Donglang Yang
Yanjun Qian *Editors*

# Proceedings of the 18th International Symposium on Advancement of Construction Management and Real Estate

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*Editor*
Donglang Yang
Yanjun Qian
School of Public Policy
and Administration & Institute
of Real Estate Research
Xi'an Jiaotong University
Xi'an, China

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# Contents

# Chapter 1
# A Study of Rural Livestock and Poultry Breeding Pollution Problems in China's Urbanization Process

**Dan Wu, Weiwen Zhang, and Yuzhe Wu**

**Abstract** In the process of rapid urbanization between 2001 and 2010, the livestock and poultry industry in China was characterized by the rigid growth in number and the large scale and intensive trend in breeding mode, thereby causing serious pollution of soil, water and air. The results in this paper show that the number of livestock and poultry manure nationwide was about 3.203 billion tons in 2010, 1.33 times that of the number of industrial solid waste and a 10.55 % increase than in 2001. Where spatial pattern is concerned, compared with the year 2001, the cultivated land load of manure (t/hm$^2$) and of nitrogen/phosphorus nutrient (kg/hm$^2$) were both increased almost in all areas except North China in 2010. Besides, it is noteworthy that the livestock and poultry pollution posed a big threat to local environment in some areas.

**Keywords** Urbanization • Livestock breeding • Manure • Cultivated land load

## 1.1 Introduction

The US economist Joseph E. Stiglitz, winner of the Nobel Prize in economics in 2001 has predicted that, there are two things that have the greatest effect on the global, that is, the high-tech industries in the United States and China's urbanization. Since reform and opening up, the urbanization rate in China rose from 17.92 % in 1978 to 51.97 % in 2012, an increase by one percent per year on average. Urbanization has been an important platform to promote China's sustainable development of society and economy.

Urbanization helps to expand domestic demand. With the development of urbanization, the income of urban and rural residents grows and people's demand

D. Wu • W. Zhang (✉) • Y. Wu
Department of Land Administration, Zhejiang University, Hangzhou 310029, China
e-mail: wudan1231130@163.com; wwzh@zju.edu.cn; wuyuzhe@zju.edu.cn

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for animal products increases, therefore the livestock and poultry breeding industry has faced with a rapid developing time. At present, China has the world's first production of meat and eggs and third production of dairy, according to China's Agriculture Ministry. The proportion of output value of livestock and poultry industry in agriculture was over 36 % in 2009, which was predicted to reach 48.6 % by 2015. With the process of urbanization, livestock and poultry industry tends to be more large-scale, intensive and specialized, thereby causing serious pollution of soil, water and air.

Rural environment improvement is an urgent must in the process of urbanization. Since livestock and poultry industry is the pillar industry of rural economy, the reduction of livestock pollution is apparently crucial to the improvement of urbanization quality. However, the previous research was mainly on qualitative discussion of rural sustainable development in the process of urbanization or on studies of manure management. This paper combines the animal waste problem with the urbanization process, focusing on the data analysis and spatial comparison of livestock pollution issue in the process of urbanization, which is discussed few in previous research.

Livestock breeding industry has entered a new phase of development since <The suggestions of promoting the livestock and poultry industry> was promulgated in 1999. And China's process of urbanization also entered the stage of accelerated development after 1998. Therefore, this paper selects the data between 2001 and 2010. Firstly, it analyzes the impact of rapid urbanization development on the livestock industry, then measures the environmental effects quantitatively and makes spatial comparison. Finally, the direction of further research is presented.

## 1.2 Data and Methodology

### *1.2.1 Data Sources*

Livestock and poultry data are from <China Animal Industry Yearbook> (2001, 2004, 2007 and 2010) and national economic indicators data are from <China Statistical Yearbook> (2001 and 2010). Table 1.1 presents number of livestock and poultry in 2001 and 2010, being mainly used in the fourth part. The rest data will be mentioned later.

### *1.2.2 Parameter Determination*

Determination of parameters references the study of Wang Fanghao et al. [1]. Table 1.2 presents the key parameters.

**Table 1.1** Number of livestock and poultry breeding in 2001 and 2010

| Species | Quantity in 2001 (10,000) | Quantity in 2010 (10,000) |
|---|---|---|
| Hogs | 54,936.8 | 66,686.43 |
| Draft cow | 12,824.2 | 10,626.43 |
| Beefs | 4,118.37 | 6,738.9 |
| Dairy cow | 566.2 | 1,420.07 |
| Horses | 826 | 677.06 |
| Donkeys and mules | 1,317.7 | 909.39 |
| Sheep and goats | 29,826.5 | 28,087.89 |
| Poultry | 808,834.8 | 1,100,577.95 |
| Rabbits | 28,992.49 | 46,452.48 |

**Table 1.2** Determination of key parameters

| Species | Feces discharge coefficient (t/a) | N content (%) | P content (%) |
|---|---|---|---|
| Hogs | 1.05 | 0.238 | 0.074 |
| Draft cow | 10.10 | 0.351 | 0.082 |
| Beefs | 7.70 | 0.351 | 0.082 |
| Dairy cow | 19.40 | 0.351 | 0.082 |
| Horses | 5.90 | 0.378 | 0.077 |
| Donkeys and mules | 5.00 | 0.378 | 0.077 |
| Sheep and goats | 0.87 | 1.014 | 0.216 |
| Poultry | 0.03 | 0.896 | 0.372 |
| Rabbits | 0.01 | 0.874 | 0.297 |

### *1.2.3 Estimation Method*

The amount of livestock and poultry excrements per year can be written as:

$$Q = N * \rho \tag{1.1}$$

Here, Q is defined as the amount of livestock and poultry excrements per year, N the amount of livestock and poultry and ρ the feces discharge coefficient.

$$A = Q * \alpha \tag{1.2}$$

Here, A is defined as the amount of N or P nutrient contained in manure per year, α represents the N/P content and Q the same as above shown.

$$q = Q/M \tag{1.3}$$

Here, q is defined as the amount of livestock and poultry excrements per area of cultivated land each year, M the year-end cultivated land area and Q the same as above shown.

$$a = q * \alpha \tag{1.4}$$

Here, a is defined as N or P nutrient contained in manure per area of cultivated land each year, q and α are the same as above shown.

## 1.3 The Impact of Urbanization on Livestock Industry

### *1.3.1 Rigid Growth in Breeding Number*

Industrialization and urbanization make the rural residents' consumption of food continue to decrease and of animal products increase quickly. At the same time, there is a large increase in urban residents' demand for high quality animal products. Since there will be an annual seven million-population increase and 12 million rural people moving to towns each year in the future, with the sustained revenue growth and further implementation of such strategies as boosting the domestic demand, the consumption for animal product will continue to increase.

After the year 2000, the urbanization rate increased by 12 % in 10 years, meanwhile, the animal husbandry-to-agriculture ratio increased from 30 to 38 % (see Table 1.3). Livestock and poultry industry has become the pillar industry of rural economy. However, there is still a large gap compared with western countries. As early as in 1983, the proportion of animal husbandry has reached 50.1 %. Given all that, the livestock industry in China still has a long way to go.

Besides, the number of main livestock breeds were all substantial-increase in 10 years (see Table 1.4).

**Table 1.3** Key indicators of national economy

| Year | Urbanization rate (%) | GDP per capita (CNY) | Household consumption level (CNY) | | | Animal husbandry-to-agriculture ratio (%) |
|---|---|---|---|---|---|---|
| | | | Nationwide | Rural area | Urban area | |
| 2001 | 37.66 | 8,622 | 3,887 | 1,969 | 7,161 | 30 |
| 2010 | 49.68 | 29,992 | 9,968 | 4,455 | 15,907 | 38 |
| Annual growth rate | 1.2 | 24.79 | 15.64 | 12.63 | 12.21 | 0.8 |

**Table 1.4** Changes in number of livestock and poultry

| Year | Hogs (10,000) | Cow (10,000) | Sheep (10,000) | Poultry (10,000) | Rabbits (10,000) |
|---|---|---|---|---|---|
| 2001 | 54,936.68 | 4,118.37 | 21,722.45 | 808,834.8 | 28,992.49 |
| 2010 | 66,686.43 | 4,716.82 | 27,220.15 | 1,100,577.95 | 46,452.48 |
| Growth rate in 10 years | 21.39 | 14.53 | 25.31 | 36.07 | 60.22 |

**Table 1.5** Changes of deferent categories of hog breeding

| | Scatter breeding (1–49) | | Moderate scale breeding (50–499) | | Large-scale breeding (more than 500) | |
|---|---|---|---|---|---|---|
| Year | Operations | Animals (10,000) | Operations | Animals (10,000) | Operations | Animals (10,000) |
| 2001 | – | – | 897,227 | 9,142.4 | 26,517 | 4,980.53 |
| 2004 | – | – | 1,385,604 | 14,884.38 | 51,429 | 8,509.71 |
| 2007 | 80,104,750 | 41,418.37 | 2,119,659 | 21,420.03 | 124,641 | 17,518.96 |
| 2010 | 59,086,923 | 33,149.5 | 2,428,051 | 27,988.1 | 220,366 | 32,262.3 |
| Growth rate in 10 years | – | – | 170.62 | 206.14 | 731.04 | 547.77 |

### *1.3.2 Large-Scale and Intensive Breeding Trend*

Between 2001 and 2010, the number of scatter breeding was decreasing while of moderate scale and large-scale breeding were both increasing, especially the large-scale breeding. Take the hog breeding for example, according to <Livestock and poultry excrement disposal technical specification> (2006, China's Ministry of Agriculture), the breeding scale can be divided into the scatter breeding, the moderate scale breeding and the large-scale breeding. As shown in Table 1.5, scatter breeding was decreasing while scale breeding was increasing from 2001 to 2010.

Intensive breeding is a high-density breeding way that more resources are put into smaller venues, adoption of new technologies and taking the careful management. Since the livestock industry has a relatively low comparative benefit, rural labor force transfers to the second and third industry continuously. Meanwhile, urban construction has occupied large amount of rural land, including the land used for the livestock breeding, all of these have caused serious environmental problems.

Intensive breeding patterns result in the increasingly obvious trend of farmland far from livestock operations. In China, there are more than 80 % of the intensive breeding operations not having enough quantity of cultivated land around to digest manure [2]. According to <Annual Report on Environment Development

of China (2012)>, there was an increase pressure in agricultural environment in 2012, intensive livestock and poultry breeding pollution has become the main agricultural sources of pollution.

## 1.4 Environmental Impact Analysis of Manure

The process of rapid urbanization has caused a series of environmental problems. Manure is the main pollution source of livestock industry. On the one hand, as the main carrier of manure, cultivated land continues to reduce with the rapid urbanization. It had decreased by 88 million acres between 2001 and 2010 in China. Research shows that there is a reduction of 6.15 million acres of cultivated land whenever the urbanization level increases by 1 % [3]. On the other hand, although the manure provides necessary nutrients for crop growth, increases soil water retention and transparent performance, in addition, combined application of organic and inorganic fertilizer always brings a higher crop productivity than of single fertilizer [4–6], the excessive manure without the harmless disposal may cause harm to the soil health, even leads to ecological risks [7, 8]. Besides, the trend of farmland far from livestock operations caused by intensive development of livestock industry increases the cultivated land load.

The immediate release of manure poses a direct threat to river basin. Meanwhile, the enrichment of manure nutrient poses a potential threat to surface water because the intensive breeding reduces the soil infiltration rate and porosity [9] and increases surface runoff. According to <China's first pollution census bulletin (2010)>, water pollution in China was mainly from agriculture rather than industry. Among the agriculture pollution, livestock was the most serious one. In addition, air pollution causes concern gradually. According to the estimates from UNFAO, emissions of greenhouse gases from livestock breeding account for 18 % of global emissions and 49.2 % of the total COD.

This part focuses on manure quantity estimates and environmental effect of manure.

### *1.4.1 Estimates of Total Feces Excretion*

Calculation results show that the amount of animal manure in China was about 2.898 billion tons in 2001, 3.26 times of the industrial solid waste. There were 12.4775 million tons of total N content and 3.3133 million tons of total P content in the feces. While in 2010, the amount of manure reached 3.203 billion tons, a 10.55 % increase over 2001 and 1.33 times of the industrial solid waste in 2010. Of which contains 13.743 million tons of total N content and 3.7683 million tons of total P content.

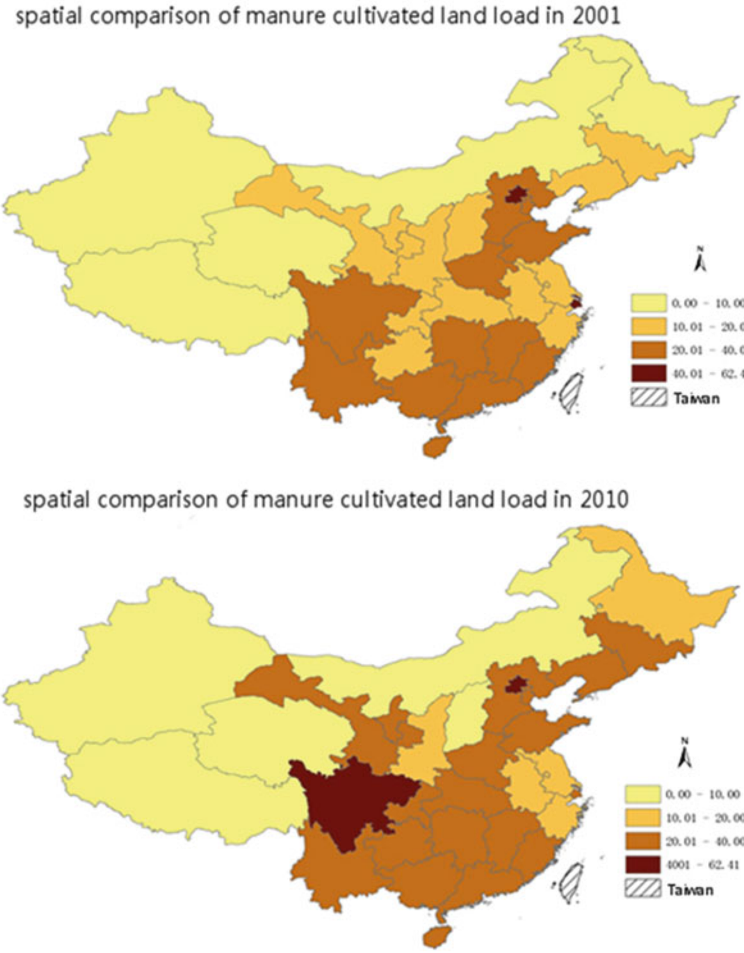


**Fig. 1.1** Manure cultivated land load in 2001 and 2010

### *1.4.2 Spatial Comparison of Manure Cultivated Land Load*

Manure cultivated land load refers to manure quantity digested by per area of cultivated land, here measured by tons per hectare. The heaviest load region in 2001 was Beijing, up to 62.41 t/hm$^2$ and 55 times of Tibet, the lightest load area. The heaviest five regions were Beijing, Shanghai, Guangdong, Henan and Hunan. The national average value was 21.26 t/hm$^2$, 14 provinces above it. While in 2010, the heaviest load region was still Beijing, but dropped to 53.9 t/hm$^2$, 31 times of the lightest area Tibet. The national average value was 23.13 t/hm$^2$, 17 provinces above it (see Fig. 1.1).

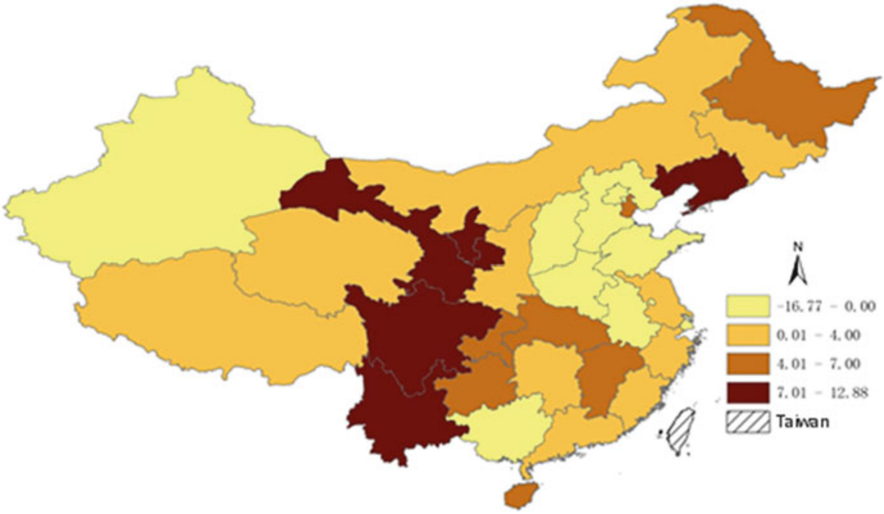


**Fig. 1.2** Load increment in 2010 compared with 2001

Figure 1.2 shows the manure cultivated land load increment in 2010 compared with that in 2001. The largest increment region was Liaoning province, up to 12.88 t/hm$^2$. The top five increment regions were Liaoning, Ningxia, Gansu, Sichuan and Yunnan. The national average value was 1.87 t/hm$^2$. It should be noted that, there were 9 provinces presenting negative load increments, mainly in North China, seen from the figure. And the largest negative load increment happened in Shanghai, with 16.77 t/hm$^2$, followed by Beijing 8.51 t/hm$^2$.

### *1.4.3 Spatial Comparison of Manure Nutrients Cultivated Land Load*

The manure nutrients cultivated land load reflects the soil pollution risk caused by manure [1], here measured by kg per hectare. As shown in Fig. 1.3, in 2001, as to the N nutrient cultivated land load, the heaviest load region, Beijing, reached 326 kg/hm$^2$, 65 times of Tibet, the lightest load region. And the heaviest five provinces were Beijing, Shanghai, Guangdong, Shandong and Henan. The national average value reached 92.58 kg/hm$^2$, 13 provinces above it. And in 2010, the heaviest load region was still Beijing, but dropped to 263 kg/hm$^2$, 38 times as the lightest load region Tibet. The national average value increased to 98.19 kg/hm$^2$ in 2010, 17 provinces above it. As to the P nutrient cultivated land load, the heaviest load region was still Beijing in 2001, up to 106 kg/hm$^2$, followed by Shanghai, Guangdong, Shandong and Henan. The national average value was 26.71 kg/hm$^2$. And the heaviest load province was still Beijing in 2010, but dropped to 86 kg/hm$^2$,

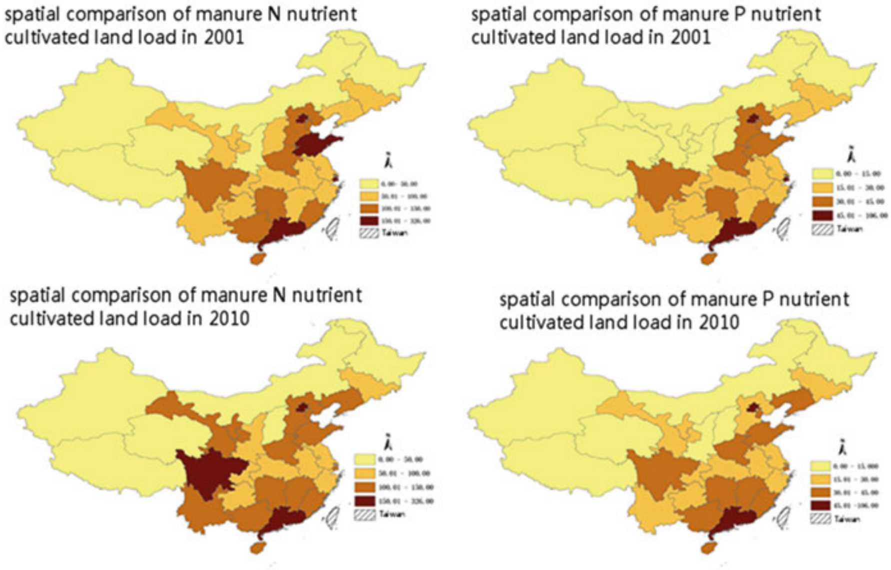


**Fig. 1.3** Manure nutrients (N and P) cultivated land load in 2001 and 2010

with a reduction of about 19 %. There were 13 provinces more than the national average value 28.77 kg/hm$^2$.

## 1.5 Conclusions and Discussion

In the process of rapid urbanization between 2001 and 2010, the livestock breeding in our country maintained rigid growth, thus resulting in large amount of manure and the increasing pressure to the environment. Calculation results show that there was about 3.203 billion tons of manure in China in 2010, a 10.55 % increase over 2001 and 1.33 times the industrial solid waste in 2010. And there were 13.743 million tons of total N content and 3.7683 million tons of P content in manure. In addition, both the trend of farmland far from livestock operations caused by the large-scale and intensive development of livestock industry, and the continuous decrease of cultivated land area caused by inevitable occupation of urban construction activities, are key factors of increasing cultivated land load of manure. Results in this paper show that, manure cultivated land load increased from 21.26 t/hm$^2$ in 2001 to 23.13 t/hm$^2$ in 2010. In addition, N and P nutrient load also increased during these 10 years. As for the spatial distribution, the heaviest five manure load provinces were Beijing, Shanghai, Guangdong, Henan and Hunan, while in 2010 were Beijing, Sichuan, Hunan, Guangdong and Hainan. It should be noted that, during these 10 years, there was an increase in cultivated land load of manure in almost all regions except North China. Besides, cultivated land load of both N and P nutrient presents similar characteristics.

Along with the advancement of urbanization, the livestock industry in China still has much room for further development. Meanwhile, the trend of large scale and intensification will be more obvious. In order to avoid the trend that environmental resources become the bottleneck of urbanization, full attention to the problem of livestock and poultry pollution should be paid, which is the main purpose of this paper. However, as to the underlying reasons of pollution and space transfer laws, as well as how to adjust urbanization strategies and transform urbanization patterns to meet the manure reduction and harmlessness targets, especially in areas with relatively high levels of manure pollution, needs further research.

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# Chapter 2
# Competition Intensity: An Institutional Perspective on Sustainable Construction

**Kunhui Ye and Weina Zhu**

**Abstract** Sustainable construction has been gaining much academic attention in recent years. Achieving sustainability through market operation presents an institutional perspective on sustainable construction, and it has been gradually accepted as a key component of sustainable construction. While increasing attention has been paid to the subject of sustainable construction, the nexus between the intensity of competition, a useful proxy for reflecting market operation, and the sustainability performance of construction industry, has not been explored explicitly. Using the method of case study, this study addresses a novel notion of sustainable construction from the perspective of institution. A number of empirical cases were collected from China's construction industry to demonstrate the impacts of business competition on the sustainability of construction project. The research findings indicate those aspects that construction business competition can determine the potential of sustainable construction. It is implied that industrial policies and measures be formulated to oversee the operation of construction market to ascertain sustainable construction.

**Keywords** Industrial sustainability • Key performance indicators • Chinese construction industry • Competitive tendering

K. Ye (✉)
Advanced Construction Management Research Center, Faculty of Construction Management and Real Estate, Chongqing University, 83# Shabei Street, Shapingba District, Chongqing, China
e-mail: Kunhui.ye@Gmail.com

W. Zhu
Faculty of Construction Management and Real Estate, Chongqing University, 174# Shazheng Street, Shapingba District, Chongqing, China
e-mail: 502601180@qq.com

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## 2.1 Introduction

Construction refers to a process or mechanism of delivering human settlements and creating infrastructure that supports socio-economic development [1]. A mainstream of thoughts in the area of construction management and economics claims that construction sector is a key driver of sustainable development. Nevertheless, this industry can also generate serious negative effects on environment and society such as air pollution, natural resources depletion, and construction materials waste. The significance of construction sector to sustainability under the heading of “sustainable construction” has thus drawn much academic attention. As a result of long evolution, the term “sustainable construction” has developed from response to the limited resources, to advanced construction technologies and to current soft issues [2].

A key soft issue of sustainable construction is institutional arrangement [3]. Researchers have called for relying on market powers to attain sustainability by virtue of innovating production technology methods (e.g., low carbon techniques) and improving market efficiency in product/service exchange. Stigson [4] opined that achieving sustainability through the market is an important business agenda. Majdalani et al. [5] found that market participants including contractors, architects/engineers and owners/developers play important role in sustainable development. The World Business Council of Sustainable Development released a report of “Sustainability through the Market” in 2001 [6]. The thrust of this report is the driver of an open, transparent market to achieve industrial sustainability. The rationale behind this strand of view is that sustainable construction means producing and managing a healthy built environment should base on an orderly operating construction market.

Although previous studies have called for relying on market powers to attain sustainability, few efforts have been put to investigate the links between business competition and sustainable construction. Therefore, the reason why business competition can determine sustainable construction has not been offered explicitly. The objective of this study is therefore to identify the relationship of market competition and the sustainability performance of the construction industry. Research questions considered from the research objective are whether competition intensity is a key to the sustainable construction, and what industrial policies and measures can be adopted to oversee the operation of construction market to ascertain sustainable construction.

## 2.2 Literature Review

### *2.2.1 Sustainable Construction*

The term “sustainable construction” has kept ongoing evolution in the past decades. In the first international conference on sustainable construction in 1994, Professor

Charles, from the University of Florida, probably for the first time gave a definition to sustainable construction. In his view, sustainable construction refers to effective measures of resources utilization to create a healthy built environment based on the principles of ecology. Similarly, Sage (1998) used the concept of sustainable construction to describe the basic objectives of sustainable development throughout the construction process. Chong et al. (2009) argued that sustainable construction is committed to strengthening the sustainability of building design, construction, production and operation through the adoption of appropriate technology and knowledge. Chen [7] pointed out that sustainable construction is to handle the relationships between the present and the future, between human and nature, and between the economic development and environmental protection. Meanwhile, Chen [7] placed the sustainable construction on project lifecycle, and pointed out that all project construction stakeholders can be the main bodies of sustainable construction. Furthermore, the study by Ren et al. [8] revealed that sustainable construction is to strengthen the control of construction activities, maximize resource conservation through the process of construction, protect the environment and reduce pollution, providing people with the health, comfortable and efficient space for use.

### *2.2.2 Construction Competition*

Construction markets are price competitive with markups that vary with the construction cycle [9]. Construction business competition mainly refers to project work bidding activities [10]. In practice, the clients organize a price competition between contractors to construct a building and the contractor who submits the most competitive price wins the right to construct the building. What contractors initially need is to design a competitive tendering price to ascertain that they can outperform their competitors. In accordance with the elementary market law, if considerable suppliers compete for serving a small number of demanders, the price of the service will drop, and vice versa. Competition is an effective way to lower construction cost, encourage innovation, and safeguard the interests of clients [11].

The competitive bidding process for awarding construction contracts is close to pure competition [12]. Among various bidding procedures for project contracting, construction competition serves to determine quality project undertaker. Nevertheless, tougher competition has become a key feature of the construction market [9]. The stiffer competition has driven the bid price down and makes it harder for contractors to undertake a profitable business, shaking the possibility of clients in receiving value for money through tendering process [13, 14]. Currently, the construction market is blamed for its cut-throat competition, posing challenges onto sustainability of the construction industry.

### *2.2.3 The Role of Construction Competition in Sustainable Construction*

Competitive tendering in construction has been demonstrated effective in determining the contractors most suitable for the given projects [15, 16]. Construction firms specialize in particular activities, according to location, the size of projects and the type of work undertaken [14], and they are preferred to build organizational competitiveness through general construction work or to become experts in one or two technical specialties [17]. These illustrate that the market furnished enterprises with a platform to pursue their own long-term sustainable development and improve their comprehensive capacities by bidding competition, which is undoubtedly beneficial to the sustainable development of the industry. Therefore, a well-developed construction market facilitates the fulfillment of construction industry to sustainable socio-economic development.

Nevertheless, competitive tendering in the construction industry forces construction companies to only focus on lowering costs, and divert their attention away from the environment and society [18]. Therefore, fierce competitions have caused all sorts of problems frequently throughout the life cycle of the project, affecting the sustainable performance of the project. Lowest price can often lead to the happening of claims, delay of project schedule, and decrease in project quality and project cost [12]. The study by Liu and Hu (2007) discloses that bribery, wastes of construction resources, and human resources are attributed to the unhealthy project competition.

## 2.3 Research Methods

In order to elaborate the relationships between the market competition and sustainable construction more clearly, we have conducted progressive analysis. Firstly, an extensive literature review is conducted to address the terms of construction business competition and sustainable construction. Then case study is to identify that the market operation can influence the sustainability performance of the industry. Finally, content analysis is adopted to explain further and comprehensively the relationship construction competition and sustainability in construction.

### *2.3.1 Cases*

The impact of competition intensity on sustainability performance of construction industry is considered by using 25 projects collected from China's construction sector. These projects are published officially in main newspapers in China concerning the competition status and the current status of project construction.

The 25 projects, respectively with the unsustainable performances, are made up of 15 projects reported on the newspaper, five projects reviewed by experts, three projects investigated by the governmental work reports, and two projects with social commentary. Details of projects collected are described in Table 2.1.

## 2.4 Findings and Discussions

### *2.4.1 Impact of Market Competition on Sustainable Construction*

Judging from the above cases and the tables, it comes to conclusions that due to the designated constructors in the bidding market without competition or the collusion bidding, bid rigging and illegal subcontracting with fierce competition in the market, there are 14 aspects of resulting unsustainable performance in total, including project quality, fatal accidents, safety, the environment, the investment cost, project payment arrears, staff training, technology, social effects, social equity, market order, administrative intervention, corruption and economic losses. In other words, sustainable performance in construction at least manifest the 14 respects above and the 14 aspects have already covered the triple bottom line (economy, society and environment) of sustainable construction, indicating the cases are more comprehensive in this research.

### *2.4.2 Principal Indicators of Competition-Based Sustainable Construction*

According to the Table 2.2, these unsustainable performances in turn mainly concentrate on, social effects, market order, the investment costs, safety and quality etc. The first five aspects attributable to social dimension demonstrate that the social sustainability within the triple bottom line (TBL) of sustainable construction is more severe than the other two of economy and environment. Just as Vanclay [19] highlighted that social indicators are unlike economic and environmental indicators, which are easy to be identified, selected and measured. The undefined socio-related factors, their subjectivity, as well as the different views and priorities of stakeholders make it difficult to identify what improvements are required [20, 21].

**Table 2.1** Cases of project competition

| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| Projects | A1-1 | Sichua Yongding bridge reservoir bidding | 2009 | Sichuan | Legal Daily | OT | CEM |
| | A1-2 | Jingzhou road brush black engineering bidding | 2008 | Hubei | Xinhua Net | OT | Low bid |
| | A1-3 | Xiamen 8 school project | 2004 | Fujian | Legal Daily | OT | Low bid |
| | | Bid-rigging | | | | | |
| | A1-4 | Hangzhou metro line 1 | 2008 | Zhejiang | Sohu Net | OT | Low bid |
| | | Xianghu satiation project | | | | | |
| | A1-5 | Yantai dangerous building of East bus station | 2009 | Shandong | (09/11) Focus Interview | OT | – |
| | A1-6 | Zhejiang province First case of construction engineering collusion | 2002 | Zhejiang | Xinhua Net | OT | – |
| | A1-7 | Ryan mega collusion case | 2007 | Zhejiang | Wenzhou Net | OT | – |
| | A1-9 | The first case of The Municipal Engineering collusion | 2005 | Zhejiang | Xinlang Net | OT | Low bid |
| | A1-10 | Dalian metro collapse accident | 2010 | Liaoning | Xinlang Net | – | – |
| | A1-11 | 300 million government projects and social welfare project corruption | 2005 | Jiangsu | Beijing Bidding Information platform | OT | – |
| | A1-14 | Shanghai “6.27” Lotus Riverside accident | 2010 | Shanghai | People’s Daily Online | – | Low bid |
| | A1-15 | Theater stage mechanical engineering bidding in a city of Sunan | 2010 | Jiangsu | Jiangsu Legal News | OT | – |
| | A1-18 | Office building project of Wenzhou branch of The bank of China | 2003 | Zhejiang | People’s Daily Online | – | Low bid |
| | A1-22 | Kunming new airport the supporting bridge approach collapse accident | 2010 | Yunnan | Xinhua News Agency | – | – |
| | A1-24 | Hunan Zhuzhou viaduct collapse accident | 2009 | Hunan | CCTV | – | – |
| Expert review | A1-8 | Pingxiang 200 million yuan collusion bidding | 2010 | Jiangxi | National Business Daily | – | – |
| | A1-12 | Low cost engineering bidding lead to engineering accident ratio greatly increased | 2010 | – | Members of the Chinese National Trade Promotion | – | Low bid |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | A1-13 | Zhu Shuying lawyer answers reporters on construction project bidding below the cost price | 2010 | – | Construction Times | – | Low bid |
| | A1-17 | Project bidding rate to 95 %, the frequency of accidents still worrying | 2009 | – | China Association of Bidding | – | – |
| | A1-23 | XX building is market hot in 2009 and experts analyze cutting corners is root cause | 2010 | – | Legal Evening News | – | – |
| The Government work report | A1-19 | Tracking audit results of Beijing-Shanghai high-speed railway construction project in 2010 | 2011 | China | The Chinese Government Network | – | – |
| | A1-20 | Tracking audit results of the Second West–East Gas Pipeline Project's eastern section in 2010 | 2011 | China | The Chinese Government Network | – | – |
| | A1-21 | No. 2 of 2007 (20): 34 high-grade highway project construction management and investment benefits audit results | 2007 | China | China's Audit Office | – | – |
| Social commentary | A1-16 | Low price bidding compress the duration, "3 without" enterprises to enter; Construction lack regulation and who did disturb the desulfurization market? | 2007 | – | China Environment News | – | Low bid |
| | A1-25 | Xinjiang Dushanzi serious safety accidents of crude oil storage tank under construction | 2006 | Xinjiang | China Chemical Industry News | – | – |

Abbreviations: *A* classification, *B* number, *C* case, *D* time, *E* province, *F* source of information, *G* tender, *H* scoring method, *OT* open tender, *CEM* comprehensive evaluation method

**Table 2.2** Effects of competition intensity on sustainability

| | | | Unsustainable performance | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W |
| Projects | A1-1 | CB | – | – | – | – | √ | – | | – | √ | – | √ | – | √ | √ |
| | A1-2 | CB | – | – | – | – | √ | – | | – | √ | – | √ | √ | √ | √ |
| | A1-3 | BR | – | – | – | – | – | – | | – | √ | – | √ | – | – | – |
| | A1-4 | BR | √ | √ | √ | √ | √ | – | √ | √ | √ | – | √ | – | – | – |
| | A1-5 | CB | √ | – | √ | – | √ | – | | – | √ | – | √ | √ | √ | – |
| | A1-6 | CB | – | – | – | – | | – | | – | √ | √ | √ | √ | √ | – |
| | A1-7 | BR | – | – | – | – | √ | – | | – | √ | √ | √ | – | – | √ |
| | A1-9 | CB | √ | – | – | – | √ | – | | – | √ | √ | √ | – | – | – |
| | A1-10 | – | √ | – | √ | – | √ | √ | √ | – | √ | – | – | – | – | √ |
| | A1-11 | CB | – | – | – | – | – | – | | – | √ | √ | √ | – | √ | √ |
| | A1-14 | IS | √ | √ | √ | – | – | – | | – | √ | – | √ | – | – | – |
| | A1-15 | – | – | – | √ | – | √ | – | | – | √ | √ | √ | – | – | – |
| | A1-18 | CB | √ | – | √ | √ | √ | – | | – | √ | √ | √ | √ | √ | √ |
| | A1-22 | IS | √ | √ | √ | √ | √ | – | √ | √ | √ | – | – | – | – | √ |
| | A1-24 | BR | √ | √ | √ | √ | √ | – | – | √ | √ | √ | √ | √ | – | √ |
| Expert comments | A1-8 | CB | – | – | – | – | √ | – | – | – | √ | √ | √ | √ | √ | – |
| | A1-12 | – | – | √ | √ | – | √ | – | – | – | √ | – | √ | – | – | – |
| | A1-13 | – | √ | √ | √ | √ | √ | – | – | – | √ | – | √ | – | √ | – |
| | A1-17 | – | √ | √ | √ | √ | √ | – | – | – | √ | – | √ | – | √ | √ |
| | A1-23 | – | √ | √ | √ | √ | √ | – | – | √ | – | – | – | – | – | – |
| The Government work report | A1-19 | DC | √ | √ | √ | √ | √ | – | √ | √ | √ | √ | √ | √ | √ | √ |
| | A1-20 | DC | √ | – | √ | √ | √ | – | – | – | √ | √ | √ | √ | √ | √ |
| | A1-21 | – | √ | √ | √ | √ | √ | – | – | √ | √ | √ | √ | √ | √ | √ |
| Social commentary | A1-16 | – | √ | – | √ | √ | – | – | – | – | √ | – | √ | – | – | – |
| | A1-25 | – | √ | √ | √ | √ | √ | – | √ | √ | √ | √ | √ | – | – | √ |
| In total | – | – | 16 | 11 | 17 | 12 | 20 | 1 | 5 | 6 | 24 | 12 | 22 | 9 | 12 | 13 |

Abbreviations: *A* classification, *B* number, *I* competition type, *J* quality, *K* fatal accident, *L* safety, *M* environment, *N* investment cost, *O* project payment arrears, *P* staff training, *Q* technology, *R* social effects, *S* social equity, *T* market order, *U* administrative intervention, *V* corruption, *W* economic losses, *CB* collusion bidding, *CR* bid rigging, *IS* Illegal subcontracting, *DC* designated contractors

### *2.4.3 Competition – Based Policies for Sustainable Construction*

In order to pursue the sustainable development of the construction industry, it is not to be ignored that some industrial policies and measures be supposed to formulated to oversee the operation of construction market to ascertain sustainable construction. For example, some countries, such as UK and Australia have codes on good tendering practice, which includes identifying that number of competing contractors in any competition should not exceed six. Likewise, our governments also need in the position of construction market to promote the sustainable development of the construction industry.

## 2.5 Conclusions

By virtue of the impact of the construction market competition intensity, each project's sustainable performance varies and all of these projects' performance adds up to the sustainable performance of the entire construction industry. As the cases above demonstrate, when there is no competitive in construction market, the resources of the construction industry doesn't achieve optimal allocation, which doesn't reflect the concept of sustainable construction; when stiff competition in the market, the development of sustainable construction will be hindered due to illegal means of market competition; thereby it can be indicated that there is a moderate competition status which can determine sustainable construction performance. In other words, there exists a certain relationship between the competitive intensity of the market and the sustainable construction industry. When the market reaches the state of moderate competition, sustainable construction can be in healthy and orderly development. But whether the relationship between competition intensity and sustainable performance in construction can be determined by the function equations will be our research to go further.

