 Introduction

Early days, "Green building" focused on building energy conservation and environmental protection. Then, the development of "Green building" came to realize the importance of comfort and health (Ji 2011); However, during the process of the development of "Green buildings" in China, only the formation of certain scale, can help to realize the goal of energy saving and environmental protection. Large-scale development of "Green buildings" refers to the amount and the quality should come into certain level and scale, thus to release the goals of energy conservation and environmental protection.

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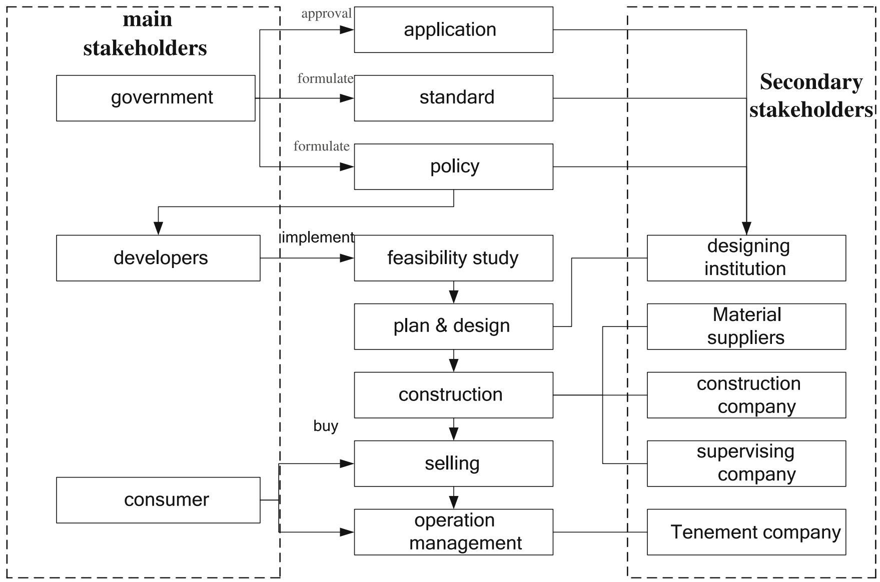

Fig. 117.1 Stakeholders of green buildings

117.2 Stakeholders and Its Game Analysis

117.2.1 Responsibility of Main Stakeholders

The entire process of construction involves a lot of stakeholders. The behaviors of the stakeholders affect the development of green buildings.

In view of the actual situation of construction, we chose government, developers, and consumers from the Fig. 117.1 as main stakeholders so as to make them main object when studying green buildings in large-scale development (Jin et al. 2010):

117.2.2 Analysis of the Game Between the Government and Green Buildings Developers

In China, government and the green buildings developers are two of the stakeholders, Because of the different benefits, when it comes to the energy conservation and emission reduction and the development of green buildings construction, there are some conflicts and contradiction on the decision (Fig. 117.2).

In the graph, x reflects the extent to which the government chose to implement incentive policies. y reflects the wishes that the developers choose the development of green building. a_0 is the income when government did not implement incentive policies. a_1 is the extra income when the developers choose to develop

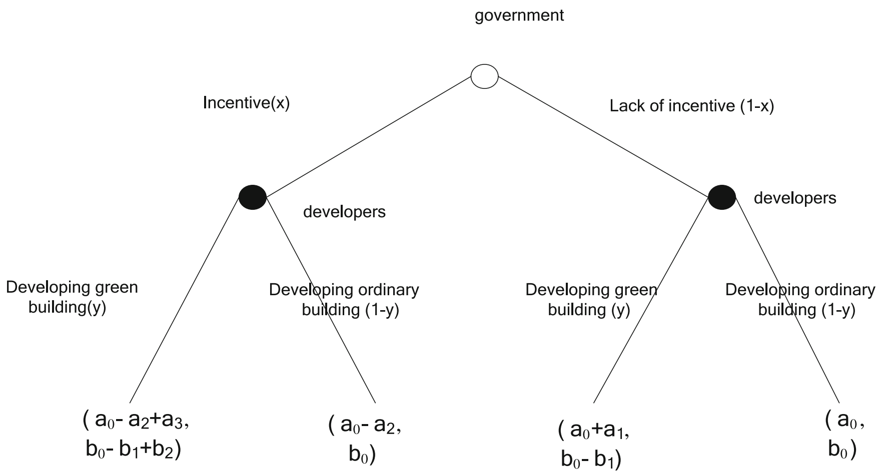

Fig. 117.2 Game model of government and green buildings developers

the green building without an incentive policies, such as the long-term income: community, resources, the environment. a_2 is the cost of the incentive policy. a_3 is the extra income when the developers respond to the incentive policy. b_0 is the income when the developers choose to develop the normal building. b_1 is the more cost when the developers choose to develop the green building instead of the normal building. b_2 is the incentive income when the developers choose to develop the green buildings (An 2012).

(1) The best choice of the government.

The expected income of the government:

$$E_1 = \{y(a_0 - a_2 + a_3) + (1 - y)(a_0 - a_2)\}x + \{y(a_0 + a_1) + (1 - y)a_0\}(1 - x)$$

Replication dynamic equation of the government:

$$F(x) = dx/dt = x(E_{11} - E_1) = x(1 - x)[y(a_3 - a_1) - a_2]$$

The developer has no wish to develop the green building and the government does not implement the incentive policy.

(2) The best choice of the green buildings developers.

The expected income of the green buildings developers:

$$E_2 = \{x(b_0 - b_1 + b_2) + (1 - x)(b_0 - b_1)\}y + \{xb_0 + (1 - x)b_0\}\,(1 - y)$$

Replication dynamic equation of the green buildings developers:

$$F(y) = dy/dt = y(E_{21} - E_2) = y(1 - y)(xb_2 - b_1)$$

when $y < y^*$, $F'(0) < 0$, $F'(1) > 0$, $y_1^* = 0$ is the evolutionary stable strategy, which means the government does not implement the incentive policy and the developer has no wish to develop the green building.

117.2.3 Analysis of the Game Between the Consumers and Green Buildings Developers

Use the same methods (Analysis of the Game between the Government and Green Buildings Developers) we can get the result: Consumer's optimal choice. The corresponding solution as the optimal choice for consumers is to buy ordinary construction (Li 2005).

The optimal choice of the developers is promotion of green buildings and purchase by the consumer, or general construction for sale and purchased by consumers.

117.2.4 Analysis of the Game Between the Government and Consumers

Use the same methods (Analysis of the Game between the Government and Green Buildings Developers). The government's optimal choice is that consumers do not want to buy green buildings, but to buy ordinary buildings, and the government do not implement economic incentive policies. Besides, Consumers' optimal choices are, the government do not implement the economic incentive policies and the consumers buying green buildings gradually disappeared, giving rise to the formation of the group selection to purchase ordinary buildings.

117.3 Dynamic Mechanism of Green Building's Development

117.3.1 The Model of Dynamic Mechanism

From the analysis of the above, the driving force of the development in scale of green building mainly comes from three aspects (Wei 2008): consumer's value orientation, competition and cooperation between producers, and the guidance of government policies (Fig. 117.3).

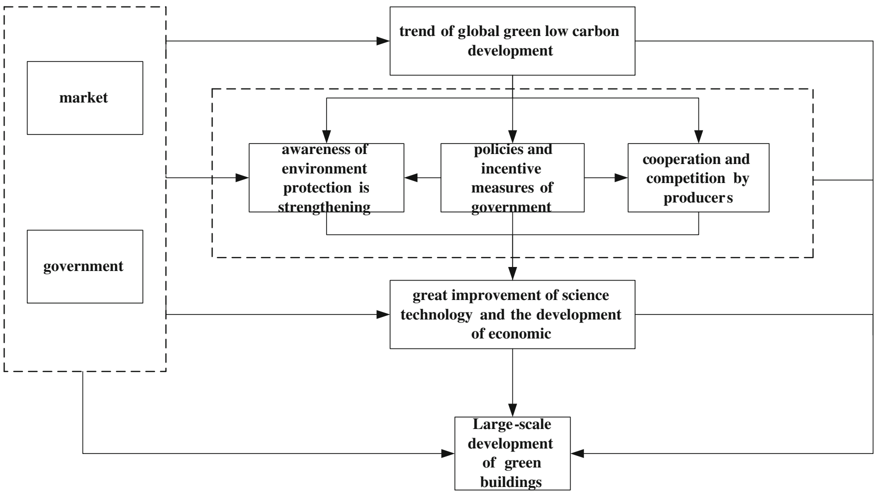

Fig. 117.3 Dynamic mechanism of green building's development

117.3.2 Analysis of the Model

(1) Consumers' value orientation. Whether green products can gain an advantage in the market competition or not is the prerequisite of gaining profit space. And the value orientation of consumers plays a decisive role in this process. Only when consumer's green needs are stimulated effectively can green building be greatly promoted.
(2) Competition and cooperation between Producers. In order to gain greater market profits, strengthen the market value and gain competitive advantage, improve self-image, producers always have a positive response to the consumption needs of the customer's environmental awareness to strengthen the relationships with customers and the customer's loyalty. And by this way, it will constitute a competitive advantage and core competition comparing with other competitors.
(3) For producers, the government with coercive powers can force the producers to have a cooperation to make producers tend to use the strategy in favor of social welfare, and when the over-high cost becomes the barriers when producers choose the production of green products, the government can guide their choice of green products by the policies of tax relief or financial subsidy. In short, government ensures the development of green building through policy guidance.

117.4 Strategy Developing Path

The field of building energy-efficient fails in market mechanism part, which couldn't drive by market mechanism, and powerful manage should be carried out by government in law, economic and administration in order to achieve substantial progress, and the participation of all parties play an important role (Cai 2011).

(1) Building good policy environment

Legislation is the fundamental in promoting green building. The two key steps in developing green building: introduce relevant regulations and strengthen administration. Moreover, the development of green building should bring into local governments' duty and daily management range and make a connection with their achievements so that establish a long-term mechanism.

(2) Perfect Standard evaluation system

Evaluation methods should combine qualitative with quantitative, especially enhance the research and application on quantitative index. In order to advocate the green building development and practise green building certification institution, the government must cultivate an independence third-party certification agency to make a fully evaluate before implementing design proposal, under construction process and building materials and devices. The green building's life-cycle evaluation is start from the whole environmental assessment, and each phase of the evaluation is based on overall grasps.

(3) Establish relative market mechanism

To form the scale effect of green construction market, the key is to forming a mature green construction industrial chain. In this way, various outstanding social resources can be properly utilized, so all the resources and technologies can be properly matched, and the interests of all parties will be fully reflected, a complete green construction industrial chain will be built and the scale development of green construction will be realized.

(4) Enhance the cultivation of concept

The education of green construction should also be multi-tiered and all round. The process of education is both the process of practice and democracy. To associate the green development with the public's interest and provide ways to safeguard this interest and ensure the effectiveness of this way will not only enhance people's consciousness but also their ability to take actions. Colleges and universities should also provide green construction courses, so as to train professionals and educate and train the ordinary people.

117.5 Conclusion

The construction area is the key area to save energy and reduce the emission of green house gases. During the 12th five-year plan, our country should use various means such as adjusting industrial structure and energy structure, saving energy and improving efficiency, to greatly reduce the intensity of energy consumption and the emission of carbon dioxide and effectively control the emission of greenhouse gases and protect the environment. To vigorously promote the construction and development of green construction is an important way to control the construction area.

At present, our country has begun to pay attention to the study and construction of green construction and has taken some actions. However, the current study only focuses on the green construction and the method is to narrow; the building of green construction is only pilot project, and it has been promoted and has not formed a green construction complex. So there should be further study about the scale development of green construction.

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Chapter 118
The Green Building Materials Enterprises in the Management of Innovation and Production Technology Improvement

Yunlu Li

Abstract In the 21st century, the world of industrialization and the development of high-tech make the entire human material civilization progress. However, our own environment has been damaged in different degrees. At present, the shortage of resources, environmental degradation becomes the main factor to hinder the rapid development of the world economic stability. In order to realize the strategic target of sustained development, we have to save energy, improve the environment. In recent years, green industry has become the world common development goals. Green building materials production enterprises in the building materials market a new force suddenly rises. High quality green building materials also quickly occupied this belongs to the traditional building materials market. This is an introductory paper of green building materials enterprises, analysis of green building materials production and the economic benefits of the enterprise and development direction.

Keywords Green building materials · Challenge · Operations

118.1 Introduction

Since the 1990s, China has been the world's largest building materials production and consumption country, cement, wall materials, flat glass, ceramic and stone and other major building materials products production has for many years in the

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world. At present in the international market, China's building materials industry has become a certain competitive industry, as well as the national economy sustained, rapid and healthy development has made important contributions, and at the same time, building materials industry in recent years has maintained a rapid development.

All the time since, industry of our country building materials go is a high energy consumption, high resource consumption and high pollution "Three-high" road of development, is a serious environmental pollution, ecological destruction of the larger industries. Efforts to develop green building, ecological building materials, environmental protection building materials in order to fundamentally change China's building materials industry has long formed the high investment, high pollution, low efficiency of the extensive mode of production (Liu 2008).Green building ecological building materials, refers to the use of clean production technology of the production of no poison, no pollution, no radioactivity, is conducive to environmental protection and human health building materials. Green building materials should be in the choice of raw materials, production process, product use, waste treatment and recycling use and other aspects of the minimum load on the earth environment, the friendliest.

In all green building materials, wall materials plays a very important role in today's China, has gradually become a global manufacturing base wall materials will more and more show development potential, and support China has become the fundamental industry of manufacturing industry (Mo 2009). Green building materials carrying the human pursuit of people-oriented, ecological, environmental, energy saving, heat preservation, health, the idea of sustainable development. This paper in the predecessor to the green building materials on the basis of the study, the main emphasis on a green wall materials production and business development, reduce energy from production to consumption in all aspects of the loss and waste, more effective and rational use of resources.

118.2 Traditional Building Materials

As we all know, the traditional building materials brought to the human material civilization and to promote the progress of human civilization. However, in the development and production process of traditional building materials not only consume a lot of resources and energy, and the negative impact of serious pollution to the ecological environment, to some extent, hindered the progress of human civilization.

According to statistics, the world's cement output in 2002 is about 1.7×109 tons, China's output of 7×108 t, the world's total cement output of nearly 40 %; CO_2 emissions of about 6×108 t of SO_2, NOx emissions were 8×105, 1×206 t. Of atmospheric pollution is serious, the total amount of atmospheric pollution emissions remain high, the 2000 National soot emissions by up to 1.4×107 t, industrial dust emissions by 1.3×107 t, is the most serious atmospheric pollution on the country in the world one. World Health Organization announced in 2000 to 272 cities in 54 countries, atmospheric pollution, evaluation results show that the most serious atmospheric pollution in 10 cities in China accounted for 7 (Song et al. 2012).

It is obvious that the traditional building materials to the environment pollution to a certain extent, seriously has restricted the sustainable development of our own. The traditional building materials manufacturing only pursue the use of material function and ignore the material environment harmony and comfort, is on the ecological environment pollution is extremely serious, destructive larger one of industry. In recent years, our export of some natural rock building materials and artificial building materials products due to radioactive, heavy metal content and other technical index more than the international standard of set limit to, rejected, detained, return and claim for compensation and terminate the contract situation to happen from time to time, some traditional building materials bulk export products was forced to withdraw from the international market.

So far, China's traditional building materials "production—use—waste" of the process, is still a kind of a large number of resources will be extracted, then a lot of waste row back to the environment vicious cycle process (Wang and Jiang 2005). This is the people in economic growth theory formed under the guidance of development outlook, values caused by. Developing green building materials is a system engineering, not only request building materials production mode transformation, but also for building materials industrial process design, production process quality control and technology development system produces major change, so from economic operation mechanism itself look for a way out, the implementation of the ecological economic benign circulation mechanism.

118.3 Green Building Materials

(1) Autoclaved aerated concrete products

Building materials produced Hong yanchi autoclaved fly ash aerated concrete products is a lightweight energy-efficient building materials, it is the fly ash, lime, cement, gas evolution materials as raw material, finely ground, ingredients, pouring, a series of cutting, and autoclave curing process which is made of. For its products internally by the hair of the gas contains a large number of uniform small pores, hence the name of aerated concrete. It is light weight, good insulation properties and process ability, etc., is to promote the earliest, the most widely used lightweight wall materials, and only in line with the national building energy target of 65 % single-wall thermal insulation material.

Hung yanchi building materials company in the production of pre-activation of the production process can significantly improve the activity of fly ash, formula, process, and technical parameters are adjusted accordingly and improve the physical properties of products better Dimension-more sophisticated construction applications more convenient and reasonable and scientific, has the following characteristics:

Light weight

Autoclaved aerated concrete block dry density only 400–800 kg/m^3, equivalent to 1/3 the clay brick, ordinary concrete 1/5, and general lightweight aggregate concrete and hollow block, hollow clay brick products also compared are much lower.

Excellent thermal insulation

Autoclaved aerated concrete block has very low thermal transmittance and thus have good thermal insulation properties. Its thermal conductivity is often 0.10–0.20 w/(mk), only 1/4–1/5 of the clay brick, plain concrete, 1/5–1/10. Its porosity and pore rate of about 70 %, which is the main reason it has excellent thermal insulation.

Good workability and convenience, on-site construction

Autoclaved aerated concrete block has good process ability, sawing, planning, drilling, nailing. When used according to need any processing. And Hong yanchi company appearance of the product size is accurate, available and appropriate binder material grout masonry techniques and application of thin plaster system provides favorable conditions to the construction.

Excellent bending performance products have a higher fold compression ratio can be effectively. Enhance the overall shear capacity of the building structure.

(2) Lightweight aggregate pure ceramsite concrete hollow block products

Automatic concrete production line equipment imported from Germany, strict implementation of industry self-regulation provisions of GB/T15229 GB light-weight aggregate concrete small hollow block" and Xinjiang brick Association, in order to ensure the quality of the product on the wall and the content of radioactive substances is not exceeded.

1. The crowd size and surface quality is very excellent, you can use the special masonry and plastering mortar, to build a thin plaster construction building system, saving the cost of construction.
2. The small water absorption, low moisture, frost resistance, carbonation coefficient and the softening coefficient of up to 0.9.
3. Radioactive indicators: at present, the construction of residential use coal cinder, slag, such as lime mixed material as the main raw materials of small hollow block, its contains a variety of harmful mineral elements, most not after radioactive monitoring, building after building exist on the human body have harmful radiation, serious harm to human health, and red goose companies use pure ceramsite production ceramsite concrete hollow block, do not contain the harmful minerals, and after authority strictly detection radioactive can index is excellent, in one hundred is the first choice of building materials.
4. Absorption decomposition NOx. Light catalytic concrete urban industrial and traffic development, can lead to city's air quality decline. Burning fuel for atmospheric environment cause serious influence, the harm the largest is the

NOx. NOx can lead to acid rain, ozone depletion, greenhouse effect and photochemical smog and damage the earth ecological environment and the harm to the health of the human body and the growth of the plants and animals a series of problems. Light catalytic concrete is one of the green building materials, it contains titanium dioxide catalyst, thus has catalyst, can oxidation most of the organic and inorganic pollutants, especially industrial combustion and automobile emission of NOx. Gas, make its degradation for carbon dioxide and water harmless substance, plays air purification, and beautify the environment effect.

118.4 Problems and Challenge

Although green building materials industry development is impressive, at the same time, the industry faces the challenge is still very serious.

(1) Start is late; green building materials in the whole building materials market share is very small. At present, China's green building materials products accounted for the proportion of building materials product no more than 5 % (Wang and Jiang 2005), and in the European and American developed country, building materials products to "green" standard of building materials product has more than 90 % of the total.
(2) Green building materials production enterprise production scale is small, the strength is not strong, the technical innovation ability weak. Although the green building materials market potential demand great, the circle, environmental protection departments actively call building materials industry to go green building materials to develop, and the vast number of consumers also expects green building materials products can enter the family, but in fact, the real pitched to the green building materials products production enterprise is not much. Many large, strong enterprises often is specialized in the production department, the difficult to change the line of production management of new products. In this case, the market flexibility is high, easy to transformation of the small and medium-sized enterprises and small and medium-sized private enterprises early into the green building materials products industry. But because of the small scale of the enterprise, the technical innovation ability is insufficient, lack of green product production management experience, leading to the lack of product market competitiveness, cannot obtain the quality and the price superiority, dampened consumer confidence, causes the production out of the product dull sale, the economic benefit of enterprise not beautiful, hindered the green building materials production enterprise development, growing. Thus affecting China's green building materials industry's healthy development.
(3) Green building materials products and common building materials price higher than. The high price of product is impeding the development of green building materials industry and one of the main factors. Although green

building materials products with high technology content, less pollution, the maintenance cost is low, the advantages of long life, however high price make consumers see green building materials product advantage, when used with a long cycle, so green building materials products within a short time is difficult to market to accept.

118.5 Operation and Innovation

With a large number of consumption of resources, extensive business for the traditional building materials industry development model has been difficult to continue, must be replaced by a resource saving, low pollution, quality good benefit, science and technology leader in sustainable development of the ecological building materials mode. New building materials development mode is the core, to protect environment as the development of the internal factors, consciously and actively into the environmental protection process, rather than to environmental protection for the community or for specialized environmental agencies, and this is the traditional building materials development pattern the most remarkable difference (Sun and Liu 2010).

(1) The Hong yanchi building materials company block factory to expand production scale, improve product quality, reduce product costs, raw materials, water feed ratio, and equipment changes on the basis of the same in the original production process, the transformation of the fabric gate, both to reduce the number of host fabric 20–30 %, but also to ensure product quality and innovation through the production process, a single shift production yields exceeded 50 cars, to improve the yield of 20 % or more, reducing the power consumption, energy consumption and equipment wear and tear charges, greatly improving the labor productivity.
(2) Import stacker crane automation control system of redevelopment. A building materials company imported Germany RH1500FVA type automatic concrete block production line in production border stone series product process, the original stacker crane design can not realize automation efficient stacking, resulting in production process a large number of occupancy wooden pallet, average every production 8 meters products will need a wooden pallet (make a wooden pallet loss capital 100 Yuan),and to ensure that products in the transportation without collapsed touch damage, and need to use artificial products referrals to pallet, high cost and low efficiency. Company for stacking machine automatic control system implement to development and innovation, this technology has been applied in the company imported Germany Hays RH1500FVA automatic concrete block production line stacker crane plant site, can realize marketable kerb product combination stacking, improve the single class yield a times, with an average annual output value added up to 600000 Yuan, every 16 m products occupy a wooden pallet, with an average

annual saving wooden pallet more than 1000, every year, saving wooden pallet processing production cost reached 100000 Yuan, at the same time completely canceled products after referral of artificial again pallet, can direct shipping transportation, greatly reduces the artificial and mechanical charge, also save the site occupancy, saving time, can improve the product production and delivery efficiency a times, in transport, also need not worry about product touch damage and driving safety, these are a great promotion and application value, have filled in the domestic blank.

In summary, implementation of cleaner production technology to improve the technological level, and reduce environmental pollution is a general trend. “Green” consumer attitudes prompted the building materials companies must establish an environmental management system and improve the level of environmental management in order to accelerate the building materials green process, thus ensuring corporate vitality and competitiveness (Yan 2012).

118.6 Conclusions

Building materials industry is not only supporting economic and social development of the essential basic raw material industries, and gradually grow into a resource-conserving and environment-friendly society, realize the sustainable development of pillar industries. Energy conservation and emission reduction in our country is related to the sustainable economic development, and benefit the future generations of a great thing, also is the relationship of the global environment a great event. Along with our country economy’s sustained and rapid development, economy is growing, energy, resources, ecological and environmental are faced with crisis, energy-saving and emission reduction pressure is more and more big, we must promote the sustainable development of enterprise production and management, to realize the economic benefits, social benefits and environmental benefits of a win–win situation.

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Chapter 119
Building Life Cycle Energy Consumption Estimation Based on the Work Breakdown Structure

Jian Xiao and Xueqing Zhang

Abstract Energy consumption of buildings is one of the major sources of greenhouse gas emissions, frequently accounting for around 40 % of the total energy consumption in urban areas. Reasonable sustainability assessment requires effective and efficient methods for energy consumption estimation of buildings. With an aim to improve the accuracy in building energy consumption estimation, this paper proposes a life cycle building energy consumption estimation method based on the work breakdown structure. For each basic work package, the relevant construction business information can support a more accurate estimation of energy consumption and thus the integration of all basic work packages can enhance the accuracy in energy consumption estimation.

Keywords Work breakdown structure · Energy consumption · Life cycle

119.1 Introduction

The energy consumption has been widely evaluated for buildings for many years. It has been extensively monitored and reported in the architecture, engineering and construction industry to aid the architectural design in order to save energy and to create new research opportunities (Harris 1999). However, one problem is the

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accuracy in the estimation of energy consumption in the different phases of a building life cycle (i.e., product, construction, occupation, demolition, and disposal). The traditional analysis of the building energy consumption mostly focuses on the occupation phase, ignoring the product phase, construction phase, demolition phase and disposal phase (Alcorn and Baird 1996). The Work Breakdown Structure (WBS) can decompose the building elements into a manageable level as a classification mechanism and provide a common perspective of relevant construction business information as an integration mechanism. The relevant construction business information associated with each basic work package allows more accurate estimation of energy consumption of each work package in the life cycle and thus the integration of the WBS into the Life Cycle Energy Analysis (LCEA) would enhance the accuracy in energy consumption estimation of buildings over their life cycles.

119.2 Building Energy Consumption Modeling Based on WBS

The LCEA is an approach to calculating energy inputs for a building in its life cycle (Chen et al. 2001). Buildings are a main source of energy consumption and gas emissions. With increasing concerns on the environment, the LCEA has been applied in the total building process in order to reduce the energy consumption and gas emissions (Hu and Yu 2011). The total building process includes raw material preparation and production, transport into the building site, construction, maintenance and operation, demolition, transport from the building site and disposal (Ramesh et al. 2010).

Based on the Uniformat (Charette and Marshall 1999; CSI and CSC 2010), a building can be divided into four levels. Level 1 includes the largest element groups such as substructure, shell and interiors. Level 2 subdivides Level 1 elements into smaller group elements. For example, the shell is subdivided into the superstructure, exterior closure and roofing. Level 3 breaks each group at level 2 into individual elements. Level 4 further breaks the individual elements at level 3 into smaller sub-elements. For example, the standard foundation sub-element includes wall foundations, column foundations, perimeter drainage and insulation (Charette and Marshall 1999; Gao and Zhu 2008).

The life cycle of a building includes five major phases (Roger et al. 2000): product phase, construction phase, occupation phase, demolition phase and disposal phase (see Fig. 119.1). This paper proposes a life cycle building energy consumption analysis model based on the WBS. In Fig. 119.1, a is a variable representing a package at level 1, $a = 1, 2, \ldots, A$, where A is the total number of packages at Level 1 of the WBS. b is a variable representing a component at Level 2, $b = 1, 2, \ldots, B$, where B is the total number of components at Level 2 of the WBS. c is a variable representing an element at Level 3, $c = 1, 2, \ldots, C$, where C

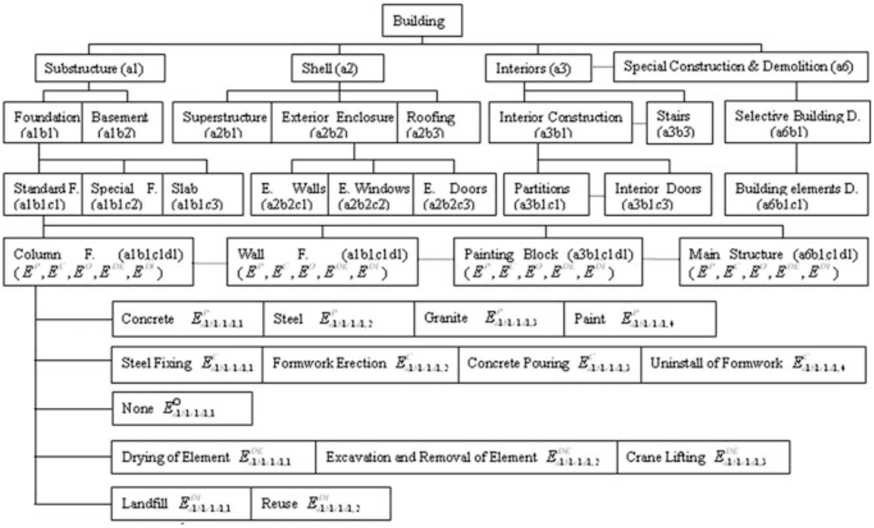

Fig. 119.1 Life cycle building energy consumption analysis based on work breakdown structure

is the total number of elements at Level 3 of the WBA. d is a variable representing a sub-element at Level 4, $d = 1, 2, \ldots, D$, where D is the total number of sub-elements at Level 4 of the WBS and so on.

As shown in Fig. 119.1 (Roger et al. 2000), the energy consumption of each work package in the building life cycle is estimated through the five phases: (1) energy consumption in the product phase (E^P), (2) energy consumption in the construction phase (E^C), (3) energy consumption in the occupation phase (E^O), (4) energy consumption in the demolition phase (E^{DE}), and (5) energy consumption in the disposal phase (E^{DI}). The energy consumption of each work package can be estimated by the energy parameters and material quantity parameters corresponding to each work package.

119.3 Life Cycle Energy Consumption Estimation

119.3.1 Product Phase

Energy consumed in the product phase includes the initial embodied energy and the renovation embodied energy. The former refers to the energy embodied in the raw materials that become the initial real building and the latter to energy embodied in the raw materials consumed in the renovations of the building over its lifespan. Based on Adalberth (1997), Chen et al. (2001), and Ramesh et al. (2010), energy consumption in the product phase can be estimated as follows:

(i) *Identification of material quantity based on the work breakdown structure*

Work package: WP = $\{WP_1, \ldots, WP_n, \ldots, WP_N\}$ where WP_1 to WP_N represents the N kinds of work package; **Materials**: $M = \{M_1, \ldots, M_m, \ldots, M_M\}$ where M_1 to M_M represents the M kinds of materials; **Quantity**: $Q = \begin{pmatrix} Q_{11} & \cdots & Q_{1n} & \cdots & Q_{1N} \\ Q_{21} & \cdots & Q_{2n} & \cdots & Q_{2N} \\ \vdots & & \vdots & & \vdots \\ Q_{m1} & \cdots & Q_{mn} & \cdots & Q_{MN} \end{pmatrix}$ where Q_{11} to Q_{MN} represents the MN kinds of materials quantity.

$$Q = U_M M_M^T \tag{119.1a}$$

(ii) *Determination of the embodied energy value*

Embodied energy: EB = $\{EB_1, \ldots, EB_m, \ldots, EB_M\}$ where EB_1 to EB_M represents the M kinds of embodied energy; **Waste factor** (Chen et al. 2001) in the production phase: WF = $\{WF_1, \ldots, WF_m, \ldots, WF_M\}$ where WF_1 to WF_N represents the M waste factor.

(iii) *Investigation of materials maintenance*

There are varieties of materials used to form a building. The materials maintenance largely depends on the lifespan between the building and materials themselves. It is well known that the design life span of building is usually 50 years. However, the materials have more (Concrete) or less (Plastic) lifespan than the building. Therefore, it is needed to account the coefficient λ (Chen et al. 2001) during the total life cycle. $\lambda = 50\left\{\frac{1}{L_{m1}}, \ldots, \frac{1}{L_{mm}}, \ldots, \frac{1}{L_{mM}}\right\}$.

(iv) *The total energy of the production phase*

$$P_i = EB_i \times (1 - WF_i)\lambda_i \tag{119.1b}$$

$$E^P = \sum_{i=1}^{M} \sum_{j=1}^{N} Q_{ij} \times P_i \tag{119.1c}$$

where E^P = energy consumption in the product phase; P_i = embodied energy per each material.

119.3.2 Construction Phase

The energy consumption in the construction phase is caused by construction activities such as mechanized operations of hammers, cranes, concrete pump and smoothing of soil (Cole and Rousseau 1992). It can be calculated as follows (Leo and Jens 2000):

$$E^C = \sum_{i=1}^{M} \sum_{j=1}^{N} C_{ij} c_i \tag{119.2a}$$

$$c_i = \sum_{l=1}^{L} p_l \cdot t_l \tag{119.2b}$$

where E^C = energy consumption in the construction phase; C_{ij} = the quantity of building material *i* dealt with in each process j; $c_{abcd,i}$ = energy intensity required for this process j *and building material* i; p_l = the rated capacity of mechanical equipment *l*; and t_l = the working time of mechanical equipment *l*.

119.3.3 Occupation Phase

Energy consumed in the occupation phase consists of heating, ventilating and air conditioning (HVAC), lighting, and equipment operation to maintain and keep the indoor environment day by day (Hirsch 2002). Energy consumed in this phase can be calculated as follows (Hu and Yu 2011):

$$E_{OO} = E_{OE} L_B = (S_{OE} K_{OE} + E_H) L_B \tag{119.3}$$

where E_{OO} = energy consumed in the occupation phase; E_{OA} = annual occupation energy; S_{OE} = the usable area of building; K_{OE} = the consumption intensity of coal and gas and the unit is MJ/m^2; and E_H = energy of heating in the occupation phase. E_H is calculated as follows (The ministry of construction 2001).

119.3.4 Demolition Phase

The building will be demolished at the end of its lifespan. Building demolition is a process opposite to building construction. According to Hu and Yu (2011), energy consumption in the demolition phase can be calculated as follows (Wenzel et al. 1994):

$$E^{DE} = \sum_{i=1}^{M} \sum_{k=1}^{N} D_{ik} d_i \tag{119.4}$$

where E^{DE} = energy of demolition phase; D_{ik} = the quantity of the building material *i* dealt with in each process k; and d_i = energy intensity required for this process k *and building material i*.

119.3.5 Disposal Phase

The demolished materials can be recycled, reused, recovered or moved as waste to landfills. The energy consumption in the disposal phase can be calculated as follows (Thormark 2000):

Types of disposal methods: $G^{method} = \left\{G^{method}_{m1}, \ldots, G^{method}_{m2}, \ldots, G^{method}_{mG}\right\}$; Numbers of disposal machines: $H^{machine}_{mGm} = \left\{H^{machine}_{mGm1}, \ldots, H^{machine}_{mGmh}, \ldots, H^{machine}_{mGmH}\right\}$; Types of final disposal components: $E^{finalm}_{mGmH} = \left\{E^{finalm}_{mGmH1}, \ldots, E^{finalm}_{mGmHe}, \ldots, E^{finalm}_{mGmHE}\right\}$.

$$\Delta E_{mGm} = \sum_{e=1}^{E} EF^{e}_{mGm} - \sum_{h=1}^{H} EP^{h}_{mGm} - ES_{m} \tag{119.5a}$$

where ΔE_{mGm} = the energy consumption in the different disposal method; $\sum_{e=1}^{E} EF^{e}_{mGm}$ = the sum of final component k energy consumption; $\sum_{h=1}^{H} EP^{h}_{mGm}$ = the sum of machine l energy consumption; ES_m = the raw material energy consumption.

$$EF^{e}_{mGm} = q^{final}_{e} \times e_{embodied} \tag{119.5b}$$

where q^{final}_{e} = the quantity of final component k;$e_{embodied}$ = the embodied energy of each component.

$$EP^{h}_{mGm} = pow^{h}_{mGm} \times \frac{q_{mi}}{pro^{h}_{mGm} \times per^{h}_{mGm}} \tag{119.5c}$$

where pow^{h}_{mGm} = the power of the machine; pro^{h}_{mGm} = the productivity of the machine; per^{h}_{mGm} = the percentage of utility machine; q_{mi} = the quantity of the waste materials.

$$ES_{m} = q^{start}_{m} \times e'_{embodied} \tag{119.5d}$$

where q^{start}_{k} = the quantity of start material m; $e_{embodied}$ = the embodied energy of each material.

119.3.6 The Life Cycle Energy

The total energy consumption over the life cycle of the building can be calculated as follows:

$$E = E^{P} + E^{C} + E^{O} + E^{DE} + E^{DI} \tag{119.6}$$

119.4 Conclusions

This paper proposes a life cycle building energy consumption estimation method based on the WBS in order to improve the accuracy in building energy analysis over its life cycle. This method can more accurately estimate the energy consumption in different phases of a building life cycle, which includes product, construction, occupation, demolition, and disposal. This WBS-based approach allows more accurate estimation of building energy consumption by incorporating the relevant construction business information associated with all work packages of the building.

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Chapter 120
Research on Railway Tunnel Construction Scheduling Technique Based on LSM

Liqiang Liu, Yisheng Liu, Yuanjie Tang and Qing Li

Abstract This paper analyzed the lack of schedule techniques for railway tunnel construction project. According to the linear project characteristics of the railway tunneling, attribute data standard for linear schedule of railway tunnel project have been studied. Moreover, an algorithm of railway tunnel project scheduling based on the Linear scheduling method is given. The algorithm is applied to an example of railway tunnel project to validate its effect.

Keywords Railway construction · Tunnel project · Linear scheduling method · Scheduling technique

120.1 Introduction

Tunnel project is typically linear construction project. Currently, the scheduling technique for the tunneling mainly adopts Network Planning Technology, among which Critical Path Method (CPM etc.) is the most frequently used. Traditional

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scheduling methods such as CPM works highly effectively in schedule making for the discrete and non-successive complex projects, but have found to be inappropriate for application to scheduling for linear and successive construction project (Yamín and Harmelink 2001). Since CPM describes construction progress of projects only at one-dimensional coordinate of time, it breaks the continuity of work for resources from one stage of an activity to another of linear construction project, and in no way could reflect accurately situations like spatial features, production rates (Chrzanowski and Johnson 1986). As for Tunneling, the planers pay more attention to the relationship between time, geographical position, the relationship between successor and predecessor activities, and production rates corresponding to different construction stages of activities. Linear scheduling method (LSM), has been developed specifically for linear construction projects (Johnston 1981; Harmelink and Rowings 1998).

This study made a comparison of current scheduling techniques railway tunneling. It also studied on the theory and data of linear scheduling model for railway tunneling according to the linear project characteristics of railway tunneling. Furthermore, an algorithm to schedule railway tunneling based on the LSM is given. An example of China railway tunneling is applied the algorithm to validate its effect.

120.2 Interview

As for linear projects, people responsible for management care more about activities' geographical positions and production rates (Kris et al. 2003). LSM have been developed specifically for linear construction projects. Linear construction projects are spatially continuous and consist of a few activities (usually with large quantities) that must be done in the same order or sequence (Hassanem 2002). LSM works as a highly effective tool to make linear projects schedule. In reference to characteristics, time and spatial location of linear project, LSM establishes the rectangular coordinate system, in which "X" stands for distance, "Y" for time, slope for "product rate". Each activity is drawn up at a time-space two-dimensional coordinate system in a LSM chart, in which the slope of the slanting line indicates the working speed (Vorster et al. 1992). Compared with CPM, LSM ensures the continuity of the construction activity or resources usage (Harmelink 1995), and this provides the powerful guarantee for the progress management and period control at the construction site.

Extensive research on theory and application of LSM has been carried out in Foreign Countries. Harmelink had developed the LSM to provide a level of analytical capability to the linear scheduling process (1995), and provided a method by which a controlling activity path can be determined in a linear schedule (1998). Ammar researched the control path of LSM (2001). Yamin provided a comparison of the CPM and LSM by identifying critical path. Mattila and Park compared the critical paths of RSM and LSM and concluded that their results, for simple activity configurations coincide (2003). Kallantzis presented a scheduling method for determining the critical path based on the time and distance relationships of activities (2004). Though the LSM has the above advantages in linear construction project compared with CPM, it has not found a wide acceptance in the construction industry. One main reason might be the lack of software package that is capable of enabling LSM (Mubarak 2010), and the lack of management theory system and data standard of linear construction schedule especially corresponding to specific construction project.

This paper investigate partial project as the research object, establish schedule model of the railway tunnel project based on LSM. The China Tunnel Construction Quality Acceptance Standard criteria railway tunneling activities are divided into eight categories.

120.3 Linear Scheduling Model for Railway Tunnel Project

120.3.1 The Category of Railway Tunnel Project Activities

Based on if the activity is throughout the entire project or not, the activity in the implementation process is continuous or intermittent, tunnel activities could be divided into: Continuous full-span linear (CFL), Intermittent full-span linear (IFL), Continuous partial-span linear (CPL), Intermittent partial-span linear (IPL), Full-span block (FB), Partial-span block (PB), Bar (B), as shown in Fig. 120.1. According to this category standard, classified the linear feature of the railway tunneling activities and coded them after investigating the railway tunneling properties as shown in Table 120.1.