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# Chapter 3
# Analysis of Urbanization's Impaction on Industrial Structure

**Haizi Wang, Enze Cui, and Dong Zheng**

**Abstract** According to the relevant data of China's urbanization and industrial structure from 1978 to 2011, this paper constructs econometric models to analyze the influence degree of industrial structure, urbanization. And the models proves that the urbanization promotes the transformation of industrial structure and employment proportion of the non-agricultural industry practitioners has changed from 29.5 % in 1978 to 65.2 % in 2011, this has affected the employment proportion of each industry practitioners. Based on the model of time series, this paper predicts the rate of urbanization from 2013 to 2020 and speculates the future trend of the development of industrial structure according to the urbanization rate predicted.

**Keywords** Urbanization • Industrial structure • Time series • Proportion of non-agricultural industry practitioners

## 3.1 Introduction

Urbanization is the population transformation from farmer to citizen, the industrial transformation from agriculture to non-agricultural industry, the industrialization level and people's living level from low to high transition. The urbanization plays a decisive role in creating jobs, improving industrial structure and promoting economic growth.

By a simple dual economic model under the division system between urban and rural areas, Cai Wu [1] analysis the non-agricultural employment and the relationship between urbanization and urban and rural residents income inequality.

H. Wang • E. Cui (✉)
Management Engineering School, Shandong Jianzhu University, Jinan, China
e-mail: cuienze111@163.com

D. Zheng
Business School, Shandong Jianzhu University, Jinan, China

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Concluded that the degree of urbanization lags behind the non-agricultural employment level.

Wang Hong & Cui Kaichang [6] studied the relationship between employment growth and the urbanization level [2–6] in China, and the results show that the equilibrium relationship exists between the employment growth and the urbanization level.

## 3.2 The Theoretical Model

To specific analysis of China's urbanization process, the model of the connection between China's urbanization rate and non-agricultural employment rate is set up as follows:

According to the data from 1978 to 2008, as shown in Fig. 3.1 and Table 3.1, non-agricultural employment rate has been higher than the urbanization rate, and maintain more than 20 % of the deviation, the reason is that a large number of employment work and live in rural areas.

As shown in Table 3.1 and Fig. 3.1, the urbanization rate keeps rising from 1978 to 2011, at the same time, the rate of non-agricultural employment is also on the rise.

Based on the analysis of charts, the urbanization rate may have a significant impact of non-agricultural employment rate, so the analysis of the relationship between the urbanization rate and rate of non-agricultural employment would be a great significance.

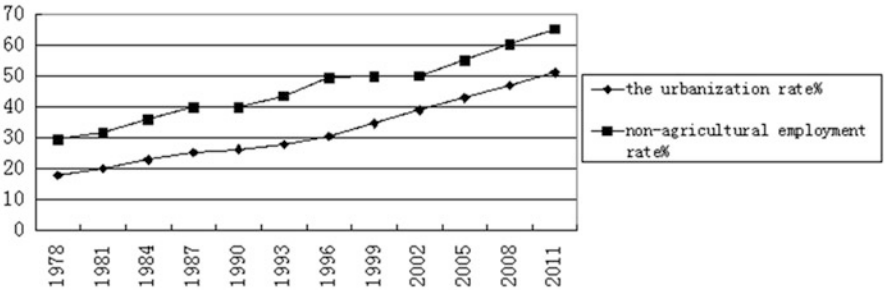


**Fig. 3.1** The relationship between urbanization rate and non-agricultural employment rate

**Table 3.1** The urbanization rate and non-agricultural employment rate from 1978 to 2011

| Time | 1978 | 1981 | 1984 | 1987 | 1990 | 1993 | 1996 | 1999 | 2002 | 2005 | 2008 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The urbanization rate % | 17.92 | 20.16 | 23.01 | 25.32 | 26.41 | 27.99 | 30.48 | 34.78 | 39.09 | 42.99 | 46.99 | 51.27 |
| Non-agricultural employment rate % | 29.5 | 31.9 | 36 | 40 | 39.9 | 43.6 | 49.5 | 49.9 | 50 | 55.2 | 60.4 | 65.2 |

Data source: The Chinese almanac. (1978–2012)

Note: The urbanization rate is calculated by the percentage of the population in cities and towns

**Table 3.2** The regression curve evaluation between the urbanization rate and non-agricultural employment rate

| Model summary and parameter estimates | | | | | |
|---|---|---|---|---|---|
| Dependent variable: the non-agricultural employment rate | | | | | |
| | Model summary | | | Parameter estimates | |
| Equation | R square | F | Sig. | Constant | b1 |
| Linear | 0.960 | 241.141 | 0.000 | 13.571 | 1.005 |
| Logarithmic | 0.969 | 312.448 | 0.000 | −64.906 | 32.405 |
| Growth | 0.927 | 126.703 | 0.000 | 3.091 | 0.022 |
| Exponential | 0.927 | 126.703 | 0.000 | 22.008 | 0.022 |
| Logistic | 0.927 | 126.703 | 0.000 | 0.045 | 0.978 |

The independent variable is the urbanization rate

X = the urbanization rate, Y1 = the non-agricultural employment rate, each variable sample interval for the relevant data from 1978 to 2011. Making the regression curve evaluation:

Synthetically in Table 3.2, Logarithmic model correlation of the analysis between the urbanization rate and the non-agricultural employment rate is the largest, so we use Logarithmic model to analyze data. The model is set up as follows:

$$lnY_1 = a_1 + b_1\, lnX \tag{3.1}$$

$X$ is the independent variable, $Y_1$ is the dependent variable of the model, $a_1$ and $b_1$ are model coefficient, sample interval for all variables related is economic datas from 1978 to 2011.

Using the sample data into (3.1), model econometric analysis results are as follows:

$$lnY_1 = 1.332 + 0.722 lnX \tag{3.2}$$

$$R_1 = 0.984 \quad F_1 = 305.214 \quad Sig._1 = 0.000$$

According to (3.2), the model correlation coefficient $R_1 = 0.984$, Correlation coefficient is close to 1, it shows that there is a strong positive linear correlation relationship between the urbanization rate and the non-agricultural employment rate. Non-agricultural employment rate is related to the urbanization rate with elasticity coefficient (ΔY/Y)/(ΔX/X) = 0.722, this suggests that as the growth of the urbanization rate, the non-agricultural employment rate raises, and the growth of the non-agricultural employment rate is less than the urbanization rate. In other words, the urbanization rate increases by 1 %, non-agricultural employment rate increases by 0.722 %. F test of significance level $Sig._1 = 0.000 < a = 0.05$, The model meets the F test.

## 3.3 The Prediction

According to the data from 2001 to 2011, the urbanization rate present proves a rising trend, the urbanization rate can be seen as a linear process of growth of rising. Therefore, we can set a date such as 1, 2, 3, . . .. . . 10, 11, to represent the time of the

**Table 3.3** The China's urbanization rate from 2001 to 2012

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| The urbanization rate % | 37.66 | 39.09 | 40.53 | 41.76 | 42.99 | 44.34 | 45.89 | 46.99 | 48.34 | 49.95 | 51.24 | 52.57 |

**Table 3.4** The regression curve between urbanization rate and the year

| Model summary and parameter estimates | | | | | |
|---|---|---|---|---|---|
| Dependent variable: the urbanization rate | | | | | |
| | Model summary | | | Parameter estimates | |
| Equation | R square | F | Sig. | Constant | b1 |
| Linear | 1.000 | 22897.922 | 0.000 | 36.345 | 1.349 |
| Logarithmic | 0.893 | 83.394 | 0.000 | 34.984 | 6.081 |
| Power | 0.918 | 112.651 | 0.000 | 35.679 | 0.138 |
| Growth | 0.998 | 5012.743 | 0.000 | 3.608 | 0.030 |
| Exponential | 0.998 | 5012.743 | 0.000 | 36.904 | 0.030 |
| Logistic | 0.998 | 5012.743 | 0.000 | 0.027 | 0.970 |

The independent variable is the year

year, and then use prediction method to predict China's urbanization rate from 2013 to 2020 (Table 3.3).

Synthetically in Table 3.4, the analysis between the urbanization rate and time, linear model correlation is the largest, so we use linear models to analyze data. Model is set up as follows:

$$Y_2 = a_2 + b_2 T \tag{3.3}$$

Among them, $Y_2$ stands for the urbanization rate, $T$ stands for the time, we set up that 1 stands for 2001, 2 stands for 2002. . ., 12 stands for 2012. $a_2$ and $b_2$ are model coefficients, use the relevant data in computing, the model is as follows:

$$Y_2 = 36.345 + 1.349\,T \tag{3.4}$$

$$\mathrm{R}_2 = 1.000 \quad \mathrm{F}_2 = 2289.992 \quad \mathrm{Sig.}_2 = 0.000$$

According to (3.4), we can predict the rate of urbanization from 2013 to 2020, and in accordance with the type (3.2), we can get the non-agricultural employment rate. The result is in Table 3.5.

## 3.4 The Conclusion

In this paper, through theoretical data model analysis, draws the following conclusion:

In this paper, the model analysis the data between China's urbanization level and the non-agricultural employment rate, demonstrates the urbanization level's

**Table 3.5** The urbanization rate and non-agricultural employment rate dates predicted from 2013 to 2020

| Time | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|
| The urbanization rate % | 53.89 | 55.23 | 56.58 | 57.93 | 59.28 | 60.63 | 61.98 | 63.33 |
| The non-agricultural employment rate % | 67.39 | 68.60 | 69.81 | 71.01 | 72.20 | 73.38 | 74.55 | 75.72 |

influence on the rate of non-agricultural employment, the urbanization level indirectly affects the country's industrial structure. In the next few years, with the improvement of the urbanization level, non-agricultural employment will continue to rise, but the growth of the non-agricultural employment rate is less than the growth of the urbanization rate. According to the time series forecasting model, this paper forecasts the China's urbanization level and non-agricultural employment development trend from 2013 to 2020.

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# Chapter 4
# On the View of Sustainable Development: The New Urbanization Evaluation and Construction Study of Shaanxi

**Wenjun Wang and Xiaoxi Hu**

**Abstract** The new urbanization construction contributes to promote the rapid economic development of Shaanxi. But the development needs sustainable construction as the basis which unifies and coordinates the economy, society, population, resources and environment. Based on what has mentioned above, this paper begins with carrying capacity to identify "Short Board" factors which constraints urbanization of Shaanxi, then we adopt the fuzzy analytic hierarchy process, classify and evaluate the level of new urbanization about ten cities of Shaanxi from the perspective of sustainable development. We concluded that, if sustainable urbanization can be carried out, we need to overcome the "Short Board" factors. Besides, the regional construction should have different focuses. In Northern Shaanxi, we should strengthen social security and regulate housing allocation. In Central Shaanxi, we should adjust the industrial structure, focus on the resources and environments, and strengthen the environmental protection and construction of low-carbon buildings. In Southern Shaanxi, we should vigorously develop eco-tourism.

**Keywords** New urbanization • Sustainable development • Comprehensive carrying capacity • Evaluation • The fuzzy analytic hierarchy process

"The eighteenth congress proposed that we should adhere to new industrialization, information technology, urbanization, agricultural modernization with Chinese characteristics". The rapid development of new urbanization, has become a powerful engine of Chinese economic growth and social development. New urbanization strategy will promote a new round of Chinese real estate development. The future of urbanization will not only become the important carrier of building

W. Wang (✉) • X. Hu
International Business School, Shaanxi Normal University, Xi'an, Shaanxi Province, China
e-mail: wwjunxida@163.com; huxiaoxi@aliyun.com

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a moderately prosperous society, but also own the greatest potential for leveraging domestic demand. Because of the special dual economic structure and huge rural background in China, the urbanization construction will be achieved by focusing on the small and medium cities.

## 4.1 Urbanization Development and Existing Problems of Shaanxi Province

As the key area of Western Development, in 2012 the urbanization rate is 47.3 % in Shaanxi, which is lower than the average 52.6 %. From the perspective of energy consumption, per 10,000 yuan unit GDP energy consumes 0.8462 t of standard coal in 2011, which is the lowest energy consumption in western provinces, but is higher than most of eastern provinces. From industrial wastewater discharge side, in the western region, Shaanxi is ranked second following Sichuan. While the wastewater standard rate 97.5 % is the highest among western regions, which is lower than most of the eastern provinces. This way to energy use with high energy consumption, high emission and low efficiency greatly hindered the economic development of Shaanxi. Under the resource and environmental constraints, the reduction of urban comprehensive carrying capacity will have a direct impact on the process of urbanization and sustainable construction.

The core of urbanization is the rural population moved to the towns. While the rural-urban migration will increase the demand for housing, then it leads real estate warming and a series of "chain effect", which deepen the contradictions between land resources and population. Secondly, the urban development will drive the local secondary industry to expand production, which cause the environmental pollution increases. In the regard, countries have put Sustainable Development Concept as important principle in the production and living, and put it into the overall social and economic development in the long-term planning. That is to say, emphasis on economic development, while ensure environmental friendly, resource conservation, generational and intergenerational equity. Therefore promoting the sustainable urbanization construction need harmonize economy, society, population, resources and environment as the basis.

For the sustainable new urbanization, the primary task is to study the urban comprehensive carry capacity. The development within the scope of capacity will ensure their sustainable urbanization. The next is to accurately grasp and evaluate the influencing factors, so that provide the basis for the region urbanization construction in the strategy and policy. Based on this, by combing the exiting literature, this paper study the evaluation of urbanization level, analyze influencing factors of restricting the urbanization development, and give some corresponding suggestion. Then put forward the path of urbanization construction to the sustainable development direction.

## 4.2 Literature Review of Sustainable Urbanization Development

Roger CK Chan and Yao Shimou (2000) [1] from the history and policy, consider that China needs urbanization construction, and the future trends need in a sustainable way to realize the urbanization development. Barney Cohen (2006) [2] studied the problem of urbanization in developing countries. With the rural population moving into cities, it makes transport and communication excessive pressure, the poverty rate of secondary cities and towns rise, and public services not be fully covered. Therefore, we must properly control the population growth, so that make all aspects of security to keep up with population growth in order to achieve sustainable urbanization development. Cheng Xiaobo (2006) [3] analyzed that improving the urban comprehensive carrying capacity can help promote sustainable urbanization from all aspects. Song Liping (2008) [4] analyzed the cause of non-sustainable development of urbanization in rural areas from the aspects of the dialectical relationship between economic development and environmental protection, unsound system and inadequate human capital investment. She suggested that we should develop ecological agriculture, establish and improve the system, vigorously develop rural education and take other measures to promote the sustainable development of rural urbanization. Cheng Licong (2009) [5] considered that we should focus on the speed of urbanization, at the same time pay more attention to the sustainable development of urbanization. Take rational allocation among the population, land and water resources, and emphasize the coordinated development in economic society instead of unilaterally measure the city scale according to the population size or land scale. Zhang Pei and Bian Kun et al. (2010) [6] described the urbanization development in northwest arid area from quality and time dimension. They proposed that the path to realize sustainable urbanization is based on the country as the research unit, differentiate the main function of country on the basis of analysis and evaluation of the ecological environment. It makes the regional economic development adapt to the objective conditions of ecological environment, and finally realize the harmony of rural urbanization and ecological environment protection. Li Jinlong and Xie Lingling (2011) [7] discussed the problems that the sustainable development of PRD urbanization would face. Then they proposed policy recommendations from the view of environmental protection, industrial restructuring and upgrading, and system innovation. Cheng Aihua and Wei Houkai (2012) [8] thought that we must fully consider the resources carry capacity and environmental capacity under a different urbanization mode, solve the urban employment in a reasonable and effective way, and finally achieve sustainable urbanization development strategy.

In summary, if the urbanization speed cannot match the urban carrying capacity, it will cause unsustainable urbanization. We not only consider the expansion of population and land, but also consider the carrying capacity of resources and environment during the construction of urbanization. Although existing papers have studied the sustainable development of urbanization, they described by a lot of status and data, and most of the studies did not establish reasonable model for quantitative analysis. Therefore, this paper establishes correlation model based on sustainable development requirement, builds an evaluation system, quantitatively analysis the shortage of urbanization development of Shaanxi. And according to these deficiencies, we propose related construction advice.

## 4.3 The Restriction Factors of Urban Carrying Capacity

Carrying capacity theory and sustainable development is the same strain. Carrying capacity studied actual carrying capacity of resources and environment proceeding from the fundamental [9]. And the sustainable development is to make the urban and regional overall coordination development of population resources environment and socioeconomic from a macro and long-term way. It requires the scale and intensity of human activities to remain within the carrying capacity. Therefore, this paper first analyzes the limited factors during the development of Shaanxi urbanization. And then we dissect it from the sustainable view in order to better and comprehensively evaluate the development level of Shaanxi urbanization. Finally we can find out restriction factors so that promote the continuous development of urban construction in the affordable range.

### *4.3.1 The Standard of Limiting Factors Status Index*

Selection of limiting factor is the core content of urban comprehensive capacity. The status evaluation is based on the "Cannikin Law", we choose several maximum indicators which have restriction to sustainable development of social economy and environment, and refer to the relevant international standards as well as the related literature [10–13], then combine with the practical situation of towns to determine the corresponding index threshold. Taking into account the positive and negative problems of index, we take the following state index(R) respectively to measure the state level (in Table 4.1).

$$R_{+} = \frac{V_{\min} - V_0}{V_{\max} - V_{\min}}, \quad R_{-} = \frac{V_0 - V_{\max}}{V_{\max} - V_{\min}}$$

$V_0$ is the actual status value of the indicator, $V_{\min}$ is the minimum of the indicator in the threshold range, $V_{\max}$ is the maximum of the indicator in the threshold range.

**Table 4.1** Status index level divided

| Status index range | Status index level |
|---|---|
| R<−1.0 | State of crisis |
| −1.0≤R<0.0 | Warning status |
| 0.0≤R≤1.0 | General condition |
| R>1.0 | Good condition |

**Table 4.2** Indicator selection and warning value

| Warning indicators | 2011 actual status value | Threshold | State index | Status index level |
|---|---|---|---|---|
| Per capita construction land ($m^2$/person) | 285.17 | 227~247 | −2.91 | State of crisis |
| The proportion of industrial land (%) | 25.8 | 15.0~25.0 | −1.08 | State of crisis |
| Pm2.5 annual average concentration (mg/$m^3$) | 0.117 | 0.04~0.07 | −2.56 | State of crisis |
| Per capita water availability ($m^3$/person) | 616.6 | 1,700~3,000 | −1.06 | State of crisis |
| Per cultivated area (mu/person) | 1,062.57 | 900~1,104 | −0.20 | Warning status |
| Per capita living apace ($m^2$/person) | 28.04 | 23.0~36.0 | −0.61 | Warning status |
| $So_2$ annual average intensity (mg/$m^3$) | 0.042 | 0.02~0.06 | −0.55 | Warning status |
| Land subsidence (mm/a) | 8.01 | 5.0~15.0 | −0.301 | Warning status |
| Per capita public green area ($m^2$/person) | 11.41 | 8~15 | 0.49 | General condition |
| Industrial wastewater attainment rate (%) | 95.67 | 94.2~100 | 0.25 | General condition |

Data source: *Shaanxi Statistical Yearbook 2012, China Statistical Yearbook 2012*

## *4.3.2 Selection of Restrictive Factors*

As we all know, urban is a center which concentrates population, industrial economy, wealth and entertainment. Of course, it is main place of all kinds of high resource consumption, pollution waste and carbon emission. Therefore, the main carrier of bearing population and industrial economy is urban construction and industrial development space, rather than agricultural production and ecological protection space. At a certain level of technology and living conditions, the criteria of urban comprehensive carrying capacity should be judged by resource endowments, constraint and utilization efficiency. In practical terms, it contains per capita construction land, per Cultivated Area, per capita living space, building volumetric fraction, the proportion of industrial land, per capita water availability, water consumption of industrial added value per 10,000 yuan, soil quality, industrial wastewater attainment rate, ambient air quality, $SO_2$ emissions intensity, $NO_2$ emissions intensity, bearing capacity, number of geological disaster, land subsidence and so on. According to the actual situation of Shaanxi and data availability, we take the following indicators (in Table 4.2).

According to the study of Table 4.2, per capita construction land, the proportion of industrial land, Pm10 annual average concentration, per capita water availability are state of crisis among the main constraint of resources and environment indicators, which are the “Short Board Factors” effecting the urban capacity. per Cultivated Area, per capita living apace, $So_2$ annual average intensity and land subsidence are warning status, which are the vigilance factors to influence the urban capacity.

## 4.4 Evaluation of Sustainable Development of New Urbanization in Shaanxi

### *4.4.1 The Establishment of Evaluation System*

Sustainable development is the development that coordinates and integrates sustainable economy, sustainable ecology and sustainable society. It requires people to pay attention to economic efficiency in the course of development and ecological harmony, to pursue social justice, and ultimately to achieve the comprehensive development. Applied in the new urbanization construction, it required us to achieve economic, social, population, resources and environment harmonious and unified development at urbanization implementation stages. And ensure that the construction of new urbanization can be sustained indefinitely [8, 14]. So we must not only pay attention to the amount of economic growth, but also to the pursuit of quality of economic development, to take the economic construction and social development in harmony with the urban carrying capacity. At the same time, we need to protect and improve the regional ecological environment, to ensure the sustainable use of natural resources and environmental costs. The urbanization development also stresses social security, and the improvement of people’s quality of life and health should be taken into account. Therefore, from the perspective of sustainable development, the new urbanization evaluation system [15] are shown in Table 4.3.

### *4.4.2 The Setting of Theoretical Model*

According to the establishment of the new evaluation system based on the theory of sustainable development, it exists hierarchical relationship between the factors and indicators, so we can select the AHP to analyze the problems. But in the traditional AHP, the consistency test of judgment matrix is very complex and difficult. And when the judgment matrix does not have the consistency, it needs to be adjusted. It may make several adjustments and testing, and the operation may be tedious and difficult. In addition, the consistency of judgment matrix is merely an empirical test data which is lack of a scientific basis. For the above reasons, this paper selects FAHP (fuzzy analytic hierarchy process) and build fuzzy consistent judgment matrix [16] to overcome the shortcomings of traditional AHP.

**Table 4.3** The evaluation system of new urbanization development

| Destination layer | Criterion layer $B_i$ | Target layer $C_i$ | Explanation |
|---|---|---|---|
| Evaluation system of new urbanization development | Economic factors | Per capita GDP (yuan) | Reaction regional economy and development level |
| | | Secondary, third industry output value ratio (%) | Reaction industrial structure |
| | | Per capita disposable income (yuan) | Reaction per capita economic level |
| | | Local financial revenue (one hundred million yuan) | Reaction the efficiency of region economic development |
| | Social factors | The basic medical insurance ratio (%) | Reaction ability of social security |
| | | Registered unemployment rate (%) | Reaction regional employment |
| | | Per capita road areas (square meters) | Reaction regional infrastructure |
| | | Per capita housing area (square meters) | Reaction per capita living standard |
| | Demographic factors | Urban population proportion (%) | Reaction urban population conditions |
| | | Natural growth rate (%) | Reaction regional population growth |
| | Resources and environment factors | Per capita arable land (mu) | Reaction regional resource endowments |
| | | Annual better weather proportion (%) | Reaction regional overall environment |
| | | Industrial wastewater attainment rate (%) | Reaction regional pollution |

#### 4.4.2.1 The Introduction of FAHP

Transform the Scale of Traditional AHP into FAHP

Suppose there is a project set $A = \{A_1, A_2, \cdots A_n\}$ relative important for a criterion, according to Delphi method, the project $A_i(i = 1, 2, \cdots, n)$ is pairwise comparison with other project to get the corresponding score. The score is express by $a_{ij}(i = 1, 2, \cdots, n)$. This N matrix can solve various options which take the priority weight of certain criterion as judgment matrix, and record $A = (a_{ij})_{n \times n}$.

Take $a \geq 81$, make $r_{ij}(a) = \log_a a_{ij} + 0.5$, so $R = (r_{ij}(a))_{n \times n}$ is fuzzy complementary judgment matrix. Obviously, $0 \leq r_{ij}(a) \leq 1$ and $r_{ii}(a) = 0.5$, $r_{ij}(a) + r_{ji}(a) = 1$. The purpose to take $a \geq 81$ is to ensure $0 \leq r_{ij}(a) \leq 1$.

Transforming the scale [17] of traditional AHP into FAHP can refer to Table 4.4.

**Table 4.4** Compare AHP with FAHP

| The scale of traditional AHP | The scale of FAHP | Definition | Explanation |
|---|---|---|---|
| 1 | 0.5 | Equally important | Two project is equally important to an attribute |
| 3 | $\log_a^3 + 0.5$ | A little important | One project is a little important than another to an attribute |
| 5 | $\log_a^5 + 0.5$ | Obviously important | One project is obviously important than another to an attribute |
| 7 | $\log_a^7 + 0.5$ | Highly important | One project is highly important than another to an attribute |
| 9 | $\log_a^9 + 0.5$ | Extremely important | One project is extremely important than another to an attribute |
| 2, 4, 6, 8 | $\log_a^i + 0.5$, i = 2, 4, 6, 8 | Intermediate values of the adjacent scale | Represent a compromise between two adjacent scale |
| Countdown of the above scale | Complementary of the above scale | Anti comparison (Complementary) | The scale of project $A_i$ to program $A_j$ is $r_{ij}$, otherwise is $1-r_{ij}$ |

Definition of Fuzzy Consistent Matrix

Suppose there is a project set $A = \{A_1, A_2, \cdots, A_n\}$, the fuzzy complementary judgment matrix of pairwise comparison importance as follows:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ & & \vdots & \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix} \tag{4.1}$$

Among that: $0 \leq r_{ij} \leq 1$ $r_{ii} = 0.5$ $r_{ij} + r_{ji} = 1$. $r_{ij}$ represents the degree of membership that the project $A_i$ is more important than project $A_j$, project $A_i$ has larger degree important than project $A_j$, when $r_{ij}$ is larger. Project $A_i$ and project $A_j$ are equally important when $r_{ij} = 0.5$. When the fuzzy complementary judgment matrix $R = (r_{ij})_{n \times n}$ meet: $\forall\ i, j, k = 1, 2, \cdots, n$, exist $r_{ij} = r_{ik} - r_{jk} + 0.5$, then fuzzy complementary judgment matrix is called fuzzy consistent judgment matrix.

#### 4.4.2.2 Procedure of Model Building

Use of FAHP to Calculate the Weight

First, aiming at the no evaluation questions, we can establish the hierarchy, and build priorities matrix according to the importance that the factors of this layer are compared with upper layer. Take 0.1~0.9 as scale (in Table 4.4).

Second, sum the priority relation matrix $R = (r_{ij})_{n \times n}$ by row, sign $r_i = \sum_{j=1}^{n} r_{ij}$, $i = 1, 2, \cdots, n$, and take the following change: $r_{ij}' = (r_i - r_j)/2n + 0.5$, the priority relation matrix will be further transformed into fuzzy consistent matrix.

Third, using the sorting method [18], we can obtain the index weight. So the weight that factor $B_i$ under factor $A_i$ is:

$$\omega_i(j) = \frac{1}{n} - \frac{1}{2\alpha} + \frac{\sum_{j=1}^{n} r_{ij}'}{n\alpha}, i = 1, 2, \cdots, n \tag{4.2}$$

Standardization Each Index

The original index attribute matrix is $D = (d_{ij})_{m \times n}$, use the formula

$$x_{ij} = \frac{d_{ij} - \min_i \left(d_{ij}\right)}{\max_i \left(d_{ij}\right) - \min_i \left(d_{ij}\right)}, \ (i = 1, \cdots, m; j = 1, \cdots, n) \tag{4.3}$$

and obtain the dimensionless matrix $X = (x_{ij})_{m \times n}$.

Evaluation of Urbanization Level

$$\text{Use the formula } G_i = \sum_{j=1}^{n} \omega_j x_i(j) \ i = 1, \cdots, m; j = 1, \cdots, n \tag{4.4}$$

Calculate the comprehensive evaluation value.

#### 4.4.2.3 Evaluation Analysis

According to the *Shaanxi Statistical Yearbook 2012*, we selected figures of ten cities in 2011 in Shaanxi Province, China.

First, based on the theory of sustainable development, economics, society, populations, resources and environmental factors are respectively given to equal weights. Second, according to the Delphi method, we synthesize ten experts' advice, illustrate hierarchical important scores of 13 indicators to get a general precedence relation matrix, and then convert it into a fuzzy preference relation matrix. Finally, fuzzy consistent matrix is constructed after transformation.

**Table 4.5** Indicator weights of the new urbanization develop

| | $B_1$ | $B_2$ | $B_3$ | $B_4$ | |
|---|---|---|---|---|---|
| Weights | 0.25 | 0.25 | 0.25 | 0.25 | $w_i$ |
| $C_1$ | 0.2850 | – | – | – | 0.0713 |
| $C_2$ | 0.2417 | – | – | – | 0.0604 |
| $C_3$ | 0.2646 | – | – | – | 0.0662 |
| $C_4$ | 0.2087 | – | – | – | 0.0521 |
| $C_5$ | – | 0.2896 | – | – | 0.0724 |
| $C_6$ | – | 0.2317 | – | – | 0.0579 |
| $C_7$ | – | 0.2658 | – | – | 0.0665 |
| $C_8$ | – | 0.2129 | – | – | 0.0532 |
| $C_9$ | – | – | 0.7292 | – | 0.1823 |
| $C_{10}$ | – | – | 0.2708 | – | 0.0677 |
| $C_{11}$ | – | – | – | 0.2978 | 0.0745 |
| $C_{12}$ | – | – | – | 0.3639 | 0.0910 |
| $C_{13}$ | – | – | – | 0.3383 | 0.0845 |

**Table 4.6** Evaluation result of ten cities in Shaanxi

| Cities | Xi'an | Baoji | Xianyang | Weinan | Tongchuan | Yan'an | Yulin | Hanzhong | Ankang | Shangluo |
|---|---|---|---|---|---|---|---|---|---|---|
| Evaluation | 64.60 % | 59.15 % | 57.27 % | 52.92 % | 52.22 % | 58.15 % | 64.27 % | 38.54 % | 30.53 % | 33.17 % |

In accordance with the formula (4.2), the weight of each indicator can be obtained by invoking MATLAB program, the results can be shown in Table 4.5.

The evaluation result of the new urbanization development of ten cities of Shaanxi according to the formula (6) can be seen in Table 4.6.

The sort orders of the development level are as follows: Xi'an> Yulin> Baoji> Yan'an> Xianyang> Weinan> Tongchuan> Hanzhong> Shangluo> Ankang. According to the development of cities in Shaanxi and regional planning, Xi'an, the capital of Shaanxi Province, takes the first place in development level. While, Second was Northern Shaanxi (Yulin, Yan'an) due to its independent character. Guanzhong (Baoji, Xianyang, Weinan, Tongchuan) as well as Southern Shaanxi (Hanzhong, Ankang and Shangluo) just win third and fourth, respectively.

## 4.5 Analysis of Sustainable Construction

The development of new urbanization needs sustainable construction as the basis. Professor Charles described sustainable construction [19] mainly from the sustainable use of resources and environment. From the perspective of sustainable development, it requires mutual construction of economic, social, demographic, natural and environment, which lie in sustainable urbanization [20]. Therefore, based on the evaluation structure mentioned above, according to the regional zoning, we have selected each regional average evaluation value as a measure of regional

**Table 4.7** Index value of regional urbanization factor

| Shaanxi area | Xi'an (%) | Average value of Northern Shaanxi (%) | Average value of Guanzhong plain except Xi'an (%) | Average value of Southern Shaanxi (%) |
|---|---|---|---|---|
| Economy | 21.91 | 16.57 | 8.37 | 1.15 |
| Society | 17.04 | 11.07 | 14 | 11.44 |
| Population | 23.19 | 15.79 | 18.62 | 6.51 |
| Resources and environment | 2.46 | 17.78 | 14.4 | 14.98 |

development index value. From the perspective of sustainable development, each factor affecting the development of new urbanization evaluation value is shown in Table 4.7.

As can be seen from Table 4.7, in the process of new urbanization construction, evaluation value of resources and environment factors of Xi'an is 2.46 %. Vertically, it turns to be a disadvantage compared to the other three factors; laterally, compared to other regions in Shaanxi, it still turns to be a disadvantage. So in terms of the sustainable urbanization construction in Xi'an, more emphasis should be put on the development of resources and environment. Sustainable development of cities in Northern Shaanxi is relatively balanced, but in the vertical and lateral view, the development of social factors slightly falls behind with the index of only 11.07 %. Therefore, in sustainable construction of new urbanization of Northern Shaanxi, we should pay attention to the community development. When it comes to the sustainable development of four cities in Central Shaanxi, economic factors takes about 8.37 %, which is slightly better than the horizontal comparison of the three cities in Southern Shaanxi. But in longitudinal comparison, the coordination of development lags behind the other three factors. So in Guanzhong plain of Shaanxi, the construction of four cities should vigorously focus on economic development. The overall development of the three cities in Southern Shaanxi fall behind other regions in Shaanxi with the economic factor of only 1.15 % and the population factor of 6.51 %, which lags far behind the other two factors, so does the horizontal comparison. Therefore, new urbanization in Southern Shaanxi needs focusing on economic development, and efforts to absorb the population.

## 4.6 Conclusions and Recommendations

### *4.6.1 Conclusions*

This paper has studied the "Short Board" factors under urban comprehensive carrying capacity from the perspective of sustainable development. Based on the above research, we evaluate the new urbanization development level of cities in Shaanxi province, and divide Shaanxi province into four major parts according to the result and regional planning. Then, specifical analysis have been taken on the economy, society, population, resources and environment factors to the four parts, and found out the key point of regional urbanization construction in the future. Through the study, the following conclusions have been made.

First, starting from the “root”, we study the factors of the comprehensive bearing capacity of Shaanxi, and find the “Short Board”. Therefore, from now on, only if the environment can be effectively governed and the resource can be reasonably used, urban sustainable construction will continue, and these factors will not be the obstacle to the new urbanization construction in Shaanxi province.

Second, based on the sustainable development theory, we take the AHP, construct the evaluation system for urbanization development, and evaluate development level of the ten cities in Shaanxi. Then Shaanxi has been divided into four major parts according to the evaluation results and regional planning. Among the four parts, xi’an is best, Northern Shaanxi is better than Guanzhong plain in second place, and Southern Shaanxi rank last.

Third, for the problems existing in the urbanization development, we analyze values of economy, society, population, resources and environment factors. It is found that there should be different emphasis in regional development: Xi’an should pay attention to the development of resources and environments, more emphasis should be put on society in Northern Shaanxi. And the four cities of Guanzhong should vigorously focus on economic development, Southern Shaanxi needs focusing on economic development, and efforts to absorb the population.

### *4.6.2 Recommendations*

With the conclusions of this paper, we put forward the following policy proposals for sustainable urbanization development, combining with the current situation of Shaanxi.

To begin with, the urbanization sustainable construction of Shaanxi should be performed under the urban carrying capacity, and the “Short Board” must be taken highly of. In the urban construction, it brings some trouble because of land urbanization is faster than the population urbanization. So the speed of land urbanization requires decreasing in order to keep the balance of arable land and building land. To be specific, the government should control the rate of approval for building land and the industrial land, and give priority to low-carbon building and environmental industry [21]. For industrial production, the policy can be tilted to the enterprises with clean production. And the water consumption in energy industry should be controlled.

In addition, Xi’an has shortcomings even though rank first among Shaanxi in urbanization development, the level of resources and environment are valued only 2.46 %. Therefore, the development of environmental industry should be encouraged, and cleaner production mechanism should be introduced. For the construction of buildings, low-carbon buildings are largely required, and the green space of the top floor of the existing buildings should be widely promoted.

In Northern Shaanxi, the sustainable development of urbanization is relatively balanced, but the social security valuation is 11.07 %, slightly less than other factors. Therefore, we must enhance social security, popularize universal health care, and raise the minimum income. Besides, income distribution gap is bigger, housing allocation is injustice and inequality, and the affluent translate unequal possession of property into income, which hinder the urbanization. Based on the characteristic of dual economic structure in China, in the process of farmers being citizens, census register policy must keep up with the pace of urbanization, housing distribution must be reasonable, and at the same time, municipal foundation facilities also need to improve. Only in this way, can we make farmers become real citizens living in the urban.

Yet the four cities in Guanzhong plain are at a disadvantage compared with the Xi'an in economic development. We analyze the changing relations of industry structure and urbanization based on the Chenery Mode, it is found that since 1978, the urbanization level and industrial structure are in the long-term uncoordinated state. Therefore, it is the "engine" of urbanization in Guanzhong plain to adjust the industrial structure, to encourage rapid development of leading industry, to develop advantages of industrial clusters, and ultimately promote rapid economic harmonious development [22].

As to Northern Shaanxi, it should vigorously promote the development of tourism localization, and set up state-level tourism demonstration area based on its ecological dominance [23, 24]. Especially, it should develop different multi-level ecological tourism products for various tourism markets, and build ecological tourism industry cluster, strengthen ecological environmental regulation and management in accordance with the industrial ecology and circular economy target [25]. And by accelerating the development of the tourism industry, it can promote sustainable and healthy development of economy in order to increase employment opportunities and absorb a large number of labors, to promote urbanization process.

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# Chapter 5
# The Empirical Analysis of Shandong Province's Urbanization Level

**Haizi Wang, Dong Zheng, and Enze Cui**

**Abstract** Based on the actual data of urbanization level in China and Shandong province, and according to Hollis B. Chenery's Development Model, this article comparatively analyzes the lag of Shandong Province's urbanization level. Studies have shown that the urbanization level of Shandong Province is lagging. That is shown as the low urbanization rate and lag right behind the average level of China and the same stage of development level of urbanization in abroad. Therefore, Shandong Province should continue to accelerate the urbanization process, in order to reduce the gap between the urbanization level of Shandong Province and China, so as to advance the comprehensive development of economic and social fields.

**Keywords** Shandong Province • The level of urbanization • Lag • Normal development • Development model

## 5.1 Introduction

In the end of the nineteenth century, the phenomenon of global urbanization emerged and it is until Mid-twentieth century that the global urbanization become into prosperity. During this period, the developed market economy countries such as Britain, the United States, Germany, Japan, etc., depending on the high development of industrialization, has completed the urbanization and the process of Urban–rural integration, while due to drawing lessons from the advanced international experience, developing countries are also accelerating the pace of urbanization. The advance of

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H. Wang (✉) • E. Cui
Department of Management Engineering, Shandong Jianzhu University, Jinan City, Shandong Province, China
e-mail: wanghz99@163.com; cuienze111@163.com

D. Zheng
School of Business, Shandong Jianzhu University, Jinan City, Shandong Province, China
e-mail: sakyya@163.com

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urbanization not only can promote local economic development, but also provide long-term effective demand for local area, thus contributing to the development of industrialization in the region [1]. But whether the rapid development of urbanization can promote the development of the economy?