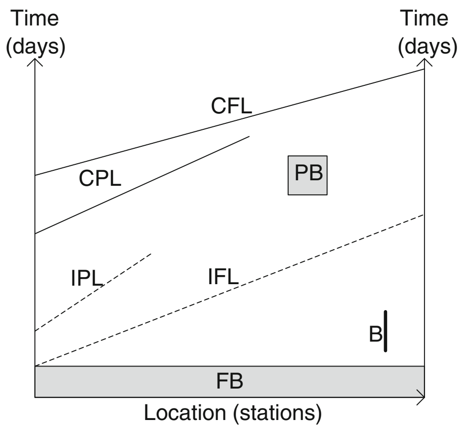


Fig. 120.1 The category of linear activities

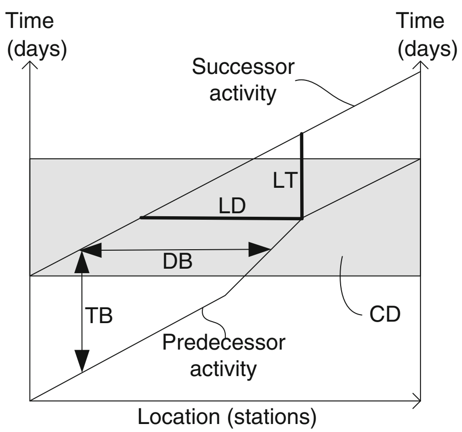
Table 120.1 Constraints of railway tunneling activities

Sequence	Activity name	Activity type	Predecessor	Constraints
A	Portal	B	–	–
B	Excavation and early support	CFL	A	LT
C	Lining	CFL	B	LD
D	Waterproofing and drainage	CFL	C	LT
E	Service gallery and affiliated chamber	IFL	D	LT
F	Subsidiary facilities	IFL	E	LT
G	Open cut tunnel	PB	–	LT
H	Site clearance	B	E	LT

120.3.2 Railway Tunneling Activities Constraints

It is not allowed to have two construction activities at the same time at the same tunnel construction location. Adjacent construction activities can be carried out in accordance with the finish to start or the start to the start logical relationship. Since construction safety, environments, technologies, and resources should be taken into account, we need have a certain space or time buffer to prevent interference from each activity. Time buffer (TB) is a time interval of two adjacent activities in a specific spatial location. For example, template cannot be removed before the concrete sets. Distance buffer (DB) is the distance separated by the horizontal level from the representatives of the two operations, i.e. tunneling line will not start until tunnel excavation reaches at 80 m to make sure operation safety. The relationship between two processes is determined by Least Time Interval (LT), Coincident Duration (CD) and Least Distance Interval (LD). For LT, it usually appears at the endpoints of two adjacent processes or the turning point of changing construction speed which is along Y axis in the figure. CD means the time range between two adjacent processes that are done at the same time. LD refers to the shortest distance of two adjacent processes which is along X axis direction in Fig. 120.2.

Fig. 120.2 Constrains of LSM



After studying the tunnel project organization design and standard procedure project specifications, proposed the constraint rules and relationship between adjacent activities as shown in Table 120.1.

120.3.3 Attribute Data of Railway Tunnel Activities

The railway tunneling partial project as activities In the LSM model of are usually described by time data, spatial data and thematic data. These data determine the spatial and temporal characteristics of each of the construction activities and adjacent activities constraints, which is the foundation of scheduling modeling based on LSM: Spatial data, Time data, and thematic data. As shown in Table 120.2, a portion of the data acquisition source have been given, such as mileage information from design file, while the other part need formula, calculation formula is as follows:

$DUT_j^i = LEN_j^i / RAT_j^i$ (5)	RAT_j^i	Production rate of activity i in section j
$ST_j^i = ST_{j-1}^i + DUT_j^i$ (2)	LEN_j^i	Quantity of work for activity i in section j
$ST_j^i = ST_j^{i-1} + LT_i$ (3)	DUT_j^i	Duration of activity i in section j
$FT_j^i = ST_j^i + DUT_j^i$ (4)	ST_j^i	Start date of linear activity type i in section j
	FT_j^i	Finish date of linear activity type i in section j
	DUT_j^i	Duration of linear activity type i in section j

Table 120.2 Attribute data collect description of the railway tunnel project activities

Data name	Variables	Unit	Data type	Data source
Start mileage	SM	km	Spatial data	Design document
Finish mileage	FM	km	Spatial data	Design document
Activity distance	LEN	m	Spatial data	Design document
Minimize distance	LD	m	Spatial data	Construction specifications
Start time	ST	day	Time data	Formula calculation
Finish time	FT	day	Time data	Formula calculation
Activity duration	DUT	day	Time data	Formula calculation
Minimize time	LT	day	Time data	Construction specifications
Activity name	ACT	–	Thematic data	Construction specifications
Activity type	AT	–	Thematic data	Construction specifications
Production rate	RAT	m/day	Thematic data	Construction specifications

120.3.4 Linear Schedule Algorithm for Railway Tunnel Project

Progress management based on the schedule, using the engineering data compilation the LSM progress of the Planning railway tunnel project schedule management is the core work of this paper. This paper designed a LSM algorithm of railway tunneling using by using Railway tunneling activities' Data collection standard in the Table 120.2. Figure 120.3 illustrates the algorithm.

Step 1: Collected and input data. The dividing of construction activities are defined according to the characterization of tunnel project.

Step 2: Establish the coordinate system. Select the first quadrant of plane rectangular coordinate system as LSM coordinate system, the abscissa (X axis) for spatial location axis of linear activities,the vertical axis (Y axis) for Timeline of linear activities. The x and y axis take the same unit length in general case, the interval scale scales selection should obey the follow principle:

(i) The Origin marks "0", identify spatial location of linear activities along the X axis, identifies duration of linear activities along the timeline (y-axis).
(ii) Spatial axis generally use tunnel project unit of measurement "meter" or milestones "DK" as coordinate value, the minimum scale with "m" integer times generally, the max scale value should be length of the tunnel project.

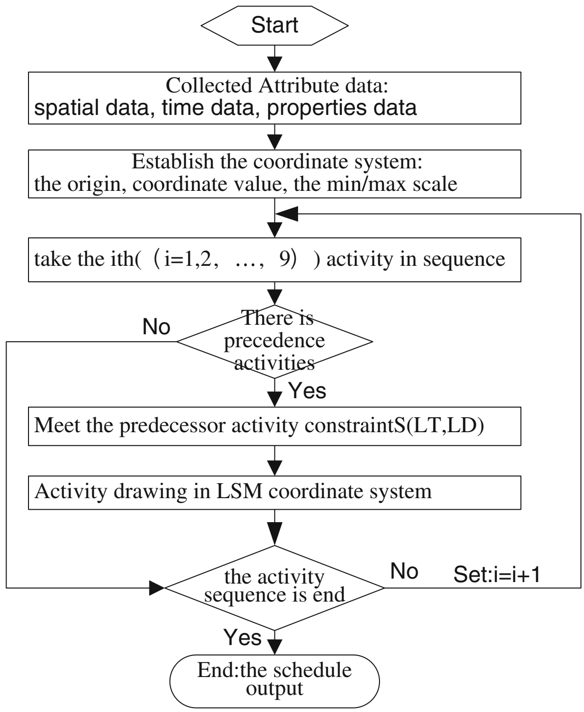


Fig. 120.3 Linear schedule algorithm

Table 120.3 The activity attribute data for linear scheduling of a tunnel project

No	ACT	AT	RAT	ST	FT	DUT	LD/LT	LEN	SD	FD
A1	Inlet portal	B	–	0	6	6	–	0	DK85 + 905	DK85 + 905
			4.2	6	18	12		52	DK85 + 905	DK85 + 957
			5	18	100	82		408	DK85 + 957	DK86 + 365
B	Excavation and early support	CFL	3	100	134	33	$LT_{AB} = 0$	100	DK86 + 365	DK86 + 465
			5	134	172	38		190	DK86 + 465	DK86 + 655
			3	172	221	49		147	DK86 + 655	DK86 + 802
A2	Outlet portal	B	–	221	226	5	–	0	DK86 + 802	DK86 + 802
			4.2	51	63	12		52	DK85 + 905	DK85 + 957
			5.2	63	141	78		408	DK85 + 957	DK86 + 365
C	Lining	CFL	3.5	141	170	29	$LD_{BC} = 80$	100	DK86 + 365	DK86 + 465
			5.2	170	207	37		190	DK86 + 465	DK86 + 655
			3.5	207	248	42		147	DK86 + 655	DK86 + 802
D	Waterproofing and drainage	CFL	4.5	57	256	199	$LT_{CD} = 6$	897	DK85 + 905	DK86 + 802
E	Service gallery and affiliated chamber	IFL	4	64	288	224	$LT_{DE} = 7$	897	DK85 + 905	DK86 + 802
F	Subsidiary facilities	IFL	3.45	75	335	260	$LT_{EF} = 11$	897	DK85 + 905	DK86 + 802
H	Site clearance	B	/	335	350	15	$LT_{FH} = 0$	–	DK86 + 802	DK86 + 802

Illustration Duration rounding up the figure. There is no open cut tunnel in the unit project

(iii) Time axis generally use time unit of measurement "day" as the coordinates value, with "day" integer times as the minimum scale, with duration as the max scale value.

Step 3: Procedure of drawing railway tunneling schedule with LSM.

(i) The activities drawing order according to the sequence of railway tunnel project activities. The first activity without predecessor activities will be drawn into the coordinate system on the basis of the attribute data and linear type directly.
(ii) Then choose second activity, judging whether the activity has precedence activities or not. If not, painted directly into the coordinate system, if predecessor activities exist, judge the constraints with predecessor activity, then draw the activity into the coordinate system with the attribute data and linear type. Then adjust the quantitative between adjacent activities of the initial LSM graph with the consideration of activities to meet the constraints.
(iii) Draw the activities orderly. When all tunnel activities were completed, that means all tunnel activities have been compiled into LSM schedule, the loop end.

Step 4: The linear schedule of railway tunnel project generate, output the scheduling.

120.4 Application

The example tunnel project is a unit project of a railway construction project in western China. The construction mileage is DK85 + 905 to DK86 + 802, with total length of 897 m, imports at DK85 + 905, exports at the DK86 + 802, with curved walls with invert the structure of reinforced concrete lining. Tunnel-way

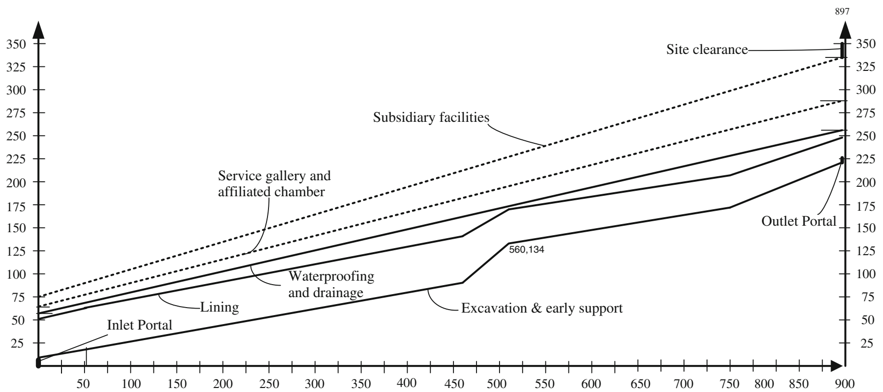


Fig. 120.4 Linear scheduling of a tunnel construction based on LSM

excavation is in one direction with parallel flow shop way. Each construction activity must be carried out in accordance with the lap logical relations.

In the illustrated example, according to the established standards of attribute data be collected. The activity attribute data for linear schedule of tunnel project as shown in Table 120.3. This paper utilizing the data given in Table 120.3, using the proposed algorithm, compiled the schedule of tunnel project based on LSM, as shown in Fig. 120.4.

120.5 Conclusions

This study presents an algorithm for compiling railway tunnel project schedule as linear project by LSM. It also provides the standard of data acquisition for railway tunnel activities, and realizes the formulation of linear schedule of railway tunnel project. The algorithm is applied to an example of China railway tunneling to validate its effect.

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Chapter 121
Solar Design in the Application of the City Planning

Xia Wang, Ze-Song Wei and Xiaolong Pang

Abstract This paper reviews the experience and wisdom of using sunlight in city from ancient to modern times. Then, it addresses the concept of solar envelope and its relationship with architectural form, winter and summer sunshine, maximum plot ratio and street orientation. It's imperative for city planners and constructors to identify the importance of transferring from solar oriented buildings to solar directed cities, and apply the concerning theory and method to determine road orientation, width, street block location and architect shape in the process of city planning.

Keywords Sunlight · Solar envelope · Urban planning

Solar radiation is one of the natural energy which has comparative advantage against other kinds of energy sources for its renewable and pollution-free characteristics. At present, although solar energy in architectural design has been used for many years, how to adapt to the sunshine running trajectory, and utilize solar energy strategy in urban community or urban planning design, has been paid less attention by planners and city builders. The intention of a single passive or active solar architecture and planning a populous community or city is to bring delighting to each building. Planners should utilize the characteristics of natural light, and achieve the balance between creating a comfort urban living environment and maximize FAR (Floor Area Rate). Through the planning and architectural design

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methods, it's imperative to optimize the environment, and create a city of low carbon and energy saving.

121.1 The Ancient Wisdom

Early in the fifth century BC, the ancient Greeks built Olynthus city. There were about 2500 people living in the city. The street grid is formed by north–south and east–west direction roads which are vertical each other, while all the houses are built around a courtyard. The houses facing south of the street can get sunshine directly from south, and the houses of the north street get sunshine into the courtyard. The layout of the streets and the houses insured all the houses receive sufficient sunshine.

In the early eleventh century and the twelfth century, in the city of ancient Pueblo in North America, Indians applied strategies to utilize sunlight. For example, houses are seated east to west to make sure that each building is facing south. Street is designed with appropriate width. Houses are dented planned to guarantee sunshine in winter and shadow in summer (Fig. 121.1).

121.2 The Use of the Sun in Modern Urban

City Barcelona is undoubtedly the most extraordinary example of city planning in the middle twenties. With its complete street space system and unique multilayer high density neighborhood form left deep impression to people, it was considered to be the largest existent planning urban according to sunshine, and fully represents the close relationship between urban development and usage of sunshine (Fig. 121.2).

Planning in space reflected a large number use of indifferent grid block. 550 blocks covered the scope of 9 km^2. The size of each block was 113.3 × 113.3 m and blocks are separated by city road of 20 m width (Fig. 121.3). Planners Cerda planned the building which can maximize sunshine and natural ventilation inside each apartment of block plot through 4 methods. First of all, he suggested the building height should be lower than 16 m on a 20 m width street. Secondly,

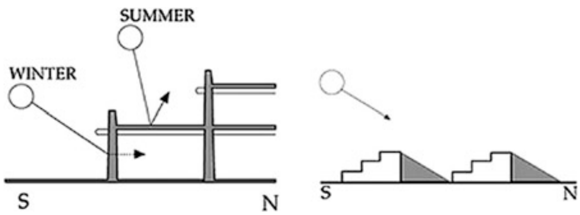


Fig. 121.1 Houses of Indians in ancient pueblo

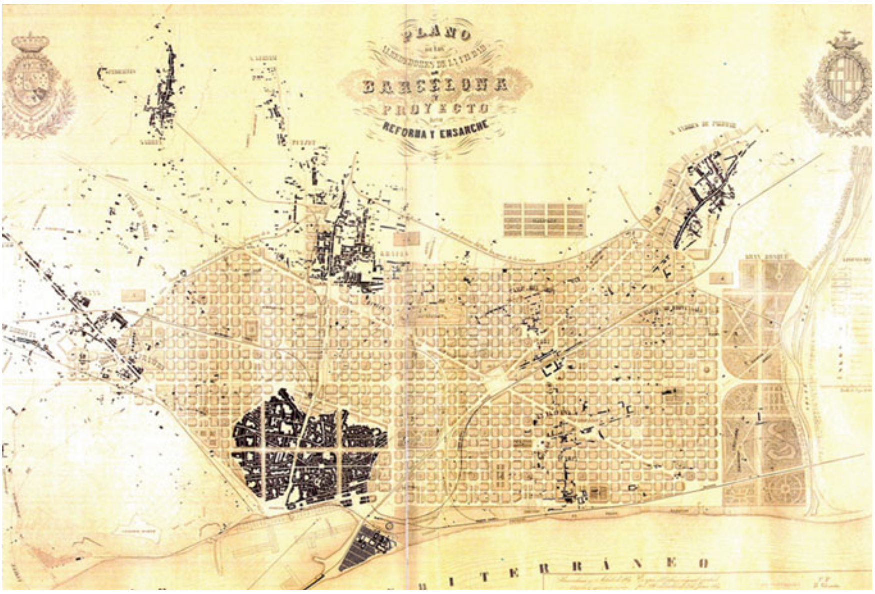
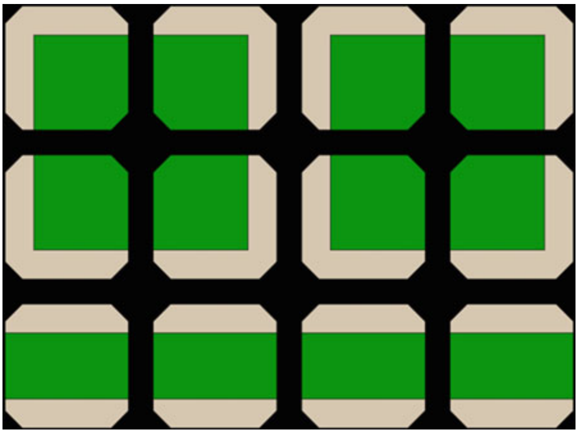


Fig. 121.2 The Barcelona aerial view and plan

he utilized parallel or L shape layout to organize five-storey buildings to acquire sufficient sunshine and fresh air. Third, each square blocks in the four corners made the tangent of 45°, form neat and tidy streets of octagonal profile, so further improved the smooth arrival of the nature of the sun. Finally, he decided not to plan street grids along the basic orientation, but along the diagonal grid, all of the apartment get more opportunity to acquire sunshine in the day, and to provide appropriate shadow for all of the streets.

Fig. 121.3 Planners Cerda's design for block model



121.3 From the Location of the Building by the Sun to the Location of the City

From the history of the city development, we can see, the passive solar design that widely used in architectural design, as long as adopt scientific and the more experienced planning strategy, can be the same used in urban planning.

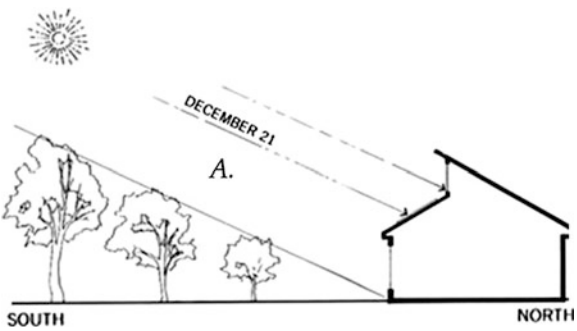
121.3.1 The Solar Access

The solar access is pointed to the sunlight directly illuminate on to the building's base, building palisade structure surface and the condition of the house (Fig. 121.4). The solar access boundary depends on how high the building ahead will hinder them to get the sunshine. If built a new building on the south side of the existing buildings, they will be restricted by the conditions of the sunshine for this building. As long as not enter the "the solar access", the new building won't cause harmful cover to the original building.

121.3.2 Solar Envelope

The honorary professor of Architecture School in American South California University, Ralph Knowles began the research in the 1970s. Knowles invented the concept of "Solar Envelope". The invention of Solar Envelope is the outcome of the combination of the time and space, its size and shape is decided by the shadow that fell on adjacent buildings or on the ground at certain time, and decided by the daily trajectory and seasonal vertical dimension (distance) of the sun in its range, its shape is more constituted by the tilt face, their forms are different pattern of geometry. The method according to the specific area space, through the adjustment

Fig. 121.4 The solar access



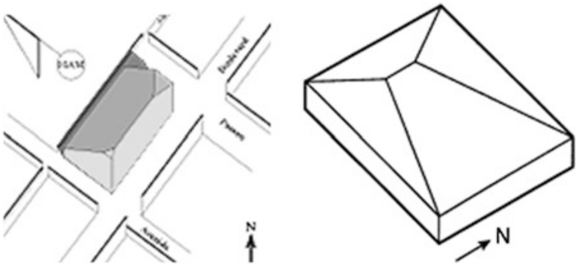


Fig. 121.5 The basic principle of "Solar Envelope"

of normal direction surrounding every building facade, make the building arrive to the biggest volume capacity in the condition of not keep out sunshine near the building (Fig. 121.5).

121.3.3 Solar Envelope and Architectural form

"Envelope" is first according to the surrounding conditions (mainly is the sunshine requirements). With computer produce, it can decorate the biggest three dimensional space range of building, and using the maximum volume as calculating target. As long as no more than building envelope body, building will not only ensure the own sunshine lighting, and not to keep out to the adjacent buildings. "Envelope" can be applied to single building, and it can also be applied to building group, the architectural colony, a regional and even the entire city. The buildings fill the fictional "Solar Envelope" and city blocks will have unique shapes. Using analysis method of "Solar Envelope", we can adjust to the building form, the position, its entrance and organized condition around the city open space,

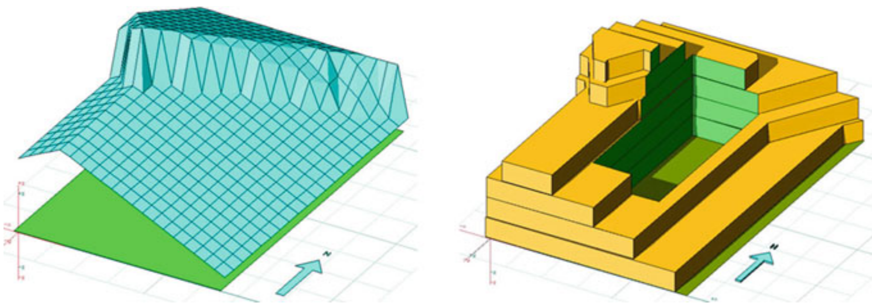


Fig. 121.6 Filing "Solar Envelope" building and city blocks will have unique shapes

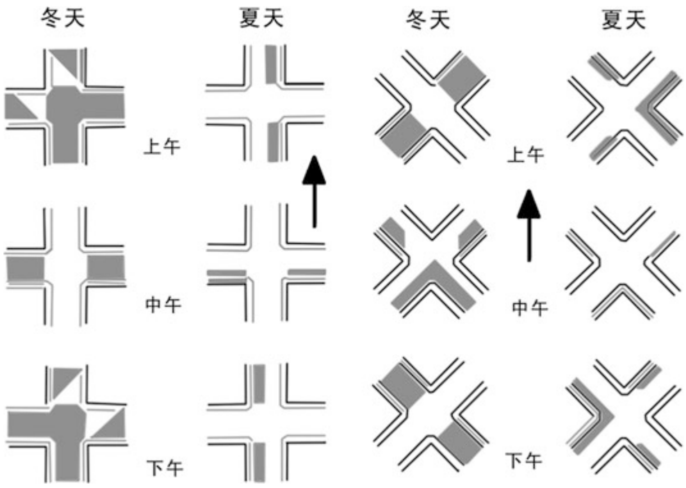


Fig. 121.7 The shadow contrast of different road orientations

in order to ensure the sunshine condition of the specific location in the space and complying with the design purpose (Fig. 121.6).

121.3.4 "Solar Envelope" and Streets Directions

The size and shape of "Solar Envelope" are influenced by the direction of the streets running. The most common shape is the so-called north–south oriented chess grid road system. In the book, "the Orientations of Construction and Sunshine Planning", William Atkinson spent a whole chapter to discuss the importance of the streets direction in sun light planning. After conducting analysis and verification, he maintains that, in order to ensure that all buildings on the both sides of streets to have good lighting conditions, the city street should take the form of 30–60° angle between street and meridian. The dedicated intersection angle can make full use of sunshine, save the limited city area. From this perspective, the road grid to south and north may be the worst arrangement. In the streets of east–west direction, the pavement receives sunshine less than six months. Building on the south side of the street is in the permanent shadow, east–west streets in winter is too black and cold, while too bright and hot in the summer. When the streets is planned with certain angle with and south and north square nets, the shadow of the building falling on the ground will be much less. The tilt grid in winter, each road can enjoy the direct sunshine at certain time from 9 a.m. to 3 p.m., in summer, every street can have the suitable cool (Fig. 121.7).

121.4 Conclusions

By applying "Solar Envelope" into city planning, we can greatly reduce the energy demand for building heating, cooling and lighting, thus depend less on fossil fuels. At the same time, "Solar Envelope" can retain a high and reasonable city density, and contribute to the development of public transport, bicycle and pedestrian traffic.

Chapter 122
Discussions on Integration Designs of Solar Collectors and Building Envelopes

Lan Chen, Ya-Fei Zhang, Wen-Jing Liu and Jia-Huan Yin

Abstract This paper briefly summarized design principles and the development process of integration of solar collectors and building envelopes in China. Through analyzing the current situation of integrated positions, tilt angles and detailed conformation designs of solar thermal collectors, some existing problems and their causes were pointed out, and then solutions were put forward including correcting policy guidance, optimizing solar collector products and integration design, and promoting architects to master technologies of buildings integrated solar systems.

Keywords Solar collector · Building envelope · Building integrated solar system · Detailed conformation design

122.1 Introduction

Due to it has been a significant strategy to utilize solar energy as one kind of clean and renewable energies for sustainable developments of today's human society, buildings integrated solar systems become important trends of contemporary

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architecture. As the most mature, commercial and economically competitive solar thermal utilization technology, utilization of solar water heating system grows fastest and most widely in China.

The device to absorb solar radiation and transfer it to the heat transfer medium is called solar collector. Solar collectors are key components of various solar water heating systems and generally need to be fixed on some parts of building envelopes such as roofs, exterior walls, windows, doors, and veranda fences. It is necessary to study integration designs of solar collectors and building envelopes to ensure that solar water heating systems can operate safely, efficiently and reliably, as well as can be combined with buildings' functions, spaces and styles in harmony.

122.2 Principles of Integration Design of Solar Collectors and Building Envelopes

According to Chinese "Technical code for solar water heating system of civil buildings" (GB50364-2005), solar water heating systems should be included in the design of building projects, and should be planned, designed and constructed with buildings synchronously. Following are some basic principles of integration design of solar collectors and building envelopes:

(1) To make full use of solar energies and ensure that solar water heating systems can operate efficiently and stably (11CJ32).
(2) To ensure both solar water heating systems and buildings are safe to peoples during systems' whole life cycle.
(3) To meet requirements of all functions of building envelopes including load bearing, good performance and aesthetic finish.
(4) To be harmonious with building appearances.

122.3 The Present Situation of Integration of Solar Collectors and Building Envelopes

122.3.1 Evolution Progress

In the early stage of application of solar water heating system in China, there were not national technical code and integration design yet, and ordinarily users chose integral collector storage solar water heaters and installed them to pre-existing building roofs or exterior walls by themselves. That sizes, forms, and installation positions of solar water heaters varied optionally and disorderly made architectural appearances and cityscapes untidy and ugly. Even worse was several serious problems emerged. For instance, added pipelines damaged waterproof layers and causing water leakage when they past trough roofs or exterior walls, metal shelves which support heaters would fall down and hurt somebody, some safety risks were brought out as lack of measures to bear added loads and protect solar heaters from wind and lightning strikes.

With the rapidly growth of the utilization of solar water heating systems, Chinese government has issued various supportive policies, technical codes, standard designs etc. so that solar water heaters can be planned, designed and constructed with buildings synchronously and are installed in order. At the same time, a new type of solar water heating system with the heat storage tank separated from the solar collector is widely used gradually, and the independent solar collector can be combined with roofs, exterior walls, and veranda fences more closely.

122.3.2 Integration Positions of Solar Collectors

In order to ensure solar water heating systems can operate efficiently, solar collectors should be integrated into building envelopes on appropriate locations. The first choice is the place on roofs as solar radiation is the most abundant there, followed by places on exterior walls and veranda fences. Designer should avoid choosing such places as the bottom or the recess of a building, and other parts likely shaded by surroundings.

122.3.3 Tilt Angle of Solar Collector

To obtain the maximum amount of solar radiation, it is best to make the tilt angle of a solar collector to change according to the sun track or to be adjusted periodically, but in these ways the initial investment will greatly increase and it will be difficult to operate, so currently the solar collector is often installed at a constant tilt angle which is consistent with the local latitude generally (Hai and Lin 2011).

It is easier and more coordinating with building facades to set solar collectors on exterior walls or veranda fences vertically than at a optimum tilt angle, but solar collecting efficiency will reduce when evacuated tube solar collectors arranged vertically or flat plate solar collectors are chosen. The mode to set solar collectors at a optimum tilt angle need relatively complex detailed conformation designs and such physical objects as metal brackets, cantilevered slab, or sloping building components to support collectors.

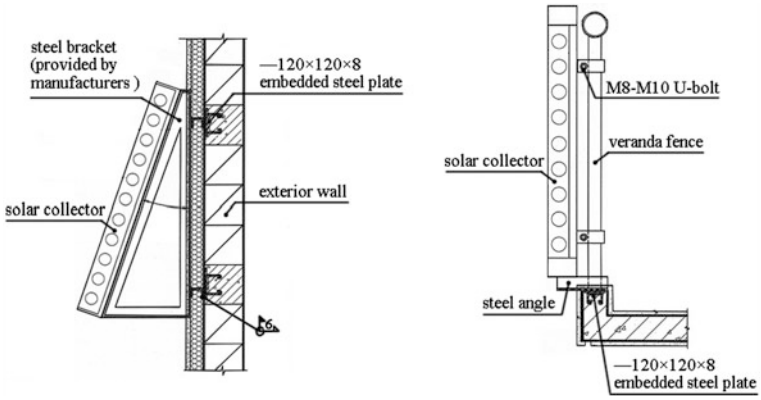

Fig. 122.1 Two examples of detailed conformation design of solar collectors integrated on building envelopes vertically or at a certain tilt angle with no cantilevered slabs (06J908-6)

122.3.4 Detailed Conformation Designs of Integration

Nowadays, although the degree of the tilt angle of collectors varies, detailed conformation designs of collector integration can be classified into two types according to whether there are slabs cantilevered from buildings structures to support those collectors.

One is that there are no cantilevered slabs, so solar collectors are directly installed on building facades vertically or fixed on some metal brackets to keep a certain tilt angle (Fig. 122.1). This integration way of solar collectors is similar to the early installation way of air conditioning outdoor units and with potential safety hazards. If the connection components used to fix solar collectors such as steel angles, bolts and metal brackets are rusty and destroyed over time, solar collectors would drop and hurt peoples and the harm would be more serious for those on high-rise buildings. In addition, it is also inconvenient and dangerous for workers to install, repair or replace solar collectors.

The other is that slabs cantilevered from building structures are designed to support solar collectors, and the span of the slab alter with the tilt angle of collectors (Fig. 122.2). In relative terms, this kind of design is superior to the former as it is more safe and expedient.

122.4 Analysis of Existing Problems and Solutions

122.4.1 Existing Problems and Causes

Regarding integration design of solar collectors and building envelopes, the above analysis shows that there are following problems at present.

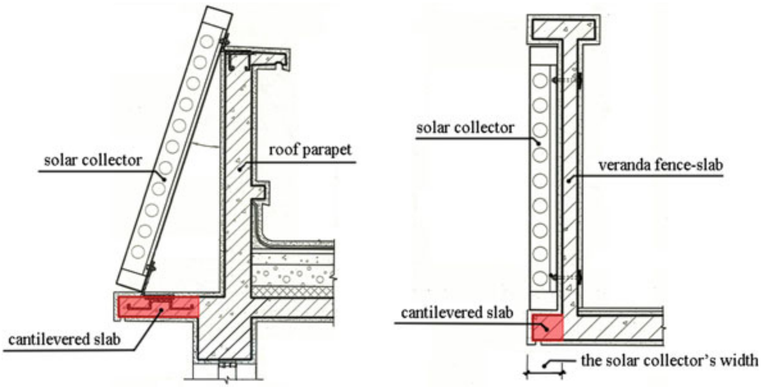

Fig. 122.2 Two examples of detailed conformation design of solar collectors integrated on building envelopes vertically or at a certain tilt angle with cantilevered slabs (06J908-6)

(1) Some existing standard designs as those have no slabs cantilevered from buildings structures to support solar collectors would cause potential safety risks.
(2) Since the fact that the service life of solar collectors far less than it of building envelope components are ignored, most of existing standard designs take no account of how to make solar collectors to be maintained or replaced safely and conveniently with no damage to building envelopes.
(3) Existing standard designs do not solve the function contradiction between solar collectors and building envelopes. For example, the latter makes the former could not be in better working conditions, and even makes its service life reduced, and the former cause basic performances of the latter such as thermal insulation, natural lighting, and water tightness get worse (Kuang 2006).
(4) Only collecting heat this single function is used now, other multiple potential functions of solar collectors such as decoration, sun shading and heat preservation need to be exploited.
(5) The color, size, shape, texture and style of solar collectors are often monotonous and not harmonious with building appearance, so that aesthetic feeling of the total building and the surroundings would be destroyed.

Causes of above problems are not only type, size and appearance of solar collectors are limited, but also architectural designs do not coordinate with solar system design. At present, most of works to design and construct building integrated solar water heating systems are done by solar equipment manufacturers, and most of architects just make some demands about safety and details to manufacturers or directly use national standard design. Many architects do not understand building integrated solar water heating systems sufficiently, and they also rarely think and study to create excellent integration designs actively. It is hard to improve design level only depending on unilateral efforts of solar equipment producers.

122.4.2 Solutions and Suggestions

In response to above-mentioned problems and causes, some suggestions and solutions are proposed here:

(1) The Government should issue policies and measures to define benefits and obligations of relevant parties involved in building integrated solar water heating system projects including solar system manufacturers, building project developers, professional designers and homeowners, and to coordinate the relationship among them. Especially the enthusiasm of architects should be encouraged and promoted as far as possible, so that they will regard the integration design of solar systems as one of the necessary parts of architectural design and accomplish it elaborately.
(2) The development of standard, modular and component-based products of solar water heating systems need to be actively furthered, to make products match buildings better. At the same time, the detailed conformation design of integration between solar collectors and building envelopes need to be studied seriously, to make the combination more coordinated in functions, spaces and forms. National technical codes and standard designs also need to be improved.
(3) Architects should be trained to fully understand the importance of solar systems in architectural design, to master design knowledge and techniques of building integrated solar water heating systems, and to actively cooperate with plumbing engineers and solar equipments manufacturers.

122.5 Summary

The integration design of solar water heating systems with building envelopes has been greatly improved after years of efforts of the solar energy industry and the construction industry nowadays, but there are still some safety, function and aesthetics problems. It is meaningful to study and innovate on the basis of existing achievements, and then to develop more suitable solar products and more safe, practical and esthetical detailed design.

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Chapter 123
Study on Collaborative Design of Green Building Based on BIM Technology

Haisha Xia and Kuangyi Yi

Abstract According to synergy and efficiency problem of today's green building design, this article explores multi-system collaborative design model relying on BIM techniques as digital design platform in the green building design, that combines building information modeling (BIM) technology development and BIM application of Beijing Jiaotong University team in SD competition. This model achieves multi-disciplinary collaboration in the design stage, precisely controlling of building performance, providing an efficient digital platform for green building and strong support for promoting the development of green building.

Keywords Green building · BIM · Digital design · Collaborative design

123.1 Collaborative Design Problem in the Development of Green Building

From the view of sustainable development, there are problems and contradictions between in the theory and practice of design, the design and construction management, the design and materials and equipment in green building development. At the same time, there is a considerable problem in the existing traditional design procedures and methods.

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Firstly, the architect is lack of support of implementation of the new design concept in green architecture design, and design professionals are lack of effective collaboration and interaction. Traditional architectural design and system design of structures and equipment is completely torn off, and there is clear the sequence of points in time. So designer consider energy consumption and environmental performance issues after determined the main factors of design such as orientation, shape, layout, window to wall ratio and so on. The result is that the design is forced to resort to complex or expensive to achieve an effect. These reasons often lead building environmental performance to deviate from the requirements of green building.

In addition, until the computer is widely used today, during the green, eco-building design, most architects and engineers still rely on their own experience, or reference to other ecological building design case, and apply the existing design techniques, energy-saving technologies. They are lack of scientific analysis and calculation for testing effect of green, energy saving, economic in design of programs and project. This phenomenon is more prominent in the period of today's large-scale construction in China.

Thus, for the green building design of sustainable development, a core issue in the design of green buildings is how to improve the exchange of architects and professionals in the integration design patterns; how to simplify the design process, allowing designers to establish a more rational basis, the establish on the basis of scientific qualitative and quantitative analysis, that the rational design decisions affect the design decision-making process.

Green architecture design is a holistic design that requires the full participation of all professionals and technology integration. A successful green building design must be the result of close coordination between the architects and other engineers. Therefore, the core areas to solve these problems and contradictions is to build a new operating mode: multi-system collaborative design mode. Multi-system interaction design approach helps to break the gap between the professional and strengthen exchanges and cooperation between the various professional, and provide organizations guarantee for the implementation of the full life cycle design (Xia 2006). BIM technology provides possibility to achieve this goal.

123.2 BIM Technology and Design Application Prospects

BIM (Building Information Modeling) is also known as building information model, that is engineering data model based on the 3D digital technology and integrated of all relevant information of construction projects. BIM technology provides a strong support to solve architectural design collaborative problems and promote the development of green building (Smith 2007).

123.2.1 The Main Features and Design Advantages of BIM Technology

BIM has five major characteristics: coordination, visualization, simulation, optimization and printing. It provides excellent design and coordination between different project participants, the different software. It has its own unique advantages in strengthening quality control, improving communication effectiveness and production efficiency (He 2011).

(1) Coordination: BIM will place original independent design results between the multi-members, multi-disciplinary, multi-system in a unified, intuitive 3D collaborative design environment. It avoids unnecessary design errors because of misunderstandings or communication behind time. It improves the design quality and efficiency.
(2) Visualization: BIM visualizes professional abstract two-dimensional construction to three-dimensional. Professional designers and non-professionals have efficient and clear judgments about project requirements.
(3) Simulation: BIM achieves the construction process and results, which requires in the real scene in the digital virtual world. It can minimize the regret of real world in the future.
(4) Optimization: With the front three characteristics, it makes the design optimization become possible and further protects the perfection of the real world. This is especially important to more and more complex modeling architectural design.
(5) Printing: Based on BIM the outcome of the project construction plans and tables will ensure the accuracy, high quality and innovation of the final product and engineering design enterprises.

At the same time, adapting to green building design needs in today's Internet age, BIM has following three major advantages:

(1) The new informationization means to improve the design efficiency.

BIM software is based on the three-dimensional space. We can observe, think, refine and modify its shape, modular by changing view in the design and finally to the program identification.

After completion of the architectural concept design, architects can make use of BIM software for preliminary design and detailed design. Several designers involve in the design in the same building information model, and share the related information each other. So everyone's work in a timely manner reflected in the model and the other designers are aware of the latest progress of the design. It is conducive to collaboration between team designs. At the same time, all drawings directly generated from the model, all modifications and changes are automatically reflected in all of the files of the entire project. Because building information model carrying materials and pricing information of building components, you can easily use this information to design economic evaluation, that provides a strong guarantee for the control of the entire project costs and improve the economic benefits of the project.

Therefore, the building information model can combine with the concept of green building design phase, preliminary design stage, the stage of detailed design and economic evaluation stage in the design, that can make the entire design to reduce costs, improve work efficiency.

(2) Collaborative design platform to improve collaboration capabilities.

The future of green building design must develop in the integrated and collaborative design direction. Integration reflects in two aspects, the integration of design information and the integration of the design process. On the basis of information integration, using of the new technology of computers and networks, it can organize the professional designers design in a collaborative work environment. The building information model can take on this task, it is digital information model for the entire construction project, all professional design information is added to this model, therefore, it is information-integrated entity. In this way, we can use it as a basis to establish a collaborative design platform that professional design staff can participate in and work, thus achieving the integration of the design process. In the source of information—the architectural design stage, it can establish a scientific building information model, which is able to support the life cycle of construction project and the environment of integrated management. Application of building information model, information are all integrated into the model, from the technology to ensure the information is not lost, so that you can virtually eliminating the phenomenon of "returning".

(3) Accurate performance analysis to improve design quality.

Making use of BIM software, the designer can do visualization performance analysis of various aspects of design object, such as sunlight analysis, spatial analysis, volume analysis and so on, that greatly improve the ability to grasp green building performance of the design process. Because we can add a variety of information of material in the building information model, such as the heat transfer coefficient, surface heat transfer coefficient, density and a variety of mechanical indicators, it create the conditions to carry out real-time performance analysis, energy consumption analysis, structural analysis. You can also use the building information model to analyze changes in the entire life cycle of the building, that create conditions for the building information management of the entire life cycle. Therefore, BIM technology provides designers with a richer set of design tools, and enhances a number of additional design capabilities, and better able to ensure the quality of green building design.

123.2.2 BIM Application Prospects for Green Building

Based on the database of physical and functional characteristics of the project, BIM realize the evolution from traditional 2D design to dynamic three-dimensional modeling. Architect is decision-maker early in the project. They can clear the tone of the technical aspects for the project as soon as possible by using BIM platform, that facilitate other professional to carry out collaborative design. For example, HVAC engineers frequently use the BIM simulation technology in piping systems and air handling equipment. Electrical engineers use BIM to do energy consumption analysis.

Based on BIM technology, green building design in some advanced countries began to try to established engineering data model of all relevant information in an integrated construction project on the basis of the three-dimensional digital technology, which support integrated management environment in construction projects, and significantly reduce risk of construction projects in its construction and come into a virtuous cycle of sustainable development. So, architectural design software based BIM support future development direction of green building design.

123.3 Applications of Green Architecture Design Based on BIM Technology

Green architecture design mostly pay attention to use efficiency of energy and resource, that can be divided into a series of building performance issues, such as architectural lighting and sunlight analysis, thermal analysis of the buildings and their materials, building energy analysis. Such question concerns a huge number of data, and developing data file or inputting file for large-scale analysis software is a great challenge. The biggest advantage of the application of BIM technology for building performance design is that the architect can conveniently obtain intuitive, accurate building energy performance feedback in the early stages of the architectural design.

Checking conflict of the professional pipeline in the design and construction deepening stage by BIM—3D information model is one of the relatively intuitive and prominent features of BIM. Especially for more complex projects, BIM automatic detect conflicts of architecture and structure and all kinds of electrical and mechanical pipeline, and timely optimize changes during the design phase to avoid time and material waste caused by reworking after finding conflict at the scene.

Because BIM is a digital model with the material, size information, you can easily calculate the amount of various materials if model information is enough. For prefabricated component, BIM provide strong technical support for more accurate processing and connectivity. With BIM technology, it can accurately estimate building materials, and avoid design wrong size of prefabricated component, that will achieve the purpose of reducing material waste.

In the construction process, by means of BIM technology, we can also pre-simulate the management of the construction site, and optimize the stacked position of building materials, methods, and the location of construction equipment, workflow. We can propose the most time-saving and resource-saving programs.

We participate in the SD competition by using BIM technology, and try to solve the problems and contradictions of the Green building collaborative design, that specific application in the following areas.

123.3.1 Collaborative Design of Green Building Sites

In the conception stage of SD competition, using of information models in Revit, our team can analyze and simulate the building shadows change and site solar radiation throughout the year by related performance-based simulation software, that help the designer to determine the solar photovoltaic modules configuration of the site.

123.3.2 The Generated Design of Green Building Volume and Shape

In the design phase, the volume ability of Revit can help us to refine the shape of the building or buildings. At the same time, it can automatically generate the walls, roof and floor after volume determined, and it can also determine the construct that architects need and display the results, generated architectural design for the environment.

123.3.3 Collaborative Design of the Indoor Environment

By the BIM tools and methods, we integrate a variety of different forms of space, materials, systems, and adapt them to physical and mental health needs of different groups. Information models created in Revit can scientifically analyze sound, light, heat, air quality and other aspects by putting standard file—IFC or GBxml into Ecotect and other software, and thus simulate and analyze the energy consumption of the building.

123.3.4 Collaborative Design of Green Building Envelope

BIM can also help us to analyze the pros and cons of heat of each specific part of the construction envelope, which include: heat gain and heat dissipation of the external structure, heat gain of doors and windows, heat and cold air infiltration, heat transfer capacity of indoor building envelope and so on. BIM can simulate building facing and external structure settings of the window, and then analyze the room natural lighting, ventilation and air conditioning as well as passive solar heating (Fig. 123.1).

123.3.5 Collaborative Design of Architects and Other Professional

In this SD competition, by the BIM, building information can be passed from the architectural profession to the structure, HVAC, and then seamlessly connected to the construction, management, and even the property management after building using. In this series of processes, building information constantly is improved and ultimately makes building sustainability has scientific judgment and management tools. BIM is passed in every professional. A professional architect or engineer strictly practices the sustainability of the building, and ultimately, sustainable design and BIM bring the maximum benefit project for investors and building owners.

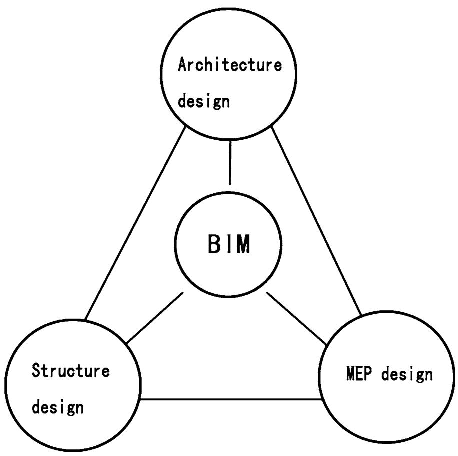

Fig. 123.1 Collaborative design based on BIM (*Source* self-drawn)

123.4 Conclusions

With the promotion of energy saving and green design concepts, green building is becoming the mainstream of architectural design. In order to achieve the goal of collaborative design of Green Building, BIM technology provides an important technical means. In support of BIM technology, green building collaborative design level and controllability of quantify will be a comprehensive manner. We can predict that the design will have a new revolutionary development if the green building has support from BIM technology platform. Architectural space and form is no longer "designed" out under the traditional concept, but "generated" out according to environmental conditions by means of parametric.

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Chapter 124
Research on the Structural Design of Real Estate Green Supply Chain

Jingjuan Guo, Ting Xie and Aibo Hao

Abstract The real estate industry has the characteristics of being highly associated with other industries, long industry chain, great resource consumption and so on. Though promoting green sustainable development strategy in the real estate industry, it can optimize the industry structure, and improve urban living environment. Referring to the characteristics of the real estate supply chain, this article introduces the real estate green supply chain management, preliminarily establishes a green supply chain structure after the component analysis and studies its operating characteristics, in order to provide some theoretical basis for the green real estate industry.

Keywords Real estate · Green supply chain · Structural design

124.1 Introduction

In the modern world, environment and resources have increasingly become two key factors which affect and restrict the economy development of the human society. As a pillar industry, the real estate industry has the characteristics of being highly associated with other industries, long industry chain, huge consumption of resource and is closely related with the life of people. To promote green sustainable development strategy in the real estate industry, not only can pull the

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green production of the upstream industries, but also boost green consumption in downstream industries, promote the structure optimization of the real estate industry and at the same time play an important role in promoting the sustainable development of urban economy. The green supply chain management will be an effective means for the sustainable development of the Chinese real estate industry.

There aren't enough researches about the development of the real estate industry to use the green supply chain management home and abroad, but they all affirmed the significance of the green supply chain for the real estate industry and even green social development. Some researches have proposed the main part of the green real estate supply chain management, and the real estate business strategies based on the green supply chain management (George 2000; Huang and Wu 2003; Liu and Zhang 2005; Zhang 2009). Overall, the whole structure and operation mode of the green supply chain still remain in the conceptual stage. Based on the previous study and referred to the characteristics of the real estate supply chain, we'll introduces the real estate green supply chain management, preliminarily establishes a green supply chain structure after the component analysis and studies its operating characteristics, provide some theoretical basis for the green real estate industry.

124.2 Characteristics and Elements of Real Estate Green Supply Chain

124.2.1 Characteristics and Requirements of the Real Estate Green Supply Chain

Green supply chain is the modern enterprise management mode under the guidance of the sustainable development, which considers the environment impact and resource efficiency. It aims to put together the economic development, environment protection and resource conservation throughout the supply chain business processes which contain procurement of raw materials, product manufacturing, distribution, transportation, warehousing, consumption and recycling. Real estate green supply chain is a development model which fully considers the dialectical relationship between the environment, resources and sustainable development.

Real estate green supply chain first emphasizes on sustainable development and environment protection. Then it requires coordination and mutual cooperation among the various companies in the real estate supply chain to achieve the unified target of environment protection. Real estate green supply chain would also like to emphasize resource conservation, which includes direct and indirect costs and also all kinds of hidden costs that can not be accounted for in monetary terms.

124.2.2 Elements and Effect of the Real Estate Green Supply Chain

The elements of the real estate green supply chain form the basis of the supply chain, including government agencies, financial institutions, real estate development companies, consulting companies, green design enterprise, green material set supply enterprise, the green contracting business, supervision units, sales agencies, property companies, consumers, recyclers and so on. Real estate development enterprises, government agencies and contractors play a major role in promoting real estate green supply chain management: government agencies should encourage and support this effective management tool; as the core enterprise of the green supply chain management, real estate developers can not avoid the responsibility that develop green real estate products; the entire building process can only be completed by the construction enterprises, so the contractors also play a fundamental role.

124.3 Structural Design of Real Estate Green Supply Chain

124.3.1 The Business Process Design of Real Estate Green Supply Chain

The business process of real estate green supply Chain is shown in Fig. 124.1. Green design process emphasizes cooperation and exchange of the participants, the design units would share the end-user demand and other useful information with the developer. Green procurement mainly considers three key points : selection of green materials, selection and management of green suppliers and collaborative procurement. Green construction create the construction environment which is efficient, low power consumption, healthy, comfort and compatible with the environment. Green marketing aims to create green demand, guide green consumer, focus on green information, concern for the tripartite interests of businesses, consumers and social environment. Green property management use the environmental protection, energy saving and modern scientific management methods to provide inhabitants with a comprehensive, thoughtful, green and efficient service. The materials can not be used within the enterprise can be recycled by recyclers into the entire chain, after the separation and recovery of recycling, re-enter the processing enterprises to re-use.

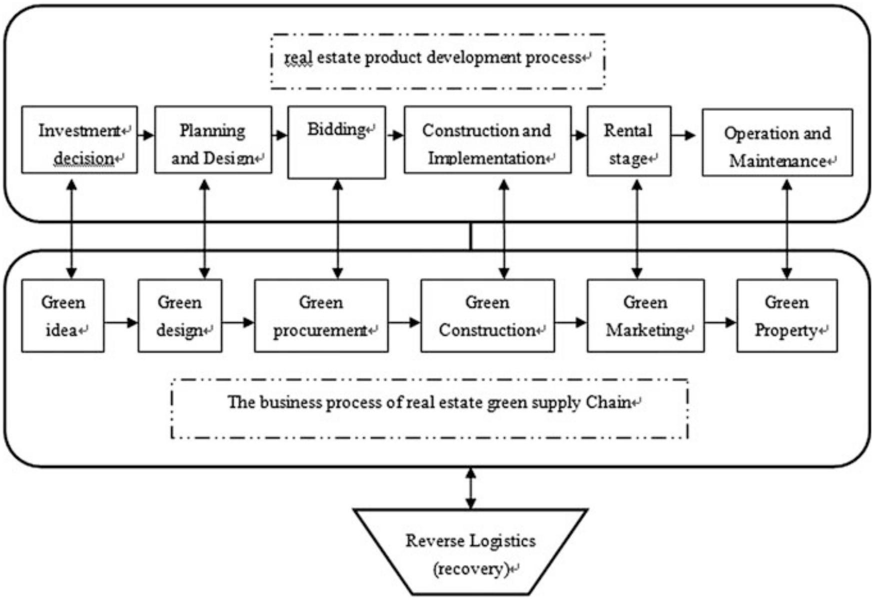

Fig. 124.1 The business process of real estate green supply chain

124.3.2 The Logistics, Capital and Information System of Real Estate Green Supply Chain

Design of logistics system. The logistics system of real estate green supply chain and that of manufacturing supply chain are very different. The visible part of the real estate industry logistics performances that the materials and equipment shipped from a supplier plant to the construction site of pre-construction, the recovery of the logistics in the entire real estate development process, as well as waste recycle and then supplied to the materials and equipment manufacturing enterprises. At the previous stage, government agencies will be transfer use rights of the land to the real estate companies, consultants and design planning agencies for providing the programs and services to real estate companies, and at a later stage, transferring the real estate products and services to the user reflects the transfer of rights. Based on this, the logistics of the real estate industry can be divided into two categories: the dominant logistics and the recessive logistics.

Design of capital system. In real estate green supply chain, the bi-directional flow of funds first reflects for lending and storing capital between financial institutions and each node enterprise, then development companies need to pay development costs to government agencies as well as government agencies pay subsidy or incentive funds for green projects. Buyers will provide funds to the sales agent or property management companies, the sales agent company will submit the income to real estate development enterprise, and real estate development companies then submit the funds to design units, green material set suppliers and construction units. The main capital flow related to recyclers contains the funds that the green contracting business and the green material set supply companies sell the waste material to recyclers, recyclers then sell the materials after the classification and preliminary treatment to green materials and equipment manufacturing enterprises.

Design of information system. In the real estate supply chain, the information flow must have followed the logistics. In addition to the information flow between node enterprises and real estate development companies, the information flow also exchanged among node enterprises. The direction of the information flow is bidirectional.

124.3.3 Real Estate Green Supply Chain Integrated Structure Model

Real estate green supply chain has shown clearly structured (The overall model structure is shown in Fig. 124.2), including two levels and four systems: a green supply chain operation layer, and the other is a green supply chain support layer. Operation layer includes the production system and consumption system, and

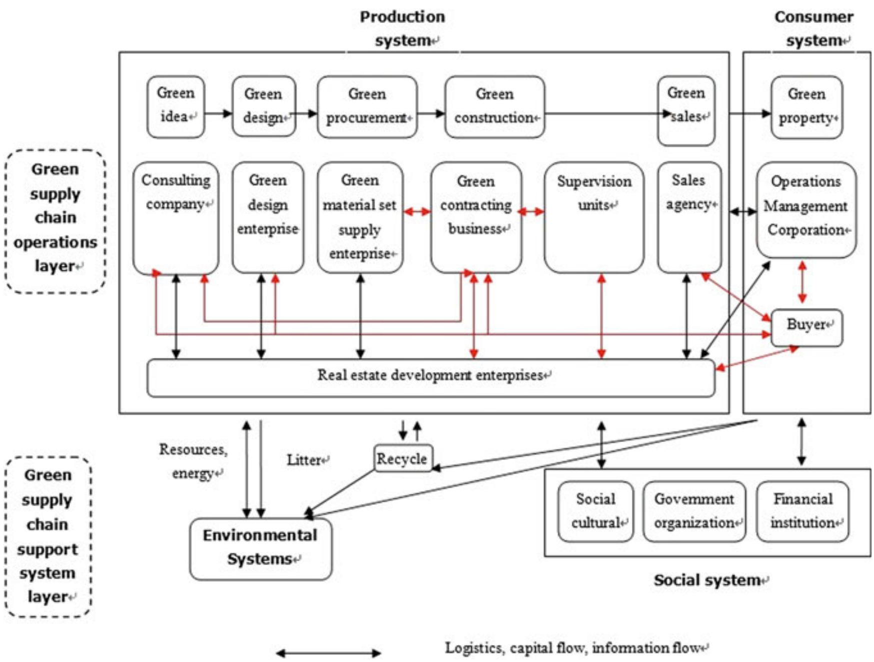

Fig. 124.2 The structural model of real estate green supply chain

support layer includes environmental system and social system. Production system has the real estate developers as the core, cooperates with the real estate companies and related enterprises, the land management agencies to achieve the real estate green design, green procurement, green construction, green marketing process. Consumption system has relationship with production system through the sales process, it consists of customers and property companies and aims at green property and green consumption. Environmental system contains the natural resource system and recycler. Waste from production systems and consumer systems is put into the environment, recycle the demolition waste, and provide resources for the production system after treatment (Mollenkop and Closs 2005). The social system is mainly consisted by government agencies, financial institutions, and social cultural systems: government departments regulatory support to affect the production and consumption system members to achieve their acts of green technology; socio-cultural forms values and ethics morality to affect the whole supply chain; financial institutions provide financial support for green supply chain operations.

124.4 Conclusion

To sum up, the real estate green supply chain is a real estate development supply chain model which fully considers the dialectical relationship between the environment, resources and sustainable development. Real estate green supply chain is a complex network, consisting of four systems and two levels. Based on the production of the final product, though the elements with different attributes and interests, they form a close cooperation chain. Through a wide range of information exchange and sharing, information flow and capital flow, so as to achieve the whole goal of economic benefits, environmental protection, resource conservation of the supply chain and continuously improve the innovative capacity of the entire industry (Yang and Yan 2005).

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Part VII
SS-Low-Carbon Technology and Low-Carbon Policy

Chapter 125
The Decoupling of Carbon Emissions from Economic Growth in Jiangsu, China: 2000–2010

Hui Zhou and Jie Cao

Abstract This paper analyzed the relationship between carbon emissions and economic growth in Jiangsu, China over 2000–2010, using the indicator of decoupling elasticity. Two weak decoupling periods, 2001–2002 and 2006–2009, were detected. The increases of carbon emissions were further decomposed with Logarithmic Mean Weight Divisia (LMDI) method and it was showed that the overall economic activity played the most important role in leading to the increase of carbon emissions, the adjustment of industry structure had positive but very small effect on carbon emissions, and the decline of sectoral carbon intensity was the only factor that drove the emissions to decrease.

Keywords Decoupling · Carbon emissions · Economic growth · Decomposition

125.1 Introduction

Since the industrial reform, the world's economy has grown more and more speedily, at the expense of exploitation of natural resources and deterioration of ecological environment. Climate change is one subsequence of large amount of anthropological carbon dioxide emissions, which are driven by the fast economic growth. Is it possible to reduce carbon emissions without impairing economic development? This is a question of great importance and interests.

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In environmental economics, the relationship between economic and environmental variables is often depicted by the environmental Kuznets curve hypothesis. It is claimed that in the early stage of economic development, the environmental pressure increases as the economy grows. As the development goes further, environmental problem gains more attention and measures will be taken, resulting in a more harmonious relationship between economic growth and environments. This latter stage can be referred to as decoupling, i.e., breaking the link between "environmental bads" and "economic goods" (OECD 2002). In terms of climate change, decoupling occurs when the growth rate of carbon dioxide emissions is less than that of the economic driving force (e.g. GDP) over a given period.

Decoupling of carbon dioxide emissions or energy consumptions from economic growth have been observed and reported recently. Some made analysis on countries, such as China, Brazil, Italy, etc. The occurrence of decoupling were observed in China and Brazil with the respective study periods (Zhang 2000; de Freitas and Kaneko 2011), while in Italy it was found that the economy did not perform absolute decoupling in terms of energy consumption and carbon dioxide emissions (Andreoni and Galmarini 2012).

Some researches focused on decoupling effects in specific industries. Transportation industries in different places were studied. In Finland, weak decoupling of GDP from road traffic volume and strong decoupling of road traffic volume and CO_2 emissions from road traffic between 1990 and 2001 were observed (Tapio 2005). In Germany and Taiwan decoupling effect was detected while coupling was observed in Japan and South Korea (Lu et al. 2007). The Chinese nonferrous metals industry was studied and two weak decoupling stages (1999–2000 and 2004–2008) were found (Ren and Hu 2012).

China is a vast country with quite different development levels among provinces and regions. Jiangsu lies on the east coast of China and is one of the most developed provinces with its regional economic output ranks second among all. In this paper we analyze the relationship between carbon emissions and economic growth of Jiangsu province for the past 10 years, trying to detect the decoupling effect, decomposing the driving factors of carbon emissions, and explaining the reasons for decoupling. The result will offer more specific evidence on decoupling than the usual analysis based on aggregated data.

125.2 Methodology

125.2.1 Framework on Decoupling

In this paper we follow Tapio (2005) and define the decoupling of carbon emissions from economic growth as the GDP elasticity of emissions:

$$\delta = \%\Delta C / \%\Delta GDP \qquad (125.1)$$

Table 125.1 Categorization of decoupling elasticity

Categorization	ΔC	ΔGDP	δ
Expansive coupling	>0	>0	0.8–1.2
Recessive coupling	<0	<0	0.8–1.2
Weak decoupling	>0	>0	0.0–0.8
Strong decoupling	<0	>0	<0
Recessive decoupling	<0	<0	>1.2
Expansive negative decoupling	>0	>0	>1.2
Strong negative decoupling	>0	<0	<0
Weak negative decoupling	<0	<0	0.0–0.8

where δ is the decoupling elasticity; $\%\Delta C$ is the percentage change of carbon emissions of Jiangsu province from fossil fuel combustion in a given time period; $\%\Delta GDP$ is the percentage change of the regional GDP in a given time period.

According to Tapio (2005), the values of decoupling elasticity can be categorized into eight types, listed in Table 125.1.

125.2.2 LMDI Decomposition Method

Logarithmic Mean Weight Divisia (LMDI) is a method first introduced by Ang et al. (1998) for factorizing changes in energy demand or gas emissions over time (Ang et al. 1998). The total energy-related carbon emission in period t can be expressed as an extended Kaya identity:

$$C^t = \sum\nolimits_i C_i^t = \sum\nolimits_i Q^t \times (Q_i^t/Q^t) \times (C_i^t/Q_i^t) \quad (125.2)$$

The sub-categories of the aggregate are industrial sector. C^t is the total carbon emission of Jiangsu from fossil fuel combustion in period t; Q^t is the GDP of Jiangsu in period t; Q_i^t is the gross industrial product of sector i in period t; C_i^t is the carbon emission of sector i in period t.

Define $S_i^t = Q_i^t/Q^t$ as the economic share of sector i in period t; $I_i^t = C_i^t/Q_i^t$ the carbon emissions every unit of gross industrial product of sector i in period t.

$$C^t = \sum\nolimits_i C_i^t = \sum\nolimits_i Q^t \times S_i^t \times I_i^t \quad (125.3)$$

Therefore changes of the regional carbon emission between a base year 0 and a target year T can be studied by quantifying the impacts of changes in three different factors: overall economic activity (activity effect), industry activity mix (structure effect), and sectoral carbon intensity (intensity effect).

In additive decomposition we decompose the difference:

$$\Delta V_C = C_T - C_0 = \Delta V_{act} + \Delta V_{str} + \Delta V_{\text{int}} \quad (125.4)$$

The subscripts *act, str, int* respectively, denote the effects associated with overall activity, activity structure and sectoral carbon intensity.

According to Ang (2005), the formulae for each effect in the right hand side of Eq. (125.4) can be computed as follows

$$\Delta C_{act} = \sum_i \left(C_i^T - C_i^0\right) / \left(\ln C_i^T - \ln C_i^0\right) \ln\left(Q^T / Q^0\right) \quad (125.5)$$

$$\Delta C_{str} = \sum_i \left(C_i^T - C_i^0\right) / \left(\ln C_i^T - \ln C_i^0\right) \ln\left(S_i^T / S_i^0\right) \quad (125.6)$$

$$\Delta C_{\text{int}} = \sum_i \left(C_i^T - C_i^0\right) / \left(\ln C_i^T - \ln C_i^0\right) \ln\left(I_i^T / I_i^0\right) \quad (125.7)$$

125.3 Data Resources

The data of the regional GDP and the gross industrial product of the three sectors during 2000–2010 are collected from *Jiangsu Statistical Yearbook* (2011) and they are all in 2000 constant price. The primary sector includes farming; forestry; animal husbandry; fishery and water conservancy. The secondary sector is comprised of mining and quarrying; manufacturing; electric power, gas and water production and supply; and construction. The tertiary sector is subdivided into transport, storage and post sector; wholesale, retail trade and hotel, restaurants; and others.

When computing the carbon emissions by fossil fuel combustion, eight types of fuels are taken into account, including coal, coke, crude oil, gasoline, kerosene, diesel oil, fuel oil, and natural gas. The data of Jiangsu fuel consumptions of each sector from 2000–2010 are collected from *China Energy Statistical Yearbook* (2001–2011) respectively. The average low calorific values (ALCV) retrieved from *China Energy Statistical Yearbook* (2011) are used to convert the original data measured in mass unit into those measured in energy unit (GJ). The carbon emission factors (EF) are collected from 2006 *IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 2*. The ALCV and EF used in this paper are listed in Table 125.2.

Table 125.2 Carbon emission factors and average low calorific values

Fuel	EF (kgC/GJ)	ALCV (KJ/kg)
Coal	25.8	20908
Coke	29.2	28435
Crude oil	20.0	41816
Gasline	20.2	43070
Kerosene	19.6	43070
Diesel oil	20.2	42652
Fuel oil	21.1	41816
Natural gas	15.3	38931 (KJ/m^3)

125.4 Results and Discussions

125.4.1 Decoupling of Carbon Emissions from Economic Growth

The GDP of Jiangsu province was 855.4 billion yuan in 2000 and reached 2963.6 billion yuan in 2010, increasing at a fairly stable rate of around 12 % annually. As far as carbon emissions are concerned, the annual increasing rates fluctuated much more significantly, ranging from 0.78 % in 2001 to 27.99 % in 2005. The carbon emissions, regional GDP and the calculated decoupling elasticity in Jiangsu from 2000–2010 are listed in Table 125.3.

By applying the decoupling framework defined in Sect. 125.2.1, we observe two weak decoupling phases: 2001–2002 and 2006–2009. The first phase was short and had an obvious increasing trend which lasted for 5 years, leading to expansive coupling in the following year 2003 and expansive negative decoupling in 2004–2005. In 2005 the decoupling elasticity reached its peak at 1.93, implying that the increasing rate of carbon emissions almost doubled that of the GDP. This fast growth in carbon emissions was controlled since 2006. In 2006–2008 the decoupling elasticity declined from 0.63 to 0.25 and slightly increased to 0.36 in 2009, indicating a much slower increasing pace of carbon emissions compared to that of the GDP.

125.4.2 Decomposition of Carbon Emissions

We apply the LMDI method to show the relative contributions of three driving forces to the changes in carbon emissions of Jiangsu. The results are shown in Table 125.4.

Table 125.3 Carbon emission, economic growth and decoupling elasticity in Jiangsu

Years	Carbon emissions (10^4 tC)	Percentage change of carbon emissions (%)	GDP (10^8 Yuan in 2000 price)	Percentage change of GDP (%)	Decoupling Elasticity
2000	6874		8554		
2001	6927	0.78	9422	10.15	0.0764
2002	7475	7.90	10521	11.66	0.6777
2003	8517	13.95	11954	13.62	1.0237
2004	10473	22.96	13718	14.75	1.5568
2005	13404	27.99	15704	14.48	1.9328
2006	14674	9.48	18050	14.94	0.6343
2007	15814	7.77	20747	14.94	0.5201
2008	16321	3.20	23382	12.70	0.2522
2009	17062	4.54	26292	12.45	0.3644
2010	19055	11.69	29637	12.72	0.9189

Table 125.4 Additive decompostion of the Jiangsu carbon emissions over 2000–2010

Time period	ΔC	ΔC_{act}	ΔC_{str}	ΔC_{int}
2000–2001	54	667	43	−656
2001–2002	548	790	94	−337
2002–2003	1042	1014	186	−158
2003–2004	1956	1302	163	491
2004–2005	2930	1606	133	1191
2005–2006	1271	1953	80	−762
2006–2007	1141	2122	63	−1043
2007–2008	505	1921	62	−1478
2008–2009	741	1958	11	−1228
2009–2010	1994	2160	45	−211

The results show that the increase in carbon emissions of Jiangsu during 2000–2010 was mainly attributed to the growth of economic activity. The economic growth rates of Jiangsu were all above 10 %, ranging from 10.15 to 14.94 %, for the past 10 years. High speed of economic growth demands for large amount of energy consumption and consequently resulted in increase in carbon emissions.

The adjustment of industry structure had a fairly small but still positive effect on the increase of carbon emissions. For the past ten years the share of the primary sector had decreased from 12.26 to 5.13 %, while the share of the secondary sector had increased from 51.86 to 57.87 %. Since the secondary sector was the main resource of carbon emissions, this change pattern of industry structure could lead to some but modest increase of the total carbon emissions.

The sectoral carbon intensity was the only factor that reduced the carbon emissions except for 2003–2005. The carbon intensity of the secondary sector and the tertiary sectors both had a decreasing trend for most of the past ten years, driving the carbon emissions to decline. But the increase of the carbon intensity of the secondary sector during 2003–2005 contributed to the expansive coupling and the expansive negative decoupling for this period of time.

125.5 Conclusions

In this article we calculated the GDP elasticity of emissions in Jiangsu province over 2000–2010 and found two weak decoupling periods: 2001–2002 and 2006–2009. The changes of carbon emissions was further decomposed using LMDI method and it was showed that the overall economic activity was the main reason that led the increase of carbon emissions, the adjustment of industry structure had positive but very modest effect on carbon emissions, and the decline of sectoral carbon intensity was the only factor that drove the emissions to decrease.

The above discovery implied that decoupling of carbon emissions from economic growth went in line with the abatement of carbon intensity. As a matter of fact, the energy saving and emissions reduction targets set by the National 11th 5-Year Plan that the energy intensity must decline by 20 % during 2006–2010 forcedly moved the energy intensity downward, and led to the weak decoupling during this period of time. Therefore, for future policy implications, emphasis could be placed on further reducing energy/carbon intensity, such as intensifying technological innovations that improve energy efficiency, etc. If the declining tendency of carbon intensity continues, we believe that strong decoupling could finally be achieved in the future.

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Chapter 126
Research of the Criteria of Choosing Leading Industry in Under developed Areas: Guangxi Province

Tong- Li, Shouji- Tu, Yin- Peng and Liqing- Li

Abstract In recent years, China had achieved great economic development, but accompanied with the more and more serious environmental problems. Now people have realized the importance of the environment and environmental protection (energy conservation and emission reduction) had become global consensus. In this context,this paper puts forward an update criterion of choosing the leading industry based on the perspective of energy conservation and emission reduction. The specific indexes of energy conservation and emission reduction were increased on the basis of the index system of traditional criteria of choosing the leading industry. The update criteria were experimented in choosing the leading industry of Guangxi province in China.

Keywords Criteria · Leading industry · Energy conservation and emission reduction

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126.1 Introduction

This paper examined the updated criteria of choosing leading industries in underdeveloped regions in China. The term "underdeveloped regions" refers to those places that possess strengths and potential, such as abundant natural resources or inexpensive labor, but lack the technology and financial resources to develop them. The productive force development in these places is uneven because of lower-level technology. In order to catch up with developed regions, underdeveloped places should cultivate a balance between economic development and environmental protection. That was to say, these regions should develop by following the environmental pollution reduction guidelines given in China's 12th Five-year plan. Therefore, choosing leading industries became a critical factor in developing these regions.

The "12th Five-Year Plan of China" put forward the emissions-reduction targets during the new period: carbon dioxide emissions per unit of GDP should be reduced by 17 %; GDP energy consumption should be decreased by 16 % per unit; emissions of major pollutants should be reduced by 8–10 %; and primary energy consumption of non-fossil fuels should rise by 3.1 %, from 8.3 to 11.4 %.

126.2 The Classical Criteria of Choosing the Leading Industry

From Ricardo, Heckscher, and Ohlin's comparative advantage theory evolved into the comparison superiority criteria. Rostow, Albert Hirschman based on linkage effect put forward the criteria of "diffusion effect" and "correlation effect". Then, Japanese scholar Shinohara proposed the famous "Shinohara two criteria", and later "Chenery-Robinson-Seer Kui's criteria", and Zhou's three criteria, etc. Various kinds of criteria (see Table 126.1) constituted the complex index system for regional leading industry selection (Armstrong and Taylor 2000; Rostow 1991; Hirschman 1988).

The classical criteria of choosing the leading industry were based on the core objectives of the economic development, the emphasis of integrating elements, and the adaptability of the market.

126.3 The Criteria of Choosing Leading Industry in Underdeveloped Areas in the New Period

With the increasing of environmental concerns, the phenomenon that some industries paid more attention to environmental protection and sustainable development when choosing leading industry has emerged. These researches about the standards of leading industry selection promoted the balance between the environment and the economic development mainly on the aspect of virescence

Table 126.1 The classical criteria of leading industry selection

Criterion	Content	Basis of opinion
Ricardo	Comparative advantage	Industrial competitiveness
Heckscher	Resource endowments	Factor intensity
Rostow	Diffusion effect	Industry spread
Hirschman	Industry correlation	Industry association
Shinohara	Income elasticity	Market equilibrium
	Rise in productivity	Industrial innovation
Chenery-Robinson-Seer Kui	Stages of economic development	Degree of industrialization
Zhou's	Momentum in the growth	Potential
	Shortage elasticity of substitution	Industry restriction degree
	Bottleneck	Industrial friction

design and choosing renewable resources (Guo and Fang 2009). This paper puts forward a new benchmark of choosing the leading industry with specific indexes of energy conservation and emission reduction on the basis of the index system of traditional benchmark of choosing the leading industry.

An update criterion of choosing the leading industry is as below:

(1) The industry correlation benchmark: that is the degree of the industrial connection; the bigger the number is, the stronger connection degree the industry has with others. The index of the traditional industry selection standards is a primary standard for a large number of candidate industries which guarantees the choice of leading industry has strong correlation.
(2) The labor productivity index:

$$X_1 = \frac{\Delta Y_i}{L_i}(i = 1, 2..n) \tag{126.1}$$

"ΔYi" refers to "value-added of i industry" and "Li" refers to "practitioners of annual average of i industry".

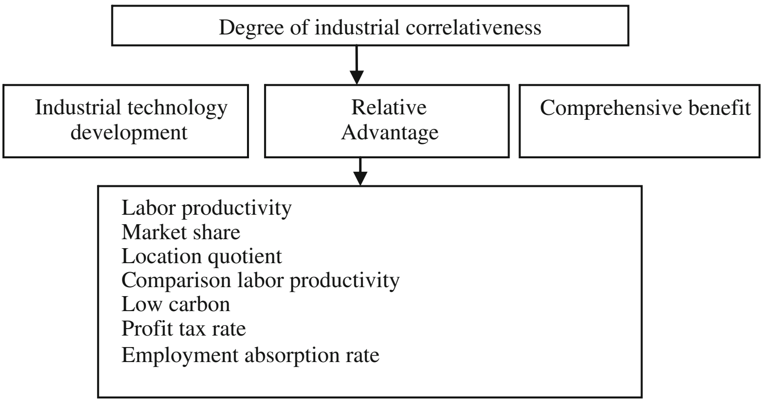

Fig. 126.1 The update criteria of choosing the leading industry

(3) The market share index:

$$X_2 = \frac{S_{il}}{S_{in}}(i = 1, 2\ldots n) \tag{126.2}$$

"S_{i1}" refers to "prime operating revenue of Guangxi of i industry" and "S_{in}" refers to "prime operating revenue of China of i industry".

(4) Location quotient:

$$X_3 = \frac{Y_{ij}/Y_{tj}}{Y_{in}/Y_{tn}}(i = 1, 2\ldots n) \tag{126.3}$$

"Y_{ij}" refers to "i industry employment of Guangxi", "Y_{tj}" refers to "total employment of Guangxi", "Y_{in}" refers to "i industry employment of China" and "Y_{in}" refers to "total employment of China".

(5) Comparison labor productivity:

$$X_4 = \frac{g_i/g}{l_i/l}(i = 1, 2\ldots n) \tag{126.4}$$

"g_i" refers to "value of industrial output of Guangxi of i industry", "g" refers to "total industrial output value of Guangxi", "l_i" refers to "i industry employment of Guangxi", "l" refers to "total employment of Guangxi".

(6) Low carbon index1: Energy consumption index:

$$X_5 = \frac{Y_i}{R_i}(i = 1, 2\ldots n) \tag{126.5}$$

"Y_i" refers to "value of industrial output of Guangxi of i industry" and "R_i" refers to "the amount of energy needed for the production of Yi".

"Y_i" refers to "value of industrial output of Guangxi of i industry".

(7) Profit tax rate:

$$X_6 = \frac{T_i/Y_i}{T_{in}/Y_{in}}(i = 1, 2\ldots n) \tag{126.6}$$

"T_i" refers to "profit and tax amount of i industry of Guangxi", "T_{in}" refers to "total profit and tax amount of Guangxi", "Y_i" refers to "profit and tax amount of i industry of China", and "Y_{in}" refers to "total profit and tax amount of China".

(8) Employment absorption rate:

$$X_7 = \frac{L_i}{R_i}(i = 1, 2\ldots n) \tag{126.7}$$

"L_i" refers to "i industry employment of Guangxi" and "R_i" refers to value of industrial output of Guangxi of i industry.

(9) Low carbon index 2: Emission index:

$$X_8 = Y_i/W_i,\ W_i\text{: waste water emission of iindustry} \quad (126.8)$$

$$X_9 = Y_i/G_i,\ G_i\text{: exhaustgasemissionofiindustry} \quad (126.9)$$

$$X_{10} = Y_i/S_i,\ S_i\text{: sulfur dioxide emission of i industry} \quad (126.10)$$

"Y_i" refers to "value of industrial output of Guangxi of i industry".

126.4 Application Effect

126.4.1 Application Case: Guangxi Province in China

Guangxi is located in the southwest of China. Although Guangxi has developed quickly recent years, it still pertains to underdeveloped regions for its lower level of productivity and weaker economic foundation. The industrial structure of Guangxi is irrational and the proportion of secondary industry is excessive. In order to optimize the industrial structure of Guangxi and make a balance between economic growth and environment protection, the leading industry has to be chosen by the update criteria with two corresponding indicators-energy conservation and emission reduction.

126.4.2 Results and Discussion

Through the principal component analysis method with SPSS as well as the quantitative and qualitative analysis, the update criteria in the perspective of energy conservation and emission reduction of choosing the leading industry was experimented on the example of Guangxi, in accordance with the construction of datum and the index system. Based on the research performed, it is concluded the five leading industries are: (1) oil processing and coking and nuclear fuel processing, (2) transportation equipment manufacturing industry, (3) metal smelting and rolling processing industry, (4) the electric power, heat power production and supply industry, (5) metals and mining.

Compared the updated criteria with the traditional one, the choice of leading industry had changed a lot except the oil processing, coking, and nuclear fuel processing industry. Other options were not consistent. In the choice of traditional benchmark, "the electric power, heat power production and supply industry" as well as "Metals and mining" were ranked second and third. "Metal smelting and rolling processing industry" and "transportation equipment manufacturing" were placed fourth and fifth.

126.5 Conclusion

Compared with the two different kinds criteria of choosing the leading industry, the results still existed certain differences, but not obvious. This is because Guangxi is an underdeveloped region, the final result obviously tends to be related closer to the economic development. Among these leading industries, innovation of application of new technology and new processes would achieve the energy conservation and emission reduction in economic sustainable development.

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Chapter 127
Analysis on China's Power Industry Development and Countermeasures in Low Carbon Economy Environment

Ze-min Yan, Zhan-feng Zhu, Wen Qiao and Xiao-dong Zhang

Abstract This paper first illustrates the importance of low-carbon electricity and then analyzes the strategic and realistic significance for China's power generation industry to operate in low-carbon state. Expounded the necessity and urgency for power generation industry in low-carbon economy, Finally it provides the thinking and policy to develop power generation industry in the low-carbon economy environment.

Keywords Low carbon economy · Power industry · Low carbon technology · Energy structure

127.1 Introduction

The global climate change has become one of the most remarkable phenomena all over the world and the most direct cause is the increasing emission of CO_2, CH_4, SO_2, etc., which leads to global "greenhouse effect", of which the role of CO_2 is as high as 77 %. Climate change has direct impact on human survival and development in the future. Therefore in 2003 the British government first put forward

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the concept of low carbon economy in the White Paper of Energy which caused extensive concerns around the world (Chen et al. 2009).