On the issue of the rationality of China's urbanization development level, it has always been the focus of academic debate. So far, the debate has not been unified, and it still exist great differences. Based on the research of the existing theory, this problem can be summarized as roughly two ideas: One is that the average annual growth of China's urbanization rate has reached 1.44 % that seems to be too fast and the urbanization rate has exceeded 50 %, resulting in China's urbanization rate violates the principle of gradual and orderly progress, led to the "aggressive style" phenomenon of urbanization [2, 3]. The second view is that although the growth rate of China's urbanization has exceeded 1 %, it is still too low [4]. At present, China's urbanization level lags behind the level of industrialization and economic development, and lags behind in the developing countries of the world which have the same level of development with China [5, 6]. Therefore, the speed of urbanization which even has exceeded one percentage point is not too high and should continue to accelerate the pace of urbanization [7].

Only when Shandong province is analyzed, however, either from the growth of urbanization rate, or from the contrast to the level of urbanization development of all over China and other normal countries around the world, hysteresis phenomenon always exists in the level of urbanization development of Shandong province.

## 5.2 Contrast of the Urbanization Level of Shandong Province and China

Since the reform and opening-up policy was taken in China, the process of urbanization has been constantly pushed on nationwide with the Market System established and the Industrialization developed. In 1981, China's urbanization rate was only 23.71 %, but during the period of the Sixth Five Year Plan, the national growth rate had reached 0.84 %. And in the next two phases, the average growth rate exceeded 0.5 %. The urbanization progress was steady at that time. But since 1996, China's urbanization speed had begun to accelerate. From 1981 to 1995, the national rate had increased by a total of 5.33 % and the average number was 0.62 %, while in the period of 1996–2010, the rate reached 10.37 % and its average number was 1.39 % (Table 5.1).

However, in 1981 the urbanization rate of Shandong province was only 9.47 %, which was equivalent to the rate before China's establishment. In the period of the Sixth Five Year Plan, Shandong's average urbanization growth rate was 0.70 %, which was behind the national level by 0.14 %. Though in the Eighth Five Year Plan period, Shandong's urbanization progress developed very fast and the average rate reached 1.19 %, the speed suddenly slow down during the next phase so that the number became 0.29 %, which was far behind the whole nation's level, as shown in Table 5.2.

**Table 5.1** China's urbanization level in different periods from 1981 to 2010

| Period | The urbanization rate of starting (%) | The urbanization rate of ending (%) | Average annual growth rate of urbanization (%) |
|---|---|---|---|
| The 6th Five-Year Plan (1981–1985) | 19.39 | 23.71 | 0.84 |
| The 7th Five-Year Plan (1986–1990) | 23.71 | 26.41 | 0.52 |
| The 8th Five-Year Plan (1991–1995) | 26.41 | 29.04 | 0.53 |
| The 9th Five-Year Plan (1996–2000) | 29.04 | 36.22 | 1.44 |
| The 10th Five-Year Plan (2001–2005) | 36.22 | 42.99 | 1.35 |
| The 11th Five-Year Plan (2006–2010) | 42.99 | 49.95 | 1.39 |
| The first 15 years (1981–1995) | 19.39 | 29.04 | 0.62 |
| The last 15 years (1996–2010) | 29.04 | 49.95 | 1.39 |
| Thirty years (1981–2010) | 19.39 | 49.95 | 0.97 |

Source of materials: (1) "Statistical Yearbook of China", China Census Press, 2011
Note: (1) Average annual growth rate of urbanization is the geometric average of the 5 years

**Table 5.2** Shandong province's urbanization level in different periods from 1981 to 2010

| Period | The urbanization rate of starting (%) | The urbanization rate of ending (%) | Average annual growth rate of urbanization (%) |
|---|---|---|---|
| The 6th Five-Year Plan (1981–1985) | 9.47 | 13.22 | 0.70 |
| The 7th Five-Year Plan (1986–1990) | 13.22 | 18.73 | 0.62 |
| The 8th Five-Year Plan (1991–1995) | 18.73 | 24.93 | 1.19 |
| The 9th Five-Year Plan (1996–2000) | 24.93 | 26.84 | 0.29 |
| The 10th Five-Year Plan (2001–2005) | 26.84 | 34.16 | 1.42 |
| The 11th Five-Year Plan (2006–2010) | 34.16 | 40.26 | 0.99 |
| The first 15 years (1981–1995) | 9.47 | 24.93 | 0.82 |
| The last 15 years (1996–2010) | 24.93 | 40.26 | 0.84 |
| Thirty years (1981–2010) | 9.47 | 40.26 | 0.83 |

Source of materials: (1) "Statistical Yearbook of Shandong", China Census Press, 2011
Note: (1) Average annual growth rate of urbanization is the geometric average of the 5 years

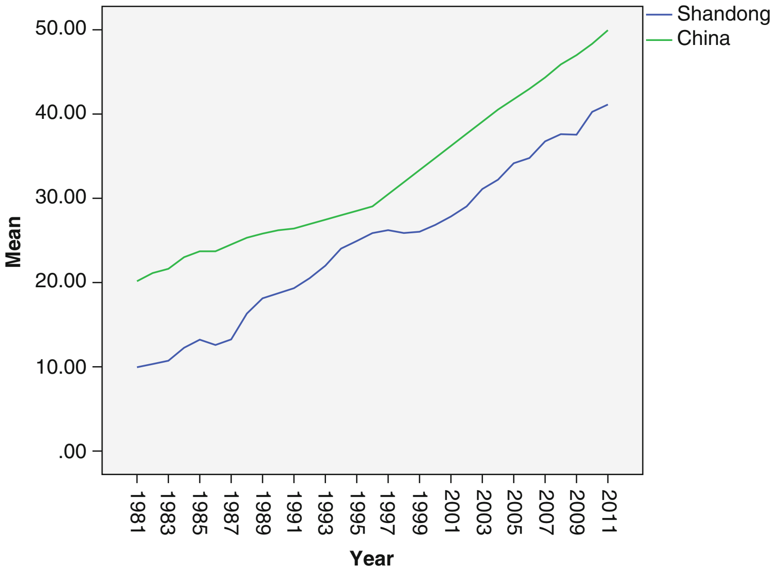


**Fig. 5.1** The comparison chart of urbanization rate in China and Shandong province from 1981 to 2010 (Source of materials: (1) "Statistical Yearbook of Shandong", China Census Press, 2011; (2) "Statistical Yearbook of China", China Census Press, 2011. Note: The vertical axis in the figure as a percentage proportion; horizontal axis is an interval of 3 years)

Now we divide the 30 years (1981–2010) into two parts, and the former 15 years is the first part while the next 15 years is the other. By contrast of the two periods, in the first 15 years, the average rate of Shandong urbanization was 0.82 %, surpassed the national number by 0.2 %, but it still lag behind the average level at the end of the period. During the next 15 years, however, the whole nation's urbanization developed so fast that the increase rate reached 1.39 %, far ahead of Shandong Province. Since then, the gap of urbanization level between Shandong and China was gradually growing.

Placed the each urbanization rate of China and Shandong Province from 1981 to 2012 in a line chart to compare, as shown in Fig. 5.1, we can find that they both are in a general upward trend in urbanization. On the whole, however, Shandong's urbanization rate in each period is lower than the national level of urbanization, and that shows Shandong province is lag behind.

## 5.3 When Compared with the World Urbanization, Shandong Province Severely Lags Behind

In "*Pattern of Development: 1950–1970*", published in 1975, Hollis B. Chenery together with other people came up with the correspondence between the urbanization rate and per-capita GNP during the urbanization process. After making a

**Table 5.3** Comparison between normal urbanization rate and China together with the urbanization level of Shandong province according to the pattern of development

| Per-capital GNP ($) | 100 | 200 | 300 | 400 | 500 | 800 | 1,000 | 1,500 |
|---|---|---|---|---|---|---|---|---|
| Normal urbanization level (%) | 22.0 | 36.2 | 43.9 | 49 | 52.7 | 60.1 | 63.4 | 65.8 |
| China's urbanization level (%) | 17.38 | 17.92 | 24.52 | 26.94 | 27.99 | 34.78 | 39.09 | 41.76 |
| Shandong's urbanization level (%) | 7.87 | 8.76 | 13.25 | 19.25 | 23.98 | 25.90 | 26.14 | 31.05 |
| Deviation 1 | 4.62 | 18.28 | 19.38 | 22.06 | 24.71 | 25.32 | 24.31 | 24.04 |
| Deviation 2 | 14.13 | 27.44 | 30.65 | 29.75 | 28.72 | 34.2 | 37.26 | 34.75 |

Source of materials: (1) Hollis B. Chenery "Pattern of development: 1950–1970", Economic and Science Press, 1988:32; (2) "Statistical Yearbook of Shandong", China Census Press, 2011; (3) "Statistical Yearbook of China", China Census Press, 2011

Note: (1) Per-capital GNP of China ($): 109 in 1970, 219 in 1978, 302.8 in 1986, 404.8 in 1991, 504.5 in 1993, around 800 in 1999, 960 in 2002, 1,488.88 in 2004; (2) Per-capital GNP of Shandong province ($): 98.66 in 1972, 200.37 in 1978, 303.86 in 1987, 398.67 in 1991, 515.27 in 1994, 811.38 in 1996, 1,024.57 in 1999, 1,602.92 in 2003; (3) Deviation one is the deviation between normal urbanization level and China's urbanization level under different per-capital GNP; Deviation two is the deviation between normal urbanization level and Shandong's urbanization level under different per-capital GNP

comprehensive analysis of the statistics concerning the economic development and urbanization among 101 countries, they proved that different per-capita GNP corresponds to different level of urbanization. According to this pattern, this paper gives a rather simple analysis by comparing the urbanization development of world and that of Shandong province.

According to the statistics mentioned in Hollis B. Chenery's "developmental pattern", as showed in chart three, with the increase of the per-capita GNP, the world urbanization increases accordingly [8]. For example, when the per-capita GNP reaches $100, the average rate of urbanization in the world should be 22 %, and when per-capita GNP reaches around $400, the average rate of urbanization in the world should be 49 %. As a result, after comparing the authentic statistics of Shandong province with the normal "developmental pattern", the rationality of the urbanization level of Shandong province can be reflected to some extend (Table 5.3).

After involving the urbanization level of different per-capita GNP in China and different per-capita GDP in Shandong and the normal urbanization level under the same standard into one chart and making a comparison, we can get from deviation one that in 1970, when national per-capital GNP reached $109, the Chinese urbanization level fell for 4.62 % under the normal urbanization level. And in 1999, when the national per-capita GNP reached $800, the Chinese urbanization level at that time fell for 25.32 % under the normal urbanization level. The horizontal comparison of deviation one shows that all the deviations are above zero and increase according to per-capita GNP. In other words, the urbanization level of China always lags behind that of the world, and with the increase of per-capita GNP, this gap increases annually (as is shown in picture two). According to the calculation based on Hollis B. Chenery's "developmental pattern", when per-capita GNP reaches around %1,500, theoretically, China's urbanization level

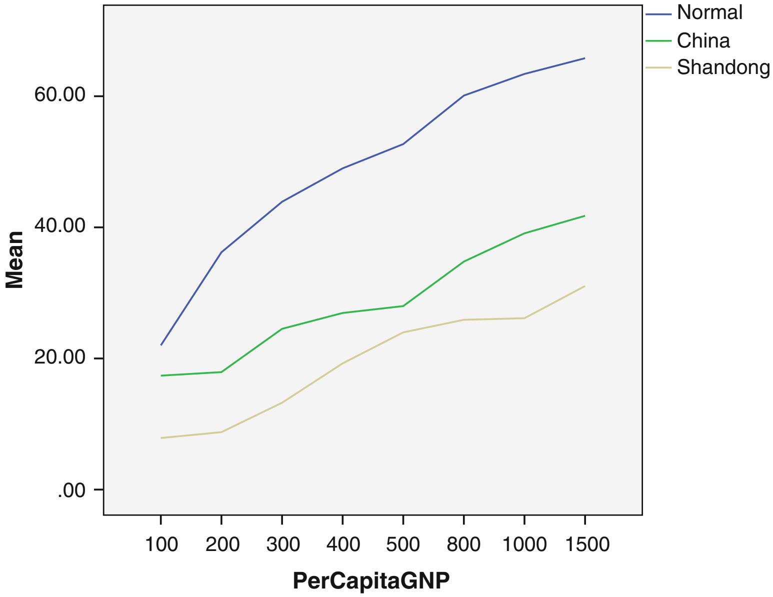


**Fig. 5.2** Comparison between normal urbanization rate and China together with the urbanization level of Shandong province according to the pattern of development (Source of materials: (1) Hollis B. Chenery "Pattern of development: 1950–1970", Economic and Science Press, 1988:32; (2) "Statistical Yearbook of Shandong", China Census Press, 2011; (3) "Statistical Yearbook of China", China Census Press, 2011)

should be 65.8 %. However, the truth is that China's urbanization level is just 31.05 %, less than half of the theoretical data.

According to deviation two, the laggard situation of the urbanization level of Shandong province is even more obvious. In 1972, when the regional per-capita GDP reached 98.66$, the urbanization level of Shandong fell for 14.13 % under the normal urbanization level. And in 1999, this gap should reached 37.26 %, which is far lower than the theoretical data: 63.4 %. The horizontal comparison of the deviation two shows that all the deviations are above zero, which means that the urbanization level of Shandong province lags behind that of the normality. And the deviations show that the urbanization of Shandong seriously lags behind the normal level (Fig. 5.2).

## 5.4 Conclusion

Based on the actual data of urbanization level in China and Shandong province, and according to Hollis B. Chenery's Development Model, this article comparatively analyzes the lag of Shandong Province's urbanization level. Studies have shown that the urbanization level of Shandong Province is lagging behind the average level of China and the same stage of development level of urbanization in abroad. Therefore, Shandong Province should continue to accelerate the urbanization process, in order to reduce the gap between the urbanization level of Shandong Province and China, so as to advance the comprehensive development of economic and social fields. At the same time, as the more developed eastern provinces, Shandong province urbanization development should pay attention to the problem of urban system development, fully realize the process of urbanization resulting from the economic and social development. So we have to focus on the promotion of the overall development of economic and social fields.

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# Chapter 6
# Measuring the Degree of Rural Victims' Satisfaction with Concentrated Rural Settlement in Post-disaster Reconstruction in China: A Conceptual Model

**Yi Peng, Liyin Shen, Weisheng Lu, and Hongping Yuan**

**Abstract** Developing concentrated rural settlement (CRS) in post-disaster reconstruction is considered as an effective means to achieve sustainable development and resilience by providing sufficient infrastructure and public services, more employment opportunities, and improved environmental quality. Several successful cases of developing CRS after 5.12 Sichuan Earthquake were reported. Existing studies have explored the critical determinant factors and decision model for developing CRS in post-disaster reconstruction in China at the macro level. However, few studies have been conducted to investigate rural victims' feelings of CRS in post-disaster reconstruction at the micro level. As a result, it remains unknown whether CRS really benefit rural victims and where can be improved to deliver better CRS. The aim of this research is to put forward a conceptual model to measure the degree of rural victims' satisfaction with CRS in post-disaster reconstruction in China. The logic and operation process of the conceptual model would be introduced. The conceptual model is helpful to guide data collection, data processing, and calculating the satisfaction degree in future. The result of

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Y. Peng (✉)
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China
e-mail: pengyihz@gmail.com

L. Shen
Faculty of Construction Management and Real Estate, The Chongqing University, Chongqing, China
e-mail: shenliyin@cqu.edu.cn

W. Lu
Department of Real Estate and Construction, The University of Hong Kong, Hong Kong, China
e-mail: wilsonlu@hku.hk

H. Yuan
School of Economics & Management, Southwest Jiaotong University, Chengdu, China
e-mail: hpyuan2005@gmail.com

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satisfaction degree is useful to help identify the potential improvements on the CRS projects in post-disaster reconstruction in China.

**Keywords** Concentrated rural settlement (CRS) • Post-disaster reconstruction • Rural victims • Satisfaction degree • Conceptual model • China

## 6.1 Introduction

Concentrated rural settlement (CRS) is where settlement is grouped into compact villages or large hamlets. By contrast, dispersed rural settlement is where the majority of farmers dwell on their own lands scattered over the commune [7]. Dispersed rural settlement is usually criticized as one of the major contributors to rural disadvantages and under-developments. It has been well appreciated that dispersed rural settlement has a relatively negative impact on landscapes, resulting in land fragmentation, proliferation of septic tanks and declining water quality [3, 15]. It is difficult to provide infrastructure and deliver services such as public transport, telecom services and emergency health services [3, 9]. It results in inaccessibility and social isolation, lower than average activity rates, scarce local services, and underemployment [4]. Dispersed rural settlement imposes extra environmental, economic and social costs and is therefore unsustainable in the long run [10]. As a result, it is necessary to control dispersed rural settlement and advocate concentrated settlement [3].

In response to the disadvantages of dispersed rural settlement, CRS is considered an effective means of improving living standards in the countryside, thus achieving sustainable development without compromising the farmers' well-being. Previous studies suggest that rural residential settlement should be close to community facilities, linking into the functional hierarchy in order to maximize access to goods, services and opportunities and reduce the need to travel [8, 14]. Concentrated settlement not only reduces the rural disadvantages and alleviates the imbalance of welfare distribution between urban and rural areas, but also contributes to achieving sustainable development by saving land consumption. Alaci [1] argued that concentrated settlement patterns serve as growth engines and stabilizers of urbanization and economic growth through linking rural and urban areas. Concentrated settlement is considered an important strategy for practicing sustainable development principles, particularly in developing countries with a growing population [13]. Moreover, developing CRS within a village increases the resilience of rural villages and provides a basis for sustainable development after a disaster [12].

Therefore many countries have been introducing various mechanisms to implement CRS. For example, Britain implemented a large-scale rural development program between the 1950s and 1970s, with the aim of concentrating the people within central villages. In line with this program, a set of comprehensive policies was formulated to guide investment in housing, infrastructure and public service facilities, and employment tilting to the central villages [2]. In China, various policies such as urban-rural coordinated development strategy, the strategy of new socialist countryside construction, and "the balance between the increase of construction land in urban areas and the decrease of that in rural areas" (namely "increasing versus decreasing balance" policy) are used to advocate CRS. However, developing CRS is usually purposely conducted under normal conditions. Few studies have explored developing CRS within a village under disaster conditions.

## 6.2 Concentrated Rural Settlement Development After the 5.12 Sichuan Earthquake

There were widely reported villages developing CRS after the 5.12 Sichuan Earthquake. A web search was therefore conducted to find villages that have developed CRS after the 5.12 Sichuan Earthquake. Dujiangyan City has various successful approaches of developing CRS. Rather than complete relocation, the CRS was developed within respective villages. It was found that there are ten successful modes of rural settlement reconstruction with seven villages developing CRS in Dujiangyan City, namely Xiangrong, Qingjiang, Shiqiao, Tai'an, Luchi, Qipan, ans Shibei Villages.

There were two means, namely unified-planning-self-reconstruction and unified-planning-unified-reconstruction to deliver CRS in post-disaster reconstruction. Unified planning was adopted for finding the suitable sites for building CRS, ensuring the scientific layout, housing design and construction of the settlement, and maintaining a harmonious relationship with other settlement. For self-reconstruction, the victims consolidated their former rural residential land and rebuilt the houses with less residential land by themselves in the selected sites. As the area of the rural residential land in the concentration site is smaller than before, many areas of rural construction land were transformed into cultivated land. According to the policy "increasing versus decreasing balance", the land use rights of the saved areas of construction land in rural areas could be transferred to urban areas, which generated income and supplemented the reconstruction financing. The victims reconstructed the houses by themselves according to the overall planning with governmental subsidies, personal funds, loans and the income from transferring the land use rights of saved rural residential land. Under this context, a single house was preferred in the concentration site.

Compared to self-reconstruction, unified-reconstruction granted all the generated income from transferring the land use right of saved rural residential land to the collaborative party. The collaborative party was in charge of building the CRS while the rural victims got the settlement for free. Under this context, a multi-storey house was preferred in the concentration site as the collaborative wanted to save more areas of rural residential land and thus get more incomes. Figure 6.1 illustrates the distribution change of the rural settlement after developing CRS within a

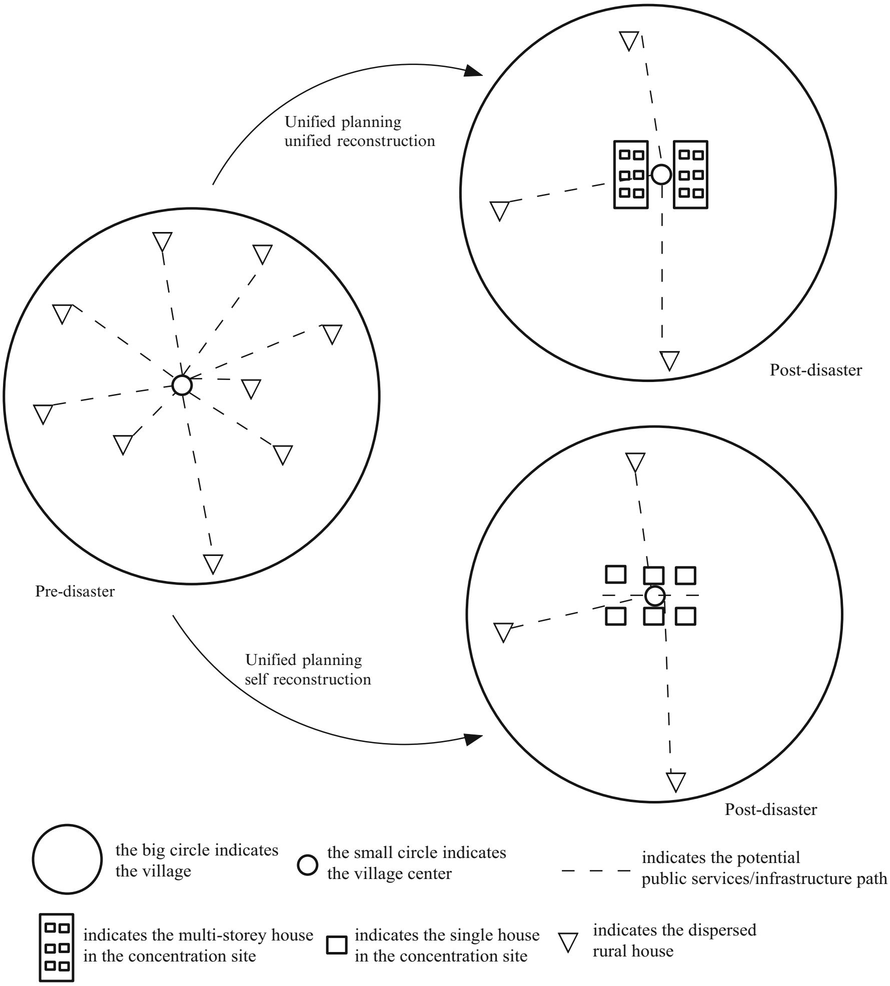


**Fig. 6.1** Illustration of distribution change of settlement after developing CRS within a village in Dujiangyan

village. It is clear that the degree of dispersion would be reduced and it is more effective to provide infrastructure and public services.

These villages were widely cited as successful CRS development modes mainly from the respect of physical reconstruction. However, few studies or reports have deeply explored whether the rural victims are satisfied with CRS in post-disaster reconstruction. This unclear understanding of rural victims' feelings presents difficulties to manage CRS after disaster and to generalize the experience of CRS development to other regions. Therefore, this study aims to provide a detailed work plan to measure the degree of rural victims' satisfaction with CRS in post-disaster reconstruction.

## 6.3 The Conceptual Model of Measuring Satisfaction Degree

In order to measure the degree of rural victims' satisfaction with CRS in post-disaster reconstruction, Weighted Summation (WS) method would be used to calculate the overall satisfaction degree. WS method has been widely used when multi-attributes are involved in measuring the performance of a specific objective [6]. Measurement factors and the relevant weights should be specified first, and then the weighted value can be attained by multiplying the performance of each factor with the corresponding weight. Although the rationale underlying the methodology is straightforward, the measurement should be conducted by following a series of analytical processes, as shown in Fig. 6.2.

Step 1: Identify the measurement factors

Various factors play a role in rural victims' satisfaction with CRS. Existing studies on CRS and housing reconstruction should be examined to identify a preliminary list of measurement factors. According to Peng et al. [12], rural victims usually concern the governmental organization, site selection, layout, housing design and construction, and further development when they are enquired whether participating in developing CRS in post-disaster reconstruction. Therefore these factors can be used as a preliminary list of measurement factors as shown in Table 6.1.

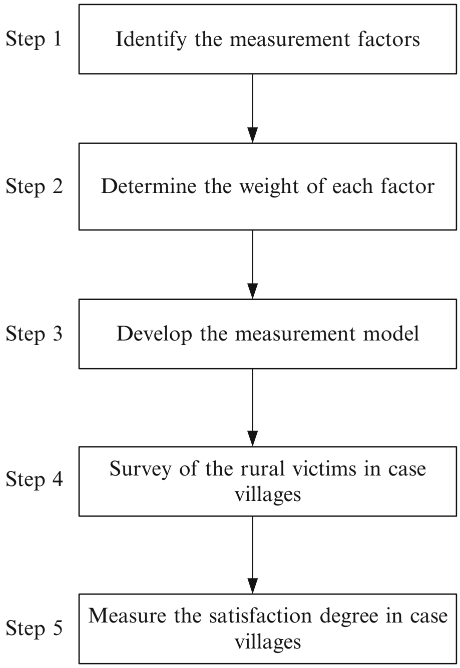


**Fig. 6.2** Flow chart of measuring the degree of rural victims' satisfaction with CRS

**Table 6.1** Preliminary list of measurement factors

| | |
|---|---|
| Organization | F1-Clear responsibility of government departments |
| | F2-Dissemination of the reconstruction policies |
| | F3-Victims' participation in the decision-making process |
| Site selection | F4-Short cultivation radius |
| | F5-Water availability |
| | F6-No secondary disaster |
| | F7-Near employment and social services |
| | F8-Near kin or the old village |
| | F9-Improved infrastructure |
| Layout | F10-Culturally constructed ritual spaces required by people |
| | F11-Sufficient space around dwellings for agricultural needs |
| | F12-Suitable degree of concentration |
| Housing design and construction | F13-Suitable size |
| | F14-Good materials and construction |
| | F15-Privacy needs |
| Further development | F16-The capability of the community to develop itself |

Source: Peng et al. [12]

It should be noticed that a pilot study is necessary to finalize the measurement factors. In the pilot study, experts and rural victims participating in developing CRS in post-disaster reconstruction should be surveyed to assess the importance of the factors in preliminary list or add new measurement factors to the list. The survey should be conducted through random sampling for ensuring the robust of results. The measurement factors can be determined according to the preset criteria. As a result of this step, a set of measurement factors can be reached as shown in Formula (6.1)

$$F = \{F_1, F_2, F_3, \ldots\ldots, F_i\} \tag{6.1}$$

Where $F$ is the set of factors measuring the degree of rural victims' satisfaction with CRS, $i$ is the sequence of the factors.

Step 2: Determine the weight of each factor

The weight of each factor reflects the relative importance of each factor influencing the degree of rural victims' satisfaction with CRS. Various methods such as analytic hierarchy process, analytic network process, fuzzy set theory, genetic algorithm, simple multi-attribute rating technique, and the combination of each method can be used to determine the weight of assessment factors [5]. However, simple multi-attribute rating technique is suggested in this study due to its applicability and simplicity. According to this technique, the weight is obtained by calculating the sum of each rating for a specific measurement factor and then dividing the sum by the total points of all measurement factors. As a result of this step, a set of weight of each measurement factor can be obtained as shown in Formula (6.2)

$$W = \{W_1, W_2, W_3, \ldots\ldots, W_i\} \tag{6.2}$$

Where $W$ is the set of weight of the corresponding measurement factors $F$, $i$ is the sequence of the factors.

Step 3: Develop the measurement model

Based on the first two steps, the model measuring the degree of a rural victim's satisfaction with CRS in post-disaster reconstruction can be established as shown in Formula (6.3).

$$S_j = \sum_{i=1}^{N} W_i \times V(F_{ij}) \tag{6.3}$$

Where $S_j$ is the total degree of satisfaction with CRS in post-disaster reconstruction for the farmer $j$ in a specific village, $W_i$ is the weight of measurement factor $F_i$, $N$ is the total number of measurement factors, $V(F_{ij})$ is value of satisfaction given by farmer $j$ on the measurement factor $F_i$. $V(F_{ij})$ is preset as a value between 0 and 100 as a common practice in China.

Furthermore, the average degree of satisfaction with CRS in post-disaster reconstruction for a specific village can be calculated by following Formula (6.4)

$$AS = \frac{1}{M} \sum_{j=1}^{M} \sum_{i=1}^{N} W_i \times V(F_{ij}) \tag{6.4}$$

Where $AS$ is the average degree of satisfaction with CRS in post-disaster reconstruction for a specific village and $M$ is the total number of rural victims participating in the survey in a specific village. Other variables are the same with those in Formula (6.3).

The developed model can be used to measure the degree of rural victims' satisfaction with CRS in post-disaster reconstruction at both the individual level and village level.

Step 4: Survey of the rural victims in case villages

According to the public report, there are seven villages implementing CRS during post-disaster reconstruction. Field study should be undertaken to understand the specific conditions of the seven villages, with special attention to the CRS construction. Interview is considered as the most suitable approach to conduct research on the issues relating to disaster victims [11]. Therefore, the rural victims living in CRS can be invited to evaluate their satisfaction with each factor during interview according to the pre-determined survey. Their background information including gender, age, number of family members, income, and income source should also be recorded during the interview. Interviewees were identified using the snowball technique, a non-probability sampling method, for obtaining new interviewees from those already interviewed. Further interviews were stopped when all the available rural victims living in CRS have been reached. As a result of this step, the value set of a rural victim's satisfaction with each factor can be obtained as shown in Formula (6.5).

$$V_j = \{V(F_{11}), V(F_{21}), V(F_{31}), \ldots\ldots, V(F_{ij})\} \tag{6.5}$$

Where $V_j$ is value set of $j$th rural victim's satisfaction with measurement factors $F$, $i$ is the sequence of the factors, $j$ is the sequence of interviewed rural victims.

Step 5: Measure the satisfaction degree in case villages

After the data has been collected through step 4, the degree of satisfaction with CRS during post-disaster reconstruction for each interviewed rural victims can be calculated by employing Formulae (6.3) and (6.5). In addition, the average degree of satisfaction with CRS for each case village can also be attained by following Formulae (6.4) and (6.5). At the individual level, the satisfaction degree can be compared against gender, age, number of family members, income and income source. This is useful to find the difference of satisfaction degree between various groups and further find approaches to response to different demands. At the village level, the satisfaction degree can be compared between the case villages. The result can facilitate to identify the villages successfully implementing CRS during post-disaster reconstruction from the aspect of rural victims rather than from the physical reconstruction. The experience generated in the identified villages can be further summarized and generalized to other villages.

## 6.4 Conclusion

Measuring the degree of rural victims' satisfaction with CRS during post-disaster reconstruction is of vital importance to improving people's understanding of rural housing reconstruction as well as to generalizing existing practices to other regions. This paper put forward a specific work plan to measure the degree of rural victims' satisfaction with CRS during post-disaster reconstruction. It is hoped that the measurement factors and relevant weight of each factor can be determined to establish the multi-attribute assessment model at the individual level and the village level. As a result of this plan, the satisfaction degree can be compared against gender, age, number of family members, income and income source at the individual level. In addition, the satisfaction degree can be compared between the case villages at the village level. These further analyses are helpful to find the difference of satisfaction degree between various groups and further find approaches to response to different demands. They can facilitate to identify the villages successfully implementing CRS during post-disaster reconstruction from the aspect of rural victims rather than from the physical reconstruction. The experience generated in the identified villages can be further summarized and generalized to other villages.

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# Chapter 7
# Defining Sustainability Requirements for Design-Build (DB) Contractor Selection in Public Sector Projects

**Bo Xia, Martin Skitmore, Jian Zuo, Zhenyu Zhao, and Madhav Nepal**

**Abstract** The design-build (DB) delivery system is an effective means of delivering a green construction project and selecting an appropriate contractor is critical to project success. Moreover, the delivery of green buildings requires specific design, construction and operation and maintenance considerations not generally encountered in the procurement of conventional buildings. Specifying clear sustainability requirements to potential contractors is particularly important in achieving sustainable project goals. However, many client/owners either do not explicitly specify sustainability requirements or do so in a prescriptive manner during the project procurement process. This paper investigates the current state-of-the-art procurement process used in specifying the sustainability requirements of the public sector in the USA construction market by means of a robust content analysis of 40 design-build requests for proposals (RFPs). The results of the content analysis indicate that the sustainability requirement is one of the most important dimensions in the best-value evaluation of DB contractors. Client/owners predominantly specify the LEED certification levels (e.g. LEED Certified, Silver, Gold, and Platinum) for a particular facility, and include the sustainability requirements as selection criteria (with specific importance weightings) for contractor evolution. Additionally, larger size projects tend to allocate higher importance weightings to

B. Xia (✉) • M. Skitmore • M. Nepal
School of Civil Engineering and Built Environment, Queensland University of Technology, Brisbane, Australia
e-mail: paul.xia@qut.edu.au; rm.skitmore@qut.edu.au; madhav.nepal@qut.edu.au

J. Zuo
School of Natural and Built Environments, University of South Australia, Adelaide, Australia
e-mail: Jian.Zuo@unisa.edu.au

Z. Zhao
Department of Engineering Management, School of Economics and Management, North China Electric Power University, Beijing, China
e-mail: zhaozhenyuxm@263.net

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sustainability requirements. This study provides public DB client/owners with a number of practical implications for selecting appropriate design-builders for sustainable DB projects.

**Keywords** Sustainable buildings • Design-build • Contractor selection • Sustainability requirements

## 7.1 Introduction

Design-build (DB) is one of the integrated delivery systems in which one single entity is contracted to perform both design and construction services for the client/owner [1]. It is an effective delivery system due to advantages such as single-point responsibility, time saving, early cost certainty and increased constructability, and has been gaining popularity around the world in recent decades [1–3].

Latest studies indicate that DB is effective in delivering high performance sustainable construction projects [4–6]. With single responsibility, higher levels of team integration and efficient communication in design and build process, DB contractors are in the better position to provide innovative project solutions for client/owners' sustainability requirements. Additionally, as DB contractors are normally selected on the basis of best-value rather than lowest price, DB provides opportunities for design-builders to pursue green objectives in addition to those relating to time, cost and quality [4]. It is not surprising, therefore, that 75 % of current new construction projects seeking sustainability certification in the USA were delivered with integrated project delivery methods including DB [7].

In order to deliver high-performance sustainable construction projects, client/owners need to clearly define their sustainability requirements at an early stage. In particular, as the success of projects depends largely on the selection of appropriate design-builders as they take full responsibility for coordination and project control [8], the client/owners should convey their sustainability requirements to the potential design-builders and include these requirements in the contractor selection process. However, to many DB client/owners, defining sustainability requirements is not an easy task, as the majority of project management plans in DB projects do not include sustainable objectives, which restricts the opportunities of contractors to evaluate sustainable solutions [4].

In order to help client/owners better define sustainability requirements for DB contractor selection, a content analysis was conducted of 40 DB request for proposals (RFPs) collected from public sector client/owners in the USA. The analysis not only provides a review of current practice in the DB industry but also offers practical implications to those involved in the delivery of sustainable construction projects.

## 7.2 Research Methods

As the primary solicitation instrument in a DB project, the RFP is a document in which DB client/owners define and convey project requirements to prospective design-builders [2, 9]. For sustainable construction projects, client/owners need also to include their sustainability requirements in the RFPs so that they can be addressed accordingly by interested DB contractors in the project proposals.

Similar to Xia et al. [10, 14] and Xia et al. [11], a rigorous content analysis of 40 DB RFPs was used to understand how USA public client/owners define their sustainability requirements for green buildings. Content analysis is an observational research methodology for studying the content of communications. It can help reveal any emerging themes in unstructured data.

Forty sustainable construction projects DB RFPs were collected online, mainly from local (County, Town, City, State) governments; public schools; colleges and universities; US Army Corps of Engineers; Naval Facilities Engineering Command; and US, State and Federal Highway Administrations. These RFPs were posted publicly from 18 States between 2000 and 2013 and with an aggregate contract value of over $1.2 billion. As shown in Table 7.1, the majority of the RFPs are for institutional buildings.

For each proposal, the information of project size and location, time of release, Leadership in Energy and Environmental Design (LEED) certification levels, statements of sustainability requirements, importance weightings of sustainability requirements and price proposal, contractor selection methods and client/owner-provided design proportions were recorded for further analysis. Once the data for these variables were collected, qualitative and quantitative analysis was used to investigate how DB client/owners define their sustainability requirements and explore the relationships between the different variables involved.

## 7.3 Data Analysis

### *7.3.1 Sustainability Certification Levels*

The LEED rating systems cover all requirements for projects needing to achieve a certain sustainability certification. Different LEED levels in RFPs reflect

**Table 7.1** Summary of the data sample

| Project type | Number of RFPs |
|---|---|
| Institutional buildings | 22 |
| Commercial buildings | 9 |
| Renovation projects | 4 |
| Residential buildings | 3 |
| Civil and industrial projects | 2 |
| Total | 40 |

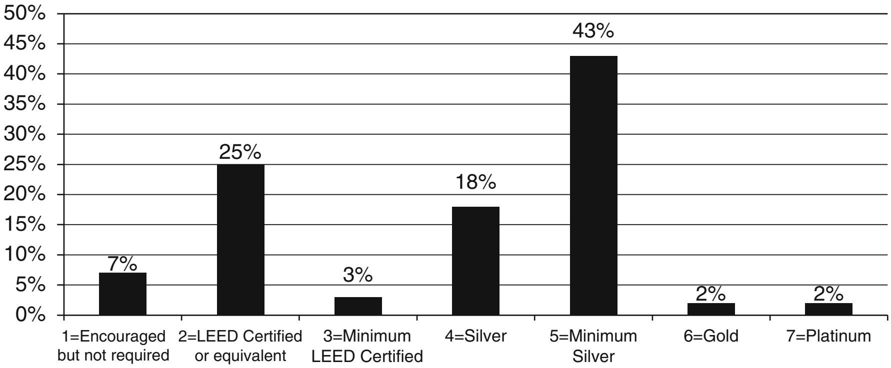


**Fig. 7.1** Sustainability requirements levels in RFPs

client/owners' sustainability objectives. As shown in Fig. 7.1, client/owners use "Encouraged but not required", "LEED Certified or Equivalent", "Minimum LEED Certified", "LEED Silver", "Minimum LEED Silver", "LEED Gold", and "LEED Platinum" to convey the message of sustainability targets. The "Minimum Silver" (43 %) is the most frequently required, and more than 60 % of the projects target silver or higher levels.