127.2 Low Carbon Economy Situation in China

127.2.1 The Position of Low Carbon Economy in the Power Generation Industry

In 2008, China's ten big power group occupied 57 % of the country's gross installed capacity and power generation capacity of ten groups are nearly 58 % of all, so ten power group have great obligations and responsibilities to optimize the energy structure and to reduce CO_2, SO_2 and other gas emissions. Because coal occupies bigger proportion in energy consumption structure, carbon dioxide emissions intensity is relatively high. Green Peace Organization (GPO) has made an investigation among ten big power groups. According to the indexes of coal quantity consumed in generating every KWH causing, capacity of CO_2 emissions, CO_2 intensity and renewable energy development GPO evaluated the impact of ten big power groups on the climate change. The results show that the total coal quantities used by ten big power groups in 2008 are more than 590 million tons, accounting for nearly 20 % of the coal output which lead to much CO_2 and SO_2 emissions. The total carbon dioxide emissions quantities of top three power groups are more than the total emission quantities gave off by the whole British, so the environmental protection mode of the power enterprise were questioned. Table 127.1 shows the total quantity of fueling coal and the carbon dioxide emissions by the ten big power groups in 2008.

Generating power in China mainly depends on thermal power which leads to serious environmental pollution problem. According to the World Bank study the pollution losses caused by Coal-fired power were as high as $87 billion, about 2.06 % of GDP in 2008. The proportion of coal in our country's energy consumption structure is nearly 70 % and the CO_2 emissions are 30 % which are more than the world average. The average carbon dioxide intensity coefficient is 1.65 times of Japan and 1.38 times of Germany, 1.1 times of the United States. Figure 127.1 describes the comparison of average CO_2 intensity coefficient among ten big power groups with Japan, Germany, the United States (Kang et al. 2009).

127.2.2 The Necessity of Low Carbon Electricity Development

Firstly, low-carbon electricity has important strategic significance on the sustainable development of the economy. Power industry is the main emitter of CO_2

Table 127.1 Total quantity of coal consumption and total carbon dioxide emissions in 2008

Group name	Total coal used by thermal power machine (ten thousand tons standard coal)	Carbon dioxide emissions by coal-fired power (ten thousand tons)
China HuaNeng Group Company	11796.9	28784.4
China DaTang Group Company	10257.7	25028.8
China GuoDian Group Company	9479.8	23130.7
China HuaDian Group Company	8840.0	21569.6
China Power Investment Group Company	5964.0	14552.2
The Yangtze River Three Gorges Project Development Corporation	0.0	0.0
GuangDong Yudean Group Co., LTD	3187.2	7776.8
ZheJing Energy Group Co., LTD	2835.0	6919.6
China ShenHua Group Company	3165.0	7772.6
China Resources Power Holdings Co., LTD	3496.9	8532.4
Total	59023.4	144017.1

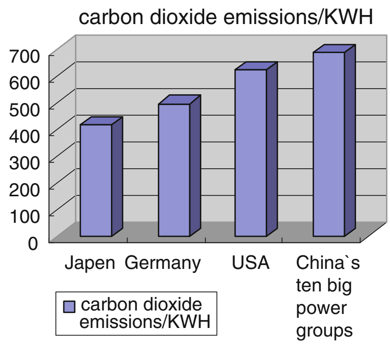

Fig. 127.1 Japan, Germany, the United States, China's top 10 power group carbon dioxide strength comparison

and it plays a key role to realize our emission-reduction goal of 40–45 % in 2020. There is a huge potential space in CO_2 reduction, so it is quite possible for us to achieve our goal as long as we take necessary measures to overcome the difficulties in the short term. Only by vigorously developing low carbon electricity power can we realize transformation to low carbon economy.

Secondly is to increase gradually the pressure to reduce emissions of electricity production. With the rapid development of economy, more and more power is demanded so the pressure of emission reduction will increase. Our country will face serious challenges and even formulate mandatory quantitative emission plan. Development of low carbon electricity is not only our task but also the most effective way to realize our macro target for emission reduction in the future.

Thirdly, low-carbon electricity is an important way to achieve sustainable development in the electricity industry. First of all, to develop low carbon power is not only to reduce emissions of CO_2 and harmful gas, but it is more beneficial to improve energy structure for china, especially to change the situation of too much dependence on coal and other natural resources. While doing this, we should develop diversified electric power, especially renewable energy and form a comprehensive clean energy supply system. Secondly, to develop low carbon electricity can not only improve power generation technology, which is helpful for the development of new technology, but also be more beneficial for human to develop and utilize resources, by which we can open up a broader space for economic development. Finally, to develop low carbon economy is helpful to improve the using efficiency of existing energy and the understanding of energy consumption and to promote energy conservation and to reduce non-renewable source consumption. If we touch the level of Japan, South Korea in coal consumption of power units, we can save nearly 210 million tons of coal annually so we can greatly reduce carbon emissions (Lin 2010) .

127.3 Countermeasures for Development of Power Industry in Low Carbon Economy Environment

127.3.1 Thinking of Development

Low carbon economy research is a comprehensive and profound field. Foreign researches, although with some development, mostly concentrate on the changes of energy structure and technology. The overall grasp in developing low-carbon electricity should be from the macro, industry, technology, and the introduction of low-carbon way of economic development in China, is bound to have a significant impact on China's power industry. Power industry emission reduction is an important part of low carbon economy, its success or not will directly affect the sustainable development of the national economy, which requires that power industry and whole electricity industry bring into correspondence with the low carbon reform of our country. Its implementation needs to coordinate with macroeconomic policies for the industrial structure adjustment, environmental management, pollution control and other environmental protections. How to qualitatively and quantitatively adjust macro layout of power industry in LCEE and coordinate energy plans will be recently the country's research question. We should make clear emission reduction targets for power generation enterprises and plan out the short, medium and long term implementation steps. So many problems we should consider such as: How much environmental cost that Low carbon electricity generation can give? How to measure it? How much spaces that China power industry has? How to keep harmonious balance between low carbon electricity generation and economic development?

127.3.2 Countermeasures for Development of Power Industry in LCEE

(1) Understanding the Connotation of Low Carbon Economy and Setting Up the Idea of Low Carbon Economy

Firstly power enterprises must set up the concept of low carbon economy fully understanding its important status and role in sustainable development of national economy and fully knowing the relationship between that and human future survival and development. Secondly we should clearly realize that under the current energy structure of economy growing rapidly but energy exhausting increasingly. So it is very important and urgent to develop low carbon economy. Finally we should clear recognize that development of low carbon economy is a frog leap and a new growth point.

(2) Optimizing Energy Structure and to Develop the Hydropower

Hydropower is clean, renewable, pollution free energy with low operating cost and it is convenient to switch the electric power load and is helpful to improve the resource utilization hence comprehensively benefits economy and society. Although the hydropower capacity our country sets up in 2010 year reached to 200 million KW, the first in the world, power generating amount in total is only 16, 5 % lower than world average. There are every rich water resources in southwest central China. Theoretically speaking the hydropower reserves are nearly 670 million KW, installed capacity in theory up to 542 million KW and the actual installed capacity can nearly be 400 million KW. Hydropower as a kind of renewable energy plays an extremely important role in our country's energy development, supporting the sustainable economic and social development.

Hydropower development also plays a positive promoting role on electricity price reform of our country. Because Hydropower has lower production costs a lot of Hydropower entering into the market can prevent the price from going up, which will promote economic development. Reduced production cost will enhance our competitive advantages in the international market. Hydropower development brings the energy consumption decreasing and enables the rare energy to play a bigger role in the future. Meanwhile it can reduce pollution and the spending in pollution management, which means using more money in the country's economic construction.

(3) To Develop Green Renewable Energy

On Jan. 6, 2011, deputy director of the national development and reform commission, the secretary of the state energy Zhang Bao-guo has put forward the energy development ideas during "twelfth five year plan" in the national energy meeting, which requires to speed up the development of new and renewable energy, especial nuclear power, wind power, solar energy and bio-energy. To ensure the sustainable development of our economy and save fossil energy we must make great efforts to develop renewable energy.

Our country area is vast so it is very suitable for wind power. The northwest, northeast, inner Mongolia all have rich wind power reserve. Estimation by China's meteorological academy sciences shows that China's wind energy reserves are more than 1 billion KW, wind energy reserves 253 million KW. At the same time, our country has long coastline, vast sea and offshore shallow areas are wider, which is suitable for offshore wind power, whose power generation resources is about three times as much as the land, having the ability to form scale advantage. This becomes a new power structure enabling China to adjust the current energy structure. Since 2002 Europe has get the energy growth with the rate of more than 30 % from wind energy only. In Denmark, 20 % energy comes from wind power; other like Germany, Italy. USA has the growth of 50 % in wind power (Zhong 2011; Zhang 2009).

In 2009 CAE (the Chinese Academy of Engineering) promulgated "The Chinese Renewable Energy Development study". The vice President, Du Xiang Wan, of CAE summarized the following aspects in the power industry development: We should mainly develop large-scale hydropower, wind power, moderately develop biological power in short-medium run; Actively develop solar energy, deep geothermal power and Marine power in medium-long period reaching the target of replacing coal and other fossil energy, so that we can make an important contribution to improve the energy structure and reduce greenhouse gas.

(4) International Cooperation and Low Carbon Innovation

Because there is certain technological gap between China and developed countries and due to the shortage in low carbon scientific research, it is quite difficult for the domestic power generation enterprises to completely depend on their technical reform and innovation to achieve a low carbon economy. So we may rely on the international technical cooperation with the developed countries and promote extensive technology exchanges with developed countries. We need to introduce and absorb advanced technology, on which basis we should innovate with our electricity generation technology especially in low carbon technology and emphasis should be put in energy saving, low carbon energy technology, carbon dioxide capture, use and storage. Our investment is not enough in thermal power technology, which makes the coals consumed to generate electricity are 10–20 % more than developed countries. In the electricity industry, the integrated gasification combined cycle technology (IGCC) and high parameter supercritical units technology, thermoelectric all-round technology are not very mature (Jin and Liu 2009).

127.4 Conclusion

Low carbon economy is the only way for our country to develop in the future. Based on the researches of sustainable development of our economy, this paper analyzes the necessity and urgency of the power industry to develop low carbon economy and studies the overall development thought of power industry in low carbon economy environment.

Firstly, to develop low carbon economy is the need of the era, which has strategic and profound significance to the power industry.

Secondly, considering the current technical status of the power industry, we need to implement low carbon policy gradually. To ensure economic development, we should speed up reform on low carbonation. The low carbonation in power industry should remain consistent with the national macroeconomic policy.

Finally, on the basis of selecting suitable policy for our current situation, we should speed up the technology introduction and increase constructions for hydropower, clean energy, and renewable energy. Utmost our best to change the energy structure of power generation and promote China's power industry to turn to low carbon economy.

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Chapter 128
System Dynamics Analysis of Port City Development Under the Low-Carbon Economy-A Case Study of Ningbo

Sen Yan and Fangchu Liang

Abstract With the idea of sustainable development and environmental protection be widely recognized, the development of low-carbon economy is emphasized increasingly. The index system of port and city is put forward in the paper taking Ningbo for example, and the model of port and city is set up based on the theory of system dynamics. Based on historic data, the model is used to forecast the results, and affects between port and city is analyzed using Sensitivity analysis theory. Finally, optimal path of port and city interaction system is brought forward based on low-carbon economy background.

Keywords Low-carbon economy · Port city · System dynamics

128.1 Introduction

With the developing of the urban economy, environment problem play a vital role in the sustainable development of the city. Developing low-carbon economy and promoting industry transformation has become the core of the urban development (Xin and Zhang 2008). Port and city connected and influenced mutually, constitute dynamic system between the port and the city. Constructing a dynamic model between interactive system of port and city has important meaning to not only further study the interactive relationship between port and city and predict the future development trends of the port city economy, but also puts forward measures

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that should be taken for improving their interactive relationship under the background of low-carbon economy. Many scholars have studied the relationship between port and city. Jing and Jing (2008) discussed the mutual influence between port and regional economy; analysis and demonstration is put forward by Zhang (2006) and Chen (2009) in addition to the interactive system model of port and city respectively, but only part of the factors are considered (Zhang 2006; Chen 2009). Liu et al. (2006) and Yuan and Hua (2009) introduced simulation analysis of interactive relationship of port and city (Lina et al. 2006; Yuan and Hua 2009).

As an essential port city in the economic circle of the Yangtze River Delta, Ningbo has typical characteristics of interactive development between port and city. Based on the study referenced, the model of port and city is set up based on the system dynamics theory. Through historic data, the model is used to forecast the results, and affects between port and city is analyzed using Sensitivity analysis theory. Finally, optimal path for interactive system of port and city is brought forward based on low-carbon economy background.

128.2 Principle for Dynamic Model Between Port and City

128.2.1 Principle of Systematization

Port and city are taken as two subsystems in the interactive system of port and city instead of two sections of the system (Zhong et al. 2009). Either the interactive relationship of the port and city or the relationship of the subsystem should be taken full consideration so as to obtain an integrated and balanced system (Cesar and Sung 2006).

128.2.2 Principle of Conciseness

The interactive system of port and city is extremely complicated. On the one hand, interactions between port and city are affected by almost all the factors of social and economic. Thus the factors should be considered are fully comprehensive and complex. On the other hand, the subsystems of port and city are also very complicate. Therefore, the system must be simplified so as to find out vital factors in analyzing the motivation of the interactive system between port and city.

128.2.3 Principle of Quantification

System dynamics model is used to analyze the system by simulation based on the equation s between the elements (Gu and Cai 2007). Therefore, all the elements must be Measurable. Thus, it is intrinsic request of constructing ports and city interactive system to choose key elements can be quantified.

128.3 Index System Reflecting Interaction Between Port and City

Variables belong to interactive system dynamics model between port and city are given in Table 128.1 based on analysis above. The definition of the index at the National Bureau of Statistics Yearbook.

Table 128.1 Variables belong to interactive system dynamics model between port and city

Category	Name of variable	Unit	Nature
City	Construction land area	Sq.km.	Numeric
	Increment of construction land area	Sq.km.	Numeric
	Growth rate of construction land area		percentage
	Total amount of talent	Thousand person	Numeric
	Increment of total amount of talent	Thousand person	Numeric
	Growth rate of total amount of talent		Percentage
	Social consumable total retail sales	Billon Yuan	Numeric
	Increment of social consumable total retail sales	Billon Yuan	Numeric
	Growth rate of social consumable total retail sales		Percentage
	Total investment in fixed assets	Billon Yuan	Numeric
	Increment of total investment in fixed assets	Billon Yuan	Numeric
	Growth rate of total investment in fixed assets		Numeric
	GDP	Billon Yuan	Numeric
	The first industrial output value	Billon Yuan	Numeric
	The second industrial output value	Billon Yuan	Numeric
	The third industrial output value	Billon Yuan	Numeric
	Foreign trade volume	Billon Yuan	Numeric
	Port investment	Billon Yuan	Numeric
	Port operating income	Billon Yuan	Numeric
	Increment of port investment	Billon Yuan	Numeric
	Growth rate of port investment		Numeric
	Loading machine quantity	Set	Numeric
Port	Accumulate of the pile field	Thousand sq.m.	Numeric
	Storage area	Thousand sq.m.	Numeric
	Quay berth quantity	Number	Numeric
	Port traffic capacity	Million ton	Numeric
	Port cargo throughput	Million ton	Numeric
	Influence coefficient of cargo throughput upon port investment		Numeric

The variables are selected from the national bureau of statistics yearbook

128.4 System Dynamics Model of Interactive System Between Port and City

Dynamical equations of the system are explored by correlation analysis, factor analysis and regression analysis. Then dynamics model of the interactive system between port and city is put forward. The arrow line between two variables indicates the relationship between them: the variable near the arrow is influenced by another one (Fig. 128.1).

Dynamic equations are obtained using factor analysis and regression analysis methods based on the 2006–2010 relevant data of Ningbo. Then the model is operated and the results are analyzed. The specific procedure is as follows:

- Calculate the correlation between elements of the system;
- Find out principal components by the principal component analysis;

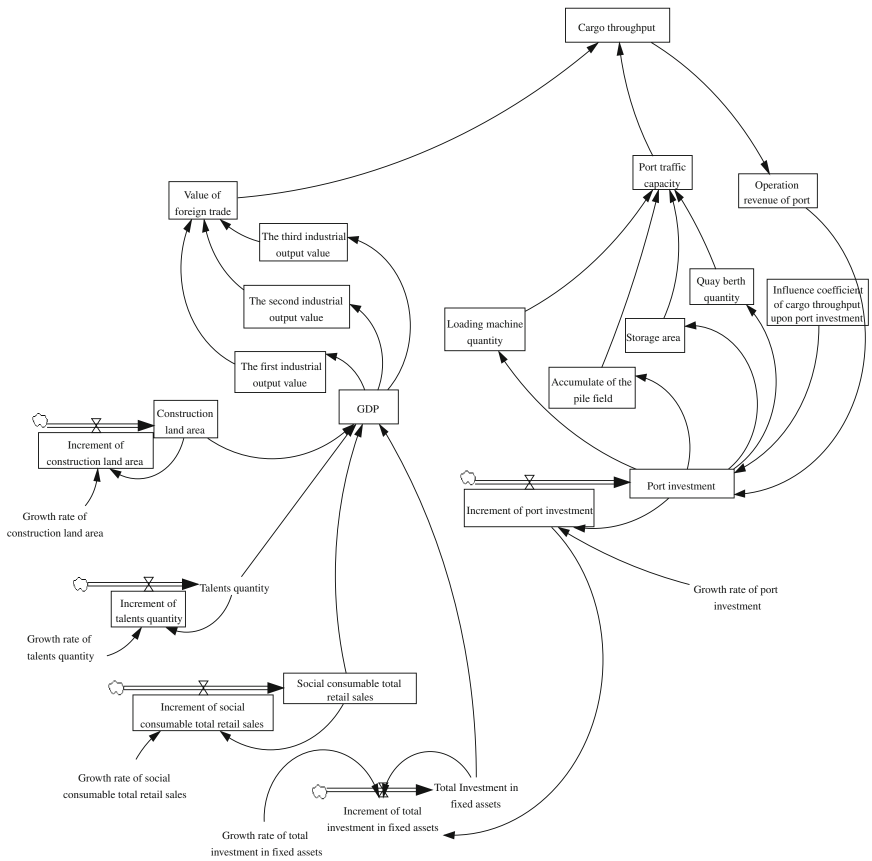

Fig. 128.1 System dynamics model of port and city

- Get Dynamic equations for each dependent variable using regression analysis;
- Operate the model by Vensim (a software for System Dynamics Analysis) and analyze the results.

128.5 Operation of the Model and Analysis of Results

The operation of the system is based on the based on the data of 2005–2009. The operation period is year 2010–2015. The data of 2010 is used as testing data. The system is operated by vensim based on the original data (Table 128.2).

Growth rate of the total amount of talent,the growth rate of social consumable total retail sales,the growth rate of total investment in fixed assets and the growth rate of port investment are assumed equal to the average growth rate during the year 2005–2009. The growth rate of construction land area is 10 %. The results of the model are in the Table 128.3.

According to the forecast results, the mutual influence among the elements of the port and city can be analyzed and evaluated quantitatively.

128.5.1 Promoting Analysis of the Port to the City

Suppose the port investment of 2005–2009 increased by 1 %, the results of the model are listed in Table 128.4. It is obviously that the port investment increase has a larger role in promoting the amount of urban GDP and foreign trade volume. From the absolute amount of 2010–2015, the port into a marginal increase in the effectiveness of the GDP is 4.65 Yuan, the marginal utility of the city's foreign trade volume is 0.97 Yuan. Therefore, increasing the investment of the port to improve the function and service of the port plays a vital role in promoting the development of the urban economy.

128.5.2 Promoting Analysis of the City to the Port

Suppose the annual growth for urban input factors of 2005–2009 (Construction land area, total amount of talent, social consumable total retail sales and total Investment in fixed assets) increased by 1 %, the results of the model are listed in Table 128.5. It shows that if the growth rate of urban input factors are increased by 1 percent, the city's GDP will increased by 3.47 % and the foreign trade volume increased by 3.99 %. Therefore, the improvement of foreign trade volume will directly increase the total port cargo throughput by 1.73 % and the corresponding port operating income increased by 1.88 %. In other words, the elasticity coefficients of the port cargo and the port revenues upon the city's GDP growth are 0.50

Table 128.2 2005–2009 data of Ningbo

Years	GDP (billion Yuan)	The first industrial output value (billion Yuan)	The second industrial output value (billion Yuan)	The third industrial output value (billion Yuan)	Port operating income (billion Yuan)	Construction land area (sq.km.)	Total amount of talent (thousand person)
2005	244.93	13.23	134.15	97.56	3.23	114.7	485
2006	287.44	13.93	158.36	115.16	3.76	120.6	534
2007	343.5	15.13	189.91	138.46	4.20	221.4	605
2008	396.41	16.74	219.67	160.00	4.57	224	690
2009	421.46	18.38	224.78	178.3	4.89	240	728

Year	Total investment in fixed assets (billion Yuan)	Social consumable total retail sales (billion Yuan)	Port cargo throughput (million ton)	Port traffic capacity (million ton)	Storage area (thousand sq.m.)	Accumulate of the pile field (ten thousand sq.m.)	Port investment (billion Yuan)
2005	133.63	75.98	268.81	238.12	112	896	13.07
2006	150.28	88.25	309.69	249.01	147	1176	15.12
2007	159.76	103.55	345.19	252.94	227.6	1774.8	14.34
2008	172.82	123.80	361.85	286.17	283.4	1982.3	16.71
2009	200.42	143.44	383.85	325.61	351.7	2343	18.52

Data sources Ningbo statistical yearbook

Table 128.3 Results for the potation of the model

Years	GDP (billion Yuan)	Foreign trade volume (billion Yuan)	Port cargo throughput (million ton)	Port operating income (billion Yuan)	Port traffic capacity (million ton)
2010	494.26	84.39	447.95	5.78	360.08
2011	560.88	98.30	498.82	6.51	403.16
2012	636.77	114.15	557.66	7.36	453.98
2013	723.27	132.21	625.78	8.35	513.95
2014	821.94	152.81	704.68	9.49	584.72
2015	934.57	176.33	796.13	10.82	668.22

Note The forecast data does not take into account price changes

Table 128.4 Influence of port investment to the city economy

	Years	GDP(billion Yuan)	Foreign trade volume (billion Yuan)	Port investment (billion Yuan)
Value in case growth rate of port investment increased by 1 %	2010	4943.89	844.21	38.43
	2011	5612.05	983.71	45.73
	2012	6373.66	1142.73	54.41
	2013	7242.48	1324.13	64.75
	2014	8234.4	1531.23	77.06
	2015	9367.74	1767.86	91.7
	Total	41774.22	7593.87	372.08
	Increment	57.28	11.963	12.33

Table 128.5 Influence of input factors from city to the port

	Years	GDP (billion Yuan)	Foreign trade volume (billion Yuan)	Port cargo throughput (million ton)	Port operating income (billion Yuan)
Value in case growth rate of input factors from city increased by 1 %	2010	498.70	85.32	449.88	5.81
	2011	570.96	100.41	503.19	6.58
	2012	653.93	117.73	565.11	7.47
	2013	749.25	137.63	637.05	8.51
	2014	858.83	160.51	720.68	9.72
	2015	984.89	186.83	817.96	11.13
	Total	4316.55	788.44	3693.87	49.22
	Growth rate	3.47 %	3.99 %	1.73 %	1.88 %

and 0.54 respectively. So, the increase of the urban investment can quickly improve the city's economic development, thereby promoting the development of foreign trade and the port's operating income indirectly.

128.6 Summaries

Some factors are neglected intentionally to simplify the problems in establishing system dynamics model of the port and city. Quantitative indexes are emphasized and the impact form changes in the external environment have not been considered. The port city is a complex system, how to reflect and evaluate the environment affects upon the system needs in-depth study.

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Chapter 129
Empirical Analysis on Technical Factors Impacting Energy Consumption Efficiency

Feixue Zhou and Zaiwu Gong

Abstract It is important to reduce energy consumption intensity and to improve the energy consumption efficiency in the low carbon economy development. Most scholars decomposed and analyzed industrial energy consumption intensity from the economic structure and the departmental energy efficiency. In this paper the impact on energy consumption efficiency was analyzed from the perspective of technical factors of social economic entities. The empirical results show that: (1) To increase energy efficiency, those methods like fiscal spending and related policy support adopted by the government are not obviously effective, and maybe further research should be done on its mechanism; (2) Market demand, public awareness, enterprise initiative and effectiveness on the energy saving help to improve energy efficiency; In view of these, more practical and reference value could be achieved with resort to the study on how to improve industrial energy consumption efficiency from these angles.

Keywords Energy efficiency · Energy consumption intensity · Technical factors

129.1 Introduction

Chinese "Twelfth Five-Year Plan" put forward clearly "seven" focuses on the development of strategic emerging industry from the industrial economy and its policy level. The designs of emerging industries highlight the promotion of the

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efficiency of energy-saving emission reduction. This paper will explore the influential factors of energy-saving emission reduction efficiency in high-quality stage. The result of this exploration has certain positive significance on how to promote the efficiency of industrial energy saving and emission reduction.

129.2 Literature Analysis

At present, one of the important indicators is mainly GDP energy intensity in the research related to energy efficiency. Most scholars propose to reduce industrial energy consumption intensity and enhance industrial energy efficiency by optimizing the structure and enhancing the sub-sector energy efficiency (Li and Zhou 2006; Qi and Luo 2009; Li and Wang 2009; Ma et al. 2010; Wang, 2011).

Many literatures show that technical factor is the most influential factor of promoting energy-saving emission reduction efficiency in the industrial level. Huang (1993) believed that the improvement of the branch energy intensity contributes more to energy intensity decline, and the change of industrial structure change caused by the change of the departmental product structure contributes less. Zhang (2003) broke down industrial energy consumption into scale effect, technology effect and structure effect. Technology effect is the dominant factor; Ma and Stern (2006) found that energy intensity increase originated from the negative technical progress since 2000 and that the energy internal substitution effect contributed less to the energy intensity.

Therefore, to reduce industrial energy consumption intensity and promote energy-saving emission reduction efficiency, the low-carbon technology innovation development is a must. Although most researchers analyzed from the structure factor and technology factor, based on the unified low carbon policy and market demand of industry, the analysis should be carried out by deeply considering how to push or pull low carbon development in the high-quality stage from the government, enterprise and market and so on.

129.3 Analysis of Influencing Factors

The trends of energy saving efficiency have the accumulative regularity of technology development. There are two trends worthy of attention on the characteristics of the 1990–2010 energy intensity change: Firstly the downward-sloping trend is obvious, but at the same time the decreasing speed will slow down. So the efficiency of energy saving should have certain long-term trend; Second, Changes in energy intensity also have some fluctuations that are also affected by other factors. Therefore it can be reached that market and government, enterprise and other external factors also play important roles in driving efficiency.

Table 129.1 The Correlation between industrial energy intensity and technical factors

	Appropriation for science and technology	Sales revenue of new products	Expenditures for technical renovation
Pearson correlation	−0.926**	−0.918**	−0.728**
Sig. (2-tailed)	0.000	0.000	0.001

** Correlation is significant at the 0.01 level (2-tailed)

The government mainly draws up policies to guide and drive the development of energy-saving. So government policies effectively promote energy efficiency and cut energy intensity. So here the data of the government appropriation for science and technology is considered as the government support.

Market factors mainly reflect the public needs, and manifest the public preferences to buy new products in which technology, economy, environmental protection and other low carbon economic elements were combined. Therefore, here sales revenue of new products is considered as the market factors.

The enterprise can decide whether low carbon innovation is adopted and promoted or not. And then scientific and technological achievements are applied in various fields of production (products, equipment, technology, etc.) to improve product quality, to save energy, to reduce consumption and to improve overall economic efficiency by the technical transformation. Therefore, here technological transformation and other business technical activities were considered as the important factors to promote the efficiency of energy-saving.

For the further research into the relation between the energy intensity and the above mentioned factors, the correlation analysis was made (as the Table 129.1 shows), and Appropriation for Science and Technology, Sales Revenue of New Products and Expenditures for technical renovation are significantly negative correlated with energy intensity.

According to the analysis on the previous factors, e_{it} is set to be the function affected

$$e_{it} = A * f(\mathrm{G_{it}}, \mathrm{C_{it}}, S_{it}, e_{it-1}) \quad (129.1)$$

by the government factors ($\mathrm{G_{it}}$), enterprise factors ($\mathrm{C_{it}}$), market factors (S_{it}) and other factors.

129.4 Empirical Analysis

The factors in the model should be confirmed by the principle of data availability. In fact a lot of data can directly or indirectly reflect a certain variable of the model, so the empirical analysis is required to determine the appropriate data, and to explain some practical problems.

129.4.1 Variable Data

This paper tries to use statistical data to reflect explaining variable and explained variable of the model. The government factor (G) is expressed as the data of the national appropriation for Science and Technology and taxation; The market factor variable (C) is expressed as the data of the sales revenue of new products; The enterprise factor variable (S) is expressed as the data of the expenditure on technical renovation, expenditures for indraught of technology, expenditures for absorb and digest or expenditures for interior technology; and explained variable is expressed as the data of energy intensity (E). These data mainly were obtained from the China Statistical Yearbook, China Statistics Yearbook on science and Technology and Chinese energy statistical yearbook, and part of the data of industrial energy consumption were obtained from the 50 years compilation of statistics of China Industry, Transportation and Energy (1949–1999) or the China's 60 years compilation of statistics, and Some data need to be obtained by simple calculations and sorting, and some of the time series data (GDP) need to remove the impact of price factors which is based on the price data of the year 2005.

129.4.2 Model

In order to reduce the effects of heteroscedasticity, we carry on logarithmetics processing to the correlation data, in addition, in order to prevent spurious regression phenomenon, the variable data are carried on first-order variance processing to meet the stability requirement of data. We take into account the lag of the effect of explaining variables to the energy consumption intensity, and adopt the delay values of variables except sales revenue of new product (its current value can directly reflect the effect of energy-saving technology innovation). The basic form of the model is showed:

$$\Delta \ln e_{it} = \alpha + c\Delta \ln \mathrm{C}_{\mathrm{it}} + g\Delta \ln G_{\mathrm{it}-1} + s\Delta \ln S_{it-1} +^{\wedge} + \gamma\Delta \ln \mathrm{e}_{it-1} + \varepsilon \quad (129.2)$$

Here, i only represents the industrial sector, e_{it} represents the t-Period of industrial energy consumption intensity; C_{it} represents the industrial sales revenue of new product of t-Period; $G_{\mathrm{it}-1}$ represents the industrial government expenditure for science and technology of first-Period-delay; S_{it-1} represents the Expenditures for technical renovation of industrial enterprise of first-Period-delay. Also the lagged dependent variable (e_{it-1}) represents the accumulation of past technological innovation. In fact we also take into account other valuable factors such as expenditures for indraught of technology (I1), expenditures for absorb and digest (I2), expenditures for interior technology (I3), income per capita (GP) and taxation (TAX).

129.4.3 Results

In order to reduce the effect of multicollinearity, analytical method of the model is the stepwise regression.

In addition, the results of residual test also show that Q-statistic, Ljung-Box statistics and Jarque–Bera statistics are not significant. So the residual sequence follows a normal distribution, and autocorrelation and heteroscedasticity of the model do not exist, therefore, the analysis shows that the model is reasonable. The final specific model is as follows:

$$\begin{aligned} \Delta(\ln \mathrm{E}) = 0.1249 &+ 1.4215^{*}\Delta(\ln \mathrm{E}(-1)) - 0.1606^{*}\Delta(\ln \mathrm{I2}(-1)) \\ &\qquad (4.4995)^{***} \qquad\qquad (-2.5292)^{**} \\ -0.3221^{*}\Delta(\ln \mathrm{C}) &- 0.1833^{*}\Delta(\ln \mathrm{S}(-1)) + 0.1067^{*}\Delta(\ln \mathrm{I1}(-1)) \\ (-2.2016)^{**} &\qquad (-2.0326)^{*} \qquad\qquad (1.8642)^{*} \end{aligned} \tag{129.3}$$

T values in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%. R-squared = 0.685976; Adjusted R-squared = 0.565198; Prob(F-statistic) =140 0.005413

129.5 Conclusion

From the regression result, we can get the following conclusions:

(1) The model shows the government support contributes nothing to the change of energy saving efficiency, and illustrates that the problems of energy saving efficiency still need to be researched deeply under the government support, or it could be the case that the contribution of government technology investment is not so obvious in improving energy-saving efficiency. Therefore it is necessary to consider how to continue to strengthen the investment of technical innovation which is beneficial to the improvement of saving energy efficiency.
(2) The model shows that the elastic coefficient of sales revenue of new product is −0.3221, which is negative to the energy consumption intensity, and illustrates that the market demand play a significant role in reducing the energy intensity. Income per capita is not brought into the model, which illustrates that the effect of the change of public income is not obvious to the change of energy consumption intensity, so the market guide of the energy-saving and the public propaganda and mobilization should be kept improving.
(3) The model also shows that the elastic coefficients of the Expenditures for technical renovation and expenditures for absorb and digest were −0.1833 and −0.1606 respectively, and the growth of the two factors is negative to the growth of the energy consumption intensity. It also illustrates that the investment initiative and Economic effectiveness of enterprises energy-saving

have positive effects on reducing energy consumption intensity. Therefore, when the policies on technology and economic relevant in developing energy saving are made, the guidance of enterprise energy-saving should be strengthened for energy-saving process of enterprises to obtain real benefits.

(4) In addition, the model shows that the growth of expenditures for in draught of technology is positive to the growth of energy consumption intensity, and illustrates that the growth of expenditures for indraught of technology has a certain crowding-out effect on other expenditures of technical innovation, which is directly in favor of energy saving. Therefore, when the introduction of advanced and applicable technologies is considered, actual effects of technical renovation, digestion and absorption should be paid more attention to.

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Chapter 130
Construction of Changsha-Zhuzhou-Xiangtan Low-Carbon Urban Agglomerations: Major Progress and Basic Experience

Xinsha Peng and Dalun Tian

Abstract Low carbon cities construction is an important content and pointcut of “Two-oriented society” construction. Since Chang-Zhu-Tan urban agglomeration was authorized to be “Two-oriented society” pilot zone by the State Council in December, 2007, Chang-Zhu-Tan Low Carbon urban agglomeration has achieved remarkable progresses and accumulated precious experience which is necessary to summarize comprehensively and systematically to provide effective strategies for the development in next step. Three aspects of contents are presented in this paper. Firstly, four major progresses of Chang-Zhu-Tan Low Carbon urban agglomeration have been summarized systematically. Secondly, successful experiences in five aspects are summarized. Lastly, three main conclusions are concluded.

Keywords Changsha-ZhuZhou-Xiangtan urban agglomeration · Pilot zone of two-oriented society · Construction of low carbon cities · Progresses · Experience · Case study

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130.1 Introduction

Global warming has become one of the most important challenges that the contemporary human society is facing. Cities are the major resources of greenhouse gas emission and major channels of energy consumption (Luo and Liu 2010; Guo et al. 2011). Therefore, cities have predominant and decisive roles in responding to climate change and curbing global warming, and the development of low carbon cities becomes to be an inevitable trend. Chang-Zhu-Tan urban agglomeration[1] lies in Northeast Hunan Province, including Changsha City, Zhuzhou City and Xiangtan City, with the total population of 13,256,000 in the end of 2007, occupying an area of 28,088 square kilometer. Chang-Zhu-Tan urban agglomeration is the transportation hub and strategic node connecting the four directions and the core growth pole of economical and social development in Hunan Province. Due to the history and natural resources, the industrial structure of Chang-Zhu-Tan urban agglomeration has long been based on the principle of high energy-consuming enterprises. The high energy consumption of the overall industry and the high emission intensity of carbon dioxide cause the urban environmental contamination very serious (Tang and Tan 2011). On December 14, 2007, authorized by the State Council, both Chang-Zhu-Tan urban agglomeration and Wuhan city cluster became “the comprehensive reform pilot zone of the national resource conservation and the environment friendly society construction” (it is briefly called “Two-oriented society” pilot zone, as follows). During the later four years since then, Chang-Zhu-Tan urban agglomeration is launched “Two-oriented society” construction in large scale. The directions and essences of the low carbon urban construction and “Two-oriented society” construction are the same, including the low carbon economy construction and low carbon society construction, which are the content and pointcut of promoting “Two-oriented society” construction. However, We found, on one hand, there were some misconceptions existing in the society in the low carbon urban agglomeration construction, such as “burning one’s figure theory of construction”, “theory of low carbon transformation hindering city’s development”, “theory that low carbon urban construction is too advanced”, and so on; on the other hand, in theoretical research, the existing literatures rarely review and summarize the practice course of Chang-Zhu-Tan Low Carbon urban agglomeration construction comprehensively and systematically. Most of the literatures are talking about what to do and how to do in the future for the Chang-Zhu-Tan Cities. The several faulty ideas above increase working resistance. But theoretical research is lack of systematical conclusion of

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[1] Chang-Zhu-Tan urban agglomeration has a difference between its broad sense and narrow sense. The broad sense means the so-called “3 + 5” city cluster, they are Changsha City, Zhuzhou City, and Xiangtan City plus cities around them, like Yueyang City, Changde City, Hengyang City, Yiyang City and Loudi City, which are eight cities in all. While the narrow sense means only Changsha City, Zhuzhou City, and Xiangtan City. And it is the narrow sense which is used in this paper.

practice course and empirical adequacy and reduces the pertinence and application value of research findings.

In the background stated above, from the perspective of the integration of the three cities, on the basis of reviewing progresses that the three cities have made on low carbon urban construction systematically, this thesis summarizes its successful experience and refutes the above "burning one's figure theory", "hindering theory", and "too advanced theory" with arrogant facts and increases people's confidence of doing well in low carbon urban construction. As well, it provides valuable practical cases and theoretical inspiration for the further promotion of Chang-Zhu-Tan urban agglomeration "Two-oriented society" construction and for exploring the new model of the development of low carbon cities cluster.

130.2 The Major Progresses of Chang-Zhu-Tan Low Carbon Urban Agglomeration Construction

According to major factors of affecting urban carbon emission, low carbon urban construction should be focused on the fields of low carbon industries, low carbon transportations, low carbon buildings, low carbon concepts and cultivation of social atmosphere. Chang-Zhu-Tan urban agglomeration has achieved encouraging results in these aspects for several years.

130.2.1 New Strategic Industries Characterized by Green and Low Carbon Develop Vigorously

The seven domains of advanced equipment manufacturings, new materials, cultural innovations, biology, new energy, information and energy conservation and environment protection are set as new prioritized strategic industries in Hunan province. These industries have achieved vigorous development in Chang-Zhu-Tan urban agglomeration during the 4 years. And the outstanding ones are as follows.

130.2.1.1 Wind Power Industry Develops Rapidly

Xiangtan and Zhuzhou City have arised a wind power equipment manufacturing industry cluster as leaders in recent years. And it has been on national leading position on the development of some key wind power equipment parts, and has held the core technology of mega watt wind power generation equipments. The orders of wind power equipments for several leading enterprises within a cluster has reached nearly 10 billion Yuan.

130.2.1.2 PV Industry has a Good Start

The 48th research institute of China Electronics Technology Group, located in Changsha City, is the developing and producing institute of national microelectronics, solar battery, photovoltaic material and power electronics and the leader of provincial PV industries. In 2008, the institute invested in PV industry officially, and at the end of 2009, it had built the first 12.5 MW of solar photovoltaic demonstration stations, 8 solar battery production lines in province in just more than a year, creating annual output value of 1.8 billion Yuan. In addition, other important investment projects of PV industries, such as Chuangke silicon industry, HuaLei photoelectric, Shenzhou photoelectric, Huarun new energy, Sansheng photoelectric and other 30 enterprises have been put into operation gradually, and the industry chain was pulled fully and rapidly, with an annual output value of more than 5 billion Yuan.

130.2.1.3 National New Energy Auto Production Base Begins to Take Shape

Electronic auto project participated by THE ZHUZHOU CSR TIMES ELECTRIC Co., LTD, Sany Heavy Industry has successfully break through the technological bottleneck of Nimh batteries and drive motor. Energy conservation and emission reduction in performance of petrol electric hybrid and pure electric driven city bus produced by THE ZHUZHOU CSR TIMES ELECTRIC Co., LTD led the domestic level. Geely Automobile Holdings Ltd has been settled in Jiuhua economic development zone of Xiangtan city since 2005. It plans to build a new energy production base with annual production of 300,000 and annual production value of 45 billion Yuan and has built a Xiangtan Geely Automobile Institute (Zhang 2010). In 2009, it started the three-phase project build with a total investment of 3 billion Yuan, which has been put into production in December, 2011, with a prediction of total production of 100,000 in 2012 and total production value of more than 10 billion Yuan (Zhong and Zhang 2011). In July, 2009, BYD Automobile Co., Ltd settled in Changsha with the only electric bus chassis production base in the world. Meanwhile, Chang-Zhu-Tan three cities also introduced a number of famous auto enterprises from both home and abroad, such as Bosch, Hitachi, Guangzhou Automobile, Beijing auto Fukuda, and GuangQi Fiat. Currently, Chang-Zhu-Tan has become the sixth major part of Chinese auto industry and its production of energy-saving and new energy automobiles and electric transmission system covers more than 70 % of the whole country. New energy auto industry base which will hopefully become the national largest one has shown its prototype (Zhang 2010).

130.2.2 Low Carbon Transportation Construction is Launched in a Large Scale

130.2.2.1 Subway Construction has Achieved Great Progress

Changsha subway construction officially started in 2009, with a first-stage project of line 1 and line 2 under building at present. First-stage project of subway line 2 totaling 22.26 km is predicted to be completed and put into test run in October, 2013. First-stage project of line 1 totaling 23.55 km is predicted to be completed and put into test run at the end of 2014 (Yue 2012).

130.2.2.2 The Inter-City Rail Transit Construction Starts

Chang-Zhu-Tan inter-city railway which is an inter-city express railway connecting Changsha, Zhuzhou, Xiangtan urban agglomeration, started its first-phase project on 30th June, 2010, totaling 96 km, with an investment of 23.3 billion Yuan and construction period of 4 years. Until 9th February, 2012, the whole line of Chang-Zhu-Tan inter-city railway has had 50 construction worksites, among which the construction of three channels and four grand bridges has made great progress (Baike Calling Card 2012; Zhang 2012).

130.2.2.3 Low Carbon Buses have been Put into Operation in a Large Scale

The office of the electric car leading group of Hunan province made the plan of energy conservation and new energy automobiles demonstration and expansion project. In 2009, 500 hybrid buses had been put into operation in cities of Changsha, Zhuzhou, and Xiangtan which had been achieved at the end of the year (Hunan Science and Technology Department 2009).

The original 627 buses had all been replaced by hybrid buses on 8th September, 2011 in Zhuzhou. Thus, Zhuzhou city has become the first city of realizing the goal of bus electrification in China (China South Locomotive and Rolling Stock Corporation Limited 2011). At the end of December, 2009, the general bus company of Xiangtan city overfulfilled the required task of *The Chang-Zhu-Tan national energy conservation and new energy automobiles implementation plan of demonstration and expansion project* with 105 hybrid buses put into operation gradually (Xu and Li 2009). Longxiang Bus Limited Liability Company in Changsha city had already had 210 new energy city buses which occupied 20 % of the total number of vehicles until February 10, 2012, including 180 natural gas automobiles and 30 hybrid vehicles (Ming and Ni 2012; Chen 2011).

130.2.2.4 Urban Public Bicycles Rental System Started in Zhuzhou City

Zhuzhou public bicycle rental system started in May, 2011, with 500 rental sites and 10,000 bicycles equipped and put into use comprehensively at the end of 2011. Citizens in Zhuzhou were advocated with public bicycles concepts of "taking in need, and returning in speed" and encouraged to transfer by bicycles which were free in 3 h. Currently, more than 1000 rental sites were built in Zhuzhou, with 120,000 rental cards transacted, 150,000 average daily usage amounts. Urban public bicycle rental system would be improved in 2012, advocating low carbon and healthy travel (Chen and Guo 2012). Since it was started officially in May last year, Zhuzhou public bicycles rental system had covered almost the whole city, and 20,000 bicycles were put into use after the New Year of 2012 (Xia 2012).

130.2.3 Low Carbon Buildings Were Paid More Attention

Before two types society pilot zone was built in 2007, Chang-Zhu-Tan three cities paid attention to energy conservation of buildings and made great achievement in respect of promoting new type wall materials. After two-oriented society pilot zone was built, energy conservation of buildings was further strengthened and expanded.

Firstly, relevant documents, work plans and technical standards are issued and implemented, such as *Regulations of demonstration project management of energy-saving buildings in Changsha, Urban general implementation plan for demonstration of renewable energy's application in architecture in Zhuzhou (for trial implementation), Implementation plan of buildings' energy conservation and new types wall materials' promotion in Xiangtan from 2008 to 2010, Standard for designing energy-saving residential buildings, Standard for designing energy-saving public buildings,* and so on.

Secondly, program of low carbon buildings' pilot site for demonstration is launched, and leading enterprises' development is supported. In 2009, there were nine programs of national energy conservation project for demonstration of green buildings in Changsha. On 8th February, 2010, "project of comprehensive improvement for energy conservation of the existing residential buildings in Broad city" by Broad Changsha Air Conditioning Co., Ltd was authorized by Ministry of Housing and Urban-Rural Development as a major national scientific project of the 11th five-year plan which was the first similar demonstration project in central and southern China with the title of integrated demonstration project of comprehensive improving technology for the existing buildings (Tang and Zhu 2010). Compared with traditional buildings, the sustainable buildings from the company has the advantage of 9° earthquake resistance, six times material conservation, five times energy conservation, 20 times purified air, 1 % architectural garbage and 100 % factory manufacture (Hunan CZT Two Types of Society Office 2011). By the end of 2010, 16 demonstration projects were completed in Zhuzhou city, with gross size 326.500 square meters (Mao 2011). And the provincial only three sample houses for renewable energy building' application were finished in Zhuzhou city.

Thirdly, on the principle of "government fostering, market running and enterprises participating", program of building energy conservation is promoted solidly. Currently, Three cities has finished energy consumption statistics, energy auditing and energy consumption publicizing to large public buildings, started constant monitoring to part of large public buildings, and strengthened technical support of building energy conservation, thus making new breakthrough. To the end of 2010, energy conservation buildings of 51,800,000 square meters were built in Changsha City. In Zhuzhou city, energy conservation design rate of annual new buildings reached 100 %. Energy conservation implementing rate reached 82.5 %, 86.7 %, 92.3 % from 2007 to 2009, and hopefully reached 97.5 % in 2010 (Hunan CZT Two-oriented Society Office 2011). By the first quarter of 2009, urban energy-saving designing rate of Xiangtan city reached 100 %, energy-saving implementing rate reached more than 80 %. In three counties of Xiangtan city, energy conservation and new type wall materials designing rate reached 100 % and energy conservation implementing rate reached more than 50 % (Xiang 2009).

130.2.4 Low Carbon Concepts were Popularized Increasingly, and Low Carbon Consumption Rises Gradually

Recently, through effective incentive mechanism and reinforced publicity and popularization activity in Chang-Zhu-Tan three cities, low carbon concept popularizes increasingly and low carbon consumption becomes to be people's conscious action gradually (Hunan CZT Two-oriented society Office 2011; Wang 2011).

Changsha popularized energy-saving knowledge, built strong public atmosphere and promoted economical way of life and low carbon consumption pattern by organizing large scale activities, such as the walk of environmental protection century, saving propaganda week, making special TV show, opening up newspaper columns, holding a competition and exhibition, and distributing *energy-saving knowledge manual* and *Changsha energy action plan* freely. "Water-saving nursery rhyme" created by the collectivity of Songxin school in Zhuzhou is widely sung in society. *Be close to nature* and *green nature and green garden* compiled by Yunlong school of Xiangtan became to be the first "two-oriented" education textbooks in the province and were recommended in middle schools and primary schools of Xiangtan. Low carbon activities were also held frequently, such as hundreds of student volunteers' art performance, Chang-Zhu-Tan three cities' cleaning Xiangjiang River together and thousands of people's low carbon travel.

Low carbon concept's popularizing increasingly brought the gradual rise of low carbon consumption. In 2009, on year on year basis, the comprehensive consumption of water, electricity and gas of the administrative center of Changsha City Hall reduced by 15 %, and saved the direct expenses of 2440,000 Yuan. Since 2009, all the hotels in Changsha have stopped providing disposable ordinary commodities. Consumption of disposable ordinary commodities in 83 star-rated hotels in Changsha reduced 110,000 sets than the same period in last year, saving capital more than a million Yuan with good social responses. After technical innovation, nearly 80 villagers from Guangming village of Bairuopu town in Wangcheng county cookes by methane, bathes by solar power and even have sewage disposal system. This is the first "two-oriented" village in Hunan built by resource conserving and environmentally friendly pattern (Hunan CZT Two-oriented Society Office 2011).

130.3 The Fundamental Experience of Chang-Zhu-Tan Low Carbon Urban Agglomeration Construction

By means of various bold explorations in each experimental site, a lot of successful experiences of developing Chang-Zhu-Tan low carbon urban agglomeration are accumulated. The following items are the main ones.

130.3.1 The Integration of Government, Market and Enterprise

Firstly, the policy of "setting provinces as the coordinators and setting cities as the main body" not only put emphasis on the formation of joint forces, but also exerted the subjectivity and positivity on each city. Finally this rule made each city adopt the advantages, avoid the short comings and develop synchronously and harmoniously. The content of setting provinces as the coordinators involved planning and arranging, coordination of organizations, formulation of significant policies, modulating the structures relating to transregional crucial benefits and so on. Setting cities as the main body defined that each city on the basis of the guidance of the unified object and course formulated by the provincial government took responsibilities, implemented the plans, did research into a peculiar developing way which consisted of demonstration of pilot sites, mobilization of overall situation, accurate positioning, malposition development, playing the role of regional characteristics and realizing the goal of regional connection and so on. Secondly, adhering to the operation of market oriented and optimizing the deployment of resources was vital. The government explored into the environmental management, investing, financing and integration of cities and countryside and so on. For example, carrying out the policy of compensation of watershed ecology, transaction of compensation authority, experimentation of responsibilities to enforce the risk of environmental pollution, encouraging and supporting the go-public of enterprises, the preferential policy for financing of minor enterprises, probing into the worthiness, transaction permits, market-oriented flow of right to the contracted management of land for agriculture and forest and so on. Thirdly, insisting on the fundamental role of the enterprises in the development of low carbon city was crucial. On one hand, the government should strongly support the enterprises' exploitation and production of commodities of low carbon, as well as the supply of low carbon service. On the other hand, taking the enterprises as the main force of accelerating the economy of low carbon. Positively encouraging and supporting the enterprises' reductive and clean production (Xu and Qin 2011).

130.3.2 The Combination of the Theory and the Pragmatism

Firstly, in terms of the theory, the government stressed the top design, planning ahead and positively boosted the theoretical research. Besides, the government strived to eliminate the cliché and provided the following actions with a logical and rational theoretical guideline, demolishing the blindness when taking actions. From the end of the year of 2007 to the end of the year of 2008, Hunan invited a lot of outstanding professional experts and scholars both at home and abroad to design the reformation and development plan of "Two-oriented society" experimental sites in Changshang, Zhuzhou and Xiangtan. After a whole year's research, they formulated *the overall project of experimental comprehensive coordinated reformation of developing resources-saving and environmental-friendly society in Changsha, Zhuzhou and Xiangtan* (Hereafter referred as *Project*). At the same time they formed the updated *regional planning of urban agglomeration in Changsha, Zhuzhou and Xiangtan* which was authorized by the State Council (for short as *Regional Planning*). This indicated that the design of construction of experimental sites in Changsha, Zhuzhou and Xiangtan was approved by our country. In terms of theoretical research, the Two-oriented society construction office (for short: TOS office) has initiated multiple issue research tasks and organized to edit, as well as publish *two-oriented society Construction in Hunan series* (including five books), *Strategic Studying Booklet of Four Modernizations and two-oriented of Hunan*, *two-oriented' Hunan Province* and so on. Hunan provincial academy of social sciences, Central South University, Hunan University, Party School of Hunan Provincial Committee of Communist Party of China, Hunan University of Technology, Tongji University and the other universities and organizations inside and outside of the province established the research organization of two-oriented society in succession. In January, 2009, the Hunan Provincial Party Committee, Hunan Provincial Government particularly established "the intelligence office of the coordination committee members of Two-oriented society experimental sites in Changsha, Zhuzhou and Xiangtan office (for short: WO in CZX)". This organization conducted plenty of theoretical and policy research, becoming the essential wisdom resources of forming policies by Hunan

Provincial Party Committee, Provincial Government (Hunan CZT Two-oriented society Office 2011; Xu and Qin 2011; Hunan CZT Two-oriented society Office 2011). Secondly, in terms of the pragmatism, the experimental sites on the basis of Scientific Outlook and Development and the masses' benefits and wishes, grasped the important fields (low carbon industry, low carbon traffic, low carbon consumption and so on) of urban construction of low carbon tightly according to the planning, standards and application projects. Because the construction conditions have been displayed in the above, I will not reveal it once again. As to the aspect of updating the outdated ideas, I have introduced it in the part of "Low carbon concept popularizes increasingly, and low carbon consumption rises gradually", and will not introduce it once again.

130.3.3 The Combination of Technological Innovation and Institutional Innovation

In terms of technological innovation, the main methods includes: establishing a platform of technological innovation, fully exert the influence of each district, positively accelerate the combination of industry, academia and the research community with innovation. As to the aspect of technological innovation, the government principally adopts the significant technology project, building a scientific research platform based on colleges and key labs. Besides, it founds a plenty of technological projects related to energy saving and emission reduction, solving 200 fatal bottleneck problems and general technical issues intensively (Hunan CZT Two-oriented Society Office 2011).

In terms of the systematic innovation, there are mainly three aspects. The first aspect is the innovation of planning and standard. The second one is the innovation of policy and law. The third one is the innovation of system and mechanism. From the perspective of innovation of planning and standard, Innovation of planning and application system is mainly indicated by the founding of "TOO" and setting a planning bureau. It infers that the planning and standardization work obtains a unified special administration and research organization. Furthermore, they establish a conference system of the joint directors of urban agglomeration planning, the mass taking part in formulating rules and so on (Hunan CZT Two-oriented Society Office 2011). From the aspects of policies, laws and systematic innovation, For more than 4 years, Hunan Standing Committee of NPC formulated at least four regional laws and the Provincial Government formed at least eight governmental principles. At the same time, Provincial Party Committee, Provincial Government, Standing Committee of NPC and Provincial People's Political Consultative Conference carry out more than 70 regulatory documents. The government and Standing Committee of NPC of each city and town form and promulgate the local relevant policies and laws (Hunan CZT Two-oriented Society

Office 2011; Hunan CZT Two-oriented Society Office 2011; Hunan CZT Two-oriented society Office 2011; Hunan CZT Two-oriented society Office 2011).

130.3.4 The Combination of High-Carbonization Storage Transformation and Low-Carbonization Increment Promotion

130.3.4.1 Positively Guiding the Development of Emerging Low Carbon Industry Thereby Forcing and Accelerating the Transformation of High Carbonization Industry

Changsha actively boosts the development of some fields, such as, biology, new energy, electric automobile, new material, energy-saving, environmental protection, engineering and machinery, aviation, electronic information and culture creativity and so on. Moreover, these fields have formed their own advantages. Zhuzhou mainly stresses developing wind power equipment, electronic automobile, new energy, new materials, track traffic and other strategic emerging industries. Furthermore, Zhuzhou has made significant progress on the fields of utilization of coal and electricity, wind power generation, electronic automobile, photovoltaic, and express trains and so on. Xiangtan government chooses to develop the programs of low energy consumption, low environment pollution, high efficiency, and emphasizes to promote the strategic industries, such as the advanced equipment production, clear energy, vehicles and installation kits, electronic information and so on. The rapid development of these emerging industries reduces the pressure on the limited resources and the environment efficiently. Furthermore the development of these industries enhances the competitive ability, activates the industrial structure, and marginalizes the traditional high carbonization industry. It can be said the development accelerates the restructure of the traditional high carbonization industry and leads the industrial structure in CZT to a direction of low carbon, high efficiency and clearance (Hunan CZT Two-oriented society Office 2011).

130.3.4.2 Accelerating the Quality Reconstruction of Traditional Industries and the Upgrading and Transformation of Primitive Industrial Bases

Except for the emphasis on the development of new emerging low carbon industry, CZT urban agglomeration experimental sites underline the adoption of low carbonization increment to improve the storage of high carbonization. Through the methods of technological transformation, industrial replacement and abandonment, the experimental sites strive to upgrade the traditional industry (Party School of Hunan Provincial Committee of the Communist Party of China, Hunan Administrative Institute, Hunan CZT Two-oriented Society Office 2012; Hunan CZT Two-oriented society Office 2011).

Changsha utilizes various ways to eliminate the obsolete industrial chains and reforms the traditional industrial technology. Firstly, concentrating on governing more than 120 paper making factories, among which 54 factories are ordered to shut down, 70 factories by importing zero emission technology and constructing paper making circulation chain are allowed to proceed operating. Secondly, implementing a project of quitting Pingtang obsolete industrial base. After the project, the CO_2, SO_2 emission will be reduced separately at least 190 thousand and 26 thousand tons per year. Thirdly, propelling the development of more hi-technological of the traditional competitive industries, inducing the steel, colored-metal, petro-chemical industry to aim at the high level of the industrial value chains and integrate various resources. Furthermore, it is necessary to utilize the advanced technology in foreign countries to transform and prompt the traditional industrial organizations to be more active and energy-saving.

Zhuzhou actively develops the circulation economy by propelling the low carbonization of the traditional industrial organizations, putting special emphasis on the key enterprise related to colored metal, chemistry, china and so on and upgrading the technology in these organizations. Especially the example of transforming the structure of Zhuzhou Qingshuitang Industrial District, is a typical demonstration. In 2008, Zhuzhou founded the Qingshuitang circulation economy administration committee. Zhuzhou government firstly referred to the relevant laws punished and shut down 13 companies which violated the laws and polluted the environment badly within 6 km of heavy metal pollution areas, and praised 121 enterprises which adhered to use clear energy, qualified 20 enterprises which stuck to the principles of saving energy and emission reduction. In June of 2010, Zhuzhou government initiated to construct a Qingshuitang heavy-metal waste water processing project which cost almost 360 million. After its foundation and operation, the water pollution accumulated for about 50 years will be solved from the root.

Xiangtan insists to keep the principal rule of upgrading, optimizing, reducing and endeavors to boost the traditional competitive industries, such as metallurgy, mechatronics, to be more modernized, scaled and high-tech owned. Therefore, during 2008–2010, Xiangtan government had invested about 46 billion industrial fund to implement a lot of technological innovation programs and activated the traditional industries. At the same time, Xiangtan sticks to the retreat system of “Enterprises of Five Smalls”. Within these years, about 118 enterprises of five smalls are shut down. In addition, Xiangtan government concentrates on accelerating the transformation of Zhubugang obsolete industrial district. Currently the policy of reducing the number of the second industry enterprises, increasing the number of the third industry enterprises are carried out. 19 enterprises in this chemical industry district have been shut down.

130.3.5 The Combination of Learn from Others Experience and Adjusting Measures to Local Conditions

CZT experimental sites adhere to the construction with a high starting point, at the same time adopt adjusting measure to the local conditions. On one hand, they humidly obtain the valuable experiences from the other cities at home and abroad. On the other hand they adjust those experiences to the local conditions and create a peculiar development way of urban agglomeration of low carbon (Hunan CZT Two-oriented society Office 2011; Hunan CZT Two-oriented society Office 2011).

The first one is by means of going out to learn and inviting experts to teach learning the advanced experiences. Since 2008, Hunan Province and experimental sites of CZT urban agglomeration have organized several representative teams to go to other countries, such as Japan, Denmark, Germany, Korea, and Russia to absorb helpful things. The representative has obtained a lot of valuable experiences. Hunan Province has currently built a system of utilizing the foreign experts to serve the development and transformation of the experimental sites. The first way is forming the wisdom collection office of the CZT experimental sites. The second way is signing a cooperative framework agreement for serving the development of CZT experimental sites with the National Bureau of Foreign Experts Affairs. Besides, Hunan government invited the experts at home and abroad by means of international invitation to bid, international convention or forum to provide more ideas to the development of experimental sites of urban agglomeration.

The second one is exploring the peculiar way of developing the low-carbon urban construction according to the local conditions. They set the goal of building the first low-carbon urban agglomeration in 2009, and explored positively from planning, industry, traffic, building, energy, technology, consumption, community administration, environmental protection. In terms of urban planning, Changsha enhanced the ideology of low carbon and incorporated the low-carbon economic development and low-carbon urban construction into the 12th five-year plan and formed the special planning of low-carbon urban construction. In terms of low-carbon industry, traffic, building, energy, consumption, technology, these three cities strongly develop the industries and goods with local characteristics on the basis of the direction of industrial transformation and urban construction. In terms of community administration, Zhuzhou positively creates the low-carbon experimental sites, and puts emphasis on the county of Yanling. Besides, in downtown, it builds experimental sites of low-carbon communities, streets and communities. Moreover, it popularizes the application of solar energy in the low-carbon communities and set the system of waste water recovery, rain recovery. In addition, it initiates to carry out the resources-saving activities, such as trash classification, recycling and so on. At the same time, it starts to try out the resource price reformation. In terms of environmental protection, Xiangtan builds the stereoscopic environmental protection system, takes the lead in on line monitoring the pollution origin, implements the “1126 project”, achieving the goal of main pollutants' reduction index ahead of the 11th five-year plan schedule. The waste water processing factories in the five counties have been completed and have begun to operate. Moreover, Xiangtan ahead of the schedule realizes the target of *three-year's planning* (2008–2010) of waste water processing in town.

130.4 Conclusion

The practice of low-carbon urban agglomeration Construction in CZT indicates that the transformation to low-carbon pattern can organically integrate with a rapid development in the inland less developed provinces. At the same time those two could facilitate each other mutually. It is significant and necessary to set "Two-oriented society" experimental site, which will exert its leading role within China. Low-carbon urban agglomeration Construction in CZT is launched under the background of "Two-oriented society" experimental site and is one of the vital contents of building "Two-oriented society". Moreover, it is the fatal pointcut and powerful method of prompting the construction of "Two-oriented society". The low-carbon urban agglomeration in CZT just experienced a 4 years' practice, and our recognition to characteristics and laws of low carbon urban agglomeration's development is still superficial and fragmented that the construction mission is still very difficult in the 12th five-year plan and the future. We need to continue practice positively on the basis of summarizing experiences and lessons to explore a road of low carbon urban agglomeration development bravely which has Hunan characteristics and popular meaning.

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Chapter 131
Constructive Research of Carbon Accounting Information Disclosure of Listed Companies

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Abstract As an important part of the carbon accounting, Carbon accounting information disclosure has attracted much attention in recent years. However, our current carbon accounting information disclosure is fragmented and not standard; the level of corporation's voluntary disclosure is not high. The lack of uniform standards and comparable information result in the value of the carbon accounting information can not be achieved. Therefore, this paper draws on the related field research to explore how to construct a model of information carbon accounting disclosure of listed companies in China, establish the principle of carbon accounting information disclosure, and design the content and ways of carbon accounting information disclosure, therefore, making our carbon accounting information disclosure a standardized basis.

Keywords Carbon accounting information disclosure · Disclosure ways · Disclosure content · List companies

131.1 Introduction

In recent years, global warming caused the appeal of the whole community to build a low carbon economy, and governments have carried out research for the theory and practice of the carbon accounting. As an important part of the carbon accounting, carbon accounting information disclosure is also an increasing concern.

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Governments, investors, consumers and other information needers require companies to disclose their carbon accounting information, and thus provide the basis for their decisions. However, China is still in the voluntary stage of the carbon accounting information disclosure, and there are no uniform standards and systems, therefore, carbon accounting information disclosure of listed companies is fragmented and not standard, and does not reflect the value of the carbon accounting information. Therefore, we draw on related areas of research to explore model of the carbon accounting information disclosure for listed companies in China, and lay the foundation for the standardization of China's carbon accounting information disclosure.

131.2 Literature Review

In 2008, the concept of carbon accounting is formally proposed. Stewart proposed "the mechanism of the measurement of carbon emission allowances of carbon dioxide emissions or bioretention is carbon accounting", and this accounting is not closely related to the traditional accounting measurement in the currency value, therefore, it is also known as the accounting of carbon emissions and carbon sequestration. Stewart and Janek (2008) also proposed two ideas to build a carbon accounting standard: First, in the framework of the Kyoto Protocol, carbon credits accounting norms of all agencies or organizations to produce carbon sinks coordinates with the IPCC's principles; second, Greenhouse Gas Protocol (GHG Protocol) formulates the measurement and report carbon dioxide emissions related to accounting issues, which not only includes corporation accounting and report basis, but also is a mature system about greenhouse gas estimated emissions. The term "carbon accounting" is the first time in the accounting literature, and at the same time it marks the "carbon accounting" began to receive attention and concern of the international accounting academics as an important and special accounting issue.

Adrian (2007) also found that the investors require enterprises to provide carbon emissions data as a basis for their investment risk. Although many companies in Europe and North America are beginning to provide relevant information, this information does not meet the needs of investors. Relevant information disclosure increases every year, but due to no unified standards or norms for domestic and international carbon accounting information disclosure, different companies take the different measurement methods, which leads to the amount of different companies information is rarely small and information is not comparable.

Ans et al. (2008) pointed out that carbon accounting information disclosure and carbon accounting are two different concepts. Carbon accounting information disclosure should include a wider range of information related to climate activities, including the measurement of carbon emissions, the organization preparation, technology investments and transactions, which do not comply with the strict forms as the carbon accounting. Kiernan (2008) thought type of carbon accounting disclosure, significance of carbon emissions data and the lack of reliable supervision make difficult to understand the report of the carbon emissions, let alone figure out the actual achievements of the enterprise, even for senior climate change and emissions data analysts, it is difficult to understand the company's reports as part of CDP. Lovell et al. (2010) pointed out that the companies desire standards makers to be able to develop carbon accounting guidelines as soon as possible, to make comparison between the companies more feasible, easier in accounting.

To sum up, in an international context, the problem of carbon accounting information disclosure in the specification missing is all faced; there is no unified carbon accounting model of information disclosure in the enterprises; and the content and form of carbon accounting information disclosure need deep study.

131.3 The Principles of Carbon Accounting Information Disclosure of Listed Companies in China

Construction of China's listed companies in carbon accounting information disclosure mode is not an easy thing, and there are a lot of problems to be solved. Therefore, in the process of building mode, we should follow some basic constructing principles to avoid deviation from the direction, such as: (*1*) *the principles of continuation, reference and innovation,* (*2*) *the principle of step by step,* (*3*) *the principle of operability, and* (*4*) *the principles of mandatory and voluntary.*

131.4 The Content of Carbon Accounting Information Disclosure of Listed Companies

131.4.1 The Disclosure Framework

From the current situation of carbon accounting information disclosure of listed companies in China, the information disclosed is mainly non-monetary information in a textual description of the qualitative table, whereas, the monetary information of the quantitative table still needs relevant accounting norms and standards. Therefore, before the introduction of the relevant norms and standards, according to the actual situation of China's corporate greenhouse gas emissions, with reference to framework of the Carbon Disclosure identified by international organizations, listed companies in China should complete carbon accounting information disclosure framework from seven sides: strategy, risks and opportunities of corporate carbon emissions, the emission situation of GHG, reduction measures, carbon emissions trading, the impact on financial data and audit forensic.

131.4.2 The Disclosure Content

Because carbon accounting is a branch of the environmental accounting, the academic circles at home and abroad did not do too much in-depth study for the content of carbon accounting information disclosure, but the study of environmental accounting is relatively more mature, so the study for carbon accounting information disclosure may refer to the environmental accounting research. Combined with carbon accounting information disclosure framework previously established, carbon accounting information disclosure should include two aspects, first, the carbon performance information, which is off-balance sheet non-monetary information, the disclosure of some information which can not be quantified in monetary terms, and the information in the financial statements which can not reflected as the formal elements, and all of this are qualitative information; second, elements of carbon accounting information, which is the information in the table, mainly refers to the disclosure in the financial statements projects, such as carbon assets, carbon liabilities, which can be measured in monetary terms.

131.5 Disclosure Ways of Carbon Accounting Information of Listed Companies

Because the financial statements of listed companies has formed a complete system, and carbon accounting as an emerging field, has not yet reached a consensus in some of the issues, if we put directly into the existing statements, it is likely to cause the information confusion. Therefore, it is recommended that the separate carbon balance sheet and carbon income statement should be prepared to be accounted for, for such disclosure approach having two advantages: first, it is clear to separate from existing financial statements; second, it is helpful for listed companies to reflect a complete associated carbon accounting information, avoiding the fragment of carbon accounting information disclosure. Separate carbon report can reflect a large number of non-monetary information, complementary to the separate carbon accounting statements; therefore it will fully reflect the carbon accounting information of listed companies to take a combination of a separate carbon accounting statements and carbon reports.

The carbon accounting statements consist of s*eparate carbon balance sheet, separate carbon profit statement,* and *notes to financial statements.*

The preparation of a separate low-carbon reports is a great help for information users to fully understand the carbon dioxide-related activities of the enterprise. However, at present whether in abroad or in China, listed companies did not form a complete report of low carbon. On the basis of the report in the environment, referring to status and actual situation of the disclosure of accounting information of listed companies in China, this paper proposes framework for a low carbon report, which is the supplement for some of the content of the carbon accounting information to make it more suitable for the requirements of the listed companies of information users.

In this low-carbon report, compared with former carbon accounting statements, several elements of the risk of low-carbon, low-carbon results and related quantitative index are included, mainly with reference to the prospectus of the listed companies and carbon accounting information in the annual report, with the goal of improving defect that carbon accounting information disclosure of listed companies is fragmented, difficult to focus on, and increasing operability.

Meanwhile, it is suggested that contents of the low-carbon report should use a variety of methods, such as tables, text, graphics, etc. In addition, the low-carbon report should be open both to the government and open to the public in order to make the effectiveness of carbon accounting of the disclosed information maximize. Low-carbon report also needs to accept an independent third party review and testing, and it should also be required for listed company emitting more carbon dioxide shall periodically prepare a special low-carbon report to ensure the objectivity and credibility of the carbon accounting disclosure, similar to the environmental information disclosure.

131.6 Conclusions and Recommendations

Adhering to principles of the continuation, reference and innovation, progression and combination of mandatory and the voluntary, based on the established summary, this paper summarizes the suitable system of framework and content of carbon accounting information disclosure of listed companies in China and focuses on the ways of accounting information disclosure of listed companies, thinks a separate carbon accounting statements and low-carbon report are suitable for our country's disclosure. The main table of carbon accounting statement disclosure provides quantitative carbon accounting information; directors' report and note to carbon accounting statements provide the environmental accounting information which has a significant impact on listed companies; low carbon report makes a qualitative description and analysis for the low-carbon information based on the natural amount, with text, graphics.

In order to implement this paper's conclusion, in order to make carbon accounting information to disclosure of listed companies more scientific and rational, the joint efforts of the three aspects of academia, government and enterprise are needed. Carbon accounting theory and practice of research work should be accelerated in the academia; the government should actively pursue the legislative work in carbon management, carbon accounting information disclosure, play the leading role of the law and strengthen the government's regulatory and guiding role in the carbon accounting information disclosure; enterprises should pay attention to cultivating awareness of corporation social responsibility, put carbon content into the areas of corporation culture, and explore the carbon accounting disclosure practices in the practical work. Only with these three aspects mutual promotion and overall operation, will it effectively promote the carbon accounting information disclosure to realize the real value of carbon accounting information.

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Chapter 132
An Empirical Study on the Factors Affecting Carbon Accounting Information Disclosure of Chinese Listed Companies

Zengjun Gu, Xuemeng Guo and Lixia Jian

Abstract This paper selects 341 from Shenzhen and Shanghai listed companies as a sample, and uses the descriptive statistical analysis to find out the status quo of disclosure from the perspective of industry type and year respectively, then this paper analyzes the influence of the industry type, company size, governance structure, business performance, development ability and the debt level on the carbon accounting information disclosure of the listed companies.

Keywords Carbon accounting information disclosure · Factors · Industry type · Company size

132.1 Introduction

Climate change is a global environmental issue and concept of low carbon economy, which has been widely accepted. Then, "carbon accounting" concept appeared; carbon information and carbon accounting information disclosure started to arouse the concern of the government, regulators and other interest holders, and also affected the company's production and operation, financial condition, investment and financing decisions. Low-carbon economy in China started late; the research of carbon accounting theory and practice is still in the stage of exploring and learning from western research results and methods. Carbon accounting information disclosure is fragmented and not standard; there are no uniform standards and systems, therefore, enterprises are lack of the motivation of

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voluntary disclosure of carbon accounting information. Therefore, this research can make up for gaps in this field with positive theoretical guiding significance to a certain extent.

132.2 Literature Review

Foreign academic circles have conducted in-depth studies on carbon accounting information disclosure issues. O'Dwyer et al. (2005) point out that companies are increasingly required to disclose the information related to greenhouse gas emissions by investors and non-governmental organizations. The reason is non-government agencies think information in the carbon disclosure can provide more reliable information related to the value of the assets. Thus, these non-governmental organizations actively mobilize large institutional investors to require companies to disclose carbon accounting information; in turn, the released information is also beneficial for them to put pressure on companies to change their behavior. Lovell H (2010) points out that the companies are keen to get standards of carbon accounting guidelines as soon as possible to make the comparison between the companies more feasible, and also easier in accounting\.

Johnston et al (2008) and other researchers find that in the American SO_2 emissions trading mechanism, the market is positively correlated with emission quota of the company in value, indicating that the investors regard emissions quota as an asset mostly. At present, China's academic research on carbon accounting information disclosure is limited, which are mostly mentioned in the carbon accounting or carbon emissions. From the perspective of game theory, Zhongqiu (2011) analyzes game relations of business and government, the enterprises and the public, as well as company management and shareholders in the process of disclosure of environmental accounting information and the corresponding equilibrium, from which it is obtained that government, the public and shareholders have played a catalytic role to different degrees in company environmental accounting information disclosure, but at the same time they will impede the environmental accounting information disclosure in some respects.

132.3 The Theoretical Analysis of Factor Affecting Carbon Accounting Information Disclosure and Hypotheses

Combined with the research results of carbon accounting and factors influencing environmental accounting information disclosure, the paper will analyze the influence of carbon accounting information disclosure and the degree in the following six aspects (Bebbington and Larrinaga-gonzalez 2008).

(1) Industry characteristics

Hypothesis 1: the extent of carbon accounting information disclosure is significantly different between the heavy pollution industries and non-heavy pollution industries, and carbon accounting information disclosure in heavy pollution industries is higher than non-heavy pollution industries.

(2) Company size

Hypothesis 2: the extent of the company's information disclosure is closely related to company size; larger companies are more willing to disclose more carbon accounting information than the smaller ones.

(3) Company governance structure

Hypothesis 3: company governance structure and carbon accounting information disclosure are related and sound company governance structure is beneficial for the company's management to disclose more carbon accounting information.

(4) Developing capacity

Hypothesis 4: the developing capacity is significantly related to the company's carbon accounting information disclosure level. The stronger enterprises are, the higher the level of carbon accounting information disclosure is.

(5) Performance

Hypothesis 5: the ability of company profitability and carbon accounting information disclosure is positively related, and the performance of good companies tends to disclose more carbon accounting information.

(6) Debt level

Hypothesis 6: companies with high debt levels tend to disclose more detailed carbon accounting information to enhance creditors' confidence in their own repayment ability.

132.4 The Empirical Study on Factors Influencing Carbon Accounting Information Disclosure

132.4.1 Sample Selection and Data Sources

This paper selects 1327 A-share listed companies in Shenzhen and Shanghai from 2007 to 2010 as a research object, and excludes the following types: (1) the newly listed company; (2) the ST, * ST, suspended and closed listed companies; (3) the finance and insurance listed companies; (4) the companies missing data. After the above screening, 341 sample companies are left. After reorganizing this carbon accounting information disclosure in the annual report of the 341 listed companies, carbon accounting disclosure index is got according to a certain approach. Financial indicators data is from Guotai'an database (http://www.gtarsc.com/); the annual reports of listed companies from Juchao (http://www.cninfo.com.cn/).

132.4.2 The Variable Definition

Carbon accounting information disclosure level is regarded as the variable explained, and environmental information disclosure index is introduced to measure it. The index is calculated as follows: environmental accounting information and environmental information are divided into specific entries, and then classify information from the statements into the appropriate category, and aggregate it into a disclosure index. Based on the business perspective, carbon accounting information is divided into macro and micro level, a total of 14 entries. And find out the number of entries in the sample companies' annual report belonging to 14 entries and then add up. Carbon accounting information disclosure level formula: carbon accounting information disclosure level (CDL) = actual disclosure items/ best disclosed entries, the best carbon disclosure of accounting information value is 1(Tang and Zhang 2006).

This paper regards industry characteristic, company size, company governance structure, development ability, performance, and debt level as explaining variable.

132.4.3 Empirical Results and Analyses

132.4.3.1 Descriptive Statistic Analysis

(1) Descriptive statistics of carbon accounting information disclosure index from different industries

Through the descriptive statistical analysis of carbon accounting information disclosure index in different industries, we find that the CDL minimum value of all sectors is 0, the maximum value ranges from 0.1 to 0.5, indicating different industries exist significant fluctuation in carbon accounting information disclosure level. From the CDL mean, CDL in heavy pollution industries is beyond the sample average, whereas CDL in non-heavy pollution industries is lower than the sample average, that is to say, heavy pollution industries are generally higher than non-heavy pollution industries in the disclosure level, preliminary showing that pollution and carbon accounting information disclosure level is positively related.

(2) Variable descriptive statistics

The mean of the sample company carbon accounting information disclosure is 0.1064, relatively low to the optimal value of CDL 1, indicating Chinese listed company's carbon accounting information disclosure level is not high. The minimum value of managerial ownership ratio is 0, the maximum value is 0.64, meaning that some companies do not use governance incentives from interest. The proportion of independent directors in different companies is significantly different, from 0.09 to 0.57, average level is 0.3615, and it complies with the law that directors of the listed company board shall include at least 1/3 independent directors. On the growth, different companies vary greatly, indicating that different companies are at different development stages.

132.4.3.2 Variable Correlation Test

Variable explained carbon accounting information disclosure index (EDI) and industry characteristics, company size and debt levels is positively related in 1 % level, showing previous hypothesis is likely to be proved, laying foundation for further multiple regression analysis.

132.4.3.3 Multiple Regression Analysis

Employing SPSS17.0 to make multiple regression analysis, we find goodness of fit (R^2) of the selected variable to the variable explained is 11.3 %, preliminary showing that the correlation of regression model is not good. But the statistical study shows that, when the adjusting $R^2 > 0.1$, it illustrates the model explaining variable ability is acceptable. Therefore, the final model explaining variables ability of this paper is limited, but it is still within the acceptable range. In addition, the statistic Significant value of model F is 0, less than 0.05, indicating regression model is remarkable. Significant value of industry characteristics, company size, proportion of managerial ownership, company developing capacity and debt level is less than 0.05, passing through the test of significance, showing the five variables in the 5 % level has a significant impact on the carbon accounting information disclosure, and other variables are not significant.

132.5 Conclusion

The research results show that: at present carbon accounting information disclosure level of listed companies in China is generally low, but gains the increasing tendency year by year; carbon accounting information disclosure level in different industries has apparent difference, heavy pollution industries are higher than the overall level of non-heavy pollution industries; the level of carbon accounting information disclosure has significant positive correlation with company size, managerial ownership and debt level, and the proportion of managerial ownership can prompt the carbon accounting information disclosure, but the developing capacity of the company is negatively related to the disclosure.

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Chapter 133
Study of Jiangsu Manufacturing Energy Consumption Structure Under Low Carbon Economy

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Abstract In order to achieve the successful development of low carbon economy in Jiangsu Province, this paper analyses the present situation of energy consumption in above-scale manufacturing enterprises which is based on the manufacturing total energy consumption and gross industrial output value data of Jiangsu Province, at the same time undertake an empirical calculation, analyses the results according to the consequence by using grey relational analysis method of grey system theory between manufacturing energy consumption and economic growth about Jiangsu Province from 2000 to 2010. At last recommend countermeasures for the development of low carbon economy.