### 7.3.2 Sustainability Requirements for Contractor Evaluation

In DB RFPs, client/owners need to establish the selection criteria, and their importance weightings, for the evaluation of prospective design-builders. According to Xia et al. [11], the most frequently used selection criteria for design-builders are *price, experience, technical approach, management approach, qualification, schedule*, and *past performance*, with *price* as the most important criterion – accounting for 27 % of the total weightings.

Of all the 40 RFPs for green DB projects, 25 % (10 RFPs) include sustainability requirements as a separate evaluation criterion in addition to those in Xia et al. [11] (see Fig. 7.2). As shown in Table 7.2, "Approach to sustainability requirements" is the most frequently used expression for the sustainability evaluation of DB contractors.

Meanwhile, 45 % of RFPs (18) include sustainability requirements as the sub-factor(s) of other selection criteria, i.e. technical approach, past performance and experience, and qualification of design-builders. The sustainability requirements are most frequently mentioned in design criteria and project performance specifications (Table 7.3).

Furthermore, the majority (68 %) of RFPs allocate importance weightings to sustainability requirements, ranging from 1 to 25 % in the contractor evaluation

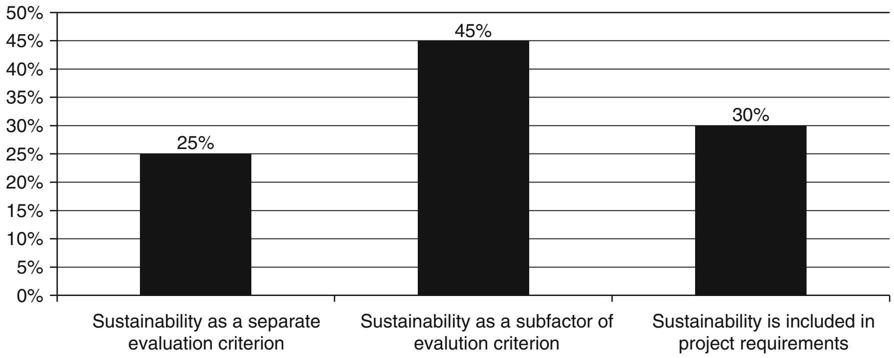


**Fig. 7.2** Sustainability requirements for DB contractor evaluation

**Table 7.2** Expression of sustainability requirements as a separate evaluation criterion

| No. | Expression of sustainability criteria | Frequency | Percentage (%) |
|---|---|---|---|
| 1. | Approach to sustainability (LEED) requirements | 5 | 50 |
| 2. | Sustainability with lower life-cycle cost (durability, maintenance, constructability) | 4 | 40 |
| 3. | Provision of LEED checklist | 1 | 10 |

**Table 7.3** Sustainability as a sub-factor of evaluation criterion

| No. | Sustainability requirements | Frequency | Percentage (%) |
|---|---|---|---|
| 1. | Sustainability as sub-factor of technical (design) approach | 10 | 56 |
| 2. | Sustainability as sub-factor of past performance, experience | 7 | 39 |
| 3. | Sustainability as sub-factor of qualification of design-builders | 5 | 28 |

system. As shown in Fig. 7.3, around 80 % of the RFPs allocate less than 10 % importance weightings to sustainability requirements. For those defining none of the specific sustainability factors and importance weightings for contractor selection, the sustainability requirements are normally covered in the description of project requirements and objectives.

### *7.3.3 Two-Way Contingency Table Analysis*

A series of Chi-Square ($\chi^2$) contingency table analyses were conducted to investigate the relationship between the importance weights of sustainability and other coded variables. According to McClave et al. [12], the Chi-square test helps to determine whether a statistical relationship exists between two variables and it is widely used for categorical data analysis. However, it should be noted that a statistical association between the two variables does not infer a causal relationship.

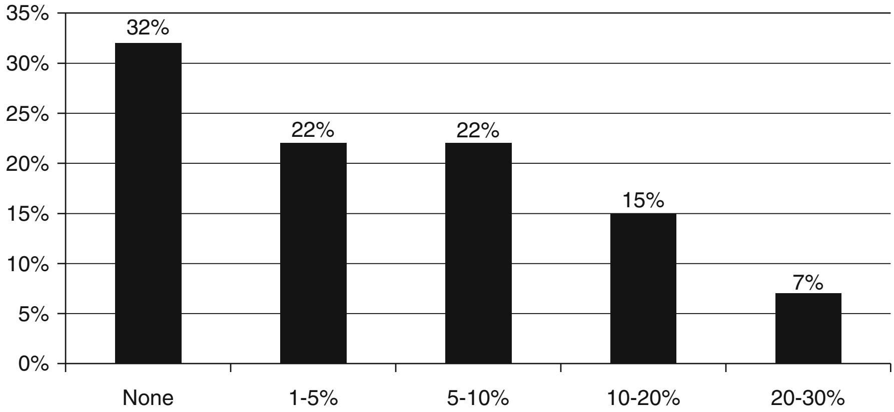


**Fig. 7.3** Sustainability weightings for the contactor evaluation (%)

**Table 7.4** Chi-square analysis of price importance and sustainability weights

| | Sustainability importance | | |
|---|---|---|---|
| Price importance in contractor evaluation | No more than 5 % | More than 5 % | Total |
| Qualification focused | 6 | 8 | 14 |
| | **42.9 %** | **57.1 %** | 100 % |
| Price focused | 17 | 4 | 21 |
| | **81 %** | **19 %** | 100 % |
| Total | 23 | 12 | 35 |
| | 65.7 % | 34.3 % | 100 % |

Note: $\chi^2 = 5.411$ ($p = .020$, d.f. $= 1$)

Based on the importance weightings of *price* (using 27 % as the threshold according to [11]), the RFPs were divided into two groups, i.e. price focused RFPs and qualification focused RFPs. According to the results as shown in Table 7.4, the null hypothesis that the "price" importance is independent of sustainability importance is rejected ($p = 0.020$). In other words, when the contractor evaluation is more price oriented, the evidence is in favour of client/owners tending to allocate less importance weight to sustainability requirements. As shown in Table 7.4, most of price-focused RFPs (81 %) allocate less than 5 % of importance weights to sustainability requirements while the majority of qualification-based RFPs (57 %) allocate more than 5 % to sustainability requirements.

As shown in Table 7.5, although the relationship between project size and sustainability importance is not statistically significant ($p = .061 > 0.05$), the results imply that larger size projects tend to have more important of sustainability requirements. The major reasons for this are that large projects are likely to benefit from life cycle analysis and can afford the green certification costs more than smaller ones.

**Table 7.5** Chi-square analysis of project size and sustainability importance

| Project size | Sustainability importance: No more than 5 % | Sustainability importance: More than 5 % | Total |
|---|---|---|---|
| Small (less than 33.5* million) | 17 | 5 | 22 |
| | **77.3 %** | **22.7 %** | 100 % |
| Large (33.5 million and over) | 6 | 7 | 13 |
| | **46.2 %** | **53.8 %** | 100 % |
| Total | 23 | 12 | 35 |
| | 65.7 % | 34.3 % | 100 % |

Note: $\chi^2 = 3.512$ ($p = .061$, d.f. $= 1$), *33.5 million USD is the standard size of small construction businesses in the North American Industry Classification System [13]

## 7.4 Discussion and Conclusions

DB is an effective delivery system for not both traditional and sustainable construction projects. With an increasing number of public client/owners resorting to DB to deliver their green buildings, it is crucial to understand how they define their sustainability requirements in RFPs.

The LEED rating system released by the United States Green Building Council (USGBC) has become one of most popular green building assessment tools. The content analysis demonstrates that almost all sustainable DB projects demand certain levels of LEED certification, with more than 60 % requesting LEED Silver or higher. Additionally, client/owners prefer to use open-ended statements, such as "minimum LEED Certified" and "minimum Silver", rather than specific LEED levels, in order to leverage DB contractors' sustainability input.

The selection criteria and importance weightings are an important component in design-builder evaluation in RFPs [11]. The majority of RFPs (70 %) include sustainability requirements as selection criteria or sub-criteria with importance weightings up to 25 %. The subsequent Chi-square test revealed that client/owners tend to allocate higher importance weights to sustainability requirements in large and qualification-oriented DB projects. This is understandable as most of large construction projects use best-value procurement methods for contractor selection. Higher sustainability requirements, while usually involving higher project cost, lead to longer durability, better constructability, and less maintenance and operation costs.

The findings of this study provide a number of practical implications for different project stakeholders. First, for experienced DB client/owners it is recommended that sustainability requirements be incorporated into the contractor selection criteria of: technical (design) approach; contractor past performance; experience; and qualifications. Second, for those with limited project delivery experience of sustainable construction projects, the requirements of LEED certification levels and LEED checklists can serve as an effective way of communicating sustainability requirements. Finally, DB contractors need to be familiar with the LEED certification process and have internal LEED certified professionals in order to achieve sustainable design solutions.

One of limitations of this study is the small number of RFPs examined. Possible subjectivity and bias are also inherent in the content analysis, which make the generalization of the results uncertain.. Future research is needed to validate the findings with inputs from client/owners and industry practitioners.

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# Chapter 8
# Dynamic Management of Organization Structure for Residential Energy-Saving Reconstruction Enterprises

**Yanjun Zhao, Xiaojun Liu, and Yan Zhao**

**Abstract** It is very important to residential energy-saving reconstruction enterprises (REREs) that the right organization structure is acquired, and dynamic management organization structure is advantageous for REREs to achieve their goals. In order to improve enterprise organization structure effectively, the method of dynamic management for organization structure is discussed. According to the character of REREs, the main influence factors of REREs' organization structure are analyzed, which include the characteristics and goals of growing phrases of enterprise, management thought, enterprise culture, enterprise strategy, enterprise types, enterprise size, market change and macro-circumstance. Based on the analysis of efficiency of organization structure, applying synthesis scoring method and addition rule of efficiency evaluation, the dynamic management model of organization structure for REREs is established. To illustrate the rationality and practicability of this model, a case study will be demonstrated.

**Keywords** REREs • Organization structure • Dynamic management • Model • Organization structure efficiency

Y. Zhao (✉)
School of Civil Engineering, Xi'an University of Architecture and Technology, Xi'an 710055, China

School of Civil Engineering, Chang'an University, Xi'an 710061, China
e-mail: jzgc0061@126.com

X. Liu • Y. Zhao
School of Civil Engineering, Xi'an University of Architecture and Technology, Xi'an 710055, China

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## 8.1 Introduction

Existing residential building energy-saving reconstruction is a problem in the field of building energy-saving, because raising money is very difficult, the owner decision-making is very difficult and the implementation is very difficult. At present, China's residential energy-saving reconstruction is almost dominated by government and some energy service companies and construction units participate in it. However, with the propulsion and deepening of the residential energy-saving reconstruction, it will be the inevitable trend that the current mode turns into the market-oriented operation. With the improvement of quantification and means of payment on energy-saving reconstruction external benefit, the market-oriented operation will meet the requirement. REREs under exploring are the kind of new undertaking, which emerge various forms. They are, the energy services companies (ESCOs) which have a mature operating mode for public building energy-saving reconstruction but has also some inadaptability for residential energy-saving reconstruction, some construction units which are in charge of energy-saving renovation construction but sometimes participate in other management work, and the other small REREs. China's "twelfth five-year" building energy saving special plan pointed out that it is necessary to cultivate energy-saving services industry. The development of REREs is very important to building energy-saving industry in china.

The external environment of REREs is highly developed corporate governance mechanism and a large number of owners possessing their houses, therefore, the organizational structure of RERE is not confined to the size or complexity. In fact, the aim of RERE is to reach the enterprise objectives including economic benefit, social benefit and environmental benefit. Different sizes of enterprises can adapt to different sizes of the target market, a good market with orderly competition will take place. At present, the researches on REREs' organization structure is relatively less, which are most related to the influence factors of REREs' organization structure, including the financing ability, risk management ability and professional ability of ESCO [4], the development and scale of ESCO [2], the operational mode of ESCO [9], the change of ESCOs' market [7], and the limitations on growth and proposal about development of ESCOs [3, 6].

Faced with increasing uncertainty and variability in modern society and the dispersibility and complexity of REREs' market, REREs need to adapt themselves to changing circumstances and their organization structure also need to be dynamically managed according to the condition change. Therefore, the influence factors and dynamic management quantitative analysis of REREs' organization structure are discussed in the paper.

## 8.2 Analysis of Influence Factors of REREs' Organization Structure

Based on the analysis of external and internal factors of RERE [1, 5, 8], the influence factors of REREs' organization structure are summarized as follows.

### 8.2.1 Characteristics and Goals of Growing Phrases of Enterprise (F1)

There are different characteristics and goals in different growth stages of RERE, so the design and application of enterprise organization will have different requirements. In general, the small RERE at the beginning of the creation is suited to adopt the organization structure that decision is efficient, power and responsibility is clear, and the form is simple, the line structure is often applied. When enterprises become mature and their sizes become bigger, depending on the degree of business development, the matrix structure or the divisional system can be used. In the field of building energy-saving, a RERE at the beginning of the creation may be a large group company integrating various resources, but even so, there are still differences between the beginning and the running on the right path in the aspect of organizational form. For example, when the divisional system is applied under the circumstances, usually, degree of separation of powers will be slightly less in the initial stage, and will be gradually achieved in later stage.

### 8.2.2 Management Thought (F2)

The management thought of RERE is the basic guiding ideology for enterprise to engage in the production and business operation activities, and to some extent, represents the character of enterprise decision-makers. What kind of management thought is what kind of enterprise destiny, the management thought profoundly affects all aspects of the enterprises. The management thought of RERE plays an important role in enterprise organization structure, because the different concepts of competition, customers, and employees will affect adopting different organizational forms for RERE.

### 8.2.3 Enterprise Culture (F3)

General enterprise culture includes the enterprise spirit culture, system culture and material culture. It as used here narrowly refers to the enterprise spirit culture and the part of system culture, which mainly represents the quality, character or personality of whole enterprise and has a direct impact on all aspects of enterprise operation. From a certain perspective, the enterprise management thought is an important part of enterprise culture, and the enterprise culture has a broader scope. Furthermore, enterprise management thought can focus more on the decision-makers character and the enterprises culture has more emphasis on overall enterprise personality. The enterprise culture of RERE influences and restricts the organizational structure in many details. For example, REREs may require employees to work overtime, because of the need to reduce the total time of the construction interference with owner life. Here, the frequency, intensity and consciousness of work overtime in the enterprise culture will directly affect the organization structure and human resource allocation.

### *8.2.4 Enterprise Strategy (F4)*

REREs in the emerging market are facing the problem of building energy-saving, need to solve the problem of survive, then consider sustainable development. Different enterprises would have different strategies, large-scale REREs may be under great cost pressure and even have a loss, after approval by the market, obtain economies of scale. Small REREs can target their customers to provide a more personalized services, such as supporting comprehensive repair, thus they gain their market share. Scale strategy and personalization strategy have difference influences on enterprise organization structure design. Therefore, the different strategies will result in different enterprise organization structure.

### *8.2.5 Enterprise Types (F5)*

In order to adapt to different target markets, REREs would be bound to form different enterprise types. Capital intensive, intelligence-intensive, technology-intensive and labor-intensive REREs have different characteristics about the financing, investment, service models, technology application and construction work, hence, the designs of organization structures will have different requirements and emphases.

### *8.2.6 Enterprise Size (F6)*

Usually large REREs are comprehensive enterprise that the overall planning, preliminary operation, funding, technology, construction or guidance, and related services are achieved in residential energy-saving reconstruction projects. Therefore, large REREs tend to adopt the divisional system or matrix organization structure, and small REREs like more using the line structure or line and staff organization because of few employees and needs to be simple and efficient organizational structure.

### 8.2.7 Market Change (F7)

When the REREs' market changes from the small-scale market with a single building or residential area to the regional or national market, the enterprise organizations need to make adaptive changes, such as from the organizational structure with line structure to the divisional system. On the other hand, if the REREs' market is shrinking, the reverse adjustment of organizational structure will also need to be done to some extent.

### 8.2.8 Macro-circumstance (F8)

The current situation and future trends of macro environment will affect the organization structure design of REREs. The macro environment, here, broadly includes industry environment, national environment and international environment. When residential energy-saving reconstruction industry environment has the bigger attraction, for example, potential competitors is not easy to enter, and political and economic environment both at home and abroad is good, will force enterprise to adopt expansion and upgrade operation, these will lead to the adaptive change of enterprise organization structure.

The RERE organization structure is affected synthetically by the above factors, the essential role of it is to reach the enterprise target, or show the adaptability to influencing factors. Nothing is fixed in form, and nothing is the best for organizational structure. The decision of organizational structure of REREs will need to be made by measuring whether the organizational structure is suitable for enterprise.

## 8.3 Dynamic Management Model of Organization Structure for REREs

Based on the analysis of the influence factors and the system efficiency of organization structure of REREs, applying synthesis scoring method and addition rule of efficiency evaluation, the dynamic management model of organization structure for REREs is established as follows.

### 8.3.1 Precondition

The precondition of dynamic management model of organization structure for REREs include the followings:

1. The weight comparison relationship of adaptability evaluations of organization structure to the influence factors exists;

2. The weight comparison relationship of efficiency evaluation indexes of organization structure exists;
3. The evaluations of efficiency indexes of organization structure can be quantitative, and addition rule exists

### 8.3.2 Organization Structure Adaptability Efficiency Function

The organization structure adaptability efficiency function of REREs refers to the function that the adaptive efficiency of a type of organizational structure is the weighted average of the adaptability evaluations of the organization structure to influence factors. From this, the organization structure adaptability efficiency function of REREs can be achieved as Eq. (8.1):

$$E_1(x) = \sum_{i=1}^{8} w_i E_{F_i}(x) \tag{8.1}$$

Where, $E_1(x)$ is the adaptability efficiency evaluation function value of Organizational Structure $x$ to influence factors; $E_{F_i}(x)$ is the adaptability efficiency evaluation value of Organizational Structure $x$ to Influence Factors $F_i$; $w_i$ is the weight of adaptability efficiency evaluation value of Organizational Structure $x$ to Influence Factors $F_i$.

### 8.3.3 Organizational Structure Future Stability Evaluation Function and Future Flexibility Evaluation Function

The organization structure adaptability efficiency function is to measure the efficiency of the enterprise organization structure under current condition. Moreover, the future stability evaluation function and the future flexibility evaluation function are to appraise the enterprise organization structure performance in the future,which are auxiliary efficiency evaluation indexes. The organizational structure future stability evaluation function can be obtained as Eq. (8.2):

$$E_2(x) = \frac{m(x)}{M(x)} \tag{8.2}$$

Where, $E_2(x)$ is the future stability evaluation function value of Organizational Structure $x$; $m(x)$ is the forecast duration years of Organizational Structure $x$; $M(x)$ is the reference duration years of Organizational Structure $x$, set by enterprises or industry organizations.

The duration of the organizational structure is too long will weaken the enterprise market competitiveness, and will bring many problems, therefore, the additional constraint conditions are given as follows: when $m(x) \geq M(x)$, get $m(x) = M(x)$.

The organizational structure future flexibility evaluation function can be obtained as Eq. (8.3):

$$E_3(x) = \frac{v(x)}{V} \tag{8.3}$$

Where, $E_3(x)$ is the future flexibility evaluation function value of Organizational Structure $x$; $v(x)$ is the evaluation value of Organizational Structure $x$, aimed at achieving increased orders; $V$ is the evaluation value of ideal organizational structure, when achieved increased orders.

### *8.3.4 Organization Structure Synthetical Efficiency Function*

Organization structure synthetical efficiency function of REREs can be given as Eq. (8.4):

$$E(x) = a_1E_1(x) + a_2E_2(x) + a_3E_3(x) \tag{8.4}$$

Where, $E(x)$ is the synthetical efficiency function value of Organizational Structure $x$; $a_1$, $a_2$, $a_3$ are respectively the weights of the adaptability efficiency evaluation function value, the future stability evaluation function value, and the future flexibility evaluation function value of Organizational Structure $x$.

### *8.3.5 Dynamic Management of Organization Structure*

Set up the alternative option set of organization structures of REREs: $X = \{x_1, \cdots, x_n\}$, the influence factors set of organization structures of REREs: $F = \{F_1, \cdots, F_8\}$, the weight set of adaptability efficiency evaluation value of the organizational structure to influence factors: $W = \{w_i, i = 1, \cdots, 8\}$, the synthetical efficiency evaluation factor set of the organizational structure: $E = \{E_1, E_2, E_3\}$ and its corresponding weight set: $A = \{a_1, a_2, a_3\}$.

Based on the precondition that adaptability evaluations of organization structure to the influence factors and efficiency evaluations of organization structure can be quantified, and the quantification of efficiency of the organizational structure conforms to the rules of addition, the best organization structure form is given as follows:

$$x_k, \text{when and only when } E(x_k) = \max\{E(x_1), E(x_2), \cdots, E(x_n)\}$$

REREs can evaluate the efficiency of the organization structure according to the change of influence factors, and will manage the enterprise organization structure dynamically. But it should be realized that this model is a kind of analysis tool, and the enterprise organization structure should have the stability and flexibility to some extent, not change frequently.

## 8.4 Case Study

The RERE is a new small enterprise, which is located in south suburb of Xi'an City, Shaanxi Province. According to characteristics of the industry and the enterprise, the analysis and the decision of the enterprise organizational structure are made. After a preliminary screening, three alternative option are given as follows: $x_1$ – line structure, $x_2$ – line and staff organization structure, and $x_3$ – simplified matrix organization structure, which has the characteristics of the project company, but can keep the ability to adapt more than project in the future. Applying the dynamic management model of organization structure for REREs, the optimizing organization structure for the enterprise will be obtained.

Above all, set up the alternative option set of organization structures of REREs: $X = \{x_1, x_2, x_3\}$, the influence factors set of organization structures of REREs: $F = \{F_1, \cdots, F_8\}$ and the synthetical efficiency evaluation factor sets of the organizational structure: $E = \{E_1, E_2, E_3\}$.

Using expert consultation method, aimed at the current internal environment and external environment of the enterprise, set up the weight set of adaptability efficiency evaluation value of the organizational structure to influence factors: $W = \{0.18, 0.15, 0.08, 0.12, 0.12, 0.12, 0.17, 0.06\}$ and the weight set of synthetical efficiency evaluation factor of the organizational structure: $A = \{0.8, 0.1, 0.1\}$.

The synthetical efficiency of Organizational Structure $x_1$ is calculated as follows. Using expert consultation method, set up the vector of adaptability efficiency evaluation result value: $E_F(x_1) = [0.8, 0.7, 0.5, 0.4, 0.6, 0.8, 0.8, 0.5]^T$.

Using Eq. (8.1), therefore, $E_1(x_1) = 0.671$.
Using Eqs. (8.2) and (8.3), $E_2(x_1) = \frac{1.5}{3} = 0.5$, $E_3(x_1) = \frac{0.5}{1} = 0.5$.
Using Eq. (8.4), hence, $E(x_1) = 0.637$.

Similarly,

$$E_F(x_2) = [0.7,\ 0.7,\ 0.8,\ 0.8,\ 0.6,\ 0.7,\ 0.7,\ 0.8]^T,\ E_1(x_2) = 0.714,$$

$$E_2(x_2) = \frac{3}{3} = 1,\ E_3(x_2) = \frac{0.68}{1} = 0.68,\ E(x_2) = 0.739$$

$$E_F(x_3) = [0.9,\ 0.6,\ 0.8,\ 0.9,\ 0.7,\ 0.8,\ 0.9,\ 0.8]^T,\ E_1(x_3) = 0.805$$

$$E_2(x_3) = \frac{3}{3} = 1,\ E_3(x_3) = \frac{0.85}{1} = 0.85,\ E(x_3) = 0.829$$

Hence, $E(x_3) = \max\{E(x_1), E(x_2), E(x_3)\}$, namely, under the current condition of the RERE, the optimizing organization structure is Organizational Structure $x_3$-simplified matrix organization structure.

## 8.5 Conclusion

Based on the analysis of the influence factors and the system efficiency of organization structure of REREs, the dynamic management model of organization structure for REREs is established in this paper. The model is suitable for REREs to update its organization structure according to the change of internal and external influence factors, so it will be an effective tool of dynamic management organization structure. Due to the complexity of the operation mechanism and a certain degree of uncertainty of the organizational structure, the decision of organizational structure should be made with the unification of the quantitative analysis and qualitative analysis. At the same time, for the quantification and measure of the efficiency of the organization structure should be further studied.

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# Chapter 9
# A Comparison of Sustainable Urban Development Indicators Between Major Cities in China

**Weijian Ren, Bei He, Jingyang Zhou, Hang Yan, and Liyin Shen**

**Abstract** Application of sustainable urban development indicators is one of the most important strategies to achieve the mission sustainable development. Appropriateness of the indicators is therefore essential to the successful achievement of the mission. Particularly, those developing countries such as China where there are huge plans of future urbanization need effective indicators to guide the practice of their urbanization plans. Previous studies have presented various sustainable urban development indicators and the methods for establishing these indicators. This paper presents a comparison of sustainable urban development indicators between 30 provincial capitals in China. There are clear differences between different cities in the perspective of choosing indicators. The results demonstrate the relationship between the choice of key indicators and the type of cities. The research findings provide valuable references for studying effective indicators in guiding the practice of urbanization towards sustainable development mission with considering special characteristics of a specific city.

**Keywords** Sustainable development • Urbanization • Sustainable urban development indicator • Comparative analysis • China

W. Ren (✉) • B. He • H. Yan • L. Shen
School of Construction Management and Real Estate, International Research Centre for Sustainable Built Environment, Chongqing University, Chongqing, China
e-mail: 291826903@qq.com

J. Zhou
School of Construction Management and Real Estate, International Research Centre for Sustainable Built Environment, Chongqing University, Chongqing, China

Department of engineering management, Shandong Jianzhu University, Jinan, China

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## 9.1 Introduction

Based on Niu's [2] report of China's new-type urbanization, the urban population of Chinese Mainland is 690.79 million, the urbanization rate has increased to 51.3 %. China's urbanization rate is estimated to reach 56.5 % in 2020 according to the Outline of the National Urban System Planning (2005–2020). By 2020, there will be 1,500 cities and 824.90 million citizens living in them [28].

In the view of economist Joseph Stiglitz, a Nobel Prize winner, "the urbanization in China and the high-tech development in the United States will be the two keys to influence the human development in the 21st century deeply . . . China's urbanization will be a locomotive for the regional economic growth and produce the most important economic benefits" [32]. Meanwhile, cities with high population density are suffering from a series of problems, such as traffic congestion, air pollution, climate change and others [36]. With the rapid expansion of modern urbanization, more and more problems will be faced by cities. For the long-term interest of mankind, the sustainable principles are necessary to guide the development of cities. Human society is difficult to sustain without the security of sustainable urbanization [39]. The Chinese Premier Li proposed that urbanization is not simple population growth and urban expansion. More importantly, the quality of urbanization should be given more attention [44]. In addition, scientific planning, reasonable allocation and intensive development should also be highlighted to achieve the transformation from rural to urban. Since reform and opening up, China's urbanization has achieved tremendous progress. However, it also brought some problems, especially huge environmental cost. According to correlation studies, the loss caused by environment pollution accounts for 5~6 % of China's GDP every year. For example, China's GDP is 47 trillion Yuan in 2011, hence the loss caused by environment pollution would reach 2.35~2.82 trillion Yuan [17]. Therefore, many experts appeal that urbanization should follow the principles of sustainable development. Li [13] claimed that the traditional way of using huge investment and urban expansion to achieve the targets of urbanization is unsustainable. These urbanization related problems present the pressing need for changing the current mode of economic development and adopting the theory of sustainable development to guide urbanization in the future.

As one of the national strategies, sustainable development is a huge system engineering. Therefore, the decision-making should be based on accurate information and effective analysis methods. While previous studies have introduced various methods to assess the sustainability of urbanization, the most effective is an indicator value by using a set of indicators [7]. Appropriate urban sustainability indicators play a crucial role in achieving the target of sustainability performance. Nevertheless, there are many studies about indicator system of urban sustainable development in China, but they are mainly related to how to establish an indicator system. The comparison of the urban sustainable development indicator systems can be rarely identified, which could improve the decision-making process of selecting indicators. Hence, the comparison of these existing urban sustainable development indicator systems is very important, because it can lead to the understanding on what and how indicators are adopted in the current practice.

Many indicator systems of urban sustainable development have been put forward by scholars. Some indicator systems cover society, economy, environment and governance aspects, while others emphasize one aspect, such as social development indicator system, economic development indicator system or ecological environment indicator system. But these indicator systems are based on a specific city respectively, there are great differences not only in the frame of these indicator systems but also in the selection of indicators. For example, the first-class indicators in Chongqing consist of economy, population, resource and environment, and social stability aspects. But they are composed of afforest level, environment quality, environment management, population, economic development and material culture life in Lhasa's by contrast. On the other hand, the first-class indicators in Yinchuan and Changsha are similarly divided into economic, social, environmental resource, but there are 20 indicators in Yinchuan's indicator system in contrast with 66 indicators in Changsha's. Scholars have established various indicator systems of sustainable development for different regions, but few studies analyze the differences of these indicators system in various areas. Actually, the analysis of the existing indicator systems has a great significance on both theory and practice which could guide the selection and application of these indicators. Hence, the aim of this study is to find out the existing indicator systems and the differences between them.

## 9.2 Research Data

A comprehensive literature review was conducted to obtain the information needed for pursuing the objectives of this research. Indicator systems to evaluate urban sustainability in China are identified firstly. Then they are selected at the level of provincial capital. Because the provincial capitals have the local representative as the political, economic and cultural center of a specific area. The indicator systems of urban sustainable development of 20 provincial capitals, five autonomous region capital cities and four municipalities are selected. But the Guiyang's indicator system of urban sustainable development is not identified. To maintain the integrity of the samples, Guizhou's sustainable development indicator system is used for replacing Guiyang's. Finally, 30 samples [2, 9, 11, 12, 14–27, 30, 34, 41–43, 46–51, 53, 54] are collected for the analysis in this study.

Various classifications of indicator system are defined by researchers, but most of the indicator systems have the same three tier structure, namely, economic, environmental and social. The studies of Shen [33] and UNDSD [38] are consulted to classify the indicators. And according to the frequency of the first-class indicators, the first-class indicators are categorized in four different dimensions: social, economic, environmental, governance. The same method is used to categorize the second-class indicators. Finally, the classification of the second-class indicators is presented in Table 9.1.

**Table 9.1** The second-class indicators

| Dimension | The second-class indicators |
|---|---|
| Social | Population, Science and educational level, Health care, Living standard, Infrastructure, Social security, Social stability |
| Environmental | Current situation of environmental resource, Environmental pollution, Environmental control |
| Economic | Economic level, Economic structure, Economic efficiency, Economic prosperity, Economic intensity, Economic export-orientation |
| Governance | Laws and regulations, Coordination capability |

**Table 9.2** The third-class indicators adopted in more than four indicator systems

| Dimension | The third-class indicators |
|---|---|
| Social | Employment rate, Per capita disposable income, Engel's coefficient, Natural population growth rate, Urbanization rate, Population density, Number of students in school per 10,000 inhabitants, Number of books per capita in public library, Proportion of invest of science, technology and sanitation, Number of sickbeds per 10,000 inhabitants, Number of doctors per 10,000 inhabitants, Per capita living space, Number of mobile phones per 10,000 inhabitants, Number of buses per 10,000 inhabitants, Per capita living power, Water consumption per capita, Road area per capita, Water supply pervasion, Penetration rate of fuel gas, Per capital passenger traffic, Social insurance coverage, Gini coefficient, Registered urban unemployment rate, Number of criminal cases per 10,000 inhabitants, Number of traffic accidents, Communication network covers |
| Economic | GDP growth rate, Per capita GDP, GDP per unit of area, Gross Domestic Product, Per capita local fiscal revenue, The first industry accounted for the proportion of GDP, The second industry accounted for the proportion of GDP, The tertiary industry accounted for the proportion of GDP, Proportion of staffs employed in the second industry, Labor productivity, Per capita total retail sales of social commodities, Energy consumption per 10,000 Yuan of GDP, Water consumption per 10,000 Yuan of GDP, Per capita amount of the actual use of foreign capital |
| Environmental | Cultivated Area per capita, Green area per capita, Urban green coverage rate, Water resources per capita, Forest coverage rate, Urban $so_2$ concentration, Industrial waste water emissions, Treatment rate of industrial effluents, Compliance rate of discharge of industrial effluents, The industry solid reject synthesis use factor, Industrial waste gas disposal, Industrial waste gas emissions rate, Living garbage harmless treatment rate, Urban sewage centralized treatment rate, Achieved rate of drinking water qualification, Noise pollution, Proportion of environmental investment in GDP |
| Governance | |

As for the third-class indicators, large differences are examined between different samples. Four hundred and thirty-five indicators are identified in the 30 indicator systems, but only a few are adopted commonly. The indicators adopted by more than five samples are listed in Table 9.2.

## 9.3 Data Analysis

It should be noted that most of the 435 indicators are not generally recognized, some of them even exist in only one or two samples. For example, “family planning rate” is identified only in Nanchang, “the output value of tertiary industry” is identified only in Kunming. There are also many indicators like that, such as “coal consumption per unit of GDP” in Taiyuan, “comprehensive utilization ratio of the three wastes” in Fuzhou, and so on.

After classifying the collected data, the frequency and distribution of 435 indicators is presented in Table 9.3. As shown in Table 9.3, sustainable indicators are mainly concentrated in three dimensions—social, economic, and environmental. The indicators of governance dimension which should be regarded as crucial indicators are underestimated. The management by government such as establishing the timely legal regulations, strengthening the official supervision, and others have a significant impact on guiding the practice of urbanization practice. Meanwhile the indicators of government dimension are also adopted as the sustainable indicators by more and more systems such as the indicator system made by US EPA Office of sustainable Ecosystems and Communities (OSEC) and University of Massachusetts (1955).

For further analysis, the indicators adopted by more than 10 samples are selected. The examination and identification have been given to those indicators which have the same meanings but different names. The results are shown in Figs. 9.1, 9.2, and 9.3 respectively.

There are 17 indicators referred to governance, but none of them is adopted by more than 10 indicator systems, thus there is no figure presented.

In Fig. 9.1, it is quite noticeable that there are five economic indicators relate to GDP. However there are obviously some drawbacks using too much indicators referred to GDP to measure the level of economic development. Take the economic indicators in Lhasa’s sustainable indicator system as an example, there are five out of six indicators referred to GDP in economic dimension to assess the sustainability of Lhasa’s economy. This phenomenon which undoubtedly reflects an overemphasis on GDP is unreasonable and unscientific because the simple GDP indicator cannot reflect the economic conditions entirely and evaluate the potentials correctly. In China Development Forum, Stiglitz [35] pointed out that the quality of China’s economic growth was more significant than GDP, and GDP cannot assess

**Table 9.3** The frequency and distribution of 435 indicators in the inclusion in 30 samples

| Dimension | Frequency | | | | Total |
|---|---|---|---|---|---|
| | 0–5 | 6–10 | 11–15 | 15–30 | |
| Society | 149 | 15 | 3 | 5 | 172 |
| Economy | 107 | 7 | 1 | 2 | 117 |
| Environment | 113 | 10 | 5 | 1 | 129 |
| Government | 17 | 0 | 0 | 0 | 17 |

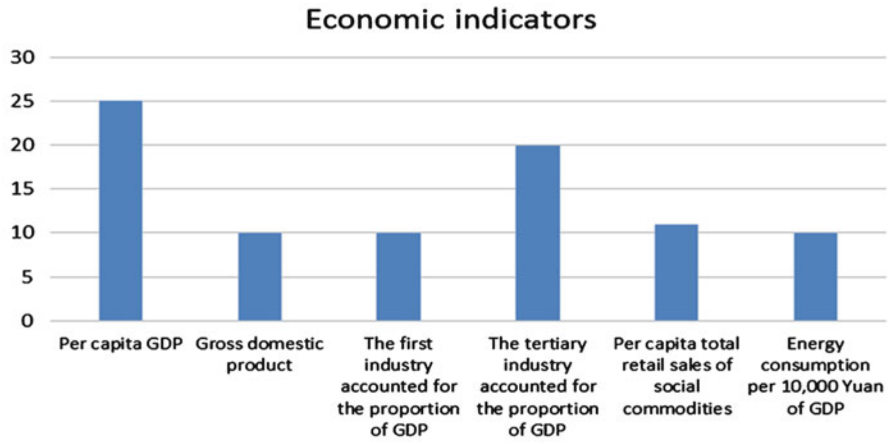


**Fig. 9.1** Economic dimension

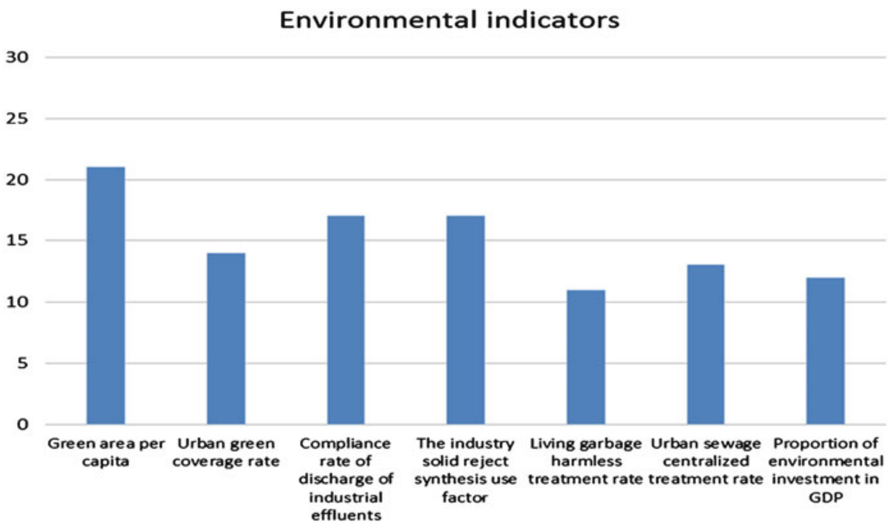


**Fig. 9.2** Environmental dimension

the quality of life and environment. Overweighting GDP but ignoring its quality will lead to extensive development at the cost of environment and cause more social and environmental problems. It is not consistent with the principle of sustainable development and will hold back the economic growth finally. To solve this problem, UNDP has adopted HDI [37] as an alternative indicator and NDRC puts forward a method to calculate green GDP [31].