Keywords Manufacturing · Energy · Low carbon economy · Grey relational analysis

133.1 Introduction

Energy is the basis of a country's national economy, the history of all countries' economic and social development has made a full explanation: energy and the development of the national economy have a close relationship. Jiangsu, as a strong economy province in China, the expansion of manufacturing relative scale

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contributes to the economic growth, but at the same time it also led to a rise in carbon emissions. Especially under the background of putting low carbon economy as a prerequisite for economic development, optimize energy structure to reduce the carbon emissions become urgent. Therefore, study on the relationship between energy consumption and economic development of Jiangsu manufacturing industry to master the energy consumption structure has extremely important practical significance.

133.2 Analysis of Data Preprocessing About Jiangsu Manufacturing Energy Consumption

133.2.1 Sample Selection

Primary index data sources: *Statistical Yearbook of Jiangsu Province, Jiangsu Bulletin of statistics* and relevant Web sites. Limited to information restrictions, data sample selection ranges from 2000 to 2010, a total of eleven years of data.

133.2.2 Analysis of Empirical Data

The standard unit of measurement used in this article is “million tons of standard coal”. Convert Table 133.1 which name is the main energy consumption of above-scale manufacturing enterprises in Jiangsu Province to Table 133.2 in accordance with the reference conversion coefficients.

Table 133.1 The main energy consumption of above-scale manufacturing enterprises in Jiangsu Province

Name (million tons)	2001	2002	2003	2004	2005
Coal	8901.0600	10056.4400	11542.6600	14260.5900	16490.6000
Coke	368.2700	446.1100	618.1500	1057.3300	1562.6600
Crude oil	1312.7600	1422.5200	1705.0200	1865.0400	2250.8600
Diesel oil	58.5700	67.7500	90.4800	134.3500	117.8800
Fuel oil	152.0600	173.5100	199.7400	302.0300	212.5200
Electricity consumption	804.1900	967.5300	1185.0600	1451.9600	1745.0700
Name (million tons)	**2006**	**2007**	**2008**	**2009**	**2010**
Coal	17750.7800	20000.2800	21487.9600	22323.7200	24786.5200
Coke	1908.7400	2270.2000	2356.4700	2519.0400	2784.1600
Crude oil	2293.1900	2444.2000	2305.2500	2652.4900	2992.1600
Diesel oil	103.5800	114.0000	121.5100	108.3600	111.3700
Fuel oil	186.4300	177.4400	138.5800	116.4700	110.6000
Electricity consumption	1645.8200	1928.8000	1998.2300	2090.2700	2447.5600

Table 133.2 Total energy consumption in above-scale manufacturing enterprises and gross output value of industry in Jiangsu Province

Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total energy consumption (million tons of standard coal)	11500.66	12323.48	14012.10	16628.69	20511.14	24182.48	25009.44	28335.80	29526.31	31096.58	35031.43
Gross output value of industry (million Yuan)	9937.75	11190.63	13243.54	17305.51	23583.09	30816.65	39153.82	50666.19	61432.06	69758.11	88030.71

133.3 Grey Relational Grade Analysis Between Jiangsu Manufacturing Energy Consumption and Economic Growth

133.3.1 The Theoretical Basis of Grey Relational Analysis

Grey relational analysis is an analysis method of grey system theory. Grey relational analysis, a kind of analysis method which is essentially based on the distance between reference point and comparative point, aims at finding out the distance and proximity of the factors from the distance, analyzing and determining the degree of influence factors.

Grey relational analysis of the mathematical model is as follows: two series:

$$X_0 = [X_0(1), X_0(2), X_0(3), \ldots, X_0(n)]. \quad X_i = [X_i(1), X_i(2), X_i(3), \ldots, X_i(n)]. \quad i = 0, 1, 2, \ldots, m. \tag{133.1}$$

Calculation model of grey absolute correlation degree:

$$\zeta_{0i} = \frac{1 + |S_0| + |S_i|}{1 + |S_0| + |S_i| + |S_i - S_0|}. \quad i = 0, 1, 2, \ldots, m. \tag{133.2}$$

Calculation model of grey relevant correlation degree:

$$\gamma_{0i} = \frac{1 + |S_0'| + |S_i'|}{1 + |S_0'| + |S_i'| + |S_i' - S_0'|}. \quad i = 0, 1, 2, \ldots, m. \tag{133.3}$$

Calculation model of grey comprehensive correlation degree:

$$\rho_{0i} = \theta\zeta_{0i} + (1 - \theta)\gamma_{0i}, \quad i = 0, 1, 2, \ldots, m. \tag{133.4}$$

Under normal circumstances, take $\theta = 0.5$.

133.3.2 Grey Relational Grade Analysis of Energy Consumption and Economic Growth in Jiangsu Province

The application of grey theory reflects the degree of mutual dependence in energy consumption and economic growth, which provide a direct basic theory for the coordination of energy and economic development.

Grey absolute correlation degree: $\zeta_{0i} = 0.85$.

Grey relevant correlation degree: $\gamma_{0i} = 0.82$.

Table 133.3 Grey relational grade of total energy consumption, gross industrial output value and energy consumption in Jiangsu Province

Series	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Y_0	0.96	0.65	0.72	0.66	0.56	0.73	0.59	0.62	0.86
Y_1	0.76	0.83	0.67	0.64	0.60	0.67	0.62	0.63	0.77

Calculate grey relevant comprehensive correlation degree: take $\theta = 0.5$, then: $\rho_{0i} = 0.835$.

133.3.3 The Analysis of Relational Grade Between Energy Consumption and Economic Growth

Take total energy consumption and gross industrial output value as system feature series: Y_0 and Y_1, take the variety of energy as system behavior series: $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9$. Then it is possible to find out the influence degree on gross industrial output value and consumption of various energy indicators. We get the grey relationship matrix as shown in Table 133.3:

Judging from the results of grey relational grade calculation, when take total energy consumption of manufacturing as system characteristic series, we can see the order of impact level on total energy consumption: coal > electricity > diesel > crude oil > petrol > coke > liquefied petroleum gas > fuel oil > kerosene. And when take gross industrial output value as system characteristic series, we can see the order of influence degree on GDP: coke > electricity > coal > diesel > crude oil > liquefied petroleum gas > fuel oil > kerosene.

From the grey relational grade sorted above we can find that: the main influence on manufacturing total energy consumption is coal, the minor is kerosene; the main influence on economic is coke, the minor is kerosene. The result indicates that if Jiangsu Province aims at achieving the target of low carbon economy development, it is important to save the use of coal and electricity.

133.4 Countermeasures

Low carbon economy is the models of sustainable economic development. To ensure the stable development of low carbon economy, we put forward four recommendations:

1. Use resources rational and promote the diversified development of energy using structure. Economic growth and energy using has a mutual promotion and mutual restriction relationship, it is necessary to increase the utilization of energy and use the resources rationally. At the same time use clean and new

sources of energy actively, so that render the energy utilization structure to diversified development.

2. Accelerate the development of low carbon technologies, improve innovation capacity of manufactures. Manufacturing enterprises should vigorously develop energy-saving technologies and rely on technological advances to increase the utilization of primary energy consumption in manufacturing. Enterprises are encouraged to use new technologies, invent new equipment and introduce innovative talents.
3. Establish and improve the legal and regulatory system. We should make a standard marking system to control relevant resources. Strictly control these enterprises which fail to meet the standard, push more environment-friendly manufacturing technologies to energy-efficient society.
4. Establish economic policies and use economic levers for self-restraint. Unreasonable use of resources, seriously waste, still exists in Jiangsu Manufacturing industry. These phenomenons also affect the achievement of resource-saving society and the promotion of sustainable development of manufacturing industry. Therefore, we should establish economic policies strictly; make a scientific and judgment analysis on manufacturing industry.

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Chapter 134
The Framework of Security Mechanism on the Internet of Things Based on RFID Boosting Low-Carbon Economy

Zhongyun Li and Xindi Wang

Abstract The Internet of Things is a new technology which once more transforms the retail sales settlement, logistics delivers and product tracking model after the bar code technology. The Internet of Things will produce tremendous effect in the development of low-carbon economy because it can provide good technical support for the development of low-carbon economy. This article describes the internet of things and Radio Frequency Identification (RFID) technology. It analyses three aspects of the security problems that the RFID system, wireless network and the internet of things business, and puts forward the security mechanisms of internet of things that authentication and access control, data encryption and legislative protection. This article can play a positive role in the development of internet of things and low-carbon economy.

Keywords Internet of things · Radio frequency identification · Wireless network · Security mechanism · Low-carbon economy

134.1 Introduction

Low carbon economy refers to an economic development pattern that we minimize the high carbon energy consumption and reduce the greenhouse gas emissions to achieve the win–win of economic and social development and ecological environmental protection under the guidance of the sustainable development concept. The developed countries have passed the bill proposing the national goals and management measures of the emission reduction (Duo 2010). China is a

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developing country. The problems of the continuous increasing of the carbon emissions and environmental pollution have affected the quality and benefit of the economic growth and the sustainability of the development (Shi 2009). So, developing low-carbon economy in China is very necessary.

The role of the Internet of things in promoting low-carbon economy is mainly reflected in three aspects: the information digitization of the material world, the remote control of objects and the intelligent management of the material world. The essence of the Internet of things is the ubiquity of the information technology application (Xiang 2010). The ubiquitous nature of the Internet of things provides a strong supporting role in low-carbon economy development.

The Internet of things (Nelson 2002) is a global network to achieve goods and information sharing by using Electronic Product Code (EPC) and RFID communication technology. At present, the security problem has become an important factor that obstacles the further development of Internet of things based on RFID. This article analyses the special network threats and attacks from the angle of its components, puts forward some safety countermeasures to ensure the security of the internet of things and offers opinions about the future of Internet security development.

134.2 Analysis of Internet of Things and RFID

134.2.1 Analysis of the Framework of Internet of Things

The Internet of things is a network to connect any object with Internet, exchange and communicate information by using RFID, Global Position System (GPS) and other information sensing equipments according to the contractual agreement.

Internet of things system has three layers: the perception layer, the network layer and the application layer. The Internet of things framework is shown in Fig. 134.1.

The perception layer includes information collection, networking and collaborative information processing. It distinguishes and collects information automatically. The network layer mainly refers to the network system composed of the mobile communication network, broadcasting network, the internet and other private network. Application layer includes the supporting technology and the practical application of the Internet of things (Yu et al. 2010).

134.2.2 Analysis of System Diagram of RFID

RFID is a wireless automatic identification technology and an innovation of the automatic identification technology. The usual RFID system includes a front radio frequency part and the background RFID information service system.

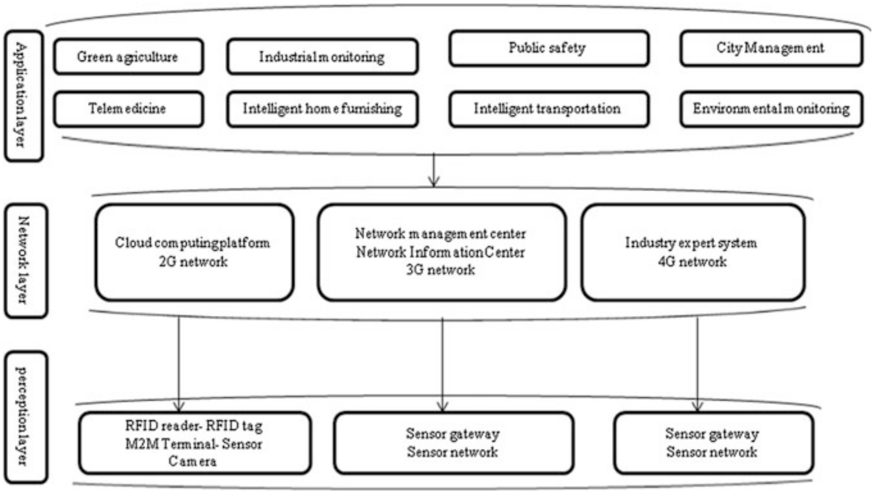

Fig. 134.1 The Internet of things framework

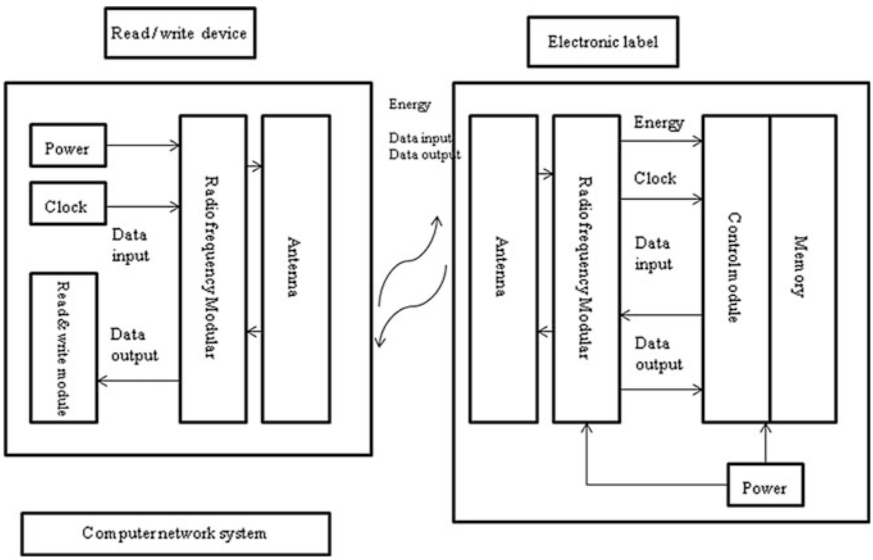

Fig. 134.2 The system diagram of RFID

Generally, the RFID system is composed of the electronic tag, the read/write device and computer network system. The system diagram is shown in Fig. 134.2 (Zhang et al. 2010).

RFID is a non-contact automatic identification technology, whose basic principle is to achieve the automatic recognition about the objects by using the radio frequency signals and the space coupling transmission characteristic. The basic principle of RFID is as follows:

(1) A radio carrier signal emits through the reader antenna.
(2) When the electronic label gets into the action area, the electronic tag is activated. Then the electronic tag transmits its information through the antenna.
(3) The carrier signal is received by the receiving antenna, and transmitted to the read/write device. The received signal is sent to the background computer controller when it is demodulated and decoded by the read/write device.
(4) The label legitimacy is judged by computer controller.
(5) The control actuator operates in accordance with the instruction signal.
(6) The computer communication network forms the general control information platform. According to the actual project requirements, the different corresponding software can be designed to perform the required function (Ma et al. 2010).

If we add RFID tags in each product, the reader will constantly receive a series of electronic product code. The detailed product information related to the EPC code is in the database of the enterprise/shopping malls.

134.3 Sources Analysis of Security Problems on Internet of Things Based on RFID

Compared with the traditional network, the sensor nodes of the Internet of things are deployed in the unmanned monitoring environment. As it expands the perception network and the intelligent processing platform, the traditional network security measures are not enough to provide reliable security.

134.3.1 Security Problems of the RFID System

RFID system is vulnerable to various attacks. There is a serious security risk in this non-contact wireless communication. Security problems of RFID mainly refer to the security risks of the radio frequency part, including the electronic label, read/write device and the air interface between them (Ning 2010), as shown in Fig. 134.3.

(1) Label security problem

Because of the label cost, technology and power restriction, it does not contain perfect security modules. The data mostly use simple encryption mechanism.

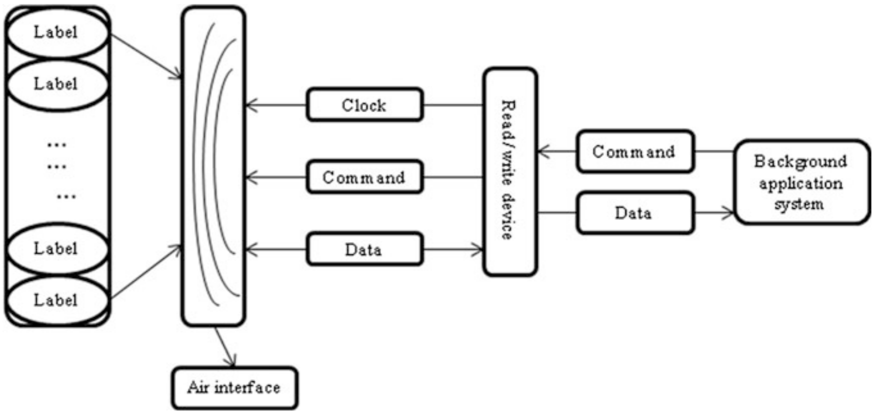

Fig. 134.3 Security issues of the RFID

(2) Communication link security problem

The communication link of the RFID system includes the air interface wireless link from the front label to the read/write device and the computer network from the back-end read/write device to the back-end system. At the air interface link of the front end, the wireless transmission signal itself is open, so, the security of data is very fragile. In the back-end communication link, the system faces the common safety problems of the computer network. Relatively speaking, it has a more mature security mechanism.

(3) RFID read/write device security problem

When the read/write device receives the data, it only provides the user service interface, and cannot provide the safety performance interface for the users.

134.3.2 Security Problems of the Wireless Network

The security and privacy issues are the focus of attention for the users. The threats the wireless network brings to the Internet mainly have the following several aspects:

(1) Perceiving node security problem

Because the number of the perceiving nodes is very large and distributed in a large area lacking the effective monitoring, the attacker can easily contact with these devices and even replace the machine's software and hardware (Li 2010) by local operation.

(2) Roaming network security problem

Wireless network attacker does not need to find the target, because the target will roam to the attacker's district. The transaction without authentication mechanism and the connection re-establish is dangerous.

(3) Physical security problem

Currently, the biggest problem of the handheld mobile device is the lack of a specific user entity authentication mechanism.

(4) The network itself problem

Wireless channel is an open channel which brings communication freedom and flexibility to the wireless users. And it also brings some security issues.

134.3.3 Security Problems of the Wireless Network

Because the Internet of Things equipment may be the first deployment and the last connection network, it becomes a difficult problem how to configure the remote subscription information and business information. It has become a new problem how to manage the safety information of the interconnection machine log. And it may split the trust relationship between the network and the service platform.

134.4 Framework of Security Mechanism of the Internet of Things

The Internet of things security mechanisms can be strengthened from the following several aspects:

134.4.1 Authentication and Access Control

The permissions of the user accessing cyber source should be set a strictly hierarchical authentication and access control. In addition, we can also make a certification about the legitimacy of the node design and other measures to improve the safety performance of the perception terminal itself.

134.4.2 Data Encryption

Encryption is an important means to protect data security. The encryption of the transmission information can solve wiretapping problems, but it requires a flexible and robust key exchange and management scheme. In addition, the key management scheme must also ensure that when some nodes are manipulated, the whole network security cannot be harmed.

134.4.3 Legislative Protection

We need make a clear and unified legal interpretation and establish a perfect protection mechanism about the regional impact data ownership problem of the Internet privacy regulations from the legislative point of view. At the same time, we should increase networking information protection related to national security, business secrets and personal privacy through policies and regulations. We should further strengthen the human, financial and material investment of the regulatory mechanism to improve the regulatory system, and form resultant force.

134.5 Conclusion

Most of core technology of the internet of things is constantly developing, and the internet of things security challenge is more serious than imagined. We should construct and improve the network security system through technology, standards, laws, policies, management and other means.

Low-carbon economy is our direction of the economic development. If we combine the Internet of things with low-carbon economy, it will play an inestimable role for us in reducing energy consumption and saving resources.

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Chapter 135
The Impact Brought by Global Warming and Countermeasures

Cuifeng Huo, Menghan Xu and Xuan Ding

Abstract This paper expounds the impact brought by global warming and its influence on China, analyzes the emission status of greenhouse gas and the development trend of our country and proposes China's prevention measures by learning experiences from other countries as follows: Government implements supervision by establishing special organization and enacting corresponding laws and policies, industrial sector formulates various solutions and measures to ensure that the tasks stipulated by state will be achieved, and propagates the danger brought by global warming and the necessity for preventing global warming, so as to reach a consensus and form conscious actions.

Keywords Global warming · Impact · Measures

The emission status of greenhouse gas caused by global warming draws increasing attention worldwide. Global warming, which will lead to a series of adverse consequences to the whole ecosystem, refers to the increase of Earth's surface temperature which is caused by greenhouse effect resulting from the influence of human's activities that give rise to a great amount of greenhouse gas (CO_2) discharged into atmosphere. Thus, it is urgent to restrain and control the emission of greenhouse gas, and the problem should be solved sooner rather than later.

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135.1 Global Warming and its Impact

135.1.1 The Meaning of the Global Warming

Greenhouse gas is mainly composed of CO_2, CH_4 and N_2O etc., while global warming is resulting from human's misconducts of burning tremendous fossil fuels such as petroleum and coal etc., which augment the CO_2 concentration in the air. It is learned from the 3rd Assessment Report (made by IPCC - Intergovernmental Panel on Climate Change) in 2001 that the average temperature of the global land increased about 0.6 degree in the twentieth century, as well as the average sea level rose 10–20 cm. Global warming degree in the twentieth century is at its highest level ever in the history. Meanwhile the warming during the past 50 years was caused by human-induced climate change. Besides, it also can be concluded from the report that the average temperature of the global land will go up by 1.4–1.5 degree by the year of 2100.

135.1.2 Extensive and Profound Impacts have been Brought by Global Warming to the Living Environment of Human and Other Creatures

Table 135.1 and 135.2

135.1.3 Impacts on China's Economy Caused by Global Warming

We can learn from the predicted results made by Chinese scientists that the impacts caused by global warming on China are as follows:

Table 135.1 Impact brought by Global Warming

Index	Changes under observation
Average temperature	Rose about 0.6 degree in the twenty-first century
Mean sea level	Increased 10–20 cm in the twentieth century
Heat index	Increasing possibilities went up
Frost days	Decreased on land
Rainstorm phenomenon	Increased in the high latitudes of the northern hemisphere
Ice river	Large-scale losing
Drought	Increased in some areas on earth
Snow area	Decreased 10 % (since 1960)

Data: According to "The 3rd Assessment Report" made by IPCC (Japan)

Table 135.2 Predictions on the impacts brought by global warming

Object	Predicted impacts
Average temperature	Average temperature used to and will increase 1.4–5.8 degree from 1990 to 2100.
Mean sea level	Mean sea level used to and will increase 9–88 cm from 1990 to 2100.
Impact on meteorology	Floods and droughts increased, and typhoon got strengthened
Influences on people's health	Aggravate heat emergency response and expand infection disease
Impact on ecosystem	A portion of the flora and fauna will die out and biological system will mutate
Impact on agriculture	Cereal production in many areas will decrease
Impact on water resources	The balance of water supply and demand will change and water quality will be deteriorated
Impact on market	Huge economic losses will be sustained by developing countries which focus on primary industry

Data: According to "The 3rd Assessment Report" made by IPCC (Japan)

Firstly, compared with the year of 2000, China's annual average temperature will increase 1.3–21 °C in 2020, and grow 2.3–3.3 °C in 2050 respectively. Temperature in the whole country will increase gradually from South to North, and it shows an obvious growth in Northwest and Northeast areas. It is predicted that, by the year of 2030, the temperature may go up by 1.9–2.3 °C in Northwest area, 1.6 –2.0 °C in Southwest area and 2.2 °C to 2.6 °C in the Tableland of Tibet. Secondly, in the next 50 years, an upward trend will be presented in the average rainfall in China, which will increase 2–3 % by 2020 and may increase 5–7 % by 2050. The highest increasing degree of rainfall concentrates on the Southeast coastal areas. Thirdly, in the future 100 years, the frequency and possibility of extreme weather and climate events will increase, which will bring great influence on the development of economic society and on people's life. Fourthly, the arid areas in China may be expanded and desertification is more likely to happen. Fifthly, the sea level of China's costal area will continuously rise. Sixth, the Tableland of Tibet and Tianshan glacier will reduce with more rapid speed, worse still, some small-sized glacier will disappear.

135.2 Emission Status and Development Trend of Greenhouse Gas in China

135.2.1 Current Situation of Chinese Greenhouse Gas Emissions

According to the Initial National Communication on Climate Change of the People's Republic of China, in 1994, the total emission of greenhouse gas in China was 4.06 Billion tons of CO_2 equivalent (the net emission amount after carbon sinks having been deducted was 3.65 Billion tons of CO_2 equivalent), in which CO_2 emission amount was 3.07 Billion tons, CH_4 is 0.73 Billion tons of CO_2 equivalent and N_2O was 0.26 Billion tons of CO_2 equivalent. In 2004, the total emission of greenhouse gas of China was approximately 6.1 Billion tons of CO_2 equivalent (the net emission amount after deducting carbon sinks was about 5.6 Billion tons of CO_2 equivalent), in which CO_2 emission amount was about 5.07 Billion tons, CH_4 was about 0.72 Billion tons of CO_2 equivalent and N_2O was approximately 0.33 Billion tons of CO_2 equivalent. From 1994 to 2004, the annual increasing rate of the total emission of greenhouse gas in China was around 4 %, and the proportion of CO_2 emission amount in the total emission of greenhouse gas increased from 76 % in 1994 to 83 % in 2004.

In 2011, per capita CO_2 emission amount in China was 7.2 tons, which increased 9 % more than that of last year and was similar with that (7.5 tons) of Europe in 2011.

135.2.2 Emission of Major Greenhouse Gases in China will Increase in the Future

With the continuous and high-speed economic development of our country and the increasing demands to energy, in the future 20–30 years, an increasing trend will be showed in the emission of major greenhouse gases such as CO_2 etc. By 2030, the emission of CO_2 generated from the activities by using energy under different circumstances will be within the range of 1.211–2.105 Billions of carbon, but per capita CO_2 emission amount is still very low, i.e. per capita CO_2 emission amount in China will only be 0.756–1.337 tons of carbon by the year of 2030, which keeps equal to the world average level in 1990 and which is not enough to reach 1/4–1/2 of the average level of OECD countries in 1990. The reasons are as follows:

First, since China is in urbanization and industrialization phase, its continuous increasing of economy will definitely bring about high energy consumption and high emission, which determines that CO_2 emission is high in China. Please see Table 135.3.

Table 135.3 CO_2 Emission Degree in Each Country

Country	Co_2 Emission Degree (kg per USD)
Brazil	0.37
Turkey	0.53
Argentina	0.92
South Africa	1.65
Egypt	1.78
India	1.78
Russia	1.80
China	2.10

Although carbon emission degree in China is expected to be decreased, it only can be realized when infrastructure construction and urbanization are finished. However, technical innovation and renovation are required during the course.

Second, the economic and industrial structure intensified the high carbon character of China's economy.

Second industry is the main part of China's economy, which determines that the major energy-consuming sectors are industrial ones; while China's backward industrial level aggravates the high-carbon character of China's economy. Caused by historical reasons, the formation of unreasonable international division of labor let the developed countries lie in high-end of industry chain, develop service and high-tech industry, thus, their emission is relatively less. However, the developing countries lie in low-end of industry chain, therefore a great amount of products they manufactured are characterized with high-energy consumption and high-emission. In 2007, the export value of finished industrial products of our country accounted for around 95 % of the total export sales. It illustrates that CO_2 emission generated in our country, which increased the emission amount of greenhouse greatly. Based on the latest statistic of IEA (International Energy Agency) made in 2011, the CO_2 emission amount of China in 2008 took up 22 % of the total carbon emission amount of the world, which means China's emission percentage exceeded USA and ranked at the top in the world. The percentage corresponded to the fact that China's population occupies 19 % (the year of 2011) of the total global population and that China is a country whose economy scale ranks second, besides, a part of carbon emission amount was caused by foreign-funded enterprises which produce in China but consume abroad. However, China's GDP only accounted for 9.5 % of GWP (Gross World Product) (in 2010) and its industrial production value accounted for 16 % of the total world industrial production. Thus, as a developing country which Per capita income was only USD 4200, the percentage of 22 % was relatively high and the carbon emission amount will increase with the economic development of China. As China's international influence is being increased and strengthened continuously, the issue of environmental pollution and carbon emission becomes the key point that draws attention of and is criticized by international society.

Third, coal-dominated energy structure of China also makes it difficult to accomplish the task of controlling the emission of greenhouse gas in China.

The resources condition of "Rich in coal, but short of gas and lack of oil" determined the coal-dominated energy structure of China and that options for low-carbon energy resources are limited. In the proved reserves of energy resources in China, 96 % are coal, while oil and gas only account for 4 % as set out in Table 135.4.

We can learn from the abovementioned Table that in the energy consumption structure, the coal consumption accounts for an absolute high proportion, which keeps over 65 % and equals to 2.5 times of the world level, while the greenhouse gas emission amount (which depends on the same heat value of petroleum and natural gas) generated from coal is 1.24 times of that of petroleum and 1.75 times

Table 135.4 Coal consumption of China and their percentage in total energy consumption

Years	Consumption Amount of Coal (Ten Thousand Tons of Standard Coal)	Percentage that Coal in (Accounts for) Total Energy Consumption
2000	93939	67.8
2001	95514	66.7
2002	100641	66.3
2003	119693	68.4
2004	138194	68.0
2005	155255	69.1
2006	170911	69.4
2007	186630	70.2

of that of natural gas. It is undoubted that this kind of energy consumption structure will increase CO_2 emission amount in China.

135.3 Environmental Protection Measures and Development Trends Under International Framework

135.3.1 Measures Under UNFCCC

United Nations Framework Convention on Climate Change (UNFCCC or FCCC) is an International Convention, which was passed and adopted at the United Nations Headquarters in New York and signed at the UNCED (United Nations Conference on Environment and Development) attended by the government heads of each country in the world and held in Rio de Janeiro Brazil in June 1992. The Convention came into force on 21st March 1994.

Conference of the Parties (COP) of the Convention is held every year since 1995, so as to make an assessment of the progress in tackling climate changes. Emission reduction has become the legal obligation of developed countries since the Kyoto Protocol was concluded in 1997. According to the stipulations specified in the Bali Roadmap which was passed and adopted in 2007 that "The Copenhagen Protocol will be concluded on the 15th meeting of COP which will be held in Copenhagen in 2009 to replace the Kyoto Protocol which will expire by 2012."

135.3.2 CDM and Climate-Related Asia–Pacific Partners

The countries involved are mainly China, Australia, India, Japan, South Korea and the United States etc. The goal is to face and handle the problems arising from energy safety, energy demands and climate changes by taking Asia–Pacific area as the center to carry out clean and high-efficient technical development, popularization and transferring.

The Secretariat of UNFCCC declared on 7th September 2012 that: the CERS to be issued according to CDM established according to the Kyoto Protocol will up to 1 Billion, which is an important milestone in respect of reducing global emission of greenhouse gases.

135.4 Measures of our Country for Facing and Tackling Global Warming

Before holding Copenhagen conference in 2009, Chinese government announced the action target that the greenhouse gas emission amount corresponding to unit GDP will decrease 40–45 % by 2020 than that of 2005 and it will be taken into national economy and social development plan as binding target for long-term planning. In March 2011, the binding targets of China for facing climate changes during the Twelfth Five-Year period proposed in the Outline of the Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China which is passed and adopted upon examination and approval of China's NPC (National People's Congress) are as follows: By the year of 2015, CO_2 emission amount corresponding to unit GDP will decrease 17 % than that of 2010, energy consumption corresponding to unit GDP will decrease 16 % than that of 2010, the proportion of non-fossil energy consumption in primary energy consumption will up to 11.4 %, newly increased forest area will be 12.5 million hectares, forest coverage will increase to 21.66 % and forest growing stock will increase 600 million cubic meters, which showed Chinese government's determination of facing and handling climate changes by promoting low-carbon development.

Although there's no reduction task which should be accomplished by our country specified in the Kyoto Protocol, however, with the acceleration of internalization progress, especially the fact that China has entered into WTO, emission reduction requirements will be definitely proposed on China. At present, all scholars have already focused on formulating new treaty for preventing global warming, which will be issued after 2012, the deadline (expiration year) of the Kyoto Protocol. It is predicted that undoubtedly it will be on the agenda of proposing requirements on the developing countries such as China and India etc. in the next treaty, which requires us to get well prepared as early as possible, establish China's unique system for preventing global warming and strive to make contributions for the development and prosperity of human. In addition, the following suggestions are proposed by learning from foreign experience.

135.4.1 Importance Attached by Government

Government is responsible for formulating laws and policies in respect of global warming and carry out supervision by establishing corresponding special organization. The problem of global warming only can be controlled efficiently by government. It is imperative for the government to organize and establish organs with high specification, treat the problem seriously just as it is vital for national economy, for people's livelihood and for state's position in the world, and to take measures duly in order to enjoy achievements. If we have a more active attitude on preventing global warming and take further efficient measures for improving global environment, it is no doubt that the political and economic position of China will be elevated. It is significant for us to take more proactive actions to protect global environment even if from the viewpoint of advancing economy.

135.4.2 Voluntary Action made by Industrial Sectors

Industrial sectors are supposed to formulate individual countermeasures and measures to ensure the duly accomplishment and achievement of the targeted tasks stipulated by the state. Industrial sectors are the intermediate links between government and individual, as well as the main parts for preventing global warming. Especially in the current phase of our country, the increase of energy demands of industrial sectors, which is caused by the high-speed development of economy, is the main source for growing greenhouse gas emission and causing global warming problem. As China is honored as "The factory of the world", it is also confronted with criticism as "the top country characterized with environmental pollution and greenhouse gas emission" worldwide. It is predicted that in the coming decades the emission in China will increase in medium speed, while by 2030 the greenhouse gas in China will be 128 million tons of carbon equivalent, which will account for 30.5 % of the total carbon emission of the world, which is the largest negative externality caused by the development of China to the world. If industrial sectors can take efficient measures to upgrade efficiency of energy utility, therefore the equivalent level of energy consumption will contribute to higher output, and the equal quantity of output will need less energy consumption. As a result, not only the pressure caused by energy demands arising from economic development of China will be reduced and slowed down, but also CO_2 emission will be decreased, so as to make contributions to the prevention of global warming.

135.4.3 Active Cooperation from Citizens

In order to arouse public awareness and to reach consensus of citizens as a whole, we citizens ought to propagate the dangers brought by global warming and the necessity for preventing global warming to citizens. At present, the consciousness of protecting global environment has been rooted in Japanese minds. And all people consciously associate their behaviors with global environment protection, including change their own life style to make contributions to protecting environment. In contrast, Chinese citizens' awareness of environment conservation is relatively weak, since a large number of people hold the opinion that: Economic development plays the most crucial role nowadays in China. To enhance economic growth, there will be pollution. Therefore it is inevitable to sacrifice the environment around us in exchange for wealthy life. We are supposed to make all citizens to realize that environment protection and global warming prevention are the responsibilities and obligations of every citizen, which is of great urgent. If environment protection and global warming prevention are delayed, it will bring adverse effects on human beings and our posterity.

Note: ① The English expression "Global Warming" in this thesis is translated into "地球温暖", which is also translated into "全球变暖" by some people.

② State scheme of China for facing climate changes (Baidu WiKi).

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Part VIII
SS-Low-Carbon Project Management

Chapter 136
Evolutionary Analysis of Cooperative Behavior of the Countries in Cancun Climate Summit

Lei Zhao, Guorong Chai, Haizhou Wang and Guoping Li

Abstract Based on different interests and strategies, this paper divides related countries in Cancun summit into developed and developing camp and proposes symmetrical evolutionary model and asymmetric evolutionary model of cooperative behavior. Then it makes a duplicated analysis on the game theoretical model utilizing the evolutional game theory and studies its evolutionary path and impact factors. The results show that only the nations in the camps unite together can the favorable results appear; the more developing countries depend on the aid of developed countries, the more disadvantageous in the negotiation. Finally this paper analyzes the policy implications of research findings.

Keywords Cancun summit · National camp · Cooperative behavior · Evolutionary game

136.1 Introduction

The 2010 United Nations Climate Change Conference was held in Cancún, Mexico, from 29 November to 10 December 2010. The conference is officially referred to as the 16th session of the Conference of the Parties (COP 16) to the

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United Nations Framework Convention on Climate Change (UNFCCC) and the 6th session of the Conference of the Parties serving as the meeting of the Parties (CMP 6) to the Kyoto Protocol. In order to formulate the 2012–2020 Global Emissions Reduction Agreement, representatives from different nations participated in the meeting and discussed follow-up program after the complement of commitment in the first stage of the Kyoto Protocol, The same period in 2009, the United Nations Climate Change Conference was held in Copenhagen, Denmark, but failed to pass any legally binding protocols. Therefore, in order to avoid making repeating mistakes resulting from high expectations and disappointing ends, most of the participants lowered their expectations to achieve some concrete results. The conference finally reached a compromising, balancing, and flexible project —"Cancun Agreement", which marked an important step to a comprehensive and legally binding global climate framework, rebuilding the confidence of the future climate negotiations (Wang 2009).

Participating countries based on their interest demands in the negotiations clearly divided into two camps, developed and developing countries. Therefore, this article uses the methods of evolutionary game theory, establishing the asymmetric evolutionary model between camps and the symmetry evolutionary model of internal camps (Chai and Zong 2010). This paper analyzes the evolutionary path of The 2010 United Nations Climate Change Conference, influencing factors and policy implications.

136.2 Asymmetric Evolutionary Model Between Camps

136.2.1 Construction of Asymmetric Evolutionary Model

Developing and developed countries propose two different options, Program A and Program B, beneficial to them accordingly (Ou and Zhang 2009). The strategy space of the developing countries is $\{M_1, M_2 | M_1 =$ (adhere to A, refuse to B), $M_2 =$ (give up A, accept B)$\}$, the strategy space of developed countries is $\{N_1, N_2 | N_1 =$ (refuse to A, adhere to B), $N_2 =$ (accept A, give up B)$\}$. Therefore, the strategy profile of developing and developed countries is (M_1, N_2), which means the passing of Program A is the result of negotiations, program in favor of developing countries. The earning is (p, q) and $(p + q) = r$ is the gross earnings in climate problem solving proceeds, restricted to $p > q > 0$. If the strategy profile is (M_2, N_1), the earning is (q, p). If the strategy profile is (M_1, N_1), the earning is $(-k, 0)$, where $k(k > 0)$ is loss of the developing countries brought by loss of support and financial assistance from developed countries. If the strategy profile is (M_2, N_2), the earning matrix is (0, 0). Income distribution matrix is shown in Table 136.1.

Supposing the proportion of the possibility of developing and developed countries accepting the strategy M_1 and N_1 are $x(0 \leq x \leq 1)$ and $y(0 \leq y \leq 1)$ accordingly, so the proposition of accepting strategy M_1 and M_2 are $(1 - x)$ and

Table 136.1 Earnings matrix of game between camps

Game between camps		Developed Countries	
		N_1	N_2
Developing countries	M_1	$-k$, 0	p, q
	M_2	q, p	0, 0

$(1-y)$ and the earnings of developing countries in choosing strategy M_1 and M_2 are $E_1 = y(-k) + (1-y)p$ and $E_2 = yq$ respectively. According to $dx/dt = x(E_1 - E)$ (Zhang 2001), speed of developing countries adopting the strategy M_1 in the evolution is as follows:

$$dx/dt = x(1-x)[p - y(r+k)] \tag{136.1}$$

Similarly speed of developing countries adopting the strategy N_1 in the evolution is as follows:

$$dy/dt = y(1-y)[p - xr] \tag{136.2}$$

Making $dx/dt = dy/dt = 0$, get five equivalent points O (0,0), A (1,0), B (0,1), C(1,1) and $D(x_D, y_D)$ on the plane $s = \{(x,y)|0 \le x \le 1, 0 \le y \le 1\}$, where $x_D = p/r$, $y_D = p/(r+k)$ (Wang and Meng 2004).

136.2.2 Analysis on Asymmetric Evolutionary Model

According to (136.1), (136.2), get matrix $J = \begin{pmatrix} (1-2x)[p - y(r+k)] & -x(1-x)(r+k) \\ -y(1-y)r & (1-2y)[p - xr] \end{pmatrix}$. According to the stability analysis by using the Jacobian matrix (Friedman 1991) on the equilibrium point, the results shown in Table 136.2.

Table 136.2 shows that the five equilibrium points A(1,0) and B(0,1) is evolutionary stable, O(0,0) and C(1,1) is unstable, $D(x_D, y_D)$ the saddle point (Fig. 136.1). Probability of evolution result to A(1,0) and B(0,1) depends on the area of the volume of quadrilateral *AODC* and *BODC* S_A, S_B:$S_A = S_{\Delta AOD} + S_{\Delta ACD} = y_D/2 + (1 - x_D)/2 = [r^2 + k(r-p)]/2r(r+k)$, $S_B = 1 - S_A = [r^2 + k(r+p)]/2r(r+k)$. Obviously $S_A < S_B$, the probability of

Table 136.2 Stability analysis on equilibrium points

Balance point	det J	tr J	Result
O(0,0)	p2 > 0	2p > 0	Unstable
A(1,0)	pq > 0	–r < 0	ESS
B(0,1)	p(q + k) > 0	–(r + k) < 0	ESS
C(1,1)	q(q + k) > 0	(2q + k) > 0	Unstable
$D(x_D, y_D)$	0	0	Saddle point

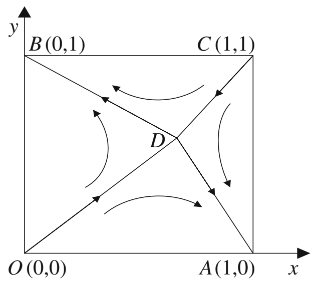

Fig. 136.1 Evolutionary path between camps

the system evolving to B(0,1) which mean more possible to pass Program B. The system eventually evolved into the A (1, 0) or B (0,1) is closely related to the initial state and parameter k (Weibull 1998).

Impact analysis on the initial state to evolution results. Boundary line ODC in Fig. 136.1 is the critical line for the system evolves to the different results. If the initial state of the game between camps fell in the AODC part, the system will gradually evolve to the A(1,0), otherwise it will gradually evolved into B(0, 1).

Impact analysis on the value of parameter k to evolution results. Making $S = S_B/S_A$, find out S the first derivative on k: $S'(k) = 2pr^2/(r^2 + kq)^2 > 0$. Therefore S and k are in positive correlation, S_B increases with the increase of k, vice versa. Which means the probability of the system evolves to B (0, 1) and accepting program B increase.

136.3 Symmetry Evolutionary Model of Internal Camps

136.3.1 Construction of Symmetry Evolutionary Model

Assuming Group 1 and Group 2 are groups of countries within the same camp with different opinions (Wang 2007), their earning matrix is showed in Table 136.3.

$s(s > 0)$ and $c(c > 0)$ are benefits and costs of countries adopting cooperative strategy. m is the financial support and technical assistance for developing countries by choosing cooperative strategy. $k(k > 0)$ is the cost to countries adopting uncooperative strategy.

According to replicated dynamic equation, $dx/dt = x(E_1 - E)$, speed of groups selecting cooperative strategy in evolution is as follows:

Table 136.3 Earning matrix of groups in camp

Games of inner groups		Group 2	
		Cooperative	Uncooperative
Group 1	Cooperative	$s-c+m, s-c+m$	$m-c, -k$
	Uncooperative	$-k, m-c$	$0, 0$

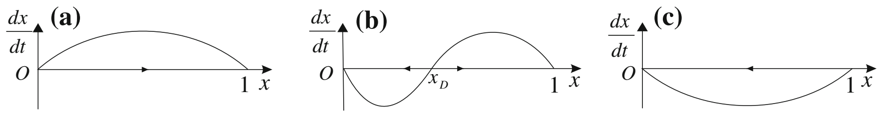

Fig. 136.2 Evolution path of internal cooperative behavior

$$dx/dt = x(1-x)[x(s+k)-(c-m)] \tag{136.3}$$

Making $dx/dt = 0$, get three critical values 0, 1 and $x_D = \frac{c-m}{s+k}\,(0 \le x_D \le 1)$

136.3.2 Analysis on Symmetry Evolutionary Model

Because of camp internal symmetry, a unilateral analysis (Liu and Gao 2006) is only need to do for the analysis of the cooperative behavior evolution. For developing countries:

When $m \ge c$, $dx/dt \ge 0$. At this time point $x = 1$ is a stable point for the evolution, the evolution path in Fig. 136.2(a) shows that all groups of countries have adopted strategies of cooperation.

When $0 < c-m < s+k$, $0 < x_D < 1$. In the interval $[0, x_D)$, $dx/dt \le 0$, in another interval $(x_D, 1]$, $dx/dt \ge 0$. At this time $x = x_D$ is unstable, and $x = 0$ and $x = 1$ are evolutionary stable points. As the evolution path shown in Fig. 136.2(b).

When $s-c+m+k \le 0$ equal to $c-s-m \ge k$, $dx/dt \le 0$. At this time, $x = 0$ is a stable point for the evolution, as the evolution path shown in Fig. 136.2(c). All groups of countries have adopted non-cooperative strategy.

For developed countries, $m < 0$ and $c > 0$, then$c > m$, only exists 2(b) and 2(c) two cases:

When $s-c+m+k > 0$, $0 < x_D < 1$ in the interval $[0, x_D)$, $dx/dt \le 0$, in another interval $(x_D, 1]$, $dx/dt \ge 0$, $x = x_D$ is the unstable point, and $x = 0$ and $x = 1$ both are evolutionary stable points, as the evolution path in Fig. 136.2(b).

When $s-c+m+k \le 0$, $dx/dt \le 0$. $x = 0$ is the evolutionary stable point, as the evolution path shown in Fig. 136.2(c).

This conclusion suggests that it is impossible for all developed countries to evolving to cooperative strategies. In order to achieve consensus, certain coercive measures are needed.

136.4 Policy Implications from Research Results

In solve the problem of global climate, developed countries should shoulder more responsibility. In the asymmetric evolutionary model between camps, $S_A < S_B$ shows that the probability of system evolution to B(0,1) equal to probability of accepting Program B is greater than the system evolution to the probability of A(1,0) equal to the probability of accepting of Program A. Therefore, while we recognize that developed countries should bear most of the responsibility to climate change, we must also recognize the western developed countries gradually shift from power orientation to rule orientation (Wang and Watson 2008) in order to maximize the relative benefits.

The developing countries should be united, to minimize internal differences. Analysis shows that $x > p/r$ is a necessary condition for developing countries to gain greater benefits, increase the proportion of x, is conducive to promoting a negotiated more favorable to developing countries. Therefore, regional integration group negotiating capacity is necessary strategy for developing countries to adopt (Wang and Gu 2010).

Excessive dependence on the developed countries is detrimental to the independent development of developing countries. As discussed in above analysis, the more dependent developing countries in addressing climate issues on developed countries, the more disadvantage developing countries will be at in negotiations. Therefore, developing countries should focus on and enhance their own development.

Establishing good political environment for reduction is an important foundation for addressing climate change. Under good political environment, it is easy to find practical reduction emission project, assessing partners lower their costs and increasing profit margins. The key lies in establishing a good political environment for the emission reduction. Legalization of emission reduction targets and measures is an urgent problem (Hassett and Watson 2002).

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Chapter 137
How Does the Carbon Emission of China's Transportation Industry Change with the Fluctuation of GDP and International Oil Price?

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Abstract This paper chooses five independent variables as the impact factors to investigate industrial carbon emission, analyses the impact mechanism of international oil price on it, and then uses the PLSR model to study its impact on carbon emission. Based on the data of 2011, the paper maintains three independent variables to study international oil prices' impact on industry carbon emission at different levels of GDP. The result shows that with the same GDP growth, the industry carbon emission increases with the rise in international oil prices, and vice versa decreases; When GDP increases to a certain extent, in both cases of international oil prices' rise or fall, the industry carbon emission will go up, and it increases even faster while the energy prices are rising.

Keywords International oil price · Transportation industry · Carbon emission · PLSR model

137.1 Introduction

In 2008, about 70 % of the oil consumption in China is consumed by its transportation industry. In July 2010, the IEA (International Energy Agency) released a report saying that China has become the world's first energy consumer with a consumption of 2.252 billion tons of oil in 2009, which is 4 % more compared to

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USA's total oil consumption of 2.17 billion tons. At the same time, transportation as the key industry in oil consumption is one of the important sources of greenhouse gases and air pollution emissions. Taken into account the facts that China's energy utilization rate in transportation at present on the whole is still 7.2 % lower than that of the United States, and 10 % lower than of Japan, therefore, China's transportation industry still has a great energy-saving space.

137.2 Literature Review

Energy occupies a strategic position in a country's economy, especially in the development of its transportation industry. Among the related researches on GDP and energy, For Fatih Birol, Jan Horst Keppler (2000) (Prices 2000), the main option influencing energy efficiency is the change of relative prices. Fisher et al. (2004) analyzed the panel data of about 2500 energy-intensive large and medium-sized industrial enterprises in China for the period 1997–1999. Their results indicate that the enhancement of relative energy prices and the changes in China's industrial structure are the main driving force of decreases in China's energy intensity. Haldenbilen and Ceylan (2005) selected such independent variables as GDP, population and traffic (km) to develop a genetic algorithm model for transportation energy forecast;

Zhiyong Han et al. (2007) supposed that energy efficiency is an important factor to develop the energy policy. Ceylan et al. (2008) undertook a forecasting for transportation energy in Turkey based on harmony search algorithm. Yuan et al (2008) pointed out the existence of bilateral causality between its GDP and overall energy consumption; Zhang et al.(2009) proposed the three factors affecting the price of crude oil by EMD (Empirical Mode Decomposition): short-term fluctuations caused by daily imbalance between supply and demand or caused by other market activities, significant event shocks and long-term trends.

Concerning the researches on the volumes of private car ownership, passenger and freight, Zhang et al. (2009) developed the PLSR model to predict China's transportation energy, in which independent variables are GDP, urbanization rate, passenger transportation volume (persons per km), freight transportation volume (ton per km). Geem (2011) (2011) took into account different independent variables such as population, GDP, oil price, vehicle registration and passenger transportation volume, and then compared the forecasting results from the 5 variables regrouped into four groups models with those from the multivariate linear regression model. Xie and Wang (2011) studied and calculated the carbon emission and the unit turnover volume of various transportation modes. Based on the inventory guideline report of IPCC (Intergovernmental Panel on Climate Change), Xu and Du (2011) undertook a factor decomposition of carbon emission by STIRPAT model, where they conducted an analysis impact of demographic factors (divided into two groups by age). Ji and Kong (2012) applied scenario simulation to China's marine transportation data by China's Ocean-related data to predict its carbon emission value and peak.

From the synthesis of the existing literature, it can be observed that the low carbon researches on the transportation industry are relatively late and of a limited nature. The models adopted in these efforts are mainly genetic algorithm, HS algorithm, multiple regression models, neural network model, SVM, STIRPAT model, etc. No doubt, the use of energy prices as an economic lever will play an active role in promoting the comprehensive, coordinated development of the national economy and in the sustainable development of the energy industry itself (Chai et al. 2012). By these, this paper chooses five independent variables of GDP, international oil price, private car population, passenger and freight transportation volume as the impact factors to investigate the industrial carbon emission.

137.3 Data, Fitting Results and Forecasting Analysis

137.3.1 Data and Fitting Results

In this paper, the calculation of carbon emission is based on the final energy consumption statistics of China's transportation industry (1994–2009), and the transportation industry-wide carbon emission in 1994–2009 is calculated by way of the emission factor method, the formula of which is as follows:

$$C = \sum_{i=1}^{n} E_i * f_{ci}, i = 1, 2, 3, \ldots, n. \tag{137.1}$$

where C stands for the carbon emissions, Ei is the consumption of energy i measured by standard coal (TCE), f_{ci} is for the carbon emission coefficient of energy i. The carbon emission coefficients for electricity and thermal energy were comprehensively calculated by Cao and Xie (2010). In this paper, the results is directly referenced.

According to the formula (137.1) and carbon emission coefficients of energy, and combined with the energy consumption of China's transportation industry, this paper calculates the carbon emission in China's transportation industry for the period of 1994–2009, the results are shown in Table 137.1.

Table 137.1 The calculated carbon emission in China's transportation industry for 1994–2009

Years	1994	1995	1996	1997	1998	1999	2000	2001
Carbon emission(Mt)	106.75	104.27	103.18	130.00	140.18	154.11	162.32	165.72
Year	2002	2003	2004	2005	2006	2007	2008	2009
Carbon emission(Mt)	177.30	200.60	229.99	251.42	278.08	309.61	333.23	341.90

The paper first constructs the corresponding numerical matrix of the five independent variables: GDP (x_1), the international oil price (x_2), private car population (x_3), passenger and freight transportation volume (x_4) (x_5), then the paper transforms it into a standard numerical matrix, which is then input into the PLSR prediction model, from which the PLSR equaqtion derived is:

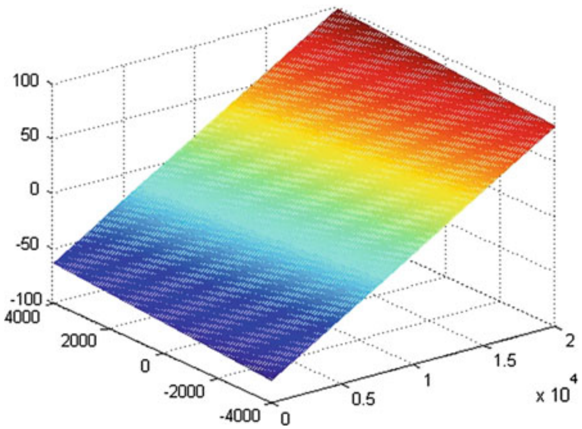
$$y = -13.3548 + 0.0008x_1 + 0.0203x_2 + 0.0093x_3 + 0.1062x_4 + 0.1056x_5 \quad (137.2)$$

Among them, the regression coefficient for the international oil price shows that, when the other factors affecting carbon emissions of China's transportation sector do not change, the average change degree of carbon emission, as an independent variable, caused by the per unit change of international oil price is 0.0203, and they are positively correlated.

137.3.2 Prediction Analysis

According to relevant national policies and China's future economic development prediction, and based on the data of 2011, the paper maintains private car population, passenger and freight transportation volume to investigate international oil price's impact on the carbon emissions in China's transportation industry at different GDP levels, that is, to study the influence mechanism between GDP, international oil price and carbon emissions in China's transportation sector. Their inter-relationship is shown in Fig 137.1, where the vertical axis indicates the changes in carbon emissions, and there are two axes in the horizontal plane, one representing the energy change of international oil prices, and the other one the change in GDP.

Fig. 137.1 Relationship between GDP, international oil price and carbon emissions



From Fig. 137.1, it can be observed that, if China's GDP (namely from the year of 2011) still rises in future, carbon emission in China's transportation industry will continue to rise, and both are positively correlated. In the case of moderate GDP growth, whether the international oil price is up or down, the value of carbon emission increasing is always negative, i.e. carbon emission in China's transportation sector will decrease. And when the international oil price drops, carbon emissions decreases even faster. In the case of subsantial GDP growth, whether the international oil price is up or down, the value of carbon emissions increase is always positive, i.e. carbon emissions in the sector will increase. And when the international oil price rises, carbon emission increases even faster.

137.4 Conclusions

According to China's future economic development prediction and national policies in regard to climate change, Coupled with the fact that the energy structure of China's transportation industry will not change much in the near future, it is possible that development and application of new energies and alternative technologies will accelerate the decrease of oil and other energy consumption in the transportation industry. Therefore, in order to maintain or reduce more carbon emissions in the industry, China should stabilize the domestic oil prices and release its oil reserves. while promoting technological advances in the new energy, the industry of new energy automobile will encounter some difficulties, the State shall take appropriate measures to protect them and intensify its efforts in technical advancements and innovations to promote the carbon emission reduction in the industry.

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Chapter 138
Cluster Analysis for Study Ecological Landscape Sustainability: An Empirical Study in Xi'an of China

Liyun Liu and Hongzhen Lei

Abstract In writing this paper, our objective was to use the concept of ecological landscape to explain why culture industrial cluster were formed. In recent years, rare extreme weather has continued coming, which made mankind living in "carbon" predicament. Compared with the extensive research on industrial sustainability in cities of the developed world, similar empirical work in developing countries is rare. We concluded from the perspective of cultural industrial space assemble, and take Qujiang cultural industry park based on local landscape design as an example, using hierarchy cluster analysis, based on selected variables that reflect the industrial advantages, government contributions, environmental management and economic performance of the enterprises. Consequently, the objective of a dynamic response to culture industrial cluster was seen as an attempt to form cultural industrial park sustainable development throughout the organizational.

Keywords Ecological landscape · Cultural industrial cluster · Industrial park · Sustainable development

138.1 Introduction

At present, many countries in the world are seeking to establish a new development mode to reduce carbon emissions as the main characteristics of low carbon economy. In China, with more than two decades of market-oriented re-form, there has been a rapid growth in the industry; Meanwhile, China's recent urbanization is

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facing an unprecedented scale, speed and range, according to the Chinese Academy of Social Sciences "Macroeconomic Blue Book" in April 2010, said China's urbanization rate of 45.68 % in 2008, with 607 million town population, the formation of the city formed 655 million megacities with populations over 118, 39 megacities. The challenges of urbanization bore the brunt of the fracture and loss of the urban form of localization; unfortunately, the development of Chinese cities is always at the expense of sacrificing the environment, the development of economy and protecting the environment, the game is always intertwined in the dilemma. Analysis of the developing countries under the condition of globalization the implementation of low carbon economy development path and the related industrial and trade policy adjustment has become increasingly urgent. Philippe Artin and Giamarco I. P. Ottavianoa combinated the new economic geography theory and Romer's endogenous growth theory, and established economic growth and economic activities between the spatial agglomeration of self-reinforcement model, further validation of the famous Myrdal's "cycle and causal accumulation theory". However, whether this model can achieve to the true meaning of low carbon city development direction transition? Therefore, to study specific culture, institutional factors on culture industry spatial pattern of Chinese native culture shaping and the influence of the enterprise, further, to avoid public affairs degradation and sustainable use of public affairs to provide independent control system based on the current academic practice becomes important and urgent task.

138.2 Literature Review

The development of low carbon economy target that scholars begin to unscramble from ecological planning to landscape urbanism (Landscape Urbanism) until to ecological urbanism development course (Waldheim and Berger 2008; Mostafavi 2010). This practice to explore its potential for urban development transformation useful inspiration (Bélanger 2010; Shannon and Marcel 2010). If "the public affairs management system as the interaction of multiple public control mechanism system", many economists emphasize the balance of competition and cooperation system establishment and for the role of forming industrial park with strict constraints (Poter 1998; Amin and Thrift 1992); Concerned about the "Primary" and "embedded" pattern. Cultural industry cluster has a strong geospatial aggregation characteristics (Scott 1996), its development path may be through the cultural industry park (Wang and Wang 2011); Or from the culture creative industry cluster development and cluster development environment problem research (Chen and Wang 2005).

Therefore, the above research urge us to think about the pattern of changes in Chinese society today, think about how to rely on the talents and wisdom of the Chinese local culture, business and government to create a future sustainable development of cultural industrial park, that is, to create a low-carbon economic development.

138.3 "Embedded" Cultural Industry Cluster Model of Ecological Landscape Approach

138.3.1 Ecological Landscape Philosophy Meaning

As we can see from Fig. 138.1, in the world scope, the cultural industry agglomeration and the cultural industry park was established, has been widely incorporated into the industrial development of the strategic idea. According to the Ministry of culture released the three batch of 135 national culture industry demonstration base and 4 national culture industry demonstration park, research findings, and foreign developed market economy conditions formed by the "primary" cultural industry cluster in our country different, cultural industry forming path is inclined to walk "embedded type" cultural industry cluster model.

138.3.2 ISM Model

In this paper, the following factors will be portrayed and analysis based on industrial rents, geographic rentals and organizational rent three dimensions.

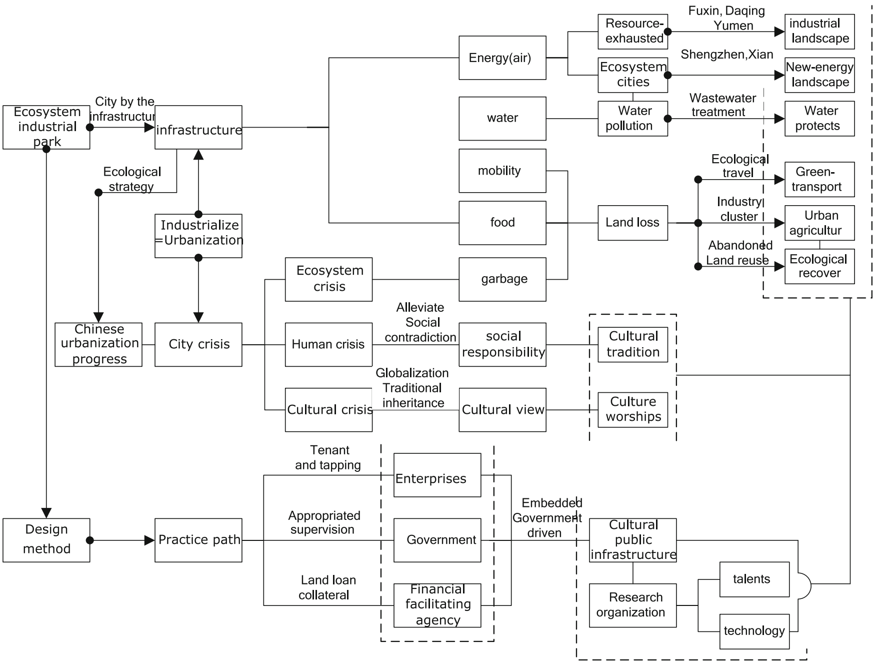


Fig. 138.1 Landscape Urbanism with Chinese City Frame

According to the nineteen eighties international business researchers are presented and the development of global value chain (Global Value Chain, referred to as GVC) theory and the production of network theory, we can notice the value chain theory emphasizes the production sequence and vertical separation, conformity, realize production network theory emphasizes the relationship between the network and enterprise the resulting with the scale of the economic community. In the industry vertical and horizontal integration based on the "Diamond Model", draw lessons from the development of the GEM model (Padmore and Gibson 1998) analysis of influence factors of cultural industry cluster. We think that determine the cultural industry cluster (S0) constitute of a serial number as following: resource endowments (S1); traffic location advantage (S2); labor agglomeration (S3); capital adequacy (S4); industrial technology advantage (S5); government incentives policies (such as finance, tax relief, land concessions) (S6); corporate profits (S7); cultural product sales network, channel (S8); cooperative condition (S9); specialized distribution market (S10); culture enterprise quantity (S11); culture enterprise scale (S12); cluster brand and trust degrees (S13); local industry association degree of perfection and action (S14); cluster's enterprises competition in the market situation and structure (S15); cluster persists the possibility that cluster duration and the effect of inter-firm cooperation (S16). Among them, 1 to 4 include the basic elements namely "geographic rent"; 5 to 8 include the elements of enterprise namely "industrial rent"; 9 to 16 include the market elements namely "organizational rent".

Set up the feature set S = {Si} between the various elements, if there exists a binary relation, there are binary relationship set R, R = {(Si, Sj)} i, j = 1,2… n, i ≠ j. Adjacency matrix A is expressed to the square of the basic binary relations between elements of the system or direct contact. Literature and theoretical study summarizes the relationship between the factors, the establishment of the adjacency matrix A. Reachability matrix M is any number of times to pass binary relation between elements of the system or to through any path between two nodes can reach the situation square. Calculated matrix reachability matrix M_5 conversion.

$M=(A-T)^5=$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
2	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
5	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
6	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
7	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
8	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
9	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
10	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
11	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
12	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
15	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0
16	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1

A=

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
6	1	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0
7	1	1	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0
8	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
9	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
10	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
12	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
13	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
14	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
15	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0
16	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0

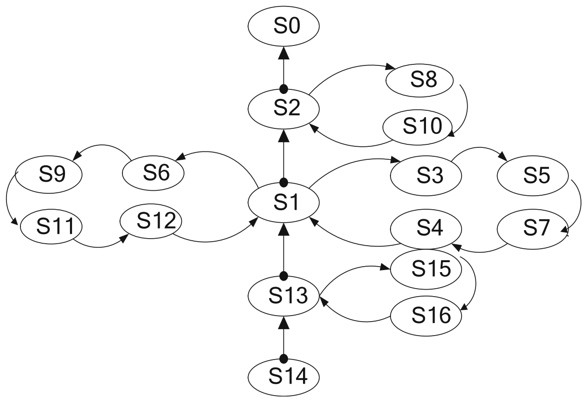
In accordance with the elements in each row of the matrix number of small to large sort, depending on the sort order, adjust the row and column. Remove the matrix has strong connection relationship factors, have a reduced matrix. The reduced matrix from upper left to lower right corner, successively separated the maximum order of unit matrix M_1.

M_1 =

	0	2	1	13	15	16	14
0	1	0	0	0	0	0	0
2	1	1	0	0	0	0	0
1	1	1	1	0	0	0	0
13	1	1	1	1	0	0	0
15	1	1	1	0	1	0	0
16	1	1	1	0	0	1	0
14	1	1	1	1	0	0	1

Seek the explanation structure model. From a backbone matrix can be intuitive to see each level contains elements from high to low, in order to draw each node in the same level, level of nodes located in the same horizontal line. The first layer is the cultural industry cluster (S0), a second layer including traffic location advantage (S2), cultural product sales network, channel (S8), specialized distribution market (S10), resource endowments (S1), labor agglomeration (S3), capital adequacy (S4), industrial technology advantage (S5), government incentives policies (such as finance, tax relief, land concessions) (S6), corporate profits (S7), cooperative (S9), culture enterprise quantity (S11), culture enterprise scale (S12), cluster brand and trust degrees (S13), enterprises cluster's competition in the market situation and structure (S15), cluster persists the possibility that cluster duration and the effect of inter-firm cooperation (S16), the fifth layer is a group of

Fig. 138.2 The Model of Hierarchical Structure



local industry association degree of perfection and action (S14). Combined circuit, in between the two adjacent layers, from lower to higher painting with arrow line, make the system structure model, as shown below. Finally, through the above five level structure decomposition, will get the Xi'an Cultural Industry Cluster multistage hierarchical structure as shown in Fig. 138.2.

138.4 Conclusions

As LTLGB 2012 theme of the conference, the practical significance of the "the intersection of technology, policy and management in low-carbon background" is that it clearly recognize that the present world is not harmonious, less common prosperity. Given the localization, contextualized research paradigm, qualitative research as the main method, provide for local culture industry development road and meticulous understanding and theoretical construction. Industrial practice of economic development also will be from our native culture to China enterprise cluster development observation, interpretation, comparison, reflection and criticism, more deeply into the culture industry historic, sociality, influence and its boundary, and academia to find in today's Chinese society change in the pattern, how to rely on the Chinese mainland culture of enterprise and government's ability and wisdom to create the future sustainable development of cultural industry park.

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Chapter 139
The Construction and Empirical Study of Low-Carbon City Comprehensive Evaluation

Chungui Liu, Zhongxing Guo, Bin Han, Huting Yuan and Shaoyin Zhu

Abstract This paper builds the low carbon comprehensive evaluation index system of city from the urban construction, the city clean ability and urban environmental protection, and use the grey correlation evaluation method to evaluate four municipalities directly under the central government comprehensively. The results show that the low carbon economy development level of Beijing is best, followed by Shanghai, Tianjin and Chongqing.

Keywords Low carbon cities · Index system · Grey relation evaluation method

139.1 Introduction

The low carbon economy is a kind of economic form that can maximize carbon productivity, improve the ability to adapt to climate change, as far as possible to slow negative climate change effects, improve human development level, and take into account the intergenerational justice and fairness in the generation, so as to make the social economy along the path of sustainable development (Tan 2011). The city as a human society economy and activities center, gathered more than half the people in the world, and the greenhouse gas accounts for about 75 % of the global total. China has paid a heavy price for its rapid economic growth, including the environment and natural resources destruction, and this also threats the base of sustainable development of social and economic (Ma et al. 2010).

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Some of the cities in China, the atmosphere, water and solid waste treatment and environmental pollution, have endanger people's health and life environment. For this, a lot of city put forward a development target of developing low carbon economy, constructing low carbon cities (Li 2010). Low carbon cities has become the common pursuit in all over the world, and many international metropolis are proud of constructing and developing low carbon cities, paying more attention to the economic cost minimization in the development process and harmonious relationship between human and nature, human relieve tolerance (Xin 2011).

In this paper, we try to build a low carbon comprehensive evaluation index system of city based on the deep investigation of the low carbon economy theory, meanwhile, take four municipalities directly under the central government for example, use the grey correlation evaluation method to evaluate the current situation of cities' the low carbon economy, provide the scientific basis for developing the cities' low carbon economy.

The remainder of this paper is organized as follows. Section 139.2 introduces the construction principle. We give the construction idea and index set in Sects. 139.3 and 139.4. While in Sect. 139.5, we offer the empirical analysis. Finally, we conclude the paper in Sect. 139.6.

139.2 Construction Principle

(1) Scientific and operability. The design of the low carbon cities evaluation index system can reflect the main features of the city low carbon economy, the index meaning and the calculation formula must be clearly and accurately, and the index data sources must be precise and collected easily.
(2) Complementary and independence. The function of index should be independent, content should complement each other, so the building of the low carbon cities evaluation index system should fully and truly reflect the urban construction, the city clean ability, urban environmental protection ability and reflect the city low carbon economy in all its aspects.
(3) Comparability and relevance. When designing the index system, we should not only reflect the current situation of the low carbon economy development of city, but also hold on to the common characteristic of different cities, to make the comparable among the cities (Fu et al. 2010).

139.3 Construction Ideas

The author based on deep investigation of the low carbon economic theory, according to the China's human development report-towards a low carbon economy and social sustainable future and the low carbon economy index structure of the city at home and abroad, puts forward three levels of the comprehensive evaluation of the low carbon city, including target layer, criterion layer and index layer. The target layer is the integrated performance in the process of city construction, the city clean ability and urban environmental protection ability. The criterion layer means development factors that sub-systems affect the low carbon economy of the city, this study selected three index of the urban construction index, the city clean ability index and urban environmental protection. The index layer means the specific index that affect the low carbon economy development of the city, these index are basic index that have been calculated.

139.4 Index Set

The low carbon economy levels of city include economy, life, social and ecological and other aspects. Therefore, in accordance with the above principles, we will divided the comprehensive evaluation index system of the low carbon city into three level and 17 index, to give the comprehensive evaluation from the urban construction, the city clean ability and urban environmental protection ability aspects (see Table 139.1).

139.4.1 The Urban Construction Index

The urban population density refers that the extent of the life in the city t are rare or intensive. Formula is as follows:

$$the\,urban\,population\,density = \frac{the\,urban\,population}{city\,area}$$

It shows that all over the world population intensive degree the index, also can reflect the per capita part-time low carbon how life quality (Xiao and Tang 2011).

The city water penetration rate refers that the city water non-agricultural population (not including temporary population and floating population) and city non-agricultural population than the total. The formula is as follows:

$$city\,water\,penetration\,rate = \frac{non\text{−}\mathrm{agricultural\,population\,of\,urban\,water}}{non\text{−}\mathrm{agricultural\,population\,of\ city}} \times 100\%$$

The calculation of city gas penetration rate in different period have different method, and the statistics have been confined within the range of the city, the gas penetration rate formula of the city in 2006 is as follows:

$$gas\,penetration\,rate = \frac{city\,gas\,supply\,population}{urban\,population\,+\,transients} \times 100\%$$

Table 139.1 The low carbon city comprehensive evaluation index system

Target layer	Criterion layer	Index layer
The low carbon city comprehensive evaluation index system	Urban construction index	The urban population density (people/km^2)
		City water penetration rate (%)
		The city gas penetration rate (%)
		Every ten thousand people have bus transportation vehicles (standard machine)
		Per capita park green space area (m^2)
	City clean ability index	Sweeping cleaning area (m^2)
		City sanitation special vehicles of total amount (Tai)
		Urban sewage treatment, ability (m^3)
		Life garbage delivering quantity (10,000 tons)
		The living waste harmless treatment rate (%)
	Urban environmental protection index	Industrial waste water discharge standard amount (10,000 tons)
		Industrial solid waste comprehensive utilization rate (%)
		"Three wastes" comprehensive utilization products value ($10,000)
		Environmental pollution control the total amount of investment in the gross domestic product (%)
		Industrial sulfur dioxide removal amount (10,000 tons)
		Industrial dust removal amount (10,000 tons)
		Industrial dust removal amount (10,000 tons)

Source National statistical yearbook

The prevalence rate of the natural gas of the urban population is higher; the pollution of the air quality is lower.

Every ten thousand people having bus transportation vehicles is through the city bus operation household register population cars per train divided by the city. Compared with cars, bus traffic carrying capacity is strong, and the average passenger less carbon emissions. This is from consumer angle measuring city low carbon levels (Huo 2012).

Per capita park green space area refers that the non-agricultural population of the city have public green land area per person (Ren 2009). Calculation formula is as follows:

$$per\ capita\ public\ green\ land\ area = \frac{urban\ public\ green\ land\ area}{city\ non\text{-}agricultural\ population} \times 100\%$$

The index is higher, reflecting a high degree of urban greening.

139.4.2 The Clean Ability Index of the City

The sweeping and cleaning area within the city is bigger, the quantity of city sanitation special vehicles improved shows that the city pays more attention of city appearance, and the urban population living environment is better.

Urban sewage treatment ability refers that design ability of a sewage treatment plant every day and night. If sewage treatment capacity is higher, the utilization rate of the water cycle will be improved, and less of the Marine ecosystem quality caused by pollution.

The urban garbage delivering quantity refers that the quantity of urban garbage can be delivered to garbage dump or transport places, if the index is smaller, shows that the urban population of low carbon consumer consciousness is higher, and the classification of life waste treatment and recycling utilization rate is higher too (Fu 2008).

The life waste harmless treatment rate refers that the harmless handling of garbage processing the ratio of total garbage, harmless handling refers that the operation process and emission has no secondary pollution, the processed materials can be used as renewable resources, if life waste harmless treatment rate is high, the lower level of the environmental pollution, resource recycling utilization rate is high, reduce the treatment process and emissions process of the emissions of carbon dioxide.

139.4.3 The Environmental Protection Index of the City

The industrial waste water discharge amount refers that each index refers to attain the state or local standards for the discharge of industrial waste water discharge amount quantity, including two parts that reached standard before disposing and reached standard after disposing (Wang 2009). Industrial waste water discharge sewage processor can produce certain carbon emissions when processing, if not making this under control, will cause serious damage to the environment. If the industrial wastewater quantity standard is high, the environmental pollution of the city is small.

The industrial solid waste comprehensive utilization rate refers that each year the comprehensive utilization of industrial solid waste compared with the total amount of industrial solid waste production with that and comprehensive utilization of the storage of the percentage of previous years combined (Wang 2011). If "Three wastes" comprehensive utilization output value of the products is higher, reflect the city technology economy capacity is higher, meanwhile the city low carbon economy capability. If the control of environmental pollution amount of investment GDP index is higher, reflect the city for environmental pollution control value degree is higher, the environmental protection ability strengthens, and carbon emissions reduce (Fu and Zhuang 2010).

If three index that the industrial sulfur dioxide removal amount, and the industrial smoke removal and industrial dust removal amount are smaller, reflecting the city low carbon economy achievements in the air environmental quality direct embodiment.

139.5 Empirical Analysis

139.5.1 Data Sources

Through consulting the 2010 national statistical yearbook, collecting low carbon cities related index and statistical data; we can get the original data of the low carbon economy comprehensive evaluation index of four municipalities directly under the central government, as shown in Table 139.2.

139.5.2 Data Dimensionless Processing

First to explain economic meaning of each index, urban water penetration rate, city gas penetration rate per ten thousand people, having bus traffic vehicles and per capita park green space area of urban construction index is positive index, the bigger index score we get, the better, and when the urban population density values reached 1000 people/km^2, the first level of population density area of municipalities directly under reached saturation value; the sweeping cleaning area, city sanitation special vehicles, total urban sewage, processing power and life waste harmless treatment rate of the city clean ability index is positive, the bigger index score is the better, but the living garbage delivering quantity index is negative, the smaller index score is the better; industrial waste water discharge quantity, the standard of industrial solid waste comprehensive utilization, the “three wastes” comprehensive utilization output value of the products, environmental pollution control the total amount of investment of gross domestic product, the sulfur dioxide removal amount, and the industrial smoke removal amount and industrial dust removal amount of Urban environmental protection index is positive, the bigger index score is, the better. According to each index economic meaning, we can get ideal samples $X_0 = (1383, 100.0, 100.0, 23.0, 13.2, 15879, 7461, 680, 183.7, 100.0, 291326.6, 2.22, 96.2, 484.5, 138.2)$ use formula $x'_{ij} = \frac{x_{ij}}{x_{0j}}$ $(i = 1, 2, \ldots, m; j = 1, 2, \ldots, p)$ In data dimensionless processing (See Table 139.3).

Table 139.2 The original data of municipalities directly under central government evaluation index

Evaluation index	Municipality directly under the central government			
	Beijing	*Tianjin*	*Shanghai*	*Chongqing*
The urban population density (people/km^2)	1383	2752	3630	1860
City water penetration rate (%)	100.0	100.0	100.0	94.1
The city gas penetration rate (%)	100.0	100.0	100.0	92.0
Every ten thousand people have bus transportation vehicles (standard machine)	23.0	14.0	12.5	7.9
Per capita park green space area (m^2)	11.3	8.6	7.0	13.2
Sweeping cleaning area (m^2)	13804	7322	15879	6136
City sanitation special vehicles of total amount (Taiwan)	7461	1951	5560	1786
Urban sewage treatment, ability (m^3)	377	224	680	191
Life garbage delivering quantity (10,000 tons)	633.0	183.7	732.0	256.7
The living waste harm_ less treatment rate (%)	97.0	100.0	81.9	98.8
Industrial waste water discharge standard amount (10,000 tons)	8096	19671	35973	42798
Industrial solid waste comprehensive utilization rate (%)	70.0	100.0	100.0	80.0
"Three wastes" comprehensive utilization products value (10,000 yuan)	34365.8	192650.4	170379.1	291326.6
Environmental pollution control the total amount of investment in the gross domestic product (%)	1.64	1.19	0.78	2.22
Industrial sulfur dioxide removal amount (10,000 tons)	13.0	37.4	35.0	96.2
Industrial smoke removal amount (10,000 tons)	190.8	484.5	472.3	377.3
Industrial dust removal amount (10,000 tons)	78.1	54.8	138.2	95.4

139.5.3 Confer the Correlation Coefficient of Each Index

According to the formula $\Delta_{ij} = |x_{ij} - 1|$, getting absolute deviation matrix of each corresponding index $\Delta_{ij}(k)$. We can get the two levels of the biggest difference from the calculation results $\Delta(\max) = 0.8820$, $\Delta(\min) = 0$, then put them into the formula $\xi_{ij} = \frac{\Delta(\min) + \rho\Delta(\max)}{\Delta_{ij} + \rho\Delta(\max)}$, make $\rho = 0.5$, then get grey correlation coefficient matrix of each index $\xi_{ij}(k)$ (See Table 139.4).

139.5.4 Confer the Weights of Each Index

Firstly, to use transformation method to standardize the index data, then use excel to describe the statistical data, calculate the minimum, maximum, mean and standard deviation of index data, at last, use the variation coefficient method to get the weight of each index (See Table 139.5).