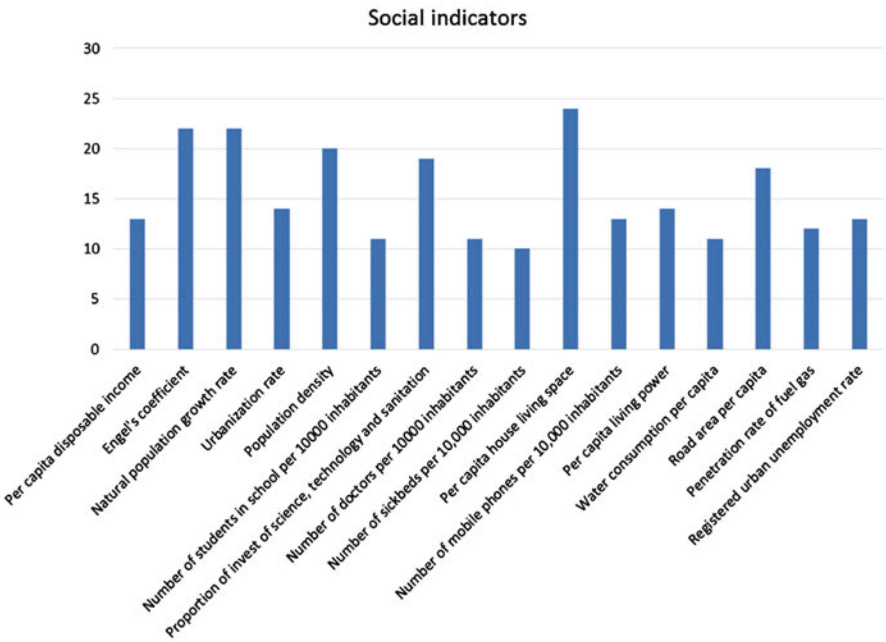


**Fig. 9.3** Social dimension

As shown in Fig. 9.2, there are seven environmental indicators adopted in more than 10 indicator systems, these seven indicators are related to the occupation of farmland, water, green fields, forest resources and disposal of waste water, exhaust fumes and waste material, which reflect resource condition and the protection of environment in a city. It is not considerate for a few indicator systems which ignore the availability of the data and public participation, which results in the indicators dispersion and ineffective communication directly. For example, it is obscure about the meaning of the indicator “proportion of nature reserves area and area with special science value in total area”. A prefect indicator system should provide effective information for experts, easy communication for policy makers and public. Only in that way can the strategies of sustainable urbanization be achieved. Therefore, researchers should fully consider the meaning of indicators, the effect to stakeholders and their maneuverability when choosing indicators.

The social indicator category involves 172 indicators, with the dispersion of indicators in terms of meaning and name. For example, when representing “per capita disposable income”, different indicator systems use different indicators such as “per capita disposable annually”, “per capita disposable income of urban households”, or “per capita disposable income of residents” and others. These differences will reduce the comparability of indicators. All social indicators mainly focus on population, consumption, social service, the elimination of poverty, health, human settlements, the security and the stability of society. However, some indicators should be rejected and replaced for their poor timeliness. Take “telephone capacity per 10,000 people” as an example, according to statistics, the number of smart mobile phones is 360 million in China in 2012 and it will reach 710 million by 2016 [8]. This indicator has not played a key role like before owing to the developed communication and rapid development of information. Another example, which is worth to mention, is that there is no indicator involving Metro. “Number of bus ownership per 10,000 inhabitants” can no longer describe the current traffic situation because 17 cities in China have had the metro system and the ridership of Beijing subway has reached 10.27 million in record [5].

## 9.4 Discussion

### *9.4.1 The Difference of Indicators Between Different Samples*

As mentioned earlier in this article, the structure and content of the 30 samples differ from each other greatly. In the three class of indicator system, only the first-class show commendable consistence which focuses on environmental, economic, and social dimensions. However, in the third class which is composed of 435 indicators, there are only 32 indicators adopted by more than five samples simultaneously which indicates large differences in the selection of indicators. The rest of indicators are not commonly adopted. It demonstrates that different researchers choose different indicators when evaluating the same thing for lacking of a certain uniform standard to set indicator system. Besides, the same indicator is included in different categories by researchers in different systems. For instance, “per capita disposable income” is assigned to economic dimension to reflect the level of economy progress in Tianjin, Chengdu, Urumchi, Yinchuan and Kunming. On the contrary, this indicator is assigned to social dimension to express living standard in Xinjiang, Fuzhou, Jinan, Nanning, Lanzhou and Shanghai. Similarly, “energy consumption per 10,000 Yuan of GDP” belongs to economic dimension to reflect the intensity of economy in Nanchang, Shijiazhuang, Tianjin, Guizhou and Urumchi, but it is classified into environmental dimension to reflect the utilization situation of natural resources in Xi’an and Jinan. These differences bring many difficulties to compare the indicator systems.

Several reasons can explain these differences. Firstly, different cities have their own characteristics and backgrounds in various aspects such as environment, economy, and society. Therefore, different researchers have different understanding to the achievement of urban sustainable development based on a given city. For example, the characteristics of desert in Xinjiang determine the speed of desertification has significant influence on its purpose of sustainable development. And for the city of Lanzhou which depends entirely on the Yellow River for water resources, the environmental quality directly affects the urban sustainable development. As a result, “rate of desertification” and “water pollution comprehensive index of the Yellow River in Lanzhou section” are adopted in indicator systems of Xinjiang and Lanzhou respectively. Secondly, there are still no standards pertinent and universal methods or criteria for selecting urban sustainability indicators [10]. Although there are many common principles for selecting indicators, the difference of methods caused the selection of different indicators. Thirdly, some indicators have more than one attribute. For example, “per capita disposable income” has dual attributes of social and economic. When the priority is given to a city’s economic development than social development, it will be included in economic dimension, and vice versa. Similarly, “energy consumption per 10,000 Yuan of GDP” can reflect both the dependence degree of economy on energy consumption and the effect of energy saving measures, therefore, it was classified into economic dimension in some cities while into environmental dimension in others. The three reasons mentioned above are the major contributors to the differences existed among 30 sample indicator systems.

### *9.4.2 The Need for Improving the Effectiveness of Indicators for Application*

An effective indicator system has important guiding significance for urban sustainable development. Nevertheless, only the indicator system is effectively applied in practice, can it realize its value. Therefore, it is important to increase the quality of indicator systems to guide sustainable urbanization practice efficiently. Meanwhile, it is considered necessary to link sustainability indicators to some reference values and targets based on some successful examples from real policy making [29]. Most of the 30 samples adopt the form of comprehensive indicator system to evaluate the performance of urban sustainability. However, the indicator systems vary considerably from each other in 30 samples for lacking of uniform standards and methods. And the coverage of indicators is very widely. The data of some indicators even are difficult to be obtained due to the lack of sources. The guiding significance of indicators for application is limited. In fact, it is hard to compare the sustainability between different cities with the considerable discrepancy of the indicator systems.

City is a complicated system, effective communication on the status of urban sustainability is very necessary, especially for the public. Only through the full participation of stakeholders, can effective sustainable urbanization strategies be developed [6]. The establishment of an effective indicator system needs proper communications between government and the public. For this reason, Doody et al. [4] proposed the Q-method to facilitate the participants of the public in making a significant contribution to the development of the indicators. It is appreciated that public participation is currently not enough in the process of decision-making in urbanization [6]. On one hand, the public’s rights to know should be strengthened by government. For example, PM2.5 which is considered as one of the most important indicators to reflect air pollution was only revealed at the requirement of public. And the monopoly of some data handled the participation of the public to the process of urban sustainable development. On the other hand, the awareness of the public to the process of urban sustainable development is still relatively poor [3]. They believe that establishing an indicator system for evaluating urbanization sustainability is the responsibility of local government. It limits the formulation of public participation mechanism.

Since the Chinese government set the China's Agenda 21 and implemented the sustainable development strategy, there are nine institutes which have proposed their indicator system of sustainable development according to statistics, such as the National Bureau of Statistics of Science Research Institute, State Environmental Protection Administration, Ministry of Science and Technology and others [52]. Although the indicator system by the State Environmental Protection Administration has been successfully used in evaluating the performance of sustainable development experience zones, there is still no widely accepted and applicable indicator system which is suitable for different regions in China. The strengths and efforts on the policy-making to promote sustainable development are still not enough. In fact, significant negative consequences have been exposed for ignoring environmental protection in the process of previous urbanization. For instance, 14 cities including Beijing, Wuhan, Nanjing and Jinan had suffered urban waterlogging in succession which seriously threaten people's lives and had caused huge economic losses to society in 1 month from June, 14 to July, 13, 2011 [45]. It is mainly because economic benefit is overemphasized rather than improving benefits of society and environment. It is worth mentioning that this kind of unsustainable urbanization model has been increasingly given attention by the top leaders in China. For example, President Xi [40] proposed that it is unwise to evaluate the achievements of urban development just relying on GDP. Therefore, an indicator system following the uniform principles of sustainable development is the premise to ensure sustainable urbanization in the future.

## 9.5 Conclusions

This paper collected 30 indicator systems for evaluating the urban sustainability. After the comparison and analysis on the contents and structure of indicators included in 30 samples, considerable differences are found between those samples for lacking of a uniform criteria and methods when establishing an indicator system. It leads to difficulties to compare the sustainability of different cities. These 30 indicator systems proposed in previous studies have limited guidance effectiveness to conduct sustainable urbanization. It indicates that the government has yet to recognize the importance of indicator system for guiding sustainable urbanization.

According to Northam Curve [1], China's urbanization process is at an accelerating stage in which the urbanization rate changes from 50 to 70 %. Under the rapid urbanization, it is imperative to transfer the pattern of economic development into more sustainable way. Therefore, it is important to adopt an effective indicator system to instruct city's development practice. And some indicators about the performance of sustainable urbanization should be considered when evaluating the performance of city decision-makers. It is also important to encourage the public to participate in the decision-making process of urban development. With the growing demands for living environment and harmonious society by the public, the sustainable development indicator system is an important way to guide the development of cities towards sustainable development.

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# Chapter 10
# Analysis of Feasibility on Integration of High-Rise Building and Wind Power

**Hong Zhou, Qi Wu, and Ding Nan**

**Abstract** As the advancement of the process of urbanization and the growth of population, the ratio of constructional energy consumption and the total energy consumption has multiplied rapidly in a short periods. At the mean while, the general energy source is limited which could not stand the huge pressure from energy consumption. However, as a kind of clean, green and effective energy, wind power draws more attention from countries than before. These countries began to focus on micro wind and put it into practice when developing large-scale wind power. The utilization of wind power in buildings is a type of micro wind utilization. This paper summarized the conditions of utilization of winds in buildings and the installation form of wind generator in high-rise buildings. The limitation of utilization of wind is its instability. Through the idea of transformation of utilization and shortening its path, we can settle the basic problem of energy loss and storage. The study indicated that wind power generation is technique with the least environmental cost. From the prospect of life cycle, wind power technique only generates Carbon dioxide in constructional phase. As a result, under the condition of sufficient wind resource and reasonable system design, the technique of wind power integration design in buildings should have obvious economic benefits.

**Keywords** High-rise building • Wind power • Integration design • Feasibility

## 10.1 Introduction

In recent years, countries all over the world began to realize the local wind resources and the use of micro wind. The latest research showed that wind power generation technology is an effective way to reduce the cost of wind power [1].

H. Zhou (✉) • Q. Wu • D. Nan
School of Architecture and Civil engineering, Xiamen University, Xiamen 361005, China
e-mail: mcwangzh@xmu.edu.cn

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The world started to try to utilize local wind power and micro wind, such as Bahrain World Trade Center, which is the world's first building using wind power as its electricity source among the similar buildings, installed three units horizontal axis wind turbines which is enough to supply a whole year electric lighting to 300 home users (2008); Kettle Foods factory [2] and Miami Cor Tower, Dubai Energy Tower and so forth. The situation of Chinese current wind power application is large-scale wind farms coexist with small independent wind farms in rural remote areas. Wind power study and application in urban high-rise buildings have also begun, such as the Guangzhou Pearl River City and Shanghai Tianshan Road 3 kW vertical axis wind turbine project. Construction is a large power consumer. The development of wind power and building integration technology can reduce more than 20 % of building energy consumption. Wind energy utilization in the building environment has the advantages of being free from delivery, the electrical energy of which can be directly used for the building itself, and this provides a new idea for the development of building energy conservation. However, in respect to the extensive use of wind energy in the high-rise building, the industry still has certain technical hesitation and efficiency concerns.

## 10.2 Wind Characteristics of Urban High-Rise Buildings

Different from the conditions of large-scale wind farm development, the urban wind velocity is generally less than the suburbs since it is blocked by buildings. However, strong local wind pressure may also appear around buildings. When the wind encounters obstacles from buildings, the direction and velocity of the wind will change and vortex or angular flux will exist. In the position of slots or holes of buildings, as the suddenly change to smaller cross-section of wind flow, a "narrow pipe effect" appears and a strong "cross-ventilation" or "canyon wind" will be formed (Figs. 10.1 and 10.2).

In order to work effectively, urban high-rise building wind power generation system should satisfy the following conditions: first: sufficient resource of local wind; second: ideal local wind environment.

## 10.3 Integrated Technical Feasibility on Urban High-Rise Buildings and Wind Power Technology

### *10.3.1 The Creation of Urban High-Rise Buildings Under Wind Environment*

Generally speaking, since the buildings of urban are dense, both utility and creation on wind environment can bring the conditions of utilization of wind power

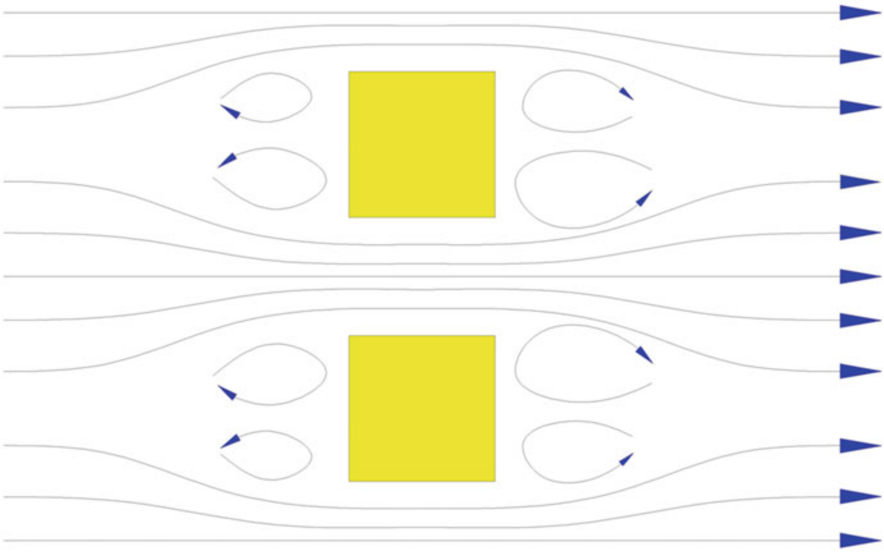

**Fig. 10.1** Sketch of horizontal wind direction of high-rise building

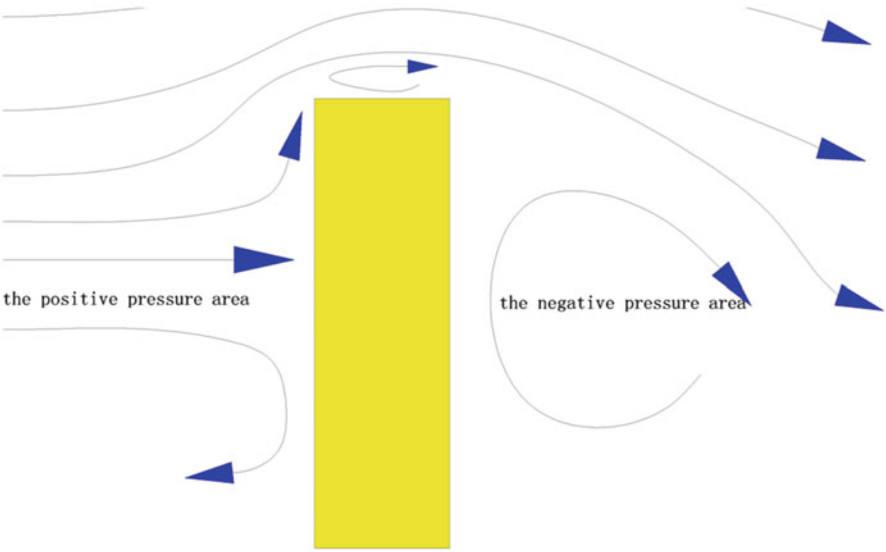


**Fig. 10.2** Sketch of vertical wind direction of high-rise building

technology. Architects can take the advantages of the principles of aerodynamics, make architecture form be friendly to wind power and thus can improve the local wind environment which could guarantee the operation of wind turbines efficiently. For example: in order to obtain more wind energy amongst buildings, we can

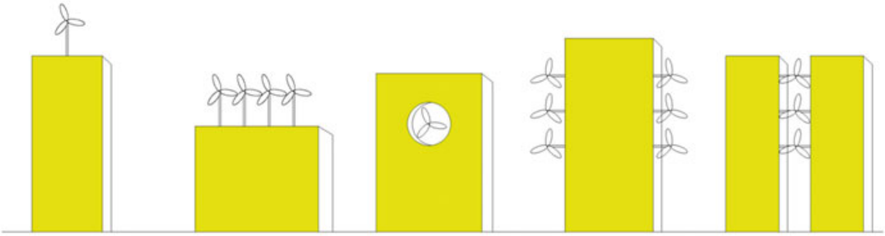

**Fig. 10.3** Sketch of feasible installation of high-rise building wind turbines

construct two buildings in a form of bell mouth, which display the vertical wall between the two buildings and the wind through where will be converged, enhanced and blown into the turbine. When the direction of wind is fixed and concentrated, along with the adsorption force of the turbine itself, power will multiply instantly. According to computation, this method yields 25 % electric power more than the traditional wind turbine. Because of the fixity of the buildings, it does not shift around. Therefore, if the angle of incidence of the wind can meets with 50°, it can be same with the traditional generators. According to the theory, 30~50° are the best angle of incident. Besides, using this kind of designing method does not have a special requirement on the roof and metope [3].

### *10.3.2 Reliable Wind Power Unit Mounting Position*

From the characteristics of high-rise buildings wind environment, we know that the following location in the building installation of wind turbine has its feasibility.

1. The roof with low wind resistance
   The top of building usually has larger wind, lower environmental interference, which is the best location for wind turbine installation. Please note the wind turbine should be made higher than a certain distance from the roof to avoid the cornice at the vortex area.
2. Building body openings
   The central building openings, where the wind is strengthened by converge, will result strong drafts, which is suitable for mounting directional wind turbine.
3. Building corners
   Buildings corners not only has free passing wind but also has the wind which is guided by architectural form where small wind turbines could be installed. You can even take the entire wall as the wind power device body or the construction of rotary building [4].
4. Building slots
   The vertical gap between buildings can produce "Canyon Wind", and the wind will increase with the building volume rising up. It is suitable for the installation of the vertical axis wind turbine or horizontal axis wind turbine (Fig. 10.3).

### *10.3.3 Performance of Small Vertical Wind Power Unit Mounting [5]*

Noise is always the major obstacle of wind power in its application. The latest vertical axis wind turbines with rapid development has wind wheel which is vertical to ground or air flows. There is no need to face the wind when the direction of wind is changed. This not only simplifies the structural design but also reduce “peg-top” force of wind wheels when facing the wind. Apart from this, vertical wind generator operates in low wind velocity with our noise which is “mute-type” wind turbine and is 10~30 % more efficient than the ones of similar types [6]. It is with comparatively higher safety, smaller damage radius, stronger wind resistance. It would not be influenced by changes of wind directions and it is easily maintained. Especially to “lift force” wind generator, it has advantages of simple systematic structure, heavy type equipments being installed above ground and flexible positions. Besides, it has less components and it could meet the low cost budget requirement. These advantages of vertical wind generators make wind power integration feasible.

### *10.3.4 Storage Access of Building Wind Power*

Another key problem that causes the use of wind power in the buildings have not been universally accepted is the storage problem. Variability and low-density bring great difficulties and technical cost to generation, energy storage, transmission, electricity using process. As wind turbine output is usually proportional to the cube of wind velocity, the subtle change of wind velocity will have a great impact on output power. One-megawatt wind farm in strong wind can instantly reach its peak of electricity supplies, while in the absence of wind, it will stopped generating. So it is difficult to guarantee the stability of the power supply and it may even threaten the stability of the grid. Therefore, the issue of storage of wind energy and supplying balanced electricity according to the grid need becomes critical. In the implementation of Iowa Park energy storage project in U.S., ultra-large-scale underground mined was used to store compressed air and a feasible approach was provided to solve this puzzle.

Apart from this, to change the way of wind utilization is also an approach to overcome the difficulties in wind storage problem. In comparisons with other studies, the features of intermittence and volatility are similar to inverter air conditioner. If we make windmill on the roof drive compressor to operate in different frequency (velocity) directly and at the mean while get hot and cold. On the contrary of difficult storage of wind power, cold and hot are easier to store. We store the cold and hot air and reduce the storage of compressed air which is more controllable in practical wind power utilization project; with the recovery of portion of expansion work from expander, we can get both cooling and partially stabilized power supply. (compressed air-driven wind turbine used as it generates).

In the energy flow of the entire environment, energy loss show a geometric increase as conversion section increases and conversion chain elongates, which at the mean while causes a great cost in the overall system operation and huge instability.

Just by the transition of idea, the long chain of generation, transmission and utilization of electrical installations (wind mechanical energy – generator – controller – storage controller – Inverter – booster – regulators – Inverter – motor – mechanical energy – compressor) changed into direct path (Wind mechanical energy – Compressor – cold storage heat storage). Such new devices vary in size, realize cold, heat, electricity co-generation, and produce large amounts of hot water/cold water/ice and pressed air which is sufficient to meet the house, office and vendor needs.

## 10.4 Environmental Impact Analysis of High-Rise Buildings and Wind Power Integration

Traditional project cost calculations did not reflect the impact on ecological environmental surroundings from project. In fact, project has inevitable of light, heat, noise, electromagnetic radiation impacts and so on. For example, light reflection from glass curtain wall might cause birds hit on mistakenly and has influence on human slumber and metal health; light pollution might interfere the some insects' mating and propagation; noise might affect human's normal life and communications or navigations of birds and insects. According to this, the impact on environment from wind power and building integration should be the factors need to be considered to partially decide whether wind power could be universally applied (Table 10.1).

## 10.5 Cost-Benefit Analysis of Integration of High-Rise Buildings and Wind Power

### *10.5.1 Environmental Cost Analysis*

In normal operation, fans scarcely produce emissions to air, water and soil. Studies showed that other forms of power generation, take coal for example, according to the current situation, 300,000 kW steam turbine generator sets which is widespread generate 100 million Kwh, at the cost of about 4 t standard coal consumption and about 0.5 t dust, 10 t $CO_2$, 0.05 t NOx and 0.08 t $SO_2$ emissions. The following table shows the different $CO_2$ emissions (t) from per 1 GWh electricity generation (Table 10.2).

**Table 10.1** Environmental influence from wind power system and its evaluations

| Influence factors | Influence degree | Remarks |
|---|---|---|
| Damage from electric wave | – | – |
| Television | Disordered simultaneousness of image and frame | Interfered field could be determined and influence could be avoidable |
| – | Great influence in High UHF (Ultra High Frequency) fields | Interfere could be eliminated or reduce, for example: to use cable television or strong directive antenna or to reduce the diameter of wind turbine wheel |
| FM broadcast, voice from television | Little influence | Basic interference mode isn't on the frequency conversion but the amplitude |
| AM broadcast | Little influence | No influence in low frequency |
| VOR and DVOR Aviation Transportation | Little influence | When wind turbine is installed followed by Aviation Authority's instructions, capability of communication would not be impaired |
| Microwave communications | Weak influence | Must followed by existing instructions |
| Noise | – | – |
| Noise in low frequency (below 16 Hz) | No damage to human health (difficult respiration or vomit and so on) | – |
| Audible sounds (16 Hz~20 kHz) | No influence on hearing or nerve | Noise produced by small sized approximately equals the level an office or a house, which will be stimulated to level 4 in the position of 15 m from tower that is noise lower than 50 dB will be covered by background noise basically without problems |
| Ecological environment | – | – |
| Migratory birds | Confliction with birds could be ignorable | As wind power mounting is integrated with buildings, the extra privation of direct or indirect habitat caused by wind turbine itself<br>The statistics indicates that the number of birds damaged by wind farm per kilometer is 10 times less than those damaged by high tension power line, which is approximate to the threaten on cars on high-speed road. Therefore, there is little damage on birds from small-sized wind turbine |

(continued)

**Table 10.1** (continued)

| Influence factors | Influence degree | Remarks |
|---|---|---|
| Insects | Confliction with insects could be ignorable | Determined by the investigations of Harmonia axyridis, Black flies, bees |
| Plants and wild animals | No effects | Has more or less influence on plants which are below to the small-sized wind turbine near ground, but has limited influence range and degree. Fields in large range could be ignored |
| Impacts from visual landscape | Little influence (decided by surroundings) | The studies show the shaking shadow brought by wind turbine rotation will produce visual pollution which will cause upset and dizzy symptoms to people and thus influence normal life |
| | | Design should be in accordance with local solar attitude and the length of the wings with calculation of the influent area which can be the basis to adjust the relative position between users and activities area |
| | | Related with shape and color and has good compatibility which can increase visual beauty through |
| | | The point is at personal virtues |
| | | Could be solved through association with residents around |
| Microclimate | Little influence | Precipitation, snowfall, evaporation, transpiration, temperature, and climate changes under wind turbines could be ignored |
| Gasoline pollution | Little influence | Installation, debugging, daily maintenance, examination need disassemble, fill in gas and clean. Pay attention to oil pollution and clean, and just try best to decrease the events of improper discard of tarpaulin or oil leaks |
| Land occupation | No influence | Attached to buildings and do not need extra fields |

**Table 10.2** $CO_2$ emissions comparison of different generation technologies generate per 1 GWh electricity

| | $CO_2$ emissions(t) in different generating stages | | | |
|---|---|---|---|---|
| Generation technologies | Resource extracting | Building | Operation | Total |
| Standard coal | 1 | 1 | 962 | 964 |
| Fuel | – | – | 726 | 726 |
| Natural gas | – | – | 484 | 484 |
| Temperature difference in ocean | – | 4 | 400 | 304 |
| Geothermic | 1 | 1 | 56 | 58 |
| Wind power | – | 7 | – | 7 |

From the table above, it is obvious that compared with other forms of generation technologies, especially coal which is universal in application, wind power has absolute environmental advantages and only emit $CO_2$ in construction of wind power which is also minimal to other forms. Therefore, wind power has a positive effect to climate environmental protection.

In consideration of environmental costs [7], researches indicate that the environmental value of wind power with 469 MW installation in the nation in 2002 is $SO_2$ created 74.54 million RMB from reduced emission benefit, NOx, 28.17 million RMB and $CO_2$, 75.34 million RMB. Other forms of pollution in addition, the total reduced emission benefit are 258.67 million RMB. In prediction on this basis, compared with coal, wind power makes a 0.28 RMB/KWh saving in environmental cost. In the application of solar energy which is known to all, the uneconomical process of production and recycle becomes its biggest problem.

### 10.5.2 Evaluation of Economic Indicator

In certain wind resource conditions, there is several factors influence the economic feasibility of building wind power system:

1. Types and sizes of wind turbine
2. Calculation of wind power generation amount
3. Initial installation cost: purchase cost, transportation cost, installation cost (infrastructure, common equipment, labor force)
4. Operation and maintenance fee: 2 % out of total invest

The first and the second point are essential to feasibility: in the calculation of electricity amount, curve fitting could be used, that is according to the feature trend wind turbine itself, combine Weibull wind velocity distributed model to calculate [8]; as for choosing the types, choosing function based on greatest profit margin could be established and consider the price of wind turbine, economic factors of depreciation, maintenance, operation of life cycle and the ability of high wind turbine initial invest in the return of investment and procurement. Through these two inspects, quantitative evaluations of construction in early stages of a building and wind power integration project could be done.

As the flexibility is great in design of building wind power setting, variations are big among each project and universal quantitative analysis of economic feasibility could hardly be done. However, according to the operation situation of established wind power integration project, economic profit is huge from building wind power under the conditions of sufficient wind resource and reasonable systematic design.

## 10.6 Conclusion

Wind power is the cleanest kind of renewable resources. Except for the development of large scale wind farms, application of wind power in urban buildings is also an effective method to building energy saving. Both of local wind environment and micro wind in high-rise buildings can be comprehensive utilized which is meaningful to building energy saving in our country.

From the aspect of technology, integration of wind power and building can not only use wind power in natural environment, but also can create local wind environment actively. Wind power does not need traditional storage anymore but could be utilized directly. From the aspect of economy, the best merit is its life cycle since it only emits small amount of $CO_2$ in construction phase to environment. The setting of wind turbines on top of or between the buildings, the development of vertical small-sized wind turbine technology allow imagine of high-rise building wind power integration possess the value of large-scale development. The policy of our country put emphasis on large or middle-scaled wind power project and our country ignore small-scaled ones, especially wind power integration projects. Besides, building and construction is a large consumer, utilization of wind power in construction is the cleanest kind of energy with least cost of renewable resource. Therefore, we should strongly push forward the utilization of wind power in urban buildings and decrease the energy consumption.

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# Chapter 11
# Exploration on Legal Issues of Transfer Market of the Use Right of Collective Construction Land

**Yongyong Zhu**

**Abstract** The reform of collective land use system plays an important role in promoting the reasonable use of agricultural land and constructing the new countryside. As a special commodity under market economy, land resources are regulated by the market mechanism. Non-standard transferring may result in the illegal occupation of large amounts of agricultural land. Though China's laws has made strict restriction and regulation on the transfer of the use right of collective construction land, there are also some problems in practice, such as the illegal occupation of collective land and the existence of hidden price in the land market. The establishment of the market mechanism of the transfer of land use right can effectively standardize the land transaction market, achieve the marketization of the transfer of land use right and reach the goal of the land use system.

**Keywords** Land transfer • Use right of collective construction lands • Transfer market system

## 11.1 Introduction

In order to establish a sound land market, provide land to various types of market subjects, reflect the interests of collective land owners and promote productivity growth, it has been the pressing demand of socialist market economy development to put the use right of collective construction land on the market [1].

Collective economic organization consisting of the ownership subjects of collective land can be divided into three groups: town-level collective economic

Y. Zhu (✉)
Civil and Commercial Law School, Southwest University of Political Science and Law, Chongqing, China

Department of economics and business administration, Chongqing University of Education, Chongqing, China
e-mail: zhuyongyong@126.com

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organization, village-level collective economic organization and villagers' group. As the most basic level of economic organization, villagers' group is organizationally distributed and solely constituted, and it has weak economic power, incomplete economic structure and non-independent economic status, making it have no corporate capacity and no possibility to become one of the subjects of collective land ownership. Village-level collective economic organization is intensively organized and led. It has strong economic power and independent ability to excise civil rights and assume civil obligations, and it has complete economic structure, making it have a corporate capacity and become one of the subjects of collective land ownership. Possibly, we can enhance the leadership and organization ability and economic power of villages' groups and establish diversified ownership subjects that take the village as their backbone, so as to provide a prerequisite for launching collective construction lands on the market.

## 11.2 Transfer Market of the Use Right of Collective Construction Land

### *11.2.1 Limiting the Scope of Transferred Construction Lands*

Because higher earnings can be obtained from collective construction land than agricultural land, if the scope of transferred construction lands is not limited, it will certainly lead to the transformation of large amount of agricultural land into construction land with people's seeking for the high profit gap between them [2]. Therefore, lands that are allowed to be transferred are limited to the following two types of collective construction lands: legally obtained collective construction land and collective construction land authorized with the land use right certificate. This is the basic condition of the transfer of collective construction land use right. Any land without the certificate of ownership or use right through legal means is not allowed to be transferred in the market. Otherwise, driven by economic interests, large amount of agricultural land illegally will enter the market, which not only undermines the protection of agricultural land, but also causes terrific chaos in land transfer market. Secondly, land use regulation must be observed to ensure that an unauthorized change is not made. The total supply of land used for commercial estate must be tightly restricted to ensure that collective construction land is not used for commercial real estate development without permission. Thirdly, collective construction land must be strictly managed in accordance with overall planning, urban planning and rural planning of land use. Only the collective construction land that confirms to the overall planning of land use can be used and transferred as construction land, and the specific uses of the land should be determined in accordance with the urban planning and rural panning to ensure that the collective land that doesn't confirm to them is not expanded, renovated and transferred.

### 11.2.2 Defining the Terms for Collective Construction Lands

One transfer subject of collective construction land should submit his/her use right or ownership certificate of collective construction land to the land administrative department of county government for applying for transfer-related right or ownership certificate. He or she should comply with the written agreements of real property transaction in traditional civil law and the principle of coming into force after registration. The land administrative department should treat such application in the way that is similar to the strict normalization set by limited liability companies, rather than in examination and approval system. Determining the land use term is a very sensitive issue: the longer the term is, the more benefited land users are; on the contrast, the shorter the term is, the more benefited land managers and owners are. Thus, one land manager may timely adjust land use direction and land use structure, while one land owner may adjust land earnings and land price so as to obtain the land value increment. According to private law's demand for autonomy, the specific transfer term ought to be determined by the parties involved. As the transferred commodities are different from general ones due to their specificity, the transfer term must not exceed the legal allowable term. The longest terms can be referred to the longest terms for the land use right transfer, which are separately 50 years for industrial land, 40 years for commercial land and 50 years for comprehensive land. Both parties may also make an agreement in the contract to give the land user priority when he/she decides to continue the use of land at the expiration of land use term.

### 11.2.3 Establishing Scientifically Sound Pricing Mechanism for Land Transfer

Land is not only a resource, but also an asset. Farmers' all living materials stem from land, and now the improvement of their living condition is dependent upon the transfer of collective land use right. Based on the fact that the transfer of collective construction land is in a state of invisibility in China due to Chinese law's ban on transfer, a sound pricing mechanism is hard to establish. In order to attract investment, farmers competitively lower their land transfer prices with each other. Under such prices that can't reflect the real value of land, land-use enterprises usually claim that the transfer contracts signed with farmers are illegal and ask for contract termination and rental refund by taking them to court, so that the interests of farmers are seriously undermined. If relevant laws allow the transfer of land, a scientifically sound pricing system can be established to curb price competition.

A sound pricing mechanism of collective construction land plays an important part in ensuring that the collective construction land transfer reform is smoothly carried out and achieves success. It should be established based on the full consideration of the influences of the law of commodity price formation as well as the supply–demand relationship and the law of circulation of paper money under the market economy [3]. Thus, the government should adopt benchmark land price system and price service mechanism.

The market should play its fundamental role in land resource allocation by establishing free negotiation mechanism between parties concerned so as to reduce improper interventions of government and human factors. Any organization should not deprive involved parties of dealing with their own affairs, and the land demanders and farmers should set the price of land autonomously through direct negotiation. With increasingly normalized transaction system as well as open and transparent market information, the transfer price of collective construction land will be gradually close to a sound market price, and price negotiation between the contract parties can be entrusted to the qualified land price negotiation agents for land evaluation.

The government should establish benchmark land price system. Because the transfer of the use right of collective construction land is different from the transaction of general commodities due to its specialty, farmers are usually put at a disadvantage owing to information asymmetry. In order, not to let farmers suffer a loss, the government should make some preventive measures by establishing a benchmark price system through grade distribution and scientific evaluation and make the proper adjustment according to the economic development and land supply/demand situation. Local land management departments may work with local price control departments to evaluate and set their benchmark land price according to the size, plot ratio, location, natural shape, use term and market situation of the land to be transferred [4].

A sound price service mechanism should be established. Intermediary organizations should be developed for the evaluation of land price, and the government should its guidance and supervision over them. A network should be established to reflect the transaction information of collective construction land across the whole country. It should take towns as the basis and land management departments as the support, registration data including quantity and price of land to be transferred in the transaction website and publish them to the public. In this way, information's openness and symmetry will be achieved.

## 11.3 Construction of the Transfer Market System of the Use Right of Collective Construction Land

### *11.3.1 Construction of the Transfer Market System of the Use Right of Collective Construction Land*

The entry of state-owned land into market refers to that the use right of state-owned land is put on market. Similarly, the entry of collective land into market refers to that the use right of collective land is put on market. Because the transfer theory of state-owned land that is based on the separation of ownership and control is for regulating the rights and interests between land owners and users, such theory can't be treated as the basis of collective construction land transfer. The transfer of collective construction land is related to the rights and interests between collectivity and locality, between nation and collectivity, or between national and locality. Such rights refer to the eminent domain and management right of collective lands, while the interests refers to earnings caused by national investment used for adjusting land's economic locations to create rent differential. The theories of separation of two rights, national investment into economic locations and rights of eminent domain and management to national lands together constitute the theoretical foundation of the entry of collective construction lands into market.

Market system is the place where market subjects live on transferring commodities, economic interests are achieved and economic relationship between market subjects is reflected. The market system of use right of collective construction land has the characteristics of uniformity, openness, competitiveness and normalization. We should establish a uniform market for the transfer of national construction land and collective construction land based on the principle of 'same land, same price and same right', work out some supporting measures, increase the supply of construction land and strengthen national regulation on land market, so as to restrain the fast growth in land price, increase farmers' earnings and promote the development of economy. The key to stock adjustment of collective construction land is to improve the uniformity between urban land planning and rural land planning. As the stock of national land is an important resource whereby urban governments increase their fiscal revenue, if one local government realizes that the prosperous transfer of collective construction land may undermine its existing interests, it will take containment activities by differing the purpose of collective construction land from that of national construction land with the same economic position, resulting in value differential.

We should standardize transfer form and operating procedure used for collective construction land and national construction land, limit the scope of land acquisition, and increase the regulation of land use. Besides, we should coordinate the uses of urban and rural land and regulate them by dividing different zones, break the limitation of ownership and administrative division, make both economic organizations and individuals have right to use collective construction land, and ensure that collective construction under land the overall planning has certain amount of stock by establishing land reserve system. Land for industrial zones and private parks that reserve collective land ownership should be legally constructed with infrastructure and supporting facilities by collective economic organizations. Such land will be reserved to ensure that collective economic organizations can have continuous land revenue and government can regulate land market favorably.

The service system of transfer market is composed of intermediary service organizations and information network. Intermediary service organizations include land enquiry organizations, land price evaluation organizations, land agencies and land insurance companies. It must have its own name, organization, fixed service place, necessary assets and funds, sufficient number of professional staff and other requirements that are in accordance with relevant laws and regulations.

## 11.4 Conclusions

Market management and supervision system are very necessary for market economy. Thus, establishing a sound market and supervision system seems become even more important. As there is a great differential between the benefit of agricultural land and collective construction land, if the management and supervision system of collective construction land is not constructed with great efforts, it may cause agricultural land's transforming into construction land disorderly. Therefore, the government should strengthen its management and supervision on collective construction land market, complete approval system for the entry of land into the market, observe land use regulation system and control the transformation of agricultural land into construction land. Furthermore, it should also complete the censorship and land price management system for transaction and registration of land. When land price seriously deviates from its value, it is necessary for the government to take all kinds of measures for a timely intervention. Lastly, the government should also establish a sound supervision and control system warning mechanism for illegal land uses.

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# Chapter 12
# Research on Evaluation of Sustainable Land Use of Resource-Based City Based on Circular Economy—A Case Study of Shuozhou City

**Ling Zhou, Chun Yuan, and Yuzhe Wu**

**Abstract** Circular economy could meet the requirement of transformation of resource-based city. According to the principles of circular economy, "reduce, reuse, recycle", and the characteristics of land use of Shuozhou city in Shanxi Province, an evaluation system is established to assess the condition of sustainable land use between 2005 and 2010. Analytic hierarchy process (AHP) is used to determine indexes' weights after qualitative and quantitative analysis. Then obstacle analysis of factors is carried out. It displays the integrative condition of sustainable land use in Shuozhou city improved on the whole. The main obstacles of sustainable land use are reduce and reuse. According to the results above, some suggestions on land resource management are put forward.

**Keywords** Sustainable land use • Resource-based city • Circular economy • Shuozhou city

## 12.1 Introduction

Resource-based cities are industrial cities rely on the supply of natural resources, which refer to non-renewable ones [1]. There are hundreds of resource-based cities in China, and since 1990s, some of them have entered into the stage of resources exhaustion. The only way out for sustainable development is transformation, and sustainable land use is part of it. Because of high dependence on resources, land use in resource-based city may easily be impacted by exploitation, production,

L. Zhou • Y. Wu (✉)
Department of Land Administration, Zhejiang University, Hangzhou 310029, China
e-mail: zhouling_yx@163.com; wuyuzhe@zju.edu.cn

C. Yuan
School of Land Science and Technology, China University of Geosciences,
Beijing, Beijing 100083, China
e-mail: yuanchun@cugb.edu.cn

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management and other activities of resources, which leads to the problems of scattered layout, function area disorder, extensive land use and ecological destruction, etc. Those problems have a negative impact on sustainable development. Therefore, it's high time to implement sustainable land use. Evaluation of sustainable land use is a tool to learn the sustainability and the basis of proposing improvements.

Circular economy is accord with the industry development of resource-based city. It's more targeted to add indexes of reduce, reuse and recycle into the evaluation. In this paper, circular economy is applied to establish an evaluation of sustainable land use in Shuozhou, are source-based city. Integration of circular economy and sustainable land use can provide a new direction for traditional land resource management. Consequently, it's significant to study sustainable land use of resource-based cities based on circular economy.

## 12.2 Literature Review

Evaluation of sustainable land use starts from *1990s*, *the Framework for Evaluation Sustainable Land Management* from the FAO, international symposium on "Evaluation for Sustainable Land Management in the Developing World" and other reaches identified the system, principles of evaluation. The development of evaluation in China focuses on the study of indexes. Currently, there are some systems widely used, including "ecology-economy-society" evaluation system [2], "productivity, stability, resilience, equitability, autonomy, harmony" evaluation system [3], PSR evaluation system [4], landscape ecological evaluation system [5], etc.

The initiation of circular economy can be traced back to*1960s* when K. Boer, an American economist, proposed the Economic Theory of Spacecraft. Then in 1968, Italian researchers in Club of Rome published *the Limit of Growth* to show the relation between resources and circulation. Since then, international symposia, organizations and other activities emerged and circular economy theory was applied to social and economic development in many aspects [6–8]. Circular economy was introduced into China in 1994 by Qingshan Liu [9]. In recent years, growing attention has been paid to the construction of a conservation-oriented society and the application of circular economy. Moreover, with the strong support of governments, academic researches related to it are thereupon springing up.

## 12.3 Method

Circular economy takes "efficient and circular utilization" a score, "reduce, reuse and recycle" as principles, "low consumption, low emission, high efficiency" as essential features. This theory is consistent with sustainable development mode and is a reform of traditional mode [10]. As for sustainable land use, Yansui Liu [11] identify it as land use strategies and measures which could meet the needs of the

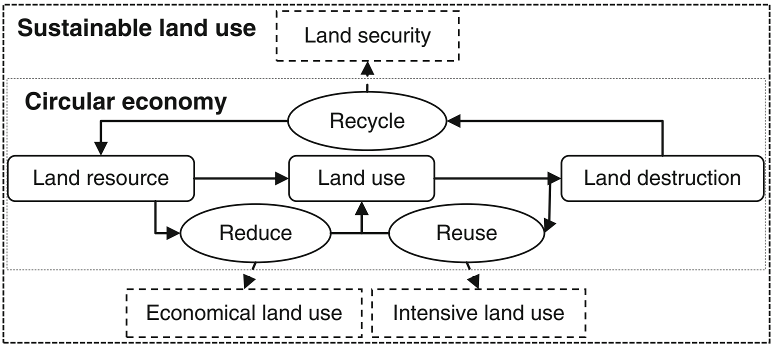



**Fig. 12.1** Theoretical framework

present without compromising the ability to meet those of the future. On the background of too many people and too little land in China, the traditional land-use type, that is "from cradle to grave", would exacerbate the contradiction between supply and demand of land. On the contrary, circular economy promotes a "cradle-to-cradle" land-use type, which has guidance on land management system, etc. According to the principles of circular economy and the basic ideas of sustainable land use, the theoretical framework is shown in the following figure (Fig. 12.1).

## 12.4 Case Study

### *12.4.1 Research Area*

Shuozhou city locates in the north of Shanxi Province with a total area of 10,624.35 km$^2$. It governs 2 districts, 4 counties, 73 towns, 1,688 administrative villages and has a total population of 1.73 million. Shuozhou city has lots of advantages, including superior location, convenient transportation, developed animal husbandry. Moreover, there are large and concentrated reserves of coal resources in Shuozhou, which are easy to exploit and regarded as ideal steam coal. Shuozhou city is a typical coal resources city with great volume of coal production and sale in China.

### *12.4.2 Indexes Selection*

When selecting indexes, we should follow the "3R" principles of circular economy and principles of sustainable land use evaluation which refers to comprehensiveness, dominant, comparison and regionality. After analysis, indexes in the evaluation of sustainable land use of Shuozhou are selected as follows.

1. **Social and economic Development**
   The main objective of land use is supporting regional social and economic development. Meanwhile, social and economic development would affect land-use system a lot. Therefore, it's insignificant to evaluate sustainability without social and economic development. In this level, sustainable land use is evaluated from economic benefit, social structure, living standards [12] and transformation capability. According to the points, GDP per unit area of land, urbanization rate, per capita annual disposable income of urban residents and percentage of new industry increasing output are selected.
2. **Reduce**
   The human-land conflict keeps intensifying with the development of economy and growth of population. It's time to advocate economical and intensive land use. Reduction includes reduction of land and pollutant at input terminal. Tendency of built-up land application and land consumption of primary industry output per 10,000 yuan are selected from the perspective of built-up land and agricultural land. Besides, primary energy production per unit area of land for mining and industry is added to indexes system according to the industrial structure of Shuozhou city and pesticide per unit cultivated land is selected in terms of pollutant.
3. **Reuse**
   Reuse belongs to the process control principles, aiming to use products as many times and ways as possible. Under the condition of limited land resources, reuse is a guarantee of efficient use of land. In this paper, multiple cropping index, total retail sales of consumer goods per unit area of land, ratio of high-tech industry output, percentage of solid wastes utilized are chosen to describe this hierarchy in view of cultivated land use degree, built-up land use degree, technology and resource reuse degree.
4. **Recycle**
   Recycle aims at reduction of pollutant at output terminal and resource recovery of waste. According to the situation of Shuozhou, volume of soot and dust emission per unit area of land, volume of solid wastes discharged per unit area of land, volume of sulfur dioxide emission per unit area of land are selected from the angles of waste's condition. Because wastewater is basically the same in the evaluation period, it's not selected. Ratio of urban domestic refuses harmlessly treated is selected to reflect the resource recovery degree.
5. **Land Resource Security**
   Land resource security is the basis of sustainability. Food security, ecological security, economic security, cultural security and property rights security [13] are chosen as angles to evaluate land resource security. Food safety is described by grain output per hectare and per capita cultivated land. Ecological security is reflected by percentage of forest cover. Economic security is described by ratio of real estate development investments. Cultural security and property rights security are excluded because of slightly changes.

All the indexes and their meanings are shown in Table 12.1.

**Table 12.1** Indexes of evaluation and meanings

| Target layer | Criterion layer | Index layer | Meanings |
|---|---|---|---|
| Sustainable land use | Social and economic development | Urbanization rate | Urban population/total population |
| | | GDP per unit area of land | GDP/total land area |
| | | Per capita annual disposable income of urban residents | Total household income-income tax paid-social security-subsidy for accounting |
| | | Percentage of new industry increasing output | Increase of new industry output/ new industry output |
| | Reduce | Tendency of built-up land application | Variable quantity of built-up land area/variable quantity of GDP |
| | | Land consumption of primary industry output per 10,000 yuan | Cultivated land area/primary industry output |
| | | Primary energy production per unit area of land for mining and industry | Primary energy production/area of land for mining and industry |
| | | Pesticide per unit area of cultivated land | Amount of pesticide applied/cultivated land area |
| | Reuse | Multiple cropping index | Sown area/cultivated land area |
| | | Total retail sales of consumer goods per unit area of land | Total retail sales of consumer goods/total land area |
| | | Ratio of high-tech industry output | High-tech industry output/GDP |
| | | Percentage of solid wastes utilized | Volume of solid wastes utilized/ volume of solid wastes produced |
| | Recycle | Volume of soot and dust emission per unit area of land | Volume of soot and dust emission/total land area |
| | | Volume of solid wastes discharged per unit area of land | volume of solid wastes discharged/total land area |
| | | Volume of sulfur dioxide emission per unit area of land | Volume of sulfur dioxide emission/total land area |
| | | Ratio of urban domestic refuses harmlessly treated | Amount of urban domestic refuses harmlessly treated/ Amount of domestic refuses |
| | Land Resource Security | Per capita cultivated land | Cultivated land area/population |
| | | Grain output per hectare | Grain output/cultivated land area |
| | | Percentage of forest cover | Forest area/total land area |
| | | Ratio of real estate development investments | Investments in real estate development/total investment in fixed assets |

### 12.4.3 Standardization

In order to eliminate the influence of dimension, value of indexes should be standardized. In the evaluation, indexes have different effects on the result. Positive indexes refer to those indexes which are better as they get bigger and negative indexes are opposite. In this paper, the calculating methods are as follows.

$$\text{Positive indexes: } a_{ij}' = \frac{a_{ij}}{a_{max}}; \tag{12.1}$$

$$\text{Negative indexes: } a_{ij}' = \frac{a_{min}}{a_{ij}}; \tag{12.2}$$

$a_{ij}'$—Standardized value;
$a_{max}$—The maximum of original values;
$a_{ij}$—Original value;
$a_{min}$—The minimum of original values.

### 12.4.4 Indexes Analysis

In this paper, AHP is applied to determinate weights. The premise of using AHP is an overall understanding of research area. Importance analysis and coefficient of variation are used to learn land use of Shuozhou in this paper.

1. **Importance analysis**
   Reduce, reuse and recycle reflect the input terminal, process and output terminal of production based on circular economy. It's critical to reduce land in the source and change land-use type because Shuozhou city is now in the transformation period. Besides, industrial transformation is the key to transformation according to the policy of "new industrialization". Deep processing of mine resource with new technology is of significance, which is consistent with the principle of reuse. After dealing with the source and process, the condition of output terminal will get better along with it. However, the reduction of pollutant at output terminal should not be ignored because of the land-use problems existing. The three points above are the key to the evaluation. Social and economic development and land resource security are results of land use, which have their significant roles in the evaluation.
2. **Coefficient of variation**
   Coefficient of variation of samples is one of impact factors of weight. It's a statistic to measure the variation degree of observations. Over the evaluation period, the influence increases with the coefficient, so does the weight. It can be calculated as follows.

$$C.V = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}}{\overline{x}}; \tag{12.3}$$

$x_i$—Value of sample;

$\overline{x}$—Mean;

N—Number of samples.

### *12.4.5 Weights of Indexes*

Based on the analyses above, AHP is used to assigned weights. With the help of yaahp 6.0, establish a hierarchical model and judgment matrix. After consistency check, the results are got. In this paper, weight sum method is used to get a comprehensive evaluation result. Calculated as follows:

$$C = \sum_{i=1}^{n} \omega_i \times a_i; \tag{12.4}$$

$\omega_i$—weight of index;
$a_i$—Value of index.

## 12.5 Research Results and Analysis

### *12.5.1 Research Results*

According to the analyses above, the evaluation results of sustainable land use of Shuozhou between 2005 and 2010 are shown as follows (Table 12.2).

It can be seen from Table 12.2 that the comprehensive scores increased on the whole, which means the sustainability of land use was getting better. The comprehensive scores of criterion layers can be seen in Fig. 12.2, Score of social and economic development and land resource security was getting higher steadily. Though reduce and recycle had a large fluctuation during the evaluation period, score of 2010 have increased by 33.54 % and 86.98 % compared to the score of 2005. Score of reuse has been decreasing in 2006, but kept rising after that, especially in 2010.

**Table 12.2** Evaluation results of sustainable land use based on circular economy

| Criterion layer | Index layer | Weights | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| Social and economic development | Urbanization rate | 0.1859 | 0.0280 | 0.0286 | 0.0293 | 0.0300 | 0.0302 | 0.0309 |
| | GDP per unit area of land | 0.3893 | 0.0213 | 0.0282 | 0.0379 | 0.0493 | 0.0542 | 0.0647 |
| | Per capita annual disposable income of urban residents | 0.2641 | 0.0220 | 0.0246 | 0.0295 | 0.0350 | 0.0388 | 0.0439 |
| | Percentage of new industry increasing output | 0.1606 | 0.0241 | 0.0266 | 0.0267 | 0.0261 | 0.0266 | 0.0259 |
| Reduce | Tendency of built-up land application | 0.2883 | 0.0100 | 0.0096 | 0.0242 | 0.0694 | 0.0087 | 0.0018 |
| | Land consumption of primary industry output per 10,000 yuan | 0.2381 | 0.0249 | 0.0285 | 0.0393 | 0.0375 | 0.0398 | 0.0573 |
| | Primary energy production per unit area of land for mining and industry | 0.2381 | 0.0273 | 0.0309 | 0.0354 | 0.0275 | 0.0288 | 0.0573 |
| | Pesticide per unit area of cultivated land | 0.2356 | 0.0567 | 0.0507 | 0.0495 | 0.0450 | 0.0439 | 0.0424 |
| Reuse | Multiple cropping index | 0.2282 | 0.0498 | 0.0496 | 0.0513 | 0.0534 | 0.0533 | 0.0502 |
| | Total retail sales of consumer goods per unit area of land | 0.3094 | 0.0280 | 0.0340 | 0.0423 | 0.0546 | 0.0650 | 0.0724 |
| | Ratio of high-tech industry output | 0.2179 | 0.0510 | 0.0361 | 0.0355 | 0.0319 | 0.0308 | 0.0315 |
| | Percentage of solid wastes utilized | 0.2444 | 0.0202 | 0.0203 | 0.0205 | 0.0209 | 0.0226 | 0.0572 |
| Recycle | Volume of soot and dust emission per unit area of land | 0.2199 | 0.0216 | 0.0240 | 0.0331 | 0.0300 | 0.0308 | 0.0457 |
| | Volume of solid wastes discharged per unit area of land | 0.2377 | 0.0463 | 0.0458 | 0.0461 | 0.0465 | 0.0494 | 0.0481 |
| | Volume of sulfur dioxide emission per unit area of land | 0.2199 | 0.0421 | 0.0438 | 0.0457 | 0.0424 | 0.0433 | 0.0449 |
| | Ratio of urban domestic refuses harmlessly treated | 0.3224 | 0.0000 | 0.0149 | 0.0476 | 0.0275 | 0.0429 | 0.0670 |
| Land Resource Security | Per capita cultivated land | 0.2297 | 0.0347 | 0.0348 | 0.0343 | 0.0342 | 0.0339 | 0.0331 |
| | Grain output per hectare | 0.2607 | 0.0314 | 0.0314 | 0.0314 | 0.0314 | 0.0314 | 0.0395 |
| | Percentage of forest cover | 0.2317 | 0.0297 | 0.0320 | 0.0313 | 0.0316 | 0.0288 | 0.0351 |
| | Ratio of real estate development investments | 0.2779 | 0.0303 | 0.0304 | 0.0325 | 0.0421 | 0.0413 | 0.0418 |
| Total | | 1 | 0.5994 | 0.6248 | 0.7235 | 0.7662 | 0.7444 | 0.8907 |

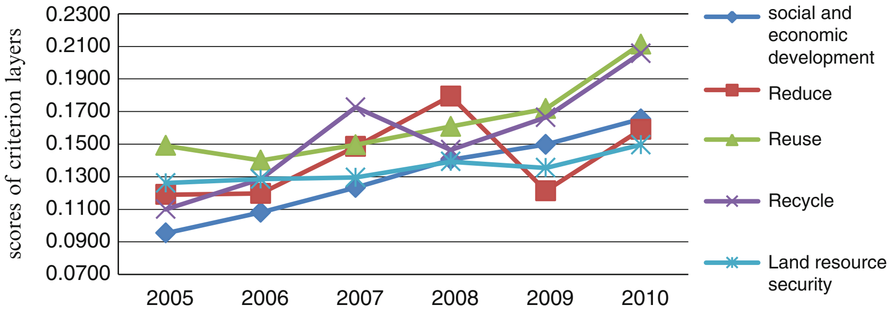



**Fig. 12.2** Scores of criterion layers

### *12.5.2 Diagnoses of Obstacles*

Diagnosis of obstacles is used to find out the main problems of sustainable land use. Obstacle degree reflects the negative influence on sustainability, Calculated as follows:

$$M_{ij} = \frac{V_{ij} \times U_{ij}}{\sum_{i=1}^{5} \sum_{j=1}^{m} \left(V_{ij} \times U_{ij}\right)}; \tag{12.5}$$

$$U_{ij} = R_i \times W_{ij}; \tag{12.6}$$

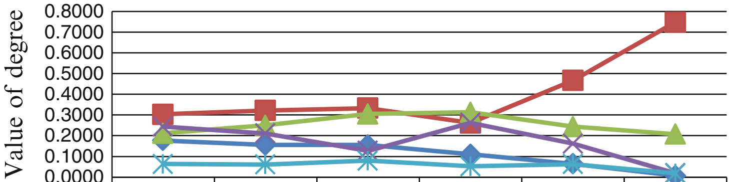
$$V_{ij} = 1 - a_{ij}{}'; \tag{12.7}$$

$$M_i = \sum_{j=1}^{m} M_{ij}; \tag{12.8}$$

$M_{ij}$—Obstacle degrees of indexes; $V_{ij}$—Deviation degree of indexes;
$U_{ij}$—Contribution degree of indexes; m—number of criterion layers;
$R_i$—Weight of criterion layer; $W_{ij}$—Weight of index in criterion;
$a_{ij}{}'$—Standardized value; $M_i$—Weight of criterion

The outcomes of diagnoses are shown as follows (Fig. 12.3).

From 2005 to 2010, the obstacle of social and economic development decreased on the whole, so as land resource security. 2010 was the last year of "the eleventh five-year plan". During "the eleventh five-year plan", Shuozhou city seizes the opportunities of rapid growth of domestic economy and rising resource prices, gives full play to the advantages of coal and coal-fired power industry, accelerate the development of emerging industries to promote the transformation of Shuozhou city. In addition, because of the special structure of the economy, Shuozhou city has always put the improvement of environment into all aspects and whole process of




| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| social and economic development | 0.1768 | 0.1549 | 0.1550 | 0.1103 | 0.0643 | 0.0071 |
| Reduce | 0.3038 | 0.3222 | 0.3333 | 0.2619 | 0.4671 | 0.7479 |
| Reuse | 0.2120 | 0.2504 | 0.3051 | 0.3131 | 0.2437 | 0.2075 |
| Recycle | 0.2440 | 0.2112 | 0.1273 | 0.2624 | 0.1619 | 0.0194 |
| Land resource security | 0.0634 | 0.0612 | 0.0794 | 0.0523 | 0.0629 | 0.0181 |

**Fig. 12.3** The trends of obstacle degrees of criterions

economic and social development, which lead to the improvement of ecological environment.

During 2009 and 2010, while recycle, reuse and social and economic development were moving in the right direction of sustainable land use, reduce was on the contrary and the value of degree was the biggest, which meant the development of Shuozhou city was supported by large amounts of land resource, especially built-up land. It is thus clear that economical use of land is also the need to improve.

The obstacle degree of reuse decreased after 2008, which reflected the intensive land use was improved in Shuozhou after 2008. However, the degree of reuse was the second biggest. The level of intensive was still low even though it was increasing. As a result, close attention should be paid to intensive land use.

The obstacle degree of recycle has been increasing before 2008 and decreased after that. According to the obstacle of index, it's due to ratio of city life rubbish harmlessly treated mainly. The economic and social development improves living standard. At the same time, discharge amount of waste also increased. Ratio of urban domestic refuses harmlessly treated fall from about 32 to 18.5 % in 2008, but increased in 2009. The condition of urban domestic refuses harmlessly treated in Shuozhou was Unstable.

## 12.6 Suggests of Sustainable Land Use Based on Circular Economy

According to the analyses, the main obstacles of sustainable land use of Shuozhou were reduce and reuse of land in 2010. Reduce requires Shuozhou controlling the input of land as well as harmful substance. Land reuse aims at extending land-use period and improving land-use efficiency. Some suggests are made as follows.

Firstly, land resource should be reduced in the source. The input of built-up land increased year by tear. In order to control the blind expansion of cities, a balance between land urbanization and population urbanization should be reached. Besides, dangerous and inefficient small mines should be banned to promote the economical land use. Secondly, it's important to rigidly enforce the policies of the idle land and promoting industry and population concentration. As for farmland, it's time to improve tillage methods and promote agricultural modernization to make better use. In addition, land consolidation and reclamation have indispensable roles in Shuozhou because of coal mining. Thirdly, it's necessary to pay more attention to land pollution and new technologies. Lastly, circular economy provides a new perspective and method for land management. It's beneficial to apply it flexibly.

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# Chapter 13
# Study on the Proportion of Industrial Land in City of Zhejiang Province

**Lei Shi, Yuzhe Wu, and Xiaoling Zhang**

**Abstract** Since the open and reform, Zhejiang Province has entered the period of fast economical development. Nowadays, its industrialization and urbanization have rapidly developed, and urban construction land is in great demand. Especially these years, the amount of industrial construction is increasing, which leads to the urban land use scale expanded constantly. Through collecting the related data about industrial land scale of Zhejiang Province, this paper takes the industrial structure, industrial land transaction administration and industrial enterprise land form into account to summarize that the proportion of urban industrial land has exceeded the reasonable range of the state, and the urban land-use structure has lost the balance. Meanwhile, this paper suggests that we should make full use of market mechanism, strengthen the government's macro regulation and control, update the development concept of industrial enterprises and introduce the mechanism of public participation to improve urban land management.

**Keywords** Urban industrial land • Urban industrial land proportion • Zhejiang province

## 13.1 Introduction

China now becomes a major multinational company processing plant, and in domestic it formed four major production bases, such as the Yangtze River Delta whose center is Jiangsu, Zhejiang province and so on. As the private economy developed province, Zhejiang province has expanded the scale of the industrial land to some extent, with the industrial agglomeration effect driving of production base, and realized the rapid

L. Shi • Y. Wu (✉)
Department of Land Administration, Zhejiang University, Hangzhou 310029, China
e-mail: zjusL0642@126.com; wuyuzhe@zju.edu.cn

X. Zhang
Department of Public and Social Administration, City University of Hong Kong, Hong Kong, China

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development of economy. However, in the long term, “factory of the world” is not a driving force of economy for long. China must increase the capacity for independent innovation and establish our own industrial advantages. In recent years, Zhejiang province’s urban land scale has expanded unceasingly and the farmland decreased continuously. It has leaded to negative effects. On one hand, it is bad for the cultivated land protection policy to be implemented effectively; on the other hand, it is difficult to guarantee the social economy to develop steadily and rapidly. Therefore, knowing about the urban industrial land research progress at home and abroad and doing research on proportion of urban industrial land use in Zhejiang province, is theoretically significant for raising the level of intensive utilization of industrial land, adjusting the structure and controlling the scale of urban land. Meanwhile, it also can provide practical reference for other provinces.

## *13.1.1 Literature Review*

### 13.1.1.1 Urban Land Use System

Liu Ailin points out that in the market economy, industrial land transfer modes are bidding, auction and listing. Because the transaction is not public and lacks competition, the non-standard market order causes the loss of state-owned land, which has led to the hoarding behavior to some extent [4]. Wu Yuzhe uses equilibrium analyses and management strategies for regional industrial land prices with game theory. He points out that the social cost should be considered when industrial land is sold at a low price [8]. Liu Yang considers that the local government plays two roles in the industrial land management, one is the delegate of city land owners, and the other is social controller. The externality of land use causes the conflict of the roles of government, and the local government officials have more opportunistic motivation to make profits for themselves [5].

### 13.1.1.2 Urban Industrial Structure

Lu Chunyang considers the earliest descriptions of the relationship between land use structure and industrial structure should be “The Isolated State” written by Johann Heinrich von Thünen, who put the agricultural location factors into the research on land use. Then another well-known model is W. Alonso’s bid rent model, reflecting that the growth of urban spatial structure results from industrial competition. This is the theory about industrial land and industrial structure [3]. Li Peixiang thinks that the process of urban economic development is just the adjustment and optimization process of industrial structure. If urban land-use structure is irrational and perpetuated, it will hinder the rational distribution of urban productivity and the economic development of the city [2]. Wang Lei also considers that in many cities of China, the land use structure is irrational, the proportion of industrial land is too high, and urban land distribution is inefficient. The distortion of urban land-use structure and that of industrial structure interacts with each other [7].

#### 13.1.1.3 Urban Industrial Structure

These days, there are many industrial parks in most of cities. Some governments blindly pursue scale because of performance and land revenue. To attract businesses into the park, the government often depresses prices of industrial land, which brings out that investors take up too much industrial land [9]. Fan Yajun analyses the situation of land use in industrial areas by industrial area planning. She believes that the current industrial area planning is out-of-date and not scientific enough [1]. Zhang Ming points out that the government should complete the constructing infrastructure and supporting tasks first, and then take over the lands according to the investment project by stages. However, the reality is contrary. This form causes both the waste of land resources and the society instability [10]. McGrath takes Chicago as an example to describe the relationship between the urban industrial sites and land pollution. He points out that industrial land pollution reduces the value of the land and the possibility of redevelopment in a short time [6].

At present, most of the scholars study the influence factors of the urban land use, and research on urban industrial land proportion is still relatively few. This paper studies on urban industrial land proportion, tries to collect and compute industrial land scale data to show the current situation of urban industrial land use in Zhejiang Province, and makes analysis of causation and countermeasures.

### *13.1.2 Methodology*

On the basis of research summary above, this paper adopts the method of horizontal longitudinal comparative analysis and inductive method. Firstly, through collecting data, we can calculate the increase about land area for residential construction per capita and industrial construction per capita of Zhejiang Province and compare the two results to analyze the growth of the scale of industrial land. Secondly, further collecting the transferred land area of industrial warehouse space and total industrial output value of Zhejiang Province, we can calculate their added value, and find industrial land and industrial development coordinating or not.

## 13.2 Data Collection and Analysis

According to the research method, first of all, we collect the data of land area for residential construction per capita and industrial construction per capita of Zhejiang Province. The below table shows that land for residential construction per capita of

**Table 13.1** Land area for residential construction per capita and industrial construction per capita of Zhejiang Province (2004–2010)

| Year | Population | Land area for residential construction ($km^2$) | Land area for industrial construction ($km^2$) | Land area for residential construction per capita ($km^2$) | Land area for industrial construction per capita ($km^2$) |
|---|---|---|---|---|---|
| 2004 | 45,772,200 | 445.1 | 382.4 | 0.097 | 0.084 |
| 2005 | 46,021,100 | 501.7 | 414.6 | 0.109 | 0.090 |
| 2006 | 46,294,300 | 417.9 | 482.0 | 0.090 | 0.104 |
| 2007 | 46,593,400 | 525.4 | 514.6 | 0.113 | 0.110 |
| 2008 | 46,878,500 | 553.3 | 533.9 | 0.118 | 0.114 |
| 2009 | 47,161,800 | 570.5 | 548.9 | 0.121 | 0.116 |
| 2010 | 47,479,500 | 614.5 | 573.6 | 0.129 | 0.121 |
| Growth | | | | 33.0 % | 44.05 % |

Note: The data of the population and land area are obtained through Zhejiang Statistical Yearbook 2011

**Table 13.2** Growth of total industrial output value and growth of transferred land area of industrial warehouse space of Zhejiang Province (2004–2008)

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| Growth of total industrial output value (billion) | 1,028.63 | 853.38 | 1,240.76 | 1,237.98 | 189.49 |
| Growth of transferred land area of industrial warehouse space (hectare) | 11,460.35 | 3,972.42 | 6,983.21 | 7,376.7 | 4,244.25 |

Note: The data of the growth of total industrial output value is obtained through Zhejiang Statistical Yearbook 2011; the data of the growth of transferred land area of industrial warehouse space is obtained through Statistical Data of Land and Resources of Zhejiang Province 2003–2008

Zhejiang Province increased from 0.097 to 0.129 $km^2$ from 2004 to 2010, and the growth percentage is 33 %. However, land for industrial construction per capita increased from 0.084 to 0.121 $km^2$, and the growth percentage is 44.05 %. The latter grew faster than the former. So we can find out that industrial land area of Zhejiang Province is growing rapidly (Table 13.1).

As you can see from Table 13.2 and Fig. 13.1, comparing to growth of total industrial output value, growth of transferred land area of industrial warehouse space is much larger. Besides, industrial land area is growing faster than industrial production. The findings might reveal in part that industrial land and industrial development are incongruous, the proportion of industrial land is not reasonable and forms of land use are extensive.

Through the above data analysis, we can draw a conclusion that urban industrial land area is growing rapidly and the proportion of industrial land is larger. Many reasons contribute to this phenomenon, such as land scale of industrial park, industrial land transaction administration and industrial enterprise land form. Concrete causes presented below.

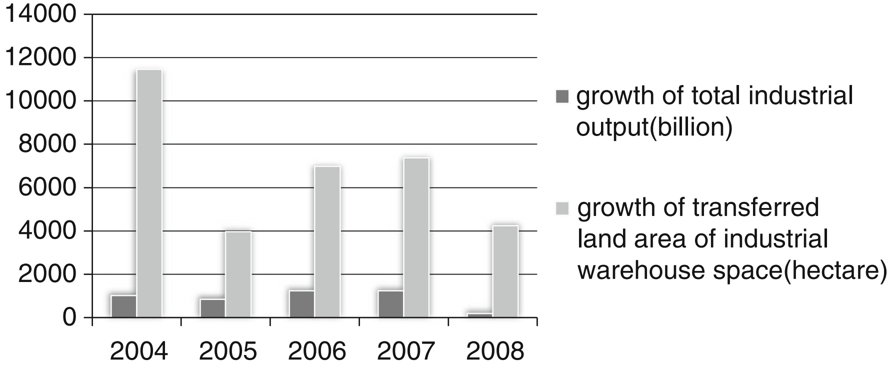


**Fig. 13.1** Histogram about growth of total industrial output and growth of transferred land area of industrial warehouse space of Zhejiang Province (2004–2008)

### *13.2.1 Industrial Land Market Mechanism*

Industrial land should be implemented strictly by means of public bidding, auction or hanging out a shingle in Zhejiang Province from 2004, which to a large extent standardizing industrial land selling methods. For investment attraction and "achievement projects", many local governments sell the land as agreed price that is far lower than development cost, even engendering "zero premium" and "negative price". Huge value-added benefits stimulate some enterprises' speculation. They hoard the land luridly and profit from that. As a result, this rent-seeking behavior not only intensifies the contradiction between human and the cultivated land, but also disturbs the normal order of land market. In 2002, Zhejiang Province enterprise survey squad conducted special investigations on 721 industrial parks, and the result indicated that the average land development cost of all the province was 6,686 yuan per hectare, and the average land transfer price was 5,956 yuan per hectare. What's more, about a quarter of the park land's price was not more than half of development cost, even 5 % of them was not more than one third.

### *13.2.2 Industrial Parks' Large Scale*

Building industrial parks are much significant for regulating urban land use structure and reducing the pressure of central area of the city. However, some regions develop blindingly which exceeds their own carrying capacity and real need of the market. At last industrial parks are too more to use effectively. On one hand, so many industrial parks will lead to illicit competition, which is against the optimized resources, on the other hand, planning area is too large, which is higher than the state-specified standard, and leaves land fallowed. A lot of factory buildings are not intensive construction and waste much land resources.

### *13.2.3 Industrial Enterprise Land Form*

Industrial enterprise land includes production departments, storehouses and accessory facilities. As we know, the site for construction is being scarcity and incremental construction land quotas assigned by Zhejiang provincial department of land resources every year can not meet the needs of industrial land. In the context, there are many companies that start the enclosure and use land extensively. However, the cost of industrial land is lower than commercial land and residential land. If the company wants to increase economic benefits as expanding enterprise scale blindingly, it will lead to increase the cost of the operation of enterprises and weaken its market competitiveness. On the premise of rising cost of resources, survival and profitability under high costs will make the sustainable development into trouble. Furthermore, because existing problems about using a piece of land by contract, some enterprises acquire land with preferential price, and that their floor space is more than they actually need. Most of workshops only build only one floor and the level of intensive utilization is low.

## 13.3 Suggestion on the Policy of Improving Urban Land Management

The above analysis gives the issues of the irrational proportion of industrial land and the incompatible relationship between industrial land use and industrial development in the urban land use structure in Zhejiang Province, and it still has a long way to go to achieve the high efficient use of land resource. Any attempt to resolve the issue of excessive proportion of urban industrial land use in Zhejiang Province requires a operational mode with the interaction among the market-oriented mechanism that plays a role of fundamental configuration, government's macroeconomic regulation and control, enterprises' changing the ways of land use and the public participation in supervision to realize the efficient and intensive industrial land use. The specific feasible measures are as follows:

### *13.3.1 Improve the Market Competition Mechanism*

Under the socialist market economic system, market is a basic measure of resource configuration. Industrial land, as an integral part in urban land use, can reflect the value of scarce land resource. If we want to promote the efficient use of industrial land resource, we can adjust industrial land supply and prices by the actions of the market mechanism. Government's persistence in strong intervention in the market economy will have a great negative impact when China is gradually perfecting its socialist market economy. Since the reform of land use system, significant progress has been made in the construction of the land market in Zhejiang Province, but the phenomena, such as agreement-based land transfer and administered pricing, continue to exist despite repeated prohibitions. Some local governments transferred industrial land at the price below cost for the purpose of profits or performance impact. The low-price agreement-based industrial land transfer has resulted in not only the low intensive use of industrial land but the shortage in industrial land supply in Zhejiang Province. Therefore, the industrial land transfer should enable the law of value and competition mechanisms in market to fully play their regulation and guidance role, accurately reflect the proper value of industrial land to manifest the openness and fairness of the market economy. By the actions of the market economy, the extensive use of industrial construction land caused by the agreement-based transfer industrial land should be reduced.

### *13.3.2 Strengthen Government's Macroeconomic Regulation*

Market mechanism has its inherent weaknesses of blindness and spontaneity. Land, as a special commodity, cannot be allocated purely relying on the market-based instruments. Proper macroeconomic regulation and control must be exerted to achieve the efficient intensive use of industrial land. The government macroeconomic regulation and control supervise the land-use practices mainly through economic and legal means, and enhance the level of intensive use of industrial land and control the size and structure of urban land use through the development and implementation of the general planning and annual supply plans of land use. In the exercise of administrative power, government should strictly implement the relevant provisions of land management laws and comprehensively strengthen the urban construction land management and strengthen the supervision of industrial land transfer in "tender, auction and listing" to rationally adjust the proportion of urban industrial land. Government macroeconomic regulation and control aim to overcome the market imperfections and promote the healthy development of the market economy. However, in actual operation, we should avoid the excessive intervention of government act and take care of the proper application of administrative means. Government's excessive administrative intervention will affect the construction and development of the land market because it not only cannot overcome the imperfections in market mechanism, but will hamper the market economy's role of basic configuration of land resource.

### *13.3.3 Upgrade Industrial Enterprises' Development Concept*

The further economic development in Zhejiang Province is bound to the changes in the existing status of processing and manufacturing low-value-added products and shifting to processing high-value-added products or producing independently developed products. Therefore, capital, talent and technology are the key elements in the long-term development of industrial enterprises. In the face of rising production costs and decreasing profit margins due to the increasing land costs, industrial enterprises shall firstly update their development philosophy, change their traditional concept of land use, recognize the importance of intensive use of land and rationally use every inch of land to explore the greater value of the existing scarce land resource and avoid idle and wasted land. They shall establish a concept of constructing multi-story plant during plant construction and other actual operations to make full use of underground space and improve space utilization of plants. Meanwhile industrial enterprises can introduce advanced management modes and advanced technologies to increase their productivity and change the extensive growth mode which is based on simply expanding the scale of land use and make efforts to improve the productivity of industrial land.

### *13.3.4 Introduce Public Participation Mechanism*

In recent years, public have high enthusiasm in community management participation, and the participating channels become more diversified. The network forms, such as forums and micro-blog, have been more used gradually, and the participation mechanism becomes sounder. The ultimate purpose of rationally adjusting the proportion of industrial land and increasing the level of intensive industrial land use and controlling urban land use scale is to achieve the interest of the masses and improve their life standard. That is why land use should be supervised by the broad masses so that their interests can be guaranteed. Government's macroeconomic regulation and control as well as enterprise production practice under the supervision of active public participation will enhance the transparency of the land market, standardize enterprises' production modes and promote the healthy development of cities.

## 13.4 Conclusion

Through collecting and analyzing data, we can find out that land area for industrial construction per capita grows faster than that for residential construction per capita. Industrial land area of Zhejiang Province is growing rapidly. Comparing to the growth of total industrial output value, growth of transferred land area of industrial warehouse space is much larger. Besides, industrial land area is growing faster than industrial production. These findings might reveal in part that industrial land and industrial development are incongruous, the proportion of industrial land is not reasonable and forms of land use are extensive. Many reasons contribute to this phenomenon, such as land scale of industrial park, industrial land transaction administration and industrial enterprise land form. Any attempt to resolve the issue of excessive proportion of urban industrial land use in Zhejiang Province requires a operational mode with the interaction among the market-oriented mechanism that plays a role of fundamental configuration, government's macroeconomic regulation and control, enterprises' changing the ways of land use and the public participation in supervision to realize the efficient and intensive industrial land use.

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# Chapter 14
# Empirical Study of the Influence of Urban Major Events on Land Use—with Shanghai Airport Park as an Example

**Yao Ni**

**Abstract** With the impact of "Big HongQiao" event on the land readjustment in Airport Park as an example, the paper counted on the quantitative research of the land use change caused by major events. Considering single dynamic index of changes of land use type and the Hedonic real estate price model, the results were obtained as follows: (1) "Big HongQiao" event, directly, accelerates the transition of research area from industrial to commercial office; (2) the model showed that, due to the change of variables, the floor price was significantly affected by external conditions. Finally, the research conclusion was that the impact of land-use changes as a result of significant events, was mainly demonstrated by the followings: (1) location choice; (2) social gathering; (3) derived system; (4) driving social damping mechanism, and etc.

**Keywords** Urban major events • Land use • Influence study • Airport park

## 14.1 Introduction

Cities are the result of accumulation of human, and events are the essential factors of the accumulation, that is, events play an important role in the formation of the city [1]. Land is the carrier, which city is interdependent on, because of mutual restriction and interdependence between urban development and land-use. Especially since the reform and opening, the land no longer acts as a role of natural resources, and economic and social value the land possess are also growing. Under this background, the interactive study between major events in the urban development and land use has become hot topic is noticed by educational circles. The city major events referred in the paper, were chosen as a specific decision-making

Y. Ni (✉)
Public Administration College, Zhejiang University, Hangzhou 310029, China
e-mail: 13916703671@139.com

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behavior, under the background of a specific political, economic and institutional situation, thus they affected the spatial structure of urban land-use, and form certain tangible change. However, considering the existing literature and published monographs, such research is relatively lacking. Only some scholars, successively, who took China's WTO accession, extension in south of Guangzhou, returning farmland to Dongting Lake and other major events for example, carried on the preliminary discussion on influence factors of land-use and reached the regular conclusions [2–4], what's more, the research content was relatively simple, research angle was relatively narrow. Therefore, in the face of the complex relationship between many driving factors and urban land-use change, seeing that it is difficult to truly reflect the effects of a major event by simple and isolate analysis, thinking must be transformed and research deeply from a holistic perspective. In view of the above facts, this article took Shanghai Airport Park as the research area, combining with the "Big Hongqiao" event (for the urban complex construction based on "Big Hongqiao" transportation hub construction engineering). At first, the influence of the major event on land evolution in the study areas was analyzed; then real-estate price model by Hedonic was used to simulate the effects of land-prices in the area caused by the important events, at the same time, based on the analysis of the model, meanwhile, the methods of economy, politics and sociology, were also used, to discuss both of the data and the driving mechanism behind the phenomenon.

## 14.2 General Situation of the Study Area and Data Collection

Shanghai Airport Park, locates in the west gate of Shanghai City, adjacent to the outer ring road, bordering Wusong River in the north, covering an area of 2.74 $km^2$. This paper referred to the city major events—"Big Hongqiao" event, namely, the development strategy about the construction of the Hongqiao integrated transport hub and development of Hongqiao business district, which was firstly claimed by the Shanghai municipal government in 2006, and it also formally established the future developing emphasis of Shanghai, especially the development of high-end manufacturing and R & D and modern service industry will be adjusted to a balanced development of "East of Pudong, west of Hongqiao". The adjustment of the urban development strategy for the Airport industrial park, adjacent to the Hongqiao business district, was faced with a cross-cutting development in historic opportunity, and land-use planning decision was influenced fundamentally.

Following the major event of urban development, Shanghai Airport Park, had experienced comprehensive adjustment of urban planning, supplemented by the strategic direction of land use adjustment, park landscape changed dramatically—a huge increase in both building economy and land tax, park location transformation from pure industrial park to comprehensive area of the functional urban, and the significant impact of land use.

**Table 14.1** Change trends of land use type of Shanghai Airport Park in 2007–2012. Unit: Hectare

| Land usage | Code | Area in 2007 | Area in 2012 | R (%) |
|---|---|---|---|---|
| Residential land | R | 22.48 | 22.78 | 1 |
| Land for public facilities | C | 22.52 | 98.85 | 339 |
| Industrial land | M | 47.21 | 36.83 | −22 |
| Warehousing land | N | 3.76 | — | −100 |
| Green land | G | 19.93 | 30.56 | 53 |
| Municipal utilities | U | 2.68 | 3.98 | 49 |
| Road and squares land | S | 52.08 | 66.63 | 28 |
| Urban space | Z | 76.31 | — | −100 |
| Water and other land | E | 26.19 | 13.74 | −49 |
| Total | | 273.31 | 273.37 | — |

Land-use is composite system with land natural ecological system and social economic subsystem and the subsystem of population as the link and interface coupling into [5]. The paper took “Airport Park land-map 2007” and “Airport Park land-map 2012” as a base map, using the spatial analysis function of ArcGIS, and measured land area ratio, as the basic data. According to the attribute data of the maps, construction land could be divided into residential land, land for public facilities, industrial land, warehousing land, green land, municipal utilities, roads and squares land, water and other land, urban space, a total of nine categories (see Table 14.1). A single dynamic land-use is selected to analyze which type of land-use changed largest in the study area. Its formula is as follows:

$$R = Ub - Ua\Big/_{Ua * T} \tag{14.1}$$

Among them: $Ua$, $Ub$ present the areas of a land use type at the beginning and end of the study period, respectively; $T$ as the period of time for research.

Put data into the dynamic formula of land-use type above, I got results of dynamic change, detailed in Table 14.1.

In 2007–2012, there were some principal characteristics in the changes of land-use types in the study area: (1) unexploited massif, planned originally to give priority of industrial land, were adjusted for the modern service industry, especially the productive service; (2) on account of the changes of land-use types and the increased amount of planning and construction, it was necessary to adjust road correspondingly in the Airport Park—widen roads, enhance the ability of foreign commuter, and increase the greening and municipal facilities.

## 14.3 Effects of “Big Hongqiao” Event on Land Price

In the study area, based on the dynamic change model of land-use, I drew the conclusion: land-use type of the maximal dynamic change was the land for public facilities (C), which mainly included commercial finance ($C_2$), scientific research and

**Table 14.2** Explanations of independent variable

| Influencing factor | Variable name | Independent variable description |
|---|---|---|
| Development intensity | Ln_land_per_unit | The reciprocal of plot ratio of building, the smaller value is, the bigger the intensity of development |
| Economic prosperity | Ln_eco_pros | The annual fixed asset price index, higher the index is, more economic prosperity |
| Land area | Ln_land_area | Target at development enterprise |
| Land type | land_type | $C_8$ type is 1, other types are 0 |

**Table 14.3** Result (1) of parameter estimation

| Parameter | Estimate of parameter | Confidence interval |
|---|---|---|
| $\beta_0$ | 8.0245 | [−9.1449 25.1938] |
| $\beta_1$ | 1.2351 | [0.7740 1.6962] |
| $\beta_2$ | 0.1512 | [−3.5665 3.8689] |
| $\beta_3$ | −0.0519 | [−0.1534 0.0495] |
| $\beta_4$ | 1.7055 | [1.3762 2.0347] |
| $R^2 = 0.8746$, $F = 64.5190$, $p = 0 <$ alpha | | |

education ($C_6$) and integrated commercial office ($C_8$), with use for the construction of non-residential buildings—office buildings, business buildings, etc. Through field survey, I also found another non-residential land in the study area, is the one for the industrial (M), such as R & D building. Thus, Hedonic price model was employed to analyze the price of non-residential buildings, [6] that is, the dependent variable was the natural logarithm of the corresponding building floor price, so the independent variable selected "development intensity, economic prosperity, land area, land types". Hedonic model is defined as follows:

$$\ln\_price = \beta_0 + \beta_1 \ln\_land\_per\_unit + \beta_2 \ln\_eco\_pros + \beta_3 \ln\_land\_area + \beta_4 land\_type + \varepsilon$$

Each variable is defined as follows (Table 14.2).

Ln_price is the floor price, in the model, the random error $\varepsilon$ of affecting other factors of ln_price, and $\varepsilon$ was supposed to be independent of other independent variables, obeying the normal distribution with mean 0.

Multiple regression commands in MATLAB software was used for, with the least squares method, estimates of the model parameter $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, and the results are seen in Table 14.3.

Alpha = 0.01

Through the analysis of estimates of model parameter, we found that:

1. The model was established from the mathematical point of view. The closer $R^2$ was to 1, F would be bigger, $p <$ alpha, showed that the regression model.
2. As $\beta_0 = 8.0$, the estimate of parameter was bigger, there might be external factors directly affecting the floor price, and they could be explained as the external economic factors, including inflation, etc.

As $\beta_1 = 1.2$, the estimate of parameter was bigger and positive, but the development intensity Ln_land_per_unit was natural logarithm for reciprocal of volume rate, are negative; it indicated that the development intensity was the greater as the price is lower, not in accordance with the general understanding. When carefully observing data provided, I discovered that, if volume rate of the data between 24 and 30, is 2 (the higher estimate), whereas floor price were the lowest, thus this affected the reliability of the calculation results.

As $\beta_2 = 0.15$, estimate of the model parameter was smaller. It suggested that economic prosperity had little influence on floor price. However, under the data observation the data provided by 33–42, which is lower degree of economic prosperity, unit-price of floor were lower.

As $\beta_3 = -0.05$, estimates of the model parameter was negative; when the greater the area was, price of the unit was lower, what was generally recognized.

As $\beta_4 = 1.7$, estimate of the model parameter was bigger; it showed that land type $C_8$ (comprehensive business office land) had significant effects for the price, as important as the development intensity, referring to influence of coefficient.

Regression results of the model showed that, during the research period, unit- price of floor in the study area changed obviously, when it was affected by a major external force. A key factor in affecting price of building floor was the type of land use, so the unit-price levels of the structures in type $C_8$, such as office buildings, business buildings, were generally higher than other types; Annual macroeconomic price index have little impact on floor price, besides the size of the block impacted on the general price of building floor weakly. Another important factor affecting real-estate price (price of building floor) was development intensity, which was higher as the real-estate price was higher in general, besides particular non-market factors.

## 14.4 Driving Mechanism Analysis of Impact of Major Events on Land Use

Dennis L. Meadows, in “the limits to growth”, pointed out that the model could only accommodate a limited number of variables, so the investigative interaction was only partial. Therefore, in order to make up for the defect of model, based on the above results of model, the paper was designed to increase the amount of social field survey, and analyzed the impact of urban major events on land use (especially the planning adjustment), with the application of mechanism in a detailed dissection, such as location choice, industrial concentration, the system analysis and social damping.

### 14.4.1 Location Choice

Case study mainly reflected the changes in regional center. Because of the "Big Hongqiao" event, the study area became to adjacent to the downtown area suddenly, therefore caused a series of changes, including changes in planning adjustments, changes of strategic value, changes in the types of land-use (transition approved by the city hall, from the industrial to commercial office land), changes in land prices and matched improvement, etc. In addition, it explained the reason in $\beta_0$, "there might be external factors, namely, external economic factors affected the floor price directly," except for the influence of inflation, the effect of the major events, could decrease the distance from the central city in the study area suddenly and highlight value of location decision. Discussion on the location early started in Thunen's theory, from layers to the sector, the polycentric, indicated that factors in affecting paying rent ability were the convenience of traffic, distance from the central city, which had bigger influence than that of industry [7]. At the same time, with the improvement of land properties and supporting municipal industrial to commercial, land (floor) price was affected by the increased more obviously.

### 14.4.2 Accumulative Effect

The dynamical statistical data reflected by changes in land-use, obviously lagged behind the actual situation resulting from the field survey. Proportion of industrial land was not reduced less than −22 %; moreover, there was no manufacturing workshop in the study area, and buildings on the industrial land were converted into settlement center or headquarters nature of commercial office buildings. The study area, with the construction of "Big Hongqiao" and adjustment of the original planning, on account of the natural advantages of comprehensive traffic hub, became the important point. It attracted a large number of airlines, freight forwarders, logistics companies, etc, generally form production agglomeration near the airport; previous industrial warehousing freight warehouses on the land, were gradually transferred into the modern logistics and third-party logistics, aviation services and transport business enterprise headquarters office. The phenomenon of "enterprises cluster effect" was obvious in the process of choosing enterprise site selection. Enterprises ranking in the forefront of the industry will set up their company's regional headquarters in the same place, because the location of regional headquarters of another enterprises which ranked in the forefront. Further, small scale or enterprises of downstream industry chain, because of the same considerations, would follow the industry leader and the industrial chain upstream enterprise to form a cluster; enterprises are as thick as hail objectively.

### 14.4.3 Derived System

At the present stage, reformation of land system in China is mainly in the transformation of the administrative transfer of supply into the paid transfer of supply. Land status in the study area from the industrial to do business, improved the degree of marketization of land configuration, so the value of the land was further recognized by the market recognition, which objectively had brought about the phenomenon of sudden high price of the land; namely $\beta_4$ was significant. Meanwhile, the normal development of land market was objectively disturbed by some decision from strong government, a kind of external force. Then, the excessive supply of land had distinct inhibitory effect on land price. When $\beta_2$ was smaller, it indicated that the unit-price of floor was hardly affected by the degree of economic prosperity, whereas, the direct reason of $\beta_1$ showed that land prices affected by the visible hand of government was greater than the invisible hand of market, that was the data of price 24–30 in the study area, "When the volume rate was 2, but price of floor was the minimum".

### 14.4.4 Social Damping

We should realize that, urban major events are not omnipotent in the process in the process of urban development. For example, "nail households". Through field survey, there were two perennial idle in the study area where people did not move. Because of the prevalent social environment, "present situation is previous to the plan, and even the plan is changed in harmony", there possibly exists the "nail house", who have a new weights after "property law" promulgates, yet the law itself to protect the legitimate rights and interests, of course, no ground for blame, but pivotal issue is that the dividing line between legitimate rights and the opportunity to seek illegal excess profits also started to blur together. The existence of the "nail house" is like a red flag, guiding the people gradually learn to wild speculations, as if the river rises the boat floats high, stars to increase on the earth of socialism with Chinese characteristics, as similar as the fjord of Japan's Narita airport runway, which can't be gone around. Maybe, time is the ultimate way to solve the problem.

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# Chapter 15
# A Study on Obstacle Diagnosis and Support System of Sustainable Urban Land Use of Huangshi City in Hubei Province

**Ping Shen, Heyuan You, and Cifang Wu**

**Abstract** One of fundamental conditions for social and economic sustainable development of city is sustainable urban land use. It is with urgent and real significance to do deep research on the sustainable urban land use of Huangshi city for Huangshi city and other similar cities because Huangshi city is typical city of secondary cities in central China. In the paper, first of all present urban land use characteristics of Huangshi city are introduced, and then obstacles which affect sustainable urban land use of Huangshi city are gained by obstacle diagnosis of sustainable urban land use of Huangshi city, finally the support system of sustainable urban land use of Huangshi city is established.

**Keywords** Urban land • Sustainable use • Obstacles • Support system • Huangshi city

## 15.1 Introduction

Sustainable land use refers to that the present utilization of land should not pose threat to future generations' sustainable utilization of land, which means land utilization not only meet the needs of contemporary, but also do not affect future generations' abilities to satisfy their needs in the long term [1]. Sustainable land use contains two meanings, the efficient utilization of land resource itself and the effective combination with other social resources to support the economic and social sustainable development. Present researches on sustainable land use mainly

P. Shen • C. Wu
College of Public Administration, Zhejiang University, Hangzhou 310029, China
e-mail: sp_sosp@sohu.com; wucifang@zju.edu.cn

H. You (✉)
College of Business Administration, Zhejiang University of Finance and Economics, Hangzhou 310029, China
e-mail: youheyuan@qq.com

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focus on the macro level, such as the whole country as well as the economically developed regions [2], especially the Yangtze River Delta or the Pearl River Delta, when reviewing from the perspective of research areas. It can be seen that the sustainable use of land is related to the economic development to some extent, so it is important to carry out the studies on the sustainable use of land in the Central regions during the Rising of Central Regions. Unlike the development of the entire region in the eastern coastal areas, the socio-economic development in Central Regions is more like ‘Point Eruptions’ with some cities developing faster and the county’s economy here is relatively weak [3]. As a result, the pivotal role of cities in the development of Central regions decides that it is urgent to highlight the studies of the sustainable use of urban land here. So this article is going to do empirical analysis in Huangshi City which can not only affect the development of Huangshi City itself, but also affect the development of sub-center cities in Central regions.

## 15.2 Characteristics of Urban Land Use in Huangshi City

### *15.2.1 Favorable Geographical Location of Urban Land Resources*

The Huangshi city, which is the second largest city in Hubei Province, locates in the southeast of Hubei Province and on the south bank of middle Yangtze River. It lies between Wuhan and Jiujiang city and is neighboring to areas of the four provinces of Hubei, Henan, Anhui and Jiangxi. Huangshi is the transportation junction of the borders of these four provinces and is an important passage linking Middle China and East China. The Hurong Expressway, or Shanghai-Chengdu Expressway, traversing the north of the city, goes north to Chongqing and Chengdu city and south to the Ningbo and Shanghai city, and the Wu-huang-jiu (Wuchang, Huangshi, Jiujiang) Railway links eastwards the Zhegan Line and westwards the Jingguang Line. In addition, via the Yangtze River the waterway runs to the ocean, the waterway transportation in Huangshi is thus very convenient.

The geological condition of Huangshi city is quite good [4]. The bearing capacity of soil here is generally high: except for some soft soil layer whose bearing capacity is below 10 t/m$^2$, it is usually between 15 and 20 t/m$^2$. The underground water is rich in storage and the engineering geological nature is favorable and is suitable for city construction.

### *15.2.2 Relatively Low Intensity of Urban Land Use*

The intensity of urban land use in this area could not be that high, which is determined by the level of economic development in central China. In view of

**Table 15.1** Comparison of urban land use strength with city of Huangshi, Ningbo and Average in China

| Region | The gross value of industrial output per unit of land use ($10^4$/km$^2$) | Investment in fixed assets on land use unit construction ($10^4$/km$^2$) | The GDP per unit of land use ($10^4$/km$^2$) |
|---|---|---|---|
| Huangshi | 91,766.770 | 7,729.176 | 5,838.034 |
| Average | 154,685.953 | 11,429.437 | 1,347.568 |
| Ningpo | 432,442.718 | 47,536.718 | 4,004.026 |

Data sources: Calculated from "China City Statistical Yearbook" and "The annual of China urban construction statistics"

**Table 15.2** Comparison of urban land use velocity extension with city of Huangshi, Ningbo and average in China

| Region | Built-up area in 1999 (km$^2$) | Built-up area in 2020 (km$^2$) | Rate of expansion (%) |
|---|---|---|---|
| Huangshi | 58 | 45 | 0.072 |
| Average | 21,926 | 14,907 | 0.118 |
| Ningpo | 110 | 66 | 0.167 |

Data sources: Calculated from "China City Statistical Yearbook"

the fact that Ningbo and Huangshi city each has the similar economic status in their own province, Ningbo city is chosen as a comparison to the developed region of Huangshi city in this paper. According to analysis of statistical data, the gross industrial output value per unit area of industrial land in Huangshi is only 3/5 of the average level in China and 1/5 of that in Ningbo; the fixed investment per unit area of construction land in the municipal district of Huangshi is only 2/3 of the average level in China and 1/6 of that in Ningbo. The intensity of land use is low. Since the area of the municipal district in Huangshi is only 234 km$^2$, thus the gross output value per unit of land in Huangshi is higher than the average level in China and Ningbo, but it cannot really reflect the actual situation of the intensity of land use in Huangshi (Table 15.1).

### 15.2.3 Relatively Slow Process of Urban Sprawl

The urban sprawl in urbanization is inevitable trends. In Table 15.2, the average rate of urban sprawl of china's cities is a 1.6 times and the rate of urban sprawl of Ningbo is 2.3 times Huangshi city. So, we can know that the rate of urban sprawl is slow in Huangshi city.

$$V = (S_t - S_{t-n})/n \qquad (15.1)$$

Where: $V$ is the rate of urban sprawl in n years; $S_t$ is the built-up area of city at $t$ time point; $n$ is the time span.

## 15.3 Obstacle Diagnosis of Sustainable Urban Land Use of Huangshi City

### 15.3.1 Index System of Sustainable Urban Land Use Evaluation

Due to the complexity and practicality of the evaluation of sustainable urban land use, the selection of index layer should follow the three standards below [5].

Objectivity of index: the index selected should be adjusted to local conditions and can reflect factors influencing or marking the sustainable urban land use level in this area to the utmost. Accessibility of index: easy access to index is a prerequisite of continuous trace for evaluation of sustainable land use level; if some index shows fracture of data in the past, the present or the future, then the evaluation of sustainable urban land use level is likely to have deviations. Quantification of index: reliability and enforceability of evaluation of sustainable urban land use based on mathematical quantitative analysis is much higher than normal qualitative evaluation and the quantification of indexes selected by the index layer will to a large extent facilitate the mathematical quantitative analysis for evaluation of sustainable urban land use.

Based on the index system which established by Tan et al. for evaluation of sustainable urban land use [6], the index system for evaluation of Huangshi sustainable urban land use is constructed according to the reality of Huangshi city, with an evaluation target of sustainable urban land use level (Table 15.3). And indexes based on which the system are constructed covering aspects such as land area, land use efficiency, land use structure and land-use management are capable of reflecting the present situation and future trend of sustainable urban land use. At the same time, out of concerns of the differences between factors of the factor layer and indexes on the index layer in terms of their power of influencing or marking the sustainable urban land use, the analytic hierarchy process (AHP) is used to further determine the weights of each index.

### 15.3.2 Dimensionless Form of Index Factors

In order to avoid the incomparability of different index brought by dimensional heterogeneity in the evaluation of sustainable urban land use, all the indexes have been dimensioned according to the characteristics of the target indicator values.

First, when the index value is in the [N, +∞] interval and the more the better, the dimensionless function is as follows:

$$\begin{cases} P_i = 1 & x_i \geq N \\ P_i = x_i/N & x_i < N \end{cases} \tag{15.2}$$

**Table 15.3** The index system of sustainable urban land use evaluation in Huangshi city in China

| Target layer | Factor layer | | The index layer | Target value | weight |
|---|---|---|---|---|---|
| City land sustainable use degree | Land use areas (0.193) | | Per capita housing area $x_1$ ($m^2$/capital) | ≥26.3 | 0.175 |
| | | | Per capita living area $x_2$ ($m^2$/capital) | [18.0, 28.0] | 0.116 |
| | | | Per capita industrial area $x_3$ ($m^2$/capital) | [10.0, 25.0] | 0.449 |
| | | | Per capita road plaza area $x_4$ ($m^2$/capital) | [7.0, 15.0] | 0.125 |
| | | | Per capita green area $x_5$ ($m^2$/capital) | ≥9.0 | 0.135 |
| | Land use efficiency (0.302) | Economic benefits | Unit land area of GDP $x_6$ ($10^4$ Yuan/$km^2$) | ≥5,293 | 0.278 |
| | | | The gross value of industrial output per unit of land use $x_7$ ($10^4$ Yuan/$km^2$) | ≥233,774 | 0.298 |
| | | Environmental efficiency | Comprehensive utilization rate of industrial solid waste $x_8$ (%) | ≥85 | 0.101 |
| | | | Industrial wastewater discharge compliance rate $x_9$ (%) | ≥95 | 0.112 |
| | | | Living garbage harmless treatment rate $x_{10}$ (%) | ≥80 | 0.097 |
| | | | Sewage treatment rate $x_{11}$ (%) | ≥45 | 0.114 |
| | Land use structure (0.278) | | Residential land proportion $x_{12}$ (%) | [20.0, 32.0] | 0.071 |
| | | | Industrial land proportion $x_{13}$ (%) | [15.0, 25.0] | 0.645 |
| | | | Road and square land proportion $x_{14}$ (%) | [8.0, 15.0] | 0.123 |
| | | | Green space proportion $x_{15}$ (%) | [8.0, 15.0] | 0.161 |
| | Land use management (0.227) | | The proportion of allocation $x_{16}$ (%) | ≤60 | 0.333 |
| | | | The proportion of paid for the area in the auction $x_{17}$ (%) | ≥40 | 0.667 |

Data sources: "The land use planning and construction standards of urban land use classification and standard in China", "The assessment indicators implementation of national environmental protection of model city in China (adjustment)", "Environment Statistics Annual Report", "Sustainable development planning in Zhejiang Province", "China City Statistical Yearbook", "The report of China market economy development", "The Research Report of Chinese residents living target Prediction in 2020"

Note: The GDP of per land use unit and the total output value of per unit industrial area were taken the average from 15 provincial capital city as the target value. They are including Nanning, Guiyang, Chengdu, Lanzhou, Urumqi, Xining, Hangzhou, Harbin, Changchun, Shijiazhuang, Nanchang, Ji'nan, Wuhan and Changsha et al.

**Table 15.4** The evaluation index value and the dimensionless value of sustainable urban land use in Huangshi city in China

| Index code | Index value | Dimensionless value | Index code | Index value | Dimensionless value | Index code | Index value | Dimensionless value |
|---|---|---|---|---|---|---|---|---|
| $x_1$ | 20.00 | 0.76 | $x_7$ | 91,766.77 | 0.39 | $x_{13}$ | 31.50 | 0.79 |
| $x_2$ | 16.33 | 1.00 | $x_8$ | 35.00 | 0.41 | $x_{14}$ | 8.53 | 1.00 |
| $x_3$ | 24.32 | 1.00 | $x_9$ | 83.42 | 0.88 | $x_{15}$ | 14.01 | 1.00 |
| $x_4$ | 6.58 | 0.94 | $x_{10}$ | 69.00 | 0.86 | $x_{16}$ | 2.10 | 1.00 |
| $x_5$ | 10.82 | 1.00 | $x_{11}$ | 39.00 | 0.87 | $x_{17}$ | 10.68 | 0.27 |
| $x_6$ | 5,838.03 | 1.00 | $x_{12}$ | 21.15 | 1.00 | | | |

Note: The index of land use management and the indicators of land use environment from the land use benefits are the index of overall city

Second, when the index value is in the [0, M] interval and the less the better, the dimensionless function is as follows:

$$\begin{cases} P_i = 1 & x_i \le M \\ P_i = M/x_i & x_i > M \end{cases} \tag{15.3}$$

Third, when the index value is in the [N, M] interval, the dimensionless function is as follows:

$$\begin{cases} P_i = 1 & x_i \in [N, M] \\ P_i = x_i/N & x_i < N \\ P_i = M/x_i & x_i > M \end{cases} \tag{15.4}$$

In line with the Huangshi city index, different dimensionless functions were adopted (Table 15.4).

### 15.3.3 The Obstacles Diagnosis of Sustainable Use

The obstacles diagnosis of Sustainable use can be divided into two steps, first, the comprehensive evaluation on the sustainable utilization, and second, the confirmation of sustainable use of obstacle factors.

Sustainable use of comprehensive evaluation is to assess the sustainability of urban land use on the overall level. The Eq. 15.5 is sustainable utilization calculation function.

$$G = \sum_{j=1}^{3} \Big(\sum_{i=1}^{n} P_i \times w_i\Big) \times r_j \tag{15.5}$$

Where: $G$ is the comprehensive evaluation value of the sustainability of urban land use; $r_j$ is the weighting value of No.$j$ factor; $w_i$ is the weighting value of No.i index;

**Table 15.5** The results of sustainable urban land use on obstacle degree in Huangshi city in China

| Index code | Obstacles degree | Index code | Obstacles degree | Index code | Obstacles degree |
|---|---|---|---|---|---|
| $x_{17}$ | 0.455 | $x_{10}$ | 0.017 | $x_6$ | 0.000 |
| $x_7$ | 0.226 | $x_9$ | 0.017 | $x_{12}$ | 0.000 |
| $x_{13}$ | 0.155 | $x_4$ | 0.006 | $x_{14}$ | 0.000 |
| $x_8$ | 0.074 | $x_2$ | 0.000 | $x_{15}$ | 0.000 |
| $x_1$ | 0.033 | $x_3$ | 0.000 | $x_{16}$ | 0.000 |
| $x_{11}$ | 0.018 | $x_5$ | 0.000 | | |

$P_i$ is the dimensionless quantity of No.i index. And, $G \in [1, 0.9]$ is defined sustainable use stage, $G \in [0.9, 0.7]$ is defined basically sustained use stage, $G \in [0.7, 0.5]$ is defined initial sustained use stage, $G \in [0.5, 0]$ is defined critically sustained use stage.

Diagnosis of its obstacle indicator would be greatly helpful finding out the influence of main obstacle factors of sustainable utilization and take effective measures to prevent these factors of critically sustainable usage. The conception of "Obstacle degree" (Eq. 15.6) were introduced to apply the sustainable utilization obstacle diagnosis.

$$A_i = (1 - w_i) \times \left(w_i \times r_j\right) / \sum_{i=1}^{17} (1 - w_i) \times \left(w_i \times r_j\right) \tag{15.6}$$

Where: $A_i$ is the Obstacle degree of No.$i$ index. $r_j$ is the weighting value of No.i index of No.$j$ factor; $w_i$ is the weighting value of No.$i$ index.

Based on the empirical analysis of Huangshi City, the results showed that the comprehensive evaluation value of the sustainability of urban land use is 0.76, and Huangshi city is in the basically sustained use stage. A further research is that the obstacle degree of every index was calculated and sort items by size, from smallest to largest (Table 15.5).

The results can be found from the diagnosis, the land of Bidding/Auction/Hanging is the low share accounted for the land compensative usage, industrial output of industrial land per hectare is lower, the proportion of industrial land is large, the percentage of treated urban sewage is lower, the percentage of urban household waste safely handled is lower, the percentage of standard discharge rate of industrial wastewater is lower, the average per-capita living space is lower and the per-capita road area is lower, these are the important obstructed elements of sustainable use of land in Huangshi city.

## 15.4 Policy Implication of Urban Land Sustainable Use of Huangshi City

According to land sustainable use obstacles was found in the diagnosis of obstacle factor, policy implication of land sustainable use would be raised.

Intensive utilization of industrial land. Consequence from the sustainable use disorder diagnosis shows that there are three big issues in Huangshi city: big proportion of industrial land; industrial land area per capita gross industrial output value is low; the area of industrial land sustainable utilization evaluation standard. To achieve industrial land sustainable utilization, it would adopt method of intensive land economical utilization industry.

Strengthen control of environmental pollution, and promote the development of circular economy, reduce the pollution of the land. Huangshi as a typical resource city, the development of circular economy can not only improve the level of sustainable utilization of urban land, but also can has important significance to improve the city's comprehensive economic strength and to promote the city economy sustained and stable development.

Moderate speeds up the infrastructure such as roads, parking lots, square, maximizing the land comprehensive benefits, maximize the externalities of land use; Focus on the development of residential district square, improve urban human settlements, grade control the image of the city square construction, to explore new means of land landscape feature release.

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# Chapter 16
# Theory and Practice of Urban Renewal: A Case Study of Hong Kong and Shenzhen

**Guoliang Ou and Gang Wu**

**Abstract** In recent years, along with the acceleration of development of cities in our country, land resources in city is becoming shortage and urban renewal in large and medium-sized city like a raging fire. Due to the serious urban renewal problems under current real estate system, like the imbalance of interests and social inequality, restricting its further development practice. Although the academic circles of our country have done more extensive research on urban renewal and related issues, but mostly only based on spatial updating method or the introduction of foreign experience. This paper describes the theory and practice of domestic and international urban renewal, taking Shenzhen and Hong Kong as an example, analyzes the characteristics of China's urban renewal and discusses how to solve the contradiction between the city transformation and sustainable development, and puts forward related suggestions.

**Keywords** Urban renewal • Urban redevelopment • Urban regeneration • Hong Kong • Shenzhen

## 16.1 Introduction

Urban renewal refers to the specific stage of city development, the process and model of development and utilization of city land. In the history of the development of western city, according to the different city development background and development organization, develop contents are different, which include city development (Urban Redevelopment), city recycling (Urban Reuse), city regeneration

G. Ou (✉) • G. Wu
School of Construction and Environmental Engineering,
Shenzhen Polytechnic, Shenzhen, China
e-mail: ouyangszpt@126.com; szwug@163.com

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(Urban Regeneration) and city revival (Urban Renaissance) and many other titles, although these concept focus on different aspects, but in essence, it refers to the city land function replacement and recycling. Thirty years of reform and opening up, the Rapid City development encounters the restriction of gradually stiffness land resources, urban renewal has become the problem that more and more city government had to face seriously. Since more than 30 years of reform and opening-up, China's rapid urbanization process has encountered gradually toughened land resource constraints, and urban renewal has become the problem that the government has to face more and more carefully.

## 16.2 Literature Review

### *16.2.1 Foreign Theory About City Renewal*

From the research results of foreign city, urban renewal is a political process, spatial structure and development area is the result of political decisions on resource redistribution. Foreign scholars study about urban renewal generally focuses on the following aspects: (1) Exploration and practice of urban renewal. [1] "City: Its Development, Decline and The Future", which rise the city beautiful movement (City Beautiful Movement), expecting through the creation of a new physical space image and order to establish a "dream city", in order to improve the city environment of industrialized after the destruction of the city. (2) The study of city renewal evolution law. James (2003) "Comparative Study of western city evolution", pointed out that the western city renovation practice path after World War II: "slum clearance – neighborhood renewal – community renewal". The guidance concept of urban renewal changed from a single large-scale transformation of the "modernism" gradually becomes broader objectives, rich content of human settlements environmental construction and to achieve sustainable development. (3) City sociology study on environmental behavior of human space. Such as Parke (R.E. Park) as the representative of the Chicago school, opened in the first person and space of the city from the angle of social ecology. Parke believes that the city is a social organism, its each part in the competition and symbiosis under the control of two factors together, city renewal activities in the city system is balanced and unbalanced alternately appeared and promote the development of the city. (4) Study on mixed mode of urban renewal. Such as Talen (2006) research on the United States of America in the early 1960s of the last century, Columbia City planning to consider the social and ethnic groups mixed problem. Europe and the United States are now generally begun to make mixed mode as the new direction of the government's housing policy.

### 16.2.2 The Main Model of Foreign Urban Renewal

1. Urban renewal in the United States of America. Because the United States with much land and few people, the urban renewal model is suburban rapid development (Qiu Baoxin 2012), in the nearly a hundred years of city development process, the city built-up area population density decreased by more than 1 times, resulting in a serious energy consumption, the destruction of the ecological environment, the reduction of arable land, social problem of polarization between the rich and the poor. In most parts of the world, including China have adopted a similar pattern, which played a larger role for the development of city.
2. The European urban renewal. Because of the earlier development and less land of European city, the pattern and urban renewal of European is quite different from that of United States of America. Its high city population density and the mode of difference development between urban and rural are worth to learn by other countries with similar intensive population, like China.

### 16.2.3 The Theory and Practice of Domestic Urban Renewal

At present domestic research on Urban renewal more focus on the transformation of the old city, transformation of old industrial areas, reconstruction of the village. In the past 10 years, including regional economics, sociology, city planning and other related fields of scholars have conducted extensive research on the transformation of the old city, village. But our country urban renewal theory research started relatively late, and emphasis on the technical level and how to realize the “tear down the reconstruction technology”. Now with the frequent “nail households”, “violence to resist demolition” phenomenon, research perspective change from a single “transformation” to “organic renewal”, “pluralism” and other update concepts. Specifically, domestic research is mainly reflected in the following aspects: Such as Lv Xiaobei, Zhao Ruoyan (2009) “The Thinking of Shenzhen Urban Renewal System Construction”, analysis the existing construction problems in the current urban renewal system, including the renewal policy dispersion, management authority dispersion, space division, the government plans to split vacancy, and city planning does not adapt to update management needs. Such as Tian Zhenyu (2005) “The Objective and Mode of village construction transformation in Shenzhen”, put forward according to the specific circumstances of different villages, the appropriate transformation way needs to be chosen. Yang Liyun (2007) “Homestead Shares: The New Mode of Village Reconstruction” take the reconstruction of Tian Xia Xin Cun for example, it prompt that the villagers can buy shares based on their homestead to conduct urban renewal activities, and to participate in the project profit distribution. Ma hang (2007) “The Analysis of Shenzhen Urban Village Reconstruction in Sociology Vision”, proposed the villages inside the city of Shenzhen are non-agricultural peasants group, “small tradition" attaches "new social space", is to protect and realize multiple interests and rights, as well as the media attaches to the city smoothly. Luo Huihua (2008) "Urban Village Reconstruction in Medical Law", take Xin Wei Village as an example, stated a practical apply of Chinese medicine therapy principle in the process of reform. Huang Yingxiao (2007) "the exploration about the update problem of old city zone", take golden paddy field area as an example, from the land use, the overall shape, construction layout, landscape environment these four aspects to think and explore the transformation of the old city.

## 16.3 Practice of Urban Renewal in Hong Kong and Shenzhen

### *16.3.1 Practice of Urban Renewal in Hong Kong*

Hong Kong and Shenzhen are separated by a river, due to limited land resource and the early development, Hong Kong as early as 2006 had more than 10,000 old buildings with more than 30 years; the urban renewal of urban reconstruction projects, repair brook requires no delay. According to the problem of urban renewal (Huang Wenwei, Wei Qingquan 2008, Hong Kong Renewal Policy), Hong Kong government has done the following three aspects:

1. In 2001, Hong Kong government set up a corporate with an independent of government but supported by government, the urban renewal authority mechanism responsible for the renewal of the city, all members are appointed by the chief executive of the HKSAR government. As it is the only mechanism of the urban renewal authority as the Hong Kong urban renewal, it can execute unified functions, clarify responsibilities and improve work efficiency.
2. For the demolition resettlement compensation of city reconstruction, Hong Kong government after the massive survey, adopted the compensation principle of people-oriented, subdivided into a single set of residential use, part for rental, all for rental, part of vacancy and multiple sets of housing compensation scheme. At the same time, Hong Kong government provides a bridge loan and excessive housing to help from two aspects of financial and housing policy.
3. For the finer city repair project, the urban renewal authority provides professional and technical support, repair support, loans and public insurance, giving all aspects help from planning to implementation.

### *16.3.2 Practice of Urban Renewal in Shenzhen*

At present, Shenzhen more concentrated in the transformation of the each district development and the old city, old industrial district, villages inside the urban renewal. In the 10 years of reform and development, Shenzhen had a set of relatively complete system and achieved good results. However, due to various problems brought by the rapid city construction, it has become the difficult of urban renewal. Therefore, academic circles of Shenzhen have made a lot of research about urban renewal. Specifically, the relevant practice of Shenzhen is mainly reflected in the following aspects:

1. Emphasis on updating of spatial structure of city. Wang Weicheng (2006) "The Main Type, Problems and suggestions of Shenzhen Urban renewal – in city spatial structure perspective", through research on the transformation of old industrial areas, storage areas, urban village reconstruction transformation – the land use function and nature of land use changes, the land development intensity changes, and its influence on population, funds, information, it gives the specific suggestions.
2. Emphasize the study of urban renewal housing arrangements. He Chuanjiao, Li Jiang (2012) pointed out in "Perfect Housing Policy, Efforts to Increase Security – Shenzhen urban renewal project of affordable housing built with the proportion research" that as the current serious shortage of Shenzhen affordable housing supply, government should expand the scope of protection, broaden the channels of supply, increase affordable housing guarantee scale, stabilize the market, stabilize prices, solve the livelihood problems and auxiliary industry development and security.
3. Stressed the role that the government plays in urban renewal. Liu Xin (2011) "The Role of Government And The Urban renewal in Shenzhen – from interests sharing as to burden sharing", through the role relationship theory, compares the changes and balance of domestic and foreign role relationship, puts forward improvement space resource differences in the establishment of system integration, innovation renew unit planning coordination means, create diversified tax incentives. These six major aspects of the path selection that government can choose to provide help to ensure the smooth the process of urban renewal.
4. Emphasis on protection of the interests of vulnerable groups in urban renewal. Lu Yuan (2005) "Program to Protect The Interests of Vulnerable Groups in City Planning – Exemplified by Urban Regeneration Process" takes the transformation of the old city as an example, presents city planning as a social purpose of social engineering, and expounds the status and reasons of city planning in reality, it is often difficult to achieve the interests of vulnerable groups. At the same time, it also reference to the public policy process theory, discusses interests protection system and procedural arrangements of the vulnerable groups in city planning process.
5. Emphasis on practical constraints in urban renewal. Li Jiang, Wang Fenfang (2006) "Research on policy evaluation and suggestions of Shenzhen urban renewal in the conditions of resource constraints", points out that Shenzhen's rapid economic development put forward new requirements for the city function and structure adjustment. Shenzhen also faces the plight of spatial resource shortage. It puts forward the existing problems in the current policy through

the reform policy that being implemented in practice, the wishes of the government and market demands, the ownership of land and other aspects of comprehensive evaluation; and from the point of policy demand perspective, analyzes the core needs to solve the renewal policy questions. As from planning, land, property these aspects to coordination a good relationship among the government, developers and owners; based on the current characteristics of Shenzhen, it also put forward a number of suggestions of making urban renewal policy from the aspects of reform methods, planning, mechanism construction.

To sum up, Shenzhen city construction is slowly getting rid of suburban development model, through the improvement of deficient project to achieve the urban renewal; can effectively inhibit the process of suburbanization.

## 16.4 Conclusions and Suggestion

According to the comparison of the domestic and foreign related urban renewal mode and Shenzhen urban renewal model, the following conclusions can be drawn:

1. Urban renewal mode should be selected to coordinate with the local cultural, economic, political environment, pay attention to the overall coordination, avoid pattern of suburbanization. Urban renewal shall be treat differently with cultivated land, cultural relics, natural attractions; in the process of urban renewal, arable land, cultural relics, natural scenic spots should be protected and inject new vitality into the city. Urban renewal mode selection should be completed in the protection of the old user's interests and rights. Urban renewal is not just renewing buildings; more is renewing city economy, transportation, education and other aspects. In the city planning, we should also consider end users and give the corresponding renew.
2. Urban renewal is the corresponding system, in order to better complete the urban renewal task, it should be done in supervision of the government and the people. Refer to international urban renewal theory, and based on the current urban renewal practice of our country. The reform of paid use of land and rural land circulation policy promotes the gradually manifest of the economic value land, attracts social capital to participate in the development process of depressed areas in different degrees, forming a powerful market driving force. At the same time, under the background of economic globalization, competition between cities becomes more intensive. In order to expand the competitive advantage, each functional area in the same city also has to develop the endogenous demand – industrial zone has a strong will of industry transformation and upgrade. "Village in city" has a strong demand to improve infrastructure, improve the living environment; waterfront has a heavy responsibility to reshape the landscape node and improve urban charm.

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# Chapter 17
# Land Reserve Patterns Selection of Brown Land: A Case Study of the Old Industrial Land Along the Zhujiang River in Guangzhou China

**Wenzhu Zhang, Ran Wang, Ting Yuan, and Zhigang Wu**

**Abstract** With rapid urbanization in China, there is a serious shortage of land resource to be developed. Development of brown land become an important way to achieve high efficient and intensive utilization of land resources. This paper introduces two types of land reserve pattern of brown land which are general land reserve and Three-old (old factory, old town, old village) land reserve, calculating their economic indicator by a cost-benefit estimates analysis. Taking the old industrial land area along the Zhujiang river in Guangzhou city as a case study, we present a land reserve pattern selection method. We find that: (1) there are large differences for these two land reserve patterns amongst the reserve procedure, the compensation standard for the original property owner, and distribution ratio of land value-added income; (2) Land area and the scale of fixed assets are key factors of pattern selection. (3) intention of land reserve for government and enterprise behaves in different ways.

**Keywords** Brown land • Land reserve pattern • Cost-benefit analysis

## 17.1 Introduction

Since the reform and opening, China has experienced remarkable economic growth and rapid urbanization process in which land resources play a key role. However, with the rapid urbanization, land resource to be developed has become a bottleneck

W. Zhang
College of Resource and Environmental Science, Qinzhou University, Qinzhou, Guangxi Province 535000, China

R. Wang • T. Yuan • Z. Wu (✉)
Center for Urban and Regional Development Studies, South China Normal University, Guangzhou 510631, China
e-mail: 61359359@qq.com

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problem. With the growth of economic development, urban land demand is increasing while the new urban construction land supply is limited. There is a recession and inefficient land use in many old industrial area in the city, being faced with the pressure of transformation of urban development, urgent need for transformation and upgrading of industrial structure, changing the existing extensive, inefficient land use pattern and realize the intensive utilization of land resources. Many cities put forward policy of "retreat secondary industry into tertiary industry" for industrial transformation and upgrading, in order to relocate the low-benefit and heavy-pollution industrial companies in the city and transfer the existing inefficient land into new development.

In 2008, Guangdong province as the pilot model of economical and intensive construction land use, has been issued a series of policies by Ministry of Land and Resources to renewal land use of old factory, old town and old village (hereinafter referred to as the "three-old renewal"). Land reserve running by government before was called the general land reserve pattern, in which the acquisition of the old industrial land planned to be reserved will be appraised and relocated. A new pattern of land reserve by the three-old policy has been proposed to promote the brown land renewal. What is the difference between the general land reserve pattern and the three-old pattern ? How does the government select the pattern of land reserve ? Based on cost-benefit analysis, we has been put forwarded a new approach to land reserve pattern selection in this paper.

## 17.2 Patterns of Brown Land Reserve

To differentiate in this paper, the pattern of land reserve in which the planned land to be reserved is usually assets-appraised and relocated, is referred to as the general land reserve; the pattern of land reserve proposed by the relevant policy of three-old renewal, is referred to as the three-old land reserve. The detail conception of this two articles is described as below.

### *17.2.1 Pattern of General Land Reserve (GLR)*

According to the two state council documents, measures for the administration of land reserve, rules of state-owned land housing levy and compensation, and the Guangdong Provincial relevant land reserve policy documents, the GLR pattern of brown land is evaluating assets and offsite relocation, the operation mechanism is that the original property owner purchases land in offsite, and does some ground treatment for industrial production and warehouse space land using to ensure existing capacity assets' offsite relocation; land reserve agency pays the costs to complete these objectives, and implements Land Consolidation after completing the above objectives, then acquires land revenue through net transferring, and proceeds to public facilities and infrastructure construction [1].

The features of GLR pattern: (1) Land reserve process: land reserve agency assesses the assets and pays compensation for factory transfer, then factory relocates in offsite, the land reserve agency implements land consolidation, transfers the land and acquires land revenue. (2) The original property owner's compensation standards: according to the GLR pattern, the compensation price is based on the original land use, complying with the principle that separating land acquisition compensation and land attachment compensation, the original property owner can get compensation for land costs and relocation costs. The land costs typically include factory offsite acquiring land costs and industrial production ground treatment costs, thus the original property owner can normally obtains compensation for fixed asset relocation costs, offsite land acquisition costs and offsite industrial land ground handling costs. (3) The land value-added benefits has nothing to do with the original property owner, land reserve agency pays factory relocation compensation, transfers land after land consolidation, and thus acquires all of the land value-added benefits.

### *17.2.2 Pattern of Three-Old Land Reserve (TLR)*

According to the Guangdong provincial and local documents such as Comments on accelerating the "Three-Old" transformation work and Additional Comments on accelerating the "Three-Old" transformation work, the TLR pattern of brown land is that factory relocates in offsite, but also implements land consolidation on the original land, then the government carries on public transferring. Its operation procedure is that the original property owner purchases land in offsite, and do some ground treatment for industrial production and warehouse space land using to ensure existing capacity assets' offsite relocation, it also implements consolidation of the original factory relocation sites, in the end, the government carries on public transferring. The original property owner is responsible for the original factory relocation and land consolidation costs of the old industrial land, acquires return part of land revenue and compensation for public purpose land expropriation; Government acquires land revenue through net transferring, pays return part of land revenue and public purpose land expropriation compensation to the original property owner, and also proceeds to public facilities and infrastructure construction [1].

The features of TLR pattern: (1) Land reserve process: factory relocates itself, applies for government reserve; land reserve agency transfers land after land consolidation and acquires land revenue, then it returns a certain proportion of land revenue to the original property owner in accordance with the provisions. (2) The original property owner's compensation standards: the compensation price is based on the planned land uses, which can be divided into available public land use and commercial land use, so the land reserve compensation is 60 % of the land transfer revenue, plus public purpose land expropriation compensation. (3) The original property owner and government share value-added benefits. After the land transferring, the both allocate land revenue by a certain percentage.

## 17.3 Pattern Selection of Land Reserve

### *17.3.1 The Principles for Pattern Selection*

Planned land reserving is one of the effective means to manage urban land, it can effectively solve problems such as Idle or inefficient urban land using caused by absent stored land and irrational land use structure, and meet the increasingly investment demand of city developments on the stocked land [2, 3]. Through acquiring, reserving, supplying and operating land, government can control the land market, and by controlling the size of supply of land, it can, on one hand, maintain the stability of land market, promoting the real estate market to develop in a stable, healthy and sustainable way, and on the other hand, contribute to ensuring fiscal income, effectively preventing the loss of land revenue, raising funds for urban construction, thus promoting urban development. Therefore, the land reserve system can be operated, so its operate process must comply with the cost-effective market rules, it means the land reserve cost should lower than the market price, so that government can acquire benefits [4–8].

In addition to profitability, the land reserve agency generally undertakes part of the government's public servicing duties actually [9]. To balance this profitability and non-profitability, the usual approach is that the non-profitability costs used for land reserve should be limited to the project directly related to the reserved parcel itself, as for the excess items, they should be solved at a higher space level, or directly solved by government's investment.

### *17.3.2 Cost-Benefit Analysis for Land Reserve*

Whether it is running successfully for land reserve mostly depends on its cost-benefit analysis varying with its pattern selection.

#### 17.3.2.1 Pattern of GLR

1. Composition of cost-benefit

On the basis of the pattern of GLR, total revenue that government acquired is land revenue derived from land transferring, the costs needed to pay include public facilities construction costs, factory relocation compensations and financing costs.

The land reserve benefits equals to remainder of land reserve costs and land revenue, as is showed in Formula (17.1).

$$P_g = V - C_g = V - (C_P + P_f + C_f) \tag{17.1}$$

$P_g$ – *government revenue;*
*V – land revenue of plots;*
$C_g$ – *government land reserve costs;*
$C_P$ – *public facilities construction costs;*
$P_f$ – *factory relocation compensations shown in* (17.2)*;*
$C_f$ – *financing costs, refers to the costs derived from cash flow in the process of government land reserve;*

Among them, factory relocation compensations contain land costs and relocation costs, and compensate follows the principle that 'separating land acquisition compensation and resettlement compensation'. The land costs typically include factory offsite acquiring land costs and industrial production ground treatment costs. Relocation costs typically include fixed assets relocation costs and temporary relocation compensation of factory.

$$P_f = C_1 + C_2 + C_3 + C_4 \tag{17.2}$$

$C_1$ – *factory relocation costs, it refers to costs of dismantling, transporting, installing and commissioning factory's fixed assets.*
$C_2$ – *offsite land acquiring costs, it refers to costs used for purchasing land.*
$C_3$ – *industrial building foundation treatment costs, it refers to ground handling costs of area in addition to land occupied by fixed assets.*
$C_4$ – *temporary movement compensation*

2. Cost-benefit calculation method

According to cost-benefit constitution of different land reserve patterns, each benefit component was calculated respectively, calculating steps are showed in Fig. 17.1.

According to formula (17.2), factory relocation compensation consists of three parts, each part's calculating method is as follows:

Factory relocation costs $C_1$ equals to the sum of all types of fixed assets' relocation costs, $C_i = \sum_i A_i B_i$;

Among them, Ai represents the i-th kind fixed asset's relocation price; Bi represents the number of the i-th fixed assets.

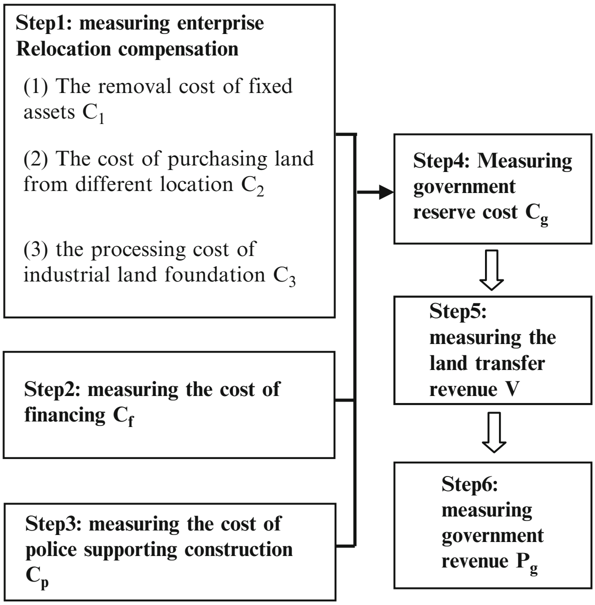


**Fig. 17.1** Cost-benefit analysis process for GLR

Offsite land acquisition costs $C_2$ equals to the product of A1 and B, $C_2 = A_1B$; *$A_1$ represents offsite land purchasing price; B represents land area.*

Industrial production ground treatment costs $C_3$ equals to the product of $A_2$ and B; $A_2$ represents ground treatment price; B represents net area of industrial land.

According to Formula (17.1), the cost item also includes financing costs $C_f$ and public facilities construction costs.

Calculation method of $C_p$: In the land reserve process, a lot of money paid by land reserve agencies is in need to put land into the reserve system. Currently, commercial banks' loan is our main source of funding land reserves. Assuming the costs of purchasing land, ground handling and relocating costs all come from bank loans, the public facilities construction costs is acquired from land revenue, lending interest rate is calculated in the lending rate's ceiling of Central Bank, term n is confirmed according to policies and regulations. The formula is:

$$C_f = P_f + [(1 + r)^n - 1] \tag{17.3}$$

Calculation method of Cp: $C_p = \sum_m A_m B_m$;

$B_m$ represents planned public facilities construction area, $A_m$ represents planned public facilities construction price.

Land revenue V is estimated according to the transferred land's area, volume ratio and floor price. The formula is as follows: $V = \sum_i X_i Y_i Z_i$;

$X_i$ represents the floor price, $Y_i$ on behalf of the transferred land's area, $Z_i$ on behalf of the volume ratio.

#### 17.3.2.2 Pattern of TLR

1. Composition of cost-benefit

On the basis of the pattern of TLR, total revenue that government acquire is land revenue derived from land transferring, the costs needed to pay include public facilities construction costs, Public land expropriation costs, and it need return part of land revenue to the original property owner. The land reserve benefits equals to remainder of land reserve costs and land revenue, as showed in Formula (17.3).

$$P'_g = V - (V \times R + C_5 + C_6) \tag{17.4}$$

$P'_g$ – *Government land reserve benefits;*
*R – the land revenue ratio returned to the factory;*
*$C_5$ – Public land expropriation costs of reserved land*
*$C_6$ – Public facilities construction costs of reserved land*

Among them, the Public land expropriation costs and the return part of land revenue are the relocation compensation factory obtain as shown in Formula (17.5).

$$P'_f = V \times R + C_5 \tag{17.5}$$

2. Cost-Benefit calculation method

According to cost-benefit constitution of different land reserve patterns, each benefit component was calculated respectively, calculating steps are shown in Fig. 17.2.

Land revenue is calculated based on transferred land's area, volume ratio and floor price. The formula is as follows: $V = \sum_i X_i Y_i Z_i$; $X_i$ represents the floor price, $Y_i$ on behalf of the transferred land's area, $Z_i$ on behalf of the volume ratio.

According to the Three-Old reform policy documents, public land expropriation compensation $C_5$ is 20 % of commercial standard land price of same location with volume ratio is 2.0. The formula: $C_5 = \sum_i 2 \times 60\ \% X_n Y_n$, $X_n$ represents the n-th commercial standard land price; $Y_n$ represents the n-th public purpose land's area.

Calculation method of $C_6$: $C_p = \sum_m A_m B_m$; $B_m$ represents public facilities construction area, $A_m$ represents public facilities construction price.

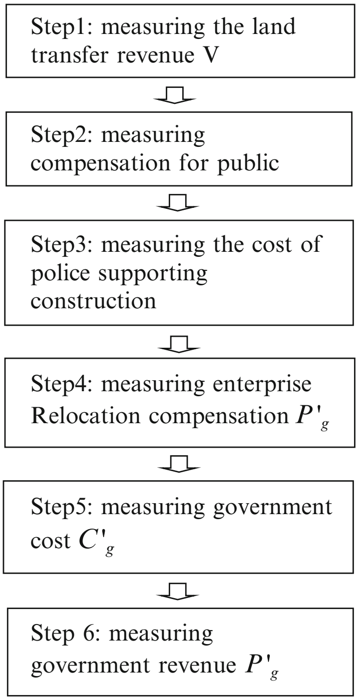


**Fig. 17.2** Cost-benefit analysis process for TLR

# 17.4 Case Study

## *17.4.1 Summary*

Studied case is situated in riverside of the east district, this region is located in the hub where the Zhujiang river empties into the sea, and it has always been an important outward maritime traffic and trade node. Currently, along the shore of the region, there are many factories, covering port logistics, chemical building materials, shipbuilding, electric power, food and other types of factory. With the rapid development of the city, some development issues gradually becomes prominent: on one hand, these factories generally cover a large area, they have certain economic scale, but their industry level is low, production technology is obsolete, benefit is low, and tax contributions are small; on the other hand, these factories occupy the forefront shore of Zhujiang River, not only the land use efficiency is low, but also the coastal environment is poor, and residents living along the river can't see river view any more, preventing the public using open space of riverside. Therefore, whether it is from the economy side or from environmental landscape level, there is an urgent need to undertake industrial transformation.

In 2009, Guangzhou City was designated as one of the pilot areas of "Three-old" transformation project which is used for promoting economical and intensive land

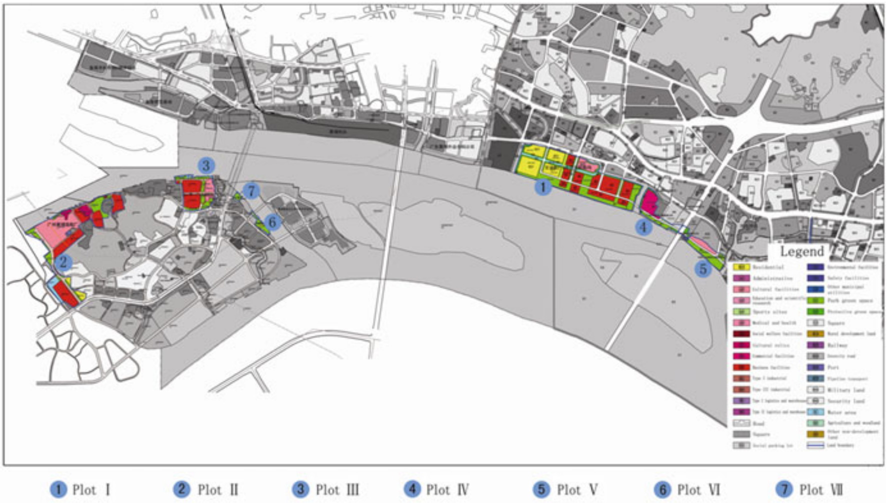


**Fig. 17.3** Distribution of the plots

use of Guangdong province, and this provides a good opportunity for the city's downtown to redevelopment land. In 2012 Guangzhou government proposed to build Zhujiang River golden coastline and planned to select the riverside of the East district as the key development area of land reserve. Thus, it has become an urgent problem that how to rationally and efficiently reserve this region's land to maximize the value of space, optimize the spatial quality, and maximize the region's contribution of the shoreline.

Selecting seven plots of this riverside region as shown in Fig. 17.3 and all the plots belong to shipbuilding factories, in accordance with key functional areas' detailed planning and field survey data, we try to evaluate land reserve costs of these seven plots, and combining with relevant theoretical knowledge and practical situation, to select and analyze the pattern of land reserve.

### *17.4.2 Data Collecting*

1. Enterprise status data collecting.

By identifying and digitizing topographic maps, we confirm target enterprises the size and the number of fixed assets such as construction, crane, dock, tanks, chimney, etc. within the scope of the present situation, to provide reliable data for estimating work.

2. Urban planning data obtains from government planning department. The used data, like the planning land nature, land area and volume ratio and so on, are from the latest and stable achievements.

**Table 17.1** Cost unit price for construction of public the existing fixed assets (Yuan/m$^2$)

| Land code | Land usage | Cost |
|---|---|---|
| A22 | Recreational activities | 3,500 |
| A3 | Education scientific research | 3,500 |
| A4 | Sports | 3,500 |
| A5 | Medical and health care | 5,000 |
| A6 | Social welfare facilities | 3,000 |
| A7 | Cultural relics sites | 600 |
| RX | Primary school | 3,500 |
| RZ | Middle school | 3,500 |
| U2 | Environmental facilities | 3,000 |
| S4 | Traffic terminal | 3,000 |
| E1 | Waters | 600 |
| E2 | Agriculture, forestry | – |
| G1 | Park green space | 300 |
| G2 | Green buffer | 100 |
| S1 | Urban roads | 1,500 |
| S3 | Integrated transport hub | 150 |
| T1 | Railway land | – |

**Table 17.2** Cost unit price for relocation of the existing fixed assets (Yuan/m$^2$)

| Assets type | Cost | Assets type | Cost |
|---|---|---|---|
| Dockyard | 11,300 | Buildings | 3,500 |
| Crane | 100 | Chimney | 8,000 |
| Chemical can | 8,000 | Foundation treatment | 800 |

3. The unit price for different kinds of construction of public facilities and infrastructure and fixed assets movement, are on the basis of the construction and installation project costs quota values in Guangdong province, as Tables 17.1 and 17.2 show. Industrial land unit in land acquisition is set to 700 Yuan/m$^2$.
4. Land price data. Commercial benchmark land price depends on the data of the city's latest land price file. Floor price is based on the standard land price and the correction factor relative to the floor price and the benchmark land price, which is amended by the three factors that are the market value of the land, similar location conditions of land sold data and land comprehensive potential value.
5. Loan rates. In loan cost, it assumes that all first land development fund loan is for 2 years, and uses the corresponding cap rate, which is 7.04 %, (the national rate policy is limited in first land and second land, so it uses the cap rate to simulate the poorest loan environment) rather than the specific fund using piecewise loan calculation.

### *17.4.3 Results of Cost-Benefit Calculation*

According to the calculation method and procedure of two land reserve patterns, we calculate the results of cost – benefit.

#### 17.4.3.1 Result and Analysis for Pattern of GLR

1. The government revenue of pattern of GLR

The result of Pattern of GLR is shown in Table 17.3. From Plot IV to Plot I, larger the operational building area, higher the land sold revenue. The operational building area is 0, the land sold revenue is 0 as well.

2. The government cost of pattern of GLR

In the pattern of GLR, the highest government cost is Plot I, which is 2.577 billion Yuan, the lowest one is Plot VII which is 0.025 billion Yuan. With the expanding the area of land, the government cost and its composition cost are increasing, except Plot V. Plot V is special. The public facilities construction cost is 0.184 billion Yuan, which accounts 46.70 % for the total cost; relocation compensation is 0.183 billion Yuan which accounts for 46.45 %; the loan cost is 0.027 billion Yuan, which accounts for 6.85 %.

From the composition cost proportion of the plots (except the Plot V), enterprise relocation compensation accounts for the highest proportion of the government land reserve cost, the proportion of every plot is more than 70 %; the public facilities construction is followed, its proportion is stably at 10–20 %; next is loan cost, its proportion is around 10 % of each proportion, Plot VI accounts for the lowest proportion, which is 9.80 %, the highest is Plot VII, which has reached 12 %.

3. The government benefit of Pattern of GLR

In the pattern of GLR, the government can get benefit only from Plot I and Plot IV among seven plots. In Plot I, land sold total revenue is 4.969 billion Yuan, cost is 2.577 billion Yuan, and government benefit is expected to be 2.392 billion Yuan. In Plot IV, land sold total revenue is 0.428 billion Yuan, cost is 0.271 billion Yuan, and government benefit is expected to be 0.157 billion Yuan.

The cost is higher than the land sold revenue in other plots, and the government land reserve will be at a loss. Among all, Plot II is at a biggest loss, land sold revenue is 0.758 billion Yuan, only the enterprise relocation compensation has reached 1.12 billion Yuan in calculation cost, the government will loss 0.687 billion Yuan if it reserves this plot. The land sold revenues of Plot V, Plot VI and Plot VII are 0 billion Yuan, so the government will totally loss the land reserve costs. Assumes that seven plots reserve with pattern of GLR at the same time, the government will get benefit totally 1.117 billion Yuan.

From Table 17.3, bigger the land area, higher the government land reserve cost, but the land sold revenue does not increase accordingly, such as Plot III and Plot IV. Compared with Plot IV, the land sold revenue of Plot III decreases, but the cost increases, so the government benefit is negative. The operational building area increases, the land sold revenue also increases; both are a positive correlation relationship.

From the Table 17.3, when the operational building area is larger than the enterprise land area of the plot, the government benefit is positive, such as Plot I and Plot IV; on the contrary, it is negative, such as Plot II and Plot III, it means that

**Table 17.3** Cost-benefit calculation for government with the pattern of GLR (billion Yuan)

| Item | Land area (ha) | Profiting floor area (10,000 $m^2$) | Land revenue | Cost | | | | Government revenue |
|---|---|---|---|---|---|---|---|---|
| | | | | Public facility and infrastructure cost | Enterprise relocation compensation | Financing cost | Total | |
| Plot I | 62.84 | 114.72 | 4.969 | 0.445 | 1.861 | 0.271 | 2.577 | 2.392 |
| Plot II | 49.34 | 22.16 | 0.758 | 0.162 | 1.12 | 0.163 | 1.445 | −0.687 |
| Plot III | 17.24 | 10.99 | 0.345 | 0.065 | 0.485 | 0.071 | 0.621 | −0.275 |
| Plot IV | 9.52 | 14.39 | 0.428 | 0.051 | 0.192 | 0.028 | 0.271 | 0.157 |
| Plot V | 7.92 | 0.00 | 0.00 | 0.184 | 0.183 | 0.027 | 0.394 | −0.394 |
| Plot VI | 1.9 | 0.00 | 0.00 | 0.009 | 0.037 | 0.005 | 0.051 | −0.052 |
| Plot VII | 0.74 | 0.00 | 0.00 | 0.003 | 0.019 | 0.003 | 0.025 | −0.025 |
| Total | 149.49 | 162.25 | 6.5 | 0.918 | 3.897 | 0.568 | 5.383 | 1.117 |

the government is at a loss. Also when the operational building area is larger than the enterprise land area, the greater the difference, the more the government benefit, like Plot I and Plot IV. Their differences are 51.88 and 4.87, the government benefits are 2.392 billion Yuan and 0.157 billion Yuan. And when the operational building area is smaller than the enterprise land area, the greater the difference, the more the government loss, like Plot II and Plot III.

#### 17.4.3.2 Result and Analysis for Pattern of TLR

Government revenues, costs and benefits of the pattern of TLR are shown in Table 17.4. From Table 17.4, we can see that government revenues of the Pattern of TLR are the same as Pattern of GLR.

In the Pattern of TLR, the government reserve cost changes from Plot VII to Plot I, larger the area, higher the cost. In the pattern of TLR, there are only two plots that the government can get benefit in seven enterprise plots reserves, these are Plot I and Plot IV. The land sold total revenue in Plot I is 4.969 billion Yuan, the cost is 0.4191 billion Yuan, the government benefit is expected to 0.0778 billion Yuan. In Plot IV, the land sold total revenue is 0.0428 billion Yuan, the cost is 0.042 billion Yuan, and the government benefit is expected to 0.0008 billion Yuan. Other enterprises land costs are more than land sold revenue. Plot II losses the most. Its land sold revenue is 0.758 billion Yuan and the calculation cost is 1.174 billion Yuan, so the government reserve it that will loss 0.415 billion Yuan. There are no land sold revenues in Plot IV, Plot VI and Plot VII. So the government will loss the costs. In Pattern of three-old reserve, the government is expected to loss 0.229 billion Yuan for seven plots.

In the pattern of TLR, there are only two plots that the government can get benefit in seven enterprise plots reserves, these are Plot I and Plot IV. The land sold total revenue in Plot I is 4.969 billion Yuan, the cost is 4.191 billion Yuan, the government benefit is expected to 0.778 billion Yuan. In plot IV, the land sold total revenue is 4.969 billion Yuan, the cost is 4.191 billion Yuan, and the government benefit is expected to 0.778 billion Yuan. Other enterprises land costs are more than land sold revenue. Plot II losses the most. Its land sold revenue is 0.0758 billion Yuan and the calculation cost is 0.1174 billion Yuan, so the government reserve it that will loss 0.0416 billion Yuan. There are no land sold revenues in Plot V, Plot VI and Plot VII. So the government will loss the costs. In Pattern of three-old reserve, the government is expected to loss 0.229 billion Yuan for seven plots.

According to the Table 17.4, when the operational building area is larger than the enterprise land area of the plot, the government benefit is positive, such as Plot I and Plot IV; on the contrary, it is negative, such as Plot II, Plot III and Plot V. Also when the operational building area is larger than the enterprise land area, the greater the difference, the more the government benefit, like Plot I and Plot IV. And when the operational building area is smaller than the enterprise land area, the greater the difference, the more the government loss, like Plot II, Plot III and Plot V. Therefore, no matter the Pattern of GLR or the Pattern of TLR, the operational land area is the important element to influence the government benefit.

**Table 17.4** Cost-benefit calculation for government with the pattern of TLR (billion Yuan)

| Item | Land area (ha) | Profiting floor area (10,000 $m^2$) | Land revenue | Cost | | | | Government revenue |
|---|---|---|---|---|---|---|---|---|
| | | | | Land revenue return | Infrastructure construction | Public benefit collection | Total | |
| Plot I | 62.84 | 114.72 | 4.969 | 2.981 | 0.445 | 0.765 | 4.191 | 0.778 |
| Plot II | 49.34 | 22.16 | 0.758 | 0.455 | 0.162 | 0.557 | 1.174 | −0.416 |
| Plot III | 17.24 | 10.99 | 0.345 | 0.207 | 0.065 | 0.237 | 0.509 | −0.164 |
| Plot IV | 9.52 | 14.39 | 0.428 | 0.257 | 0.051 | 0.112 | 0.42 | 0.008 |
| Plot V | 7.92 | 0 | 0 | 0 | 0.184 | 0.159 | 0.343 | −0.343 |
| Plot VI | 1.9 | 0 | 0 | 0 | 0.009 | 0.057 | 0.066 | −0.066 |
| Plot VII | 0.74 | 0 | 0 | 0 | 0.003 | 0.023 | 0.026 | −0.026 |
| Total | 149.49 | 162.26 | 6.5 | 3.9 | 0.919 | 1.91 | 6.729 | −0.229 |

## 17.4.4 Patterns Selection

### 17.4.4.1 Factors to Be Considered

The government not only undertakes public duties, but also in pursuit of more profit. What factors it should consider when selects the pattern of each land block?

1. The earning results of the two patterns

When Plot I, Plot IV, Plot VI and Plot VII choose the pattern of GLR, the government can get more income, 2.392 billion Yuan, 0.157 million Yuan, −0.052 million Yuan and −0.025 million Yuan respectively. No matter which way the government reserve income are at a loss, but the result that Plot II, Plot III and Plot V choose the pattern of TLR could reduce the government income.

The yellows stand for the government's biggest benefit choices, on the contrary, the blues stand for the enterprises' biggest benefit choices.

2. The relocation willingness of the enterprises

The land reserve as a government behavior is mandatory, but the enterprises' willingness to relocation must be considered before the government reserves. According to the related regulations on the management of land resources, land reserve institutions should contract with the original land users for the State-owned land use right purchase, and then land reserve institutions pay the land acquisition compensation fee to the original users in order to obtain the land use right.

No matter which reserve pattern we choose, the relocation cost of fixed assets ($C_1$), the cost of land purchase from allopatry ($C_2$) and the cost of industrial land foundation treatment ($C_3$) are bound to produce in the process of relocation. These costs are also the relocation compensation among the GLR pattern. If the income when enterprises choose the land reserve pattern is lower than the relocation compensation when enterprises choose the GLR pattern, the enterprises should pay part of the relocation costs that would weaken their willingness to relocation. In the opposite, the enterprises would increase the willingness to move. As a rational economic man, the enterprises tend to choose the pattern with more benefits. From Table 17.5, the enterprises will not loss when Plot II, Plot III and Plot V choose the pattern of GLR; the enterprises can obtain more benefits when Plot I, Plot IV, Plot VI and Plot VII choose the pattern of TLR.

From the angle of feasibility, the pattern of GLR is an inevitable choice for Plot II, Plot III and Plot V when fully consider the enterprises relocation willingness. To encourage the original property owners moving around the land block actively, suggested that Plot I, Plot IV, Plot VI and Plot VII choose the pattern of TLR.

3. Land externality

External effect is refers to a party of economic activity to the external effects caused by the other party [10]. Its effects are very significant in land exploitation and utilization that had formed a unique land externality economic [11]. For instance, along with the increasingly convenient transportation, the land values around the traffic lines rise gradually, bring additional revenue for the land owners

**Table 17.5** Comparison of government revenue between GLR & TLR (billion Yuan)

| Item | Land area (ha) | Profiting floor area (10,000 $m^2$) | Land revenue | Pattern of GLR | | Pattern of TLR | |
|---|---|---|---|---|---|---|---|
| | | | | Enterprises income | Government revenue | Enterprises income | Government revenue |
| Plot I | 62.84 | 114.72 | 4.969 | 1.861 | 2.392 | 3.746 | 0.778 |
| Plot II | 49.34 | 22.16 | 0.758 | 1.12 | −0.687 | 1.012 | −0.416 |
| Plot III | 17.24 | 10.99 | 0.345 | 0.485 | −0.275 | 0.444 | −0.164 |
| Plot IV | 9.52 | 14.39 | 0.428 | 0.192 | 0.157 | 0.369 | 0.008 |
| Plot V | 7.92 | 0 | 0 | 0.183 | −0.394 | 0.159 | −0.343 |
| Plot VI | 1.90 | 0 | 0 | 0.037 | −0.052 | 0.057 | −0.066 |
| Plot VII | 0.74 | 0 | 0 | 0.019 | −0.025 | 0.023 | −0.026 |
| Total | 149.49 | 162.25 | 6.5 | 3.897 | 1.117 | 5.810 | −0.229 |

or users; green space increasing to improve the land ecological environment, greatly improving its ecological value, so that the surrounding land value rise.

The land for research is along the river and each block has green space after transforming. Among them, the green space in Plot VII is more than 90 %, and can improve the ecological environment of surrounding land, greatly improve its ecological value, so that the land value also rise. The government should fully considers the external effect of land and takes the functions of public welfare when it makes the land reserve plans, in addition, encourages the original property owners around the land block relocation to promote the process of the land reserve.

4. The risk of adjustment of the regulatory detailed planning

The regulatory detailed planning is based on urban master planning or district planning, which determines the nature of land use, the planning control indexes of the land use intensity, the control position of roads and engineering pipelines and the environmental control requirements.

The nature of land use and the planning control indexes of the land use intensity of urban construction land come from the regulatory detailed planning. According to the related regulations on the regulatory detailed planning, central area, old region, recent construction area and planning for land reserves or land sell area shall give priority to compile the regulatory detailed planning. For the land reserves planning of N city, the key areas' land reserve planning have clear the nature of land use and the planning control indexes of the land use intensity, but the plot ratio and the land character will also be constantly checking and adjustment according to the implementation conditions and demand of city construction. Therefore, land reserve has the risk of adjustment of the regulatory detailed planning.

Based on the following judge whether there is a risk adjustment in the block or not. (1) If the layout and function orientation is stable, the infrastructure is perfect and the development is mature in this region; (2) if there is urban renewal driver.

The orientation of the research region is "a key area with business, shipping, culture, ecology, tourism and living in one". The function structure can be summarized as "two functional areas, one central district", namely the riverfront modern shipping service area, the riverfront ecological cultural tourism area and the riverfront living service center. As a result, convenient traffic system and municipal infrastructure should be first constructed in here. The land use type of the research region is the industrial land which needs more costs in the process of land reserve. Even so, it's less likely to increase the profit-oriented land through adjusting the regulatory detailed planning. Similarly, in order to keep the landscape along the river, it's less likely to greatly increase the plot ratio of the profit-oriented land, too.

5. The land reserve timing

From the perspective of the cost-income, for maximum profit, the government will increase the land revenue or reduce the cost of land reserve. July 1, 2010 is the valuation date of the standard land price in this case study which was entered into force from February 1, 2012. The standard land price updated once usually 2–3 years, and the price usually increased according to the previous experience of adjusting. If the government purchases land before the next update of the standard land price, it can reduce the cost of land reserve and increase the land revenue.

Land reserve institutions should be reasonable arrangement the land reserve timing according to the planning control and function division. Recent reserve target should be the developments that can produce economic benefits as soon as possible then promoting economic development; midterm reserve goal should be the projects that have medium benefits; to the long-term target, the most important thing is strictly controlled the land resource by the planning to prevent the loss of land assets potential value.

#### 17.4.4.2 Patterns Selection Results

Considering various aspects factors from the economic maximum benefit perspective, the government should choose the land reserve pattern that makes the relocation enterprises maximum benefit. Results are shown in Table 17.6, Plot I, Plot IV