Table 139.3 Data dimensionless processing

X_0	X_1	X_2	X_3	X_4
1.0000	1.0000	0.5025	0.3810	0.7435
1.0000	1.0000	1.0000	1.0000	0.9410
1.0000	1.0000	1.0000	1.0000	0.9200
1.0000	1.0000	0.6087	0.5435	0.3435
1.0000	0.8561	0.6515	0.5303	1.0000
1.0000	0.8693	0.4611	1.0000	0.3864
1.0000	1.0000	0.2615	0.7452	0.2394
1.0000	0.5544	0.3294	1.0000	0.2809
1.0000	0.2902	1.0000	0.2510	0.7156
1.0000	0.9700	1.0000	0.8190	0.9880
1.0000	0.1892	0.4596	0.8405	1.0000
1.0000	0.7000	1.0000	1.0000	0.8000
1.0000	0.1180	0.6613	0.5848	1.0000
1.0000	0.7387	0.5360	0.3514	1.0000
1.0000	0.1351	0.3888	0.3638	1.0000
1.0000	0.3938	1.0000	0.9748	0.7787
1.0000	0.5651	0.3965	1.0000	0.6903

Table 139.4 Grey correlation coefficient

1.0000	0.469931	0.4160	0.6323
1.0000	1.0000	1.0000	0.8820
1.0000	1.0000	1.0000	0.8465
1.0000	0.5299	0.4914	0.4018
0.7539	0.5586	0.4843	1.0000
0.7714	0.4500	1.0000	0.4182
1.0000	0.3739	0.6338	0.3670
0.4974	0.3967	1.0000	0.3801
0.3832	1.0000	0.3706	0.6080
0.9363	1.0000	0.7090	0.9735
0.3523	0.4494	0.7344	1.0000
0.5952	1.0000	1.0000	0.6880
0.3333	0.5656	0.5151	1.0000
0.6280	0.4873	0.4047	1.0000
0.3377	0.4191	0.4094	1.0000
0.4211	1.0000	0.9460	0.6659
0.5035	0.4222	1.0000	0.5875

139.5.5 Calculating the Correlation Coefficient

From $E_i = \sum_{k=1}^{m} \omega(k)\xi_{ij}(k) \quad (k = 1, 2, \cdots, m)$, we know the score of low carbon economy comprehensive evaluation of four municipalities directly under the Central Government E_i = (0.7266, 0.6201, 0.7055, and 0.6070), in 2010, the low

Table 139.5 The evaluation index weight list

Evaluation index	Average	Standard deviation	Variation coefficient	Weight coefficient	Rank
City population density	0.5446	0.4423	0.8120	0.0531	12
City water penetration rate	0.7500	0.5000	0.6667	0.0436	17
City gas penetration rate	0.7500	0.5000	0.6667	0.0436	16
Every ten thousand people have bus transportation vehicles	0.4272	0.4188	0.9804	0.0641	5
Per capita park green space area	0.4879	0.4455	0.9131	0.0597	8
Sweeping cleaning area	0.4772	0.4911	1.0291	0.0673	4
The total number of city appearance and sanitation special vehicles	0.4235	0.4918	1.1612	0.0760	2
Urban sewage, processing power	0.3620	0.4565	1.2612	0.0825	1
Life garbage delivering quantity	0.5119	0.4953	0.9677	0.0633	6
The living waste harmless treatment rate	0.6920	0.4663	0.6739	0.0441	15
The emission standard industrial wastewater quantity	0.5342	0.4528	0.8476	0.0555	11
Industrial solid waste comprehensive utilization rate	0.5833	0.5000	0.8571	0.0561	10
"Three wastes" comprehensive utilization output value of the products	0.5363	0.4119	0.7680	0.0502	13
Environmental pollution control the total amount of investment of gross domestic product	0.4705	0.4291	0.9120	0.0597	9
Industrial sulfur dioxide removal amount	0.3894	0.4279	1.0988	0.0719	3
Industrial smoke removal amount	0.6484	0.4620	0.7126	0.0466	14
Industrial dust removal amount	0.4416	0.4224	0.9566	0.0626	7

carbon economy level from high to low is: Beijing, Shanghai, Tianjin, Chongqing (See Table 139.6).

139.5.6 Evaluation Analysis

From the index weight coefficient, it is known that the construction index weight of the city low carbon economy comprehensive evaluation, add up to 0.2641, the city clean ability index weight, add up to 0.3332, urban environmental protection index weight, add up to 0.4027, the factors which affects the low carbon economy development level, including urban sewage processing power, city sanitation special vehicles total sulfur dioxide removal, industrial quantity, sweeping cleaning area, each ten thousand people have bus traffic vehicles and living garbage delivering quantity, in which one urban construction index, four city clean ability index, one urban environmental protection index, indicating that the city clean ability index play a key role in the low carbon economy development process.

In the study of the four municipalities directly under the central government, the low carbon economy development level of Beijing is the highest,

Table 139.6 The low carbon economy comprehensive evaluation score of municipalities directly under

Evaluation index	Municipality directly under the central government			
	Beijing	*Tianjin*	*Shanghai*	*Chongqing*
City population density	0.0531	0.0250	0.0221	0.0336
City water penetration rate	0.0436	0.0436	0.0436	0.0385
The city gas penetration rate	0.0436	0.0436	0.0436	0.0369
Every ten thousand people have bus transportation vehicles	0.0641	0.0340	0.0315	0.0258
Per capita park green space area	0.0450	0.0334	0.0289	0.0597
Sweeping cleaning area	0.0519	0.0303	0.0673	0.0282
The total number of city appearance and sanitation special vehicles	0.0760	0.0284	0.0482	0.0279
Urban sewage, processing power	0.0410	0.0327	0.0825	0.0314
Life garbage delivering quantity	0.0243	0.0633	0.0235	0.0385
The living waste harmless treatment rate	0.0413	0.0441	0.0313	0.0429
The emission standard industrial wastewater quantity	0.0195	0.0249	0.0407	0.0555
Industrial solid waste comprehensive utilization rate	0.0334	0.0561	0.0561	0.0386
"Three wastes" comprehensive utilization output value of the products	0.0168	0.0284	0.0259	0.0502
Environmental pollution control the total amount of investment of gross domestic product	0.0375	0.0291	0.0241	0.0597
Industrial sulfur dioxide removal amount	0.0243	0.0301	0.0294	0.0719
Industrial smoke removal amount	0.0196	0.0466	0.0441	0.0310
Industrial dust removal amount	0.0315	0.0264	0.0626	0.0368
Comprehensive evaluation score	0.7266	0.6201	0.7055	0.6070

comprehensive evaluation score is 0.7266, the capital Beijing is the economy, science and technology, human and international fusion of the international metropolis and rapid economic development, and university gathered, the development of science and technology more quickly, but the city's environmental quality also has two problems: one problem is the natural environment, including the sand dust, water scarcity and industrial production leading to air pollution, etc. (Zheng 2010); another problem is that the city's population is crowded, traffic jams ongoing etc. The process of Tianjin in the low carbon economy development of economic development lagging a little, and the ecological environment is not optimistic, environmental air quality is poor, urban construction being to be further strengthen and improve. In low carbon economy development, the problems between Shanghai and Beijing is roughly same, densely populated, traffic jams for private cars, as a representative of the urban air pollution to industrial zone, as a representative of the centralized comprehensive pollution. The low carbon economy development level of Chongqing is among the lowest of the four municipalities directly under, investigate its reason: the geographical position, science and technology, and the lagged disadvantage limits the development of economic society, industrial layout is reasonable, the city infrastructure severity shortage, traditional industrial extensive growth mode make ecological deterioration of the environment and energy consumption structure is unreasonable etc.

139.6 Conclusions

The research builds low carbon city comprehensive evaluation index system, introduce the gray system theory, to evaluate low carbon economy development level of the city, through the variation coefficient method to quantify the influence degree of each index, and transfer qualitative problem into a quantitative analysis, which made the assessment more scientific and effective, but the content of low carbon city comprehensive evaluation index system remains need to be perfect and improvement, to make the evaluation content more comprehensive.

Acknowledgments This research was supported in part by the Soft Science Research Program of Shanxi Province under Grant No. 2011041069-03, a grant from the Humanities and Social Sciences Young Foundation of the Ministry of Education under grant No. 10YJC630423 and the Teaching and Research Program Shanxi Datong University under Grant No. 2008JYZD08.

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Part IX
Workshop on Low-Carbon Transportation and Low-Carbon Tourism

Chapter 140
SLP Method Based on Low-Carbon Logistics in Professional Agricultural Logistics Park Layout

Yong Chen

Abstract Professional agricultural logistics park is a logistics operation mode accompanied by intensification of agricultural production, using the SLP method based on the requirements of the low-carbon economy of logistics activities to sort the various functional areas to form a position to optimize the layout in order to complete professional agricultural logistics park layout to achieve low-carbon effect based on full analysis of logistics relationship between functional parks. Logistics object, logistics volume and logistics job line and support services should be fully considered in the process of professional agricultural logistics park layout with low-carbon concept of improving operating efficiency, reduce the intensity of logistics operations in the region.

Keywords Low-carbon logistics · SLP method · Professional logistics park of agricultural products · Layout

140.1 Introduction

The ultimate goal of agricultural logistics is to reduce transportation, reduce vehicle emissions and promote low-carbon logistics of agricultural products. Agricultural logistics mode, agricultural logistics marketing mode and distribution pattern decided by agricultural park layout can contribute to the effect of low-carbon

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economy. Thus, applying SLP (Systematic Layout Planning) method accompanied with low-carbon idea is conducive for agricultural products to enter low-carbon logistics, find and innovate low-carbon logistics mode, accelerate agricultural trade and promote agricultural products to enter low-carbon logistics (Chai 2007) .

140.2 Analysis of Basic Elements of the SLP Method in Professional Logistics Park Layout Planning

140.2.1 Logistics Object P

Logistics object P is one of the basic elements when applying SLP into the logistics park layout planning. Different agricultural species and nature determines the requirements of factors like logistics facilities storage and processing conditions, thereby affecting the professional logistics park layout (Zhang and Ge 2012). The following table is a research on logistics objects of some types of agricultural products (Table 140.1, Fig. 140.1).

140.2.2 Logistics Route R

Usually, the logistics route of fruits and vegetables professional logistics park tends to be 1 → 2 → 3 → 4.1; the logistics route of meat professional logistics park tends to be 1 → 2 → 3 → 4.2 → 4.3 → 5.2; the logistics route of grain and oil professional logistics park tends to be 1 → 2 → 3 → 4.3 → 5.2; the logistics route of Poultry and eggs professional logistics park tends to be 1 → 2 → 3 → 4.2 → 5.1.

140.2.3 Support Services Sector S

Professional logistics park generally includes business marketing area, tally processing area, storage and trans-shipment area, leisure and display area, and waste

Table 140.1 Logistics object's influence on the layout of functional area in logistics park

Logistics object	Functional area in the professional logistics park			
	Process	Storage	Transportation	Distribution
Grain and oil	●●	●●●	●	●
Fruits and vegetables	●	●●	●●●	●
Meat	●●●	●●	●	●●
Poultry and eggs	●●	●	●	●●●

● stands for concentration level

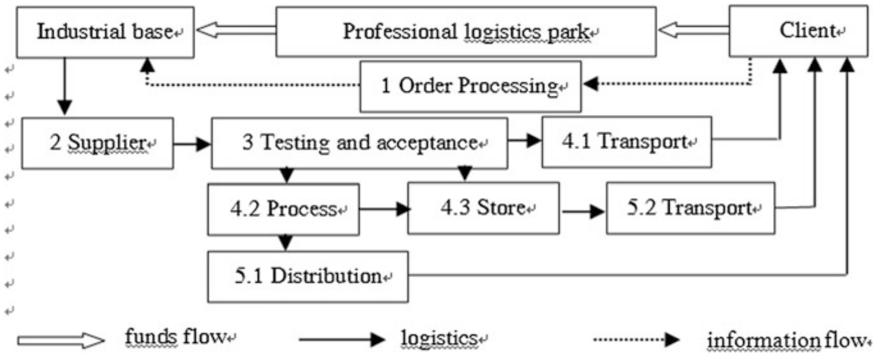

Fig. 140.1 Road map of logistics operations in professional logistics park

disposal area (Zhou 2012), among which leisure and display area is a functional form emerging in recent years from professional logistics parks across the country, and it combines agricultural products related leisure tourism and product promotion to meet people's demand for fine living (Guo 2012). Area function as shown in the (Table 140.2).

140.3 The Optimal Layout Based on SLP Method of Low-Carbon Logistics

140.3.1 Clear the Layout Target of SLP Method Based on Low-Carbon Logistics

To simplify the working process and transport operations such as to minimize the material handling workload, transportation distance and the people movement; improve scientific management level;

Table 140.2 Function of professional logistics park

Support services sector	Function
Business marketing area	To transact business procedures, dispatch logistics facilities and resource and be in charge of day-to-day management of the park, business activities and negotiation.
Tally processing area	Agricultural products inspection, sorting, labeling, packaging, packing, code disk.
Storage and trans-shipment area	According to the storage nature of agricultural products, the storage area should includes normal temperature warehouses, cold storage, freezer, with logistics facilities like vehicles to transport and distribute agricultural products.
Waste disposal area	Responsible for waste from activities like sorting and processing.
Leisure and display area	To provide place for leisure and tourism projects and agricultural products show.

To achieve a situation where least resource is consumed and least waste is released, and to rationally design waste disposal areas, to reduce pollution, to minimize the impact of entire operation process on the environment;

To comprehensively consider the long-term development of the park combining with the goal of regional economic and agricultural development to avoid being too aggressive for future development.

140.3.2 Form Figure of Logistics Relationship Between Each Functional Area

SLP typifies logistics strength into 5 grades, respectively represented by A (absolutely important), respectively, with E (extremely important), I (important), O (Ordinary important), U (unimportant), corresponding to extra high logistics strength, high logistics strength, large logistics strength, general logistics strength and negligible logistics strength (Fig. 140.2).

140.3.3 Sort Comprehensive Closeness of all the Areas

Besides considering the logistics relationship between functional areas, it's necessary to ensure the non-logistics relationship, obtain the factors that influence the relationship between these areas, grade them according to non-logistics relationship grade requirements, ensure the relationship between operation units to calculate (Table 140.3).

140.3.4 Form the Location of the Various Functional Areas Layout

The closeness of the value of high functional area instructions more closely linked with other functional areas, should be in the layout of the functional area layout in the center, forming a location map of the various functional areas (Fig. 140.3) (Shi 2011).

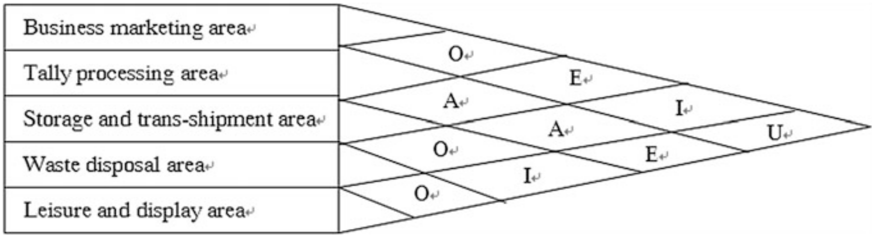

Fig. 140.2 Figure of logistics relationship between each functional area

Table 140.3 Sort table of comprehensive closeness between areas

Functional areas		Relationship closeness							
		Logistics relationship (weight value 3)		Non-Logistics relationship (weight value 1)		Integrated relationship		Rank	
		Rating	Score	Rating	Score	Rating	Score		
1	Business marketing area	Tally processing area	O	1	E	3	O	6	6
2	Business marketing area	Storage and trans-shipment area	E	3	A	4	E	13	2
3	Business marketing area	Waste disposal area	I	2	U	0	O	6	6
4	Business marketing area	Leisure and display area	U	0	U	0	U	0	9
5	Tally processing area	Storage and trans-shipment area	A	4	A	4	A	16	1
6	Tally processing area	Waste disposal area	A	4	U	0	E	12	3
7	Tally processing area	Leisure and display area	I	2	I	2	I	8	5
8	Storage and trans-shipment area	Waste disposal area	O	1	U	0	O	3	8
9	Storage and trans-shipment area	Leisure and display area	E	3	U	0	I	9	4
10	Waste disposal area	Leisure and display area	O	1	O	1	O	4	7

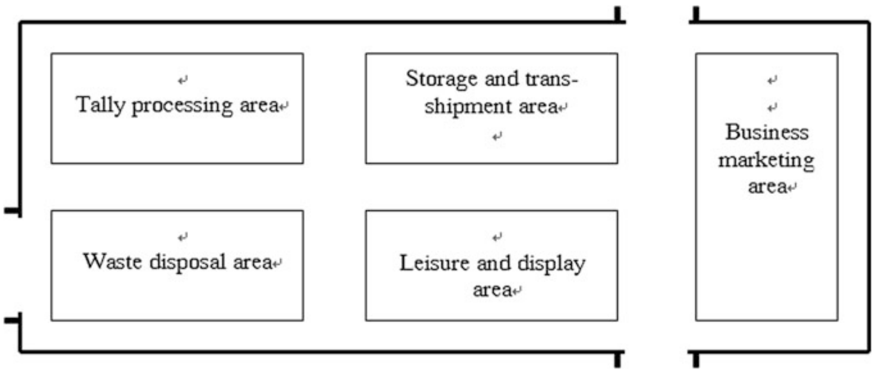

Fig. 140.3 Location optimization layout of each functional area

140.4 Conclusion

Compared with general agricultural logistics park, professional agricultural logistics park has outstanding functions in processing and storage because of the products' singleness; besides, professional agricultural logistics park is often close to production base of such agricultural products, and agricultural products' deep processing activities generate large amounts of organic waste, which is green fertilizer that can be recycled to the base; we can also create the "planting (cultivation)—processing—business—travel" functional professional agricultural logistics park by developing leisure and tourism promotion of agricultural products, which is the direction of development of professional logistics park layout planning under the environment of low-carbon economy (Zhong 2012).

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Chapter 141
Low-Carbon Tourism Planning Study: A Theoretical Framework

Ping Yin

Abstract Low-carbon mode is the inevitable choose for tourism development, while seldom work has linked to low-carbon tourism planning. This article aims to propose a framework to low-carbon tourism planning. Firstly, the low-carbon tourism system with energy cosumption subsystem,waste emission subsystem, and four elements is proposed. Based on the direct and indirect carbon emission analysis, a low-carbon tourism planning framework with five subsystems is developed. The low-carbon tourism planning framework can be used to any region that wants to develop low-carbon tourism, especially to those places which have natural scenic and fragile ecosystem.

Keywords Low-carbon development · Low-carbon tourism · Tourism planning

141.1 Introduction

Tourism is the biggest industry in the world (WTO 2007), and the revenue of this industry is one of the main sources of income in 46 of among 50 of the world's most backward countries (UNWTO 2006). A study found that tourists cause 4.4 % of global CO_2 emissions, and these emission are projected to grow at an average rate of 3.2 % per year up to 2035 (Peeters and Dobois 2010). UNWTO/UNEP/WMO reported that the travel and tourism industry, including aviation, is responsible for about 3 % of greenhouse gas (GHG) emission. It is estimated that CO_2 emission from tourism (excluding aviation) will grow at 2.5 % per year until

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2035. The entire world has taken efforts to committee to emissions reduction targets to lower its impact on climate change. Therefore, the low-carbon development of tourism is currently considered to play a significant role in a low carbon economy.

China government announced at the Copenhagen Conference that Chiba aims to reduce the intensity of carbon per unit of gross domestic product (GDP) by 40–45 % by 2020, based on 2005 levels (Xu et al. 2011). To meet this promise, the economic development way and consumption mechanisms should be changed, including tourism development and tourists' behaviors.

In the past, some scholars made the qualitative and quantitative analysis to consider the low-carbon tourism development. Stefan Gossling believed that energy using modes were the important factor in tourism's influence of the global environment (Gŏesling 2002). Ghislain Dubois predicted the GHG emission in France's tourism development till 2050 (Dubois and Ceron 2006). Sabine Perch-Nielse built a construction system to calculate the density of GHG discharged by tourism (Perch et al. 2009). Tzu-Ping Lin examined the tourism transportation carbon emission in five national parks, and suggested that the government should take positive management effort to introduce the tourists take more public transportation facilities than self-driving (Lin 2010). Jiuping Xu et al. took Leshan City as the studying case to simulate the low-carbon tourism in world natural and cultural heritage areas (Xu et al. 2011). Z. Tang et al. analyzed the fundamental conception of low-carbon tourism and reviewed the main research on low-carbon tourism within and outside China (Tang et al. 2011).

Basically most aspects of low-carbon tourism development were discussed, while low-carbon tourism planning was seldom paid attention to. Tourism planning is the first and most important step in the development route of tourism exploitation, and the level of low-carbon development is determined by the planning principle to the large extent. This paper aims to build the theoretical framework to low-carbon tourism planning. Section 141.2 introduced the low carbon tourism system and the causal relationship in the system. In Sect. 141.3, on the basis of the dynamic system with the subjective consciousness of human energy conservation and emission reduction, we proposes a framework of the low-carbon tourism planning, and gives detailed measure to every sector. And in Sect. 141.4, we make a conclusion about the effectiveness of such a framework and discuss the necessary further research.

141.2 Low-Carbon Tourism System

In order to develop low-carbon tourism planning framework, the low-carbon tourism system should be introduced first, and the relationship between factors and low-carbon should be discussed.

141.2.1 Low-Carbon Tourism System

Joe Kelly and Peter W. Williams divided GHG emission in tourism into three aspects: emission in tourism destination, emission in commuting transportation of tourism employees, and emission in transportation of tourists (Kelly and Williams 2007). Jiuping Xu et al. developed a low-carbon tourism system with five subsystems (Xu et al. 2011). Basic on the two models experiences, this paper develops a low-carbon tourism system with two subsystems and four elements. The two subsystems are energy consumption system and waste emission system. Tourists start from the origins, take transport facilities, and arrive at the tourism destination. Exception the tour process in tourism attractions, the tourists spend a lot of time in the accommodation facilities. The tour process is supported by energy consumption, and each step release waste. The system structure is showed in Fig. 141.1.

141.2.2 Causal Relation Analysis in Low-Carbon Tourism System

In the low-carbon tourism system, the initial cause is the tourists demand. The tourism industry blooms based on the tourist's motivation. Tourists' consumption preference about products and the quantity of the tourists are the two key calculation standards of tourism demands. To meet the consumption preference of tourists, the tourism supply enterprises promote the quality and quantity of products. The process of tourism industry consumes energy and liberates waste. The detailed causal relationship of the system is showed in Fig. 141.2.

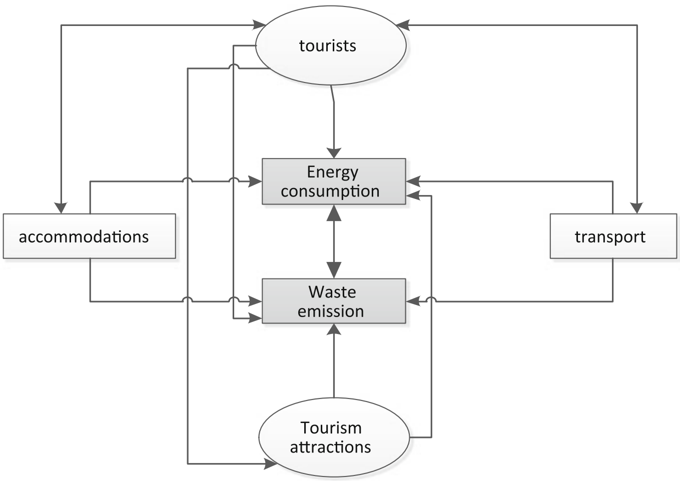

Fig. 141.1 Structure of low-carbon tourism system. Sources: the author's elaboration

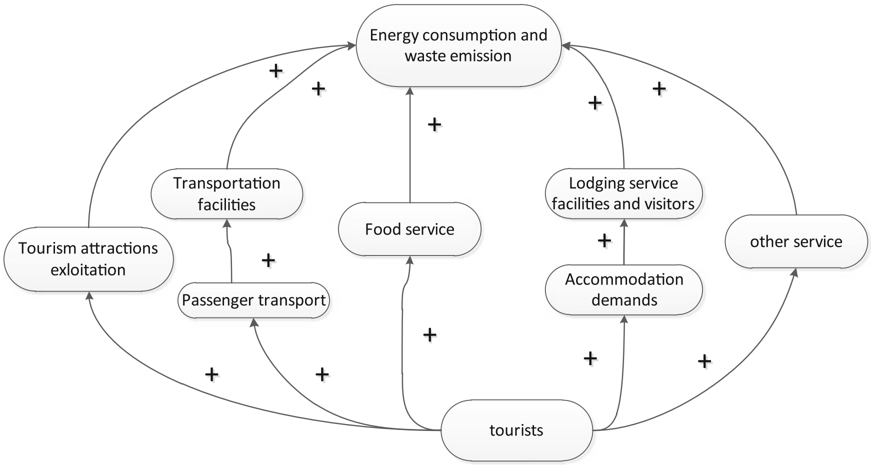

Fig. 141.2 Interactive causal relationship in the low-carbon tourism system Sources: the author's elaboration

Transport, accommodation, and tourism activities are the three distinct clusters in carbon emissions contribution from tourism economic activities. Each cluster contributes both direct and indirect GHG emissions. Carbon emissions from sources that are directly engaged in the economic activity of the tourism are considered direct emissions. For example, the emissions from the usage transportation facilities, electricity in hotels are direct emission. While the consequence of the tourism activities of the companies in tourism are indirect carbon emissions, such as the energy consumption food productions. The relationship is mapped in Fig. 141.3.

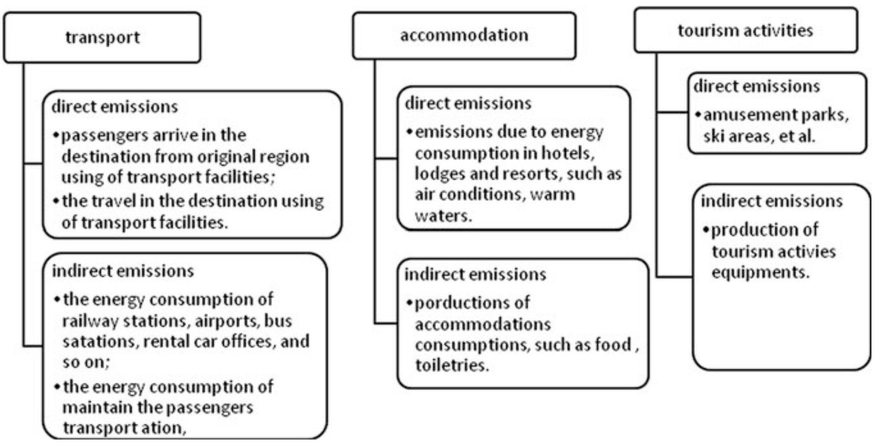

Fig. 141.3 Direct and indirect carbon emissions sources for tourism clusters. Sources: the author's elaboration

141.3 Low-Carbon Tourism Planning Framework

It is posited that integrative approach should be used to explain the low-carbon tourism planning. Based on the multiple motivation of low-carbon tourism development, four basic principles should be carried out in the process of tourism planning, and each element has the pointed measures. As to the tourism development administration, there is really a lot of work to do to promote the low-carbon development.

141.3.1 Tourists Behaviors Planning

Currently, several sustainability benchmarking standards exist but as yet few tourists obey the standards strictly. Tourists are the demand factor in tourism development, and the activities can impact the environment a lot. In order to product clean/green tourism productions, reduce the carbon emission, and save the nature environment, the first and the most important work is to educate the tourists to respect the nature.

141.3.2 Low-Carbon Transportation Service Planning

Land transport, air transport, and water transport are the three main tourism transportation ways. According to UNWTO's statistics, the carbon emission from transportation in 2005 achieved 1192 Mt CO_2. The automotive industry should pursue more efficient vehicles, cleaner fuels and smart driving choices to reduce the impact of car emissions on climate change. The transportation service enterprises should reduce the inefficient infrastructures in management; the transportation administration should develop more convenient mass transportation facilities and networks, such as track traffic network, public buses, and so on, to substitute the cars traffic.

141.3.3 Low-Carbon Accommodation Planning

The accommodation cluster carbon emissions are calculated as the product of tourism volume: energy use per guest night; and emission factors per energy unit for power and heat. For 2005, worldwide accommodation emissions are estimated at 284 Mt CO_2. According to UNWTO, accommodation emissions are estimated to increase by 156 % by 2035, and the biggest growth in emissions will occur in Asia-Pacific in the next 20 years. Despite the limitations of globally agreed sustainability benchmarks, a series of measure options for the accommodation cluster can be carried out, including operational and technical measure, changes in energy sources, and changes in consumers' behavior.

141.3.4 Low-Carbon Tourism Attractions Development Panning

Tourism attractions are places that tourists spend most of the time in. Recreation productions are developed in tourism attractions. To meet the low-carbon development, the tourism attractions should be maintained as the natural characteristics as much as possible, and offer the tourists' basic recreation demands. Any artificial work is to violate the spirit of low-carbon development.

141.3.5 Low-Carbon Development Suggestions for Local Government

As the supervisor and administrator of tourism industry, local government should play a pro-active role in low-carbon tourism development. The efforts can be listed as following:

To create incentives to promote adoption of renewable energies and to foster local/regional collaborative sourcing of renewable energies between tourism industry and energy companies.

To set appropriate market incentives to foster the adoption and technological exploration of next-generation bio-fuels by fuel producers and the energy sector.

To foster and support cross-sector partnerships to accelerate R&D and technological exploration for large scale commercialization.

To set up the intelligent telemetric, smart traffic management systems and infrastructure improvement projects to reduce traffic congestion and to increase capacity of existing transportation capacities.

To create a simplified but verifiable certification approach for low-carbon sustainable fuels by aviation authorities to accelerate the introduction of new fuels and to lower the risk for suppliers.

141.4 Conclusions

This paper aims to propose a low-carbon tourism planning framework. Five subsystems are integrated into a comprehensive tourism planning system. Reducing carbon emission, protecting the environment and sustainable development are the three development motivation; there are four principles, which are using renewable or clean energy, carrying out the energy saving technology, developing public mass transportation, and integrating tourism infrastructures. Basic on the motivations and principles, detailed suggestions are put forward to five subsystems.

In the current discussion to construct a low-carbon tourism planning framework, the suggestions can be used to any place that wants to development low-carbon tourism, especially those places which have natural scenic and fragile ecosystem.

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Chapter 142
Measuring the Ecological Embeddedness of Tourism Industrial Chains

Yan Wang and Hui Zhang

Abstract The author intends to contribute to the operationalization of the ecological embeddedness concept through the development of tourism chain, by a first attempt to measure ecological embeddedness, technologically, conceptually and structurally and institutionally. The paper starts with a critical outline of the academic discourse on embeddedness in tourism chain studies. In the second section, general developments in domestic tourism chain and their ecological implications are illustrated for the national level. Thereafter, the author tries to measure the ecological embeddedness of the tourism chains from cognitive, political, structural and cultural perspectives, through the ranking of each index; the status of the ecological embeddedness is concluded based on the ecological environment quality classification.

Keywords Tourism industrial chain · Embeddedness · Ecology

142.1 Introduction

In the 1990s, the trend of ecological industry development becomes the national strategy of industrial development at the macroscopic level, and also makes the masterstroke of regional industry park construction layout at the medium level and enterprise production technology modification microscopically. Tourism industrial chain has been gradually focusing on buyer-driven market system. Travel

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consumers express their ecological taste on travel products within a globalized travel service system, such as, environmental issues, nature conservation and animal welfare, artisan skills and the utopia of the simple life, interest in supporting local farmers and knowledge of the places of interest's provenance (regional flair, identity and uniqueness). Based on a critical outline of the academic discourse on embeddedness in tourism chain studies, the paper starts with a definition of a coherent terminology of ecological embeddedness. In the second section, the paper illustrates general developments in the Chinese tourism system and the ecological implications for the national level. Thereafter how the ecological embeddedness is measured of the tourism industrial chain. The concluding section discusses the challenges and potential benefits of measuring and communicating ecological embeddedness for the tourism development.

142.2 The Concept of Embeddedness in Tourism Studies

The concept of "embeddedness" has wide application in social sciences, such as economic geography, economic sociology, rural sociology or institutional economics. Granovetter firstly defines the concept "embeddedness", the continuous contextualization of economic behavior in certain social structure (Granovetter 1985). Zukin and Dimaggio state that embeddedness is classified into four types: (1) Cognitive embeddedness, the structured regularities of mental processes limit the exercise of economic reasoning and a keen sense of the limits to rationality posed by uncertainty, complexity, and the costs of information. (2) Cultural embeddedness, the role of shared collective understandings in shaping economic strategies and goals. Culture sets limits to economic rationality by proscribing or limiting market exchange in sacred objects and relations. (3) Structural embeddedness, the contextualization of economic exchange in patterns of ongoing interpersonal relations. The term "structure" refers to the manner in which dyadic relations are articulated with one another. The structure of ongoing social relations is crucial as well in economic actors' efforts at self-regulation, or policing markets. (4) Political embeddedness, the global context of investment flows and shifts in the sites of production (Zukin and Dimaggio 1990). Murdoch et al. argue that the "notion of embeddedness can be extended to include natural, as well as social, relations" (Murdoch et al. 2000).

For the context of tourism studies, an immediate answer to a simple question: what is embedded in what? Four types of ecological embeddedness concepts could be concluded through the links between the economic activities of the tourism industrial chain.

142.2.1 The Ecologically Cognitive Embeddedment of Tourism Chain Activities

The embeddedness is applied to illustrate the signification of moral and environmental considerations (e.g. Ilbery et al. 2000; Tovey 1997). Under the ecological awareness, there is a general argument that actors are increasingly willing to "offset purely personal financial incentives against cognitive criteria involving collective, community or environmental benefits" (Sage 2003).

142.2.2 The Ecological-Oriented Cultural Embeddedness of Tourism Chain Activities

The notion of embeddedness is based on the assumption that cultural identity is relevant for creating trust among producers, processors and consumers, such as the higher quality of social relations (Hinrichs 2000) and environmental friendliness (Winter 2003). Ecological embeddedness presents in the wider adoption of voluntary or compulsory carbon offset schemes, possible modal shifts in transport use and demand for environmentally responsible behavior.

142.2.3 The Ecologically Structural Embeddedness of Tourism Chain Activities

The structural embeddedness or positional perspectives on networks go beyond the immediate ties of firms and emphasize the information value of the structural position these partners occupy in the network. In the context of tourism chain activities, information takes a role of great importance in ecological protection modules. By means of the information technology, the scientific nature of the tourism planning is improved with ecological environment quality monitoring.

142.2.4 The Political Embeddedness of Tourism Chain Activities with the Ecological Multi-faceted Challenges

The political embeddedness of tourism chain activities takes four forms: political institutions, political actors, the political activities and political resources. The political institutions provide a framework of rules and regulations within which market actors have to play. With the climate change and sustainability, the critical importance of a “whole of government” approach as a creative political institution is highlighted to tourism policy, recognizing environmental, social and cultural considerations.

142.3 Measuring the Ecological Embeddedness of Tourism Industrial Chains

The analytic hierarchy process is used to divide evaluation system into comprehensive evaluation, evaluation of project layer and evaluation of factors layer, and then the experts consultation method is used for universities and research institutions, government experts involved to mean the weight of each index based on the experts' index allocation by the low level of discrete method after three rounds of expert investigation. The unit of measurement is a specific tourism destination. In the context of complex social-ecological systems, the interplay among tourists, quality of ecosystem goods and services, and capital enable an integrated assessment of ecological, social and economic factors (Lacitignola et al. 2007). Marin et al. developed a numerical model to understand socio-ecological tourism systems, with ecological components (system's carrying capacity), social participation and association incorporated (Marin et al. 2012).

142.3.1 Data Collection

The data sources include the relevant destination development information, such as local economic, political, cultural and ecological material, regional development planning, special agricultural planning, infrastructure planning; and the operating conditions, such as the relevant index of the economic, social and ecological changes from tourism development and community participation. In addition, comprehensive use of observation, interview methods are used for understanding rural tourism development, specifically, process technology and ecological protection measures and the application of the original facilities, local characteristic and level of integration, and for investigating tourists satisfaction with the degree of ecological awareness, and residents' perception on tourism benefit.

142.3.2 Respondents Selected

A certain number of 7–15 representatives are selected to score each index, mainly consisting of stakeholders, with higher quality. Experts' representatives are familiar with the local tourism development; Operators selected include exotic operators and local operators; the representatives from the community residents are tourism participants; the government officials are from tourism department, environment department, agriculture, forestry and others involved. The training for representatives is required to formulate detailed measurement criterion, and clearly state the highest marks for 100, lowest is 0. Back-to-back scoring method is implemented to make evaluation objective and fair.

142.3.3 Data Processing

Assumed that the ecological embeddedment degree of tourism chains for U, measurement project layers for ecological degree V. U = {U1, U2, U3}, U1 for cognitive and cultural embeddedment degree, U1 = {V1 and V2 and V3}, measure the ecological contribution degree of economy, society and environment in tourism destinations; U2 for ecological structure embeddedment, U2 = {V4, V5, V6} to measure the maturity degree of the tourism industrial chain itself, and the potential of sustainable development; U3 for political embeddedment, U3 = {V7, V8, V9}, tourism's ecological coordination and degree of stakeholder cooperation.

Introduce weight or weight distribution set A, A = (a1, a2,…, a21), including ai > 0, and $\sum$ai = 1, (see Table 142.1), scores on indexes for Qj (j = 1, 2,…, n), n for the number of representatives, Qi = $\sum$Qj/n, (i = 1, 2, 3,……, 21, j = 1, 2,…, n); specific V value and U value are obtained from the above calculations.

$$\mathrm{V1} = \sum \mathrm{WiQi} / \sum \mathrm{Wi},\ (\mathrm{i} = 1, 2) \tag{142.1}$$

$$\mathrm{V2} = \sum \mathrm{WiQi} / \sum \mathrm{Wi},\ (\mathrm{i} = 3, 4) \tag{142.2}$$

V3, V4,…, V9 is done by that analogy.

Also,

$$\mathrm{U1} = \sum \mathrm{WiQi} / \sum \mathrm{Wi},\ (\mathrm{i} = 1, 2, \ldots, 5) \tag{142.3}$$

U2, U3,… is calculated in the same manner.

The degree of ecological measurement of tourism industrial chain

$$\mathrm{U} = \sum \mathrm{WiQi},\ (\mathrm{i} = 1, 2, \ldots, 21). \tag{142.4}$$

142.3.4 Data Analysis

With reference to the environmental protection industry standard The Ecological Environment Assessment Technical Specifications (for trial implementation) issued by the state environmental protection administration of the People's

Table 142.1 Measurement of the ecological embeddedness of tourism industrial chains

Comprehensive dimensions	Project layers	Factors index	Index weight
Cognitive and cultural embeddedness 0.35	Economic efficiency 0.12	The local GDP contribution	0.04
		The increased per capita income for local residents	0.05
		The contribution for economic development potential	0.04
	Social effectiveness 0.11	The improvement of social security, e.g. community culture sports facilities, medical treatment, and retirement security	0.04
		The democratic civilization (the decision-making power of local residents)	0.04
		The employment of the community residents	0.04
	Community benefit 0.12	The natural ecological effect (the protection of the natural ecology)	0.04
		The cultural ecological protection (original harmonious order in communities, nature and the traditions)	0.03
		The improvement of community environment (community health status, sewage, food safety, disease control and prevention)	0.04
Structural embeddedness 0.42	Localization characteristic 0.17	The degree of community participation (in investment, service and management, the proportion of the decision-making power and the degree of control)	0.06
		The degree of Local features reserve (product localization and style localization)	0.06
	Scale rationality 0.12	The level of tourist capacity (over-commitment or idle facilities)	0.11
		The satisfaction of tourist products (the diversified demands of the visitors)	0.06
	Resource utilization reasonableness 0.11	The degree of ecological technology use (resources reduce, reuse and recycling, new energy sources)	0.06
		The degree of local existing resources utilization	0.04
		Integration degree (involving he horizontal integration or vertical integration degree of tourism enterprises	0.03
Political embeddedness 0.23	Science of tourism planning 0.08	The consistency of the regional development planning with regional development planning	0.04
		The cohesion of tourism development planning	0.04
	Cooperation 0.09	The cooperation of stakeholders in policy-making and performance	0.04
		The external cooperation from investors, travel agencies and related organizations	0.05
	Policies and regulation 0.06	The maturity level of related policies and regulations	0.06

Republic of China (H J/T192-2006), each index represents the status of the ecological embeddedness and overall level is divided into five levels, namely A(75–100), B(55–75), C(35–55), D(20–35) and E(0–20), based on the ecological environment quality classification. Combined with each index score from the data processing, the level of ecological embeddedness is converted into the level of ecological oriented progress in specific tourism destinations. A destination with the ecological embeddedness level of E(0–20) give large negative impact on the ecological landscape. Operators' environmental consciousness with economic benefit is light. The tourism planning is formulated mainly from the angle of profit. The monitoring function lacks pertinence on measures and policies. However, when a certain degree of receipts is acquired from eco-tourism development, the amount of the revenue may cover the increasing funds for the protection and development of the tourist areas and the supplement of residents' total income, the destination represents a high level of ecological embededdness with the local ethnic culture coordinated.

142.4 Conclusion

The measurement of ecological embeddedness to tourism chain activities proposed a research method on cognitive, cultural, structural and political embeddedness dimensions. Its versatility makes an outlet for the longitudinal and horizontal comparison on the degree of ecological embeddedness. To further comparative research on tourism performance in different destinations, deficiency, problems find their expression in the measurement data processing; therefore specific problem-solving programs take effective performance accordingly. The study aims to strengthen the ecological awareness of stakeholders, and promote the comprehensive, coordinated development of the rural tourism destination, eventually improve the whole ecological level of tourism destinations.

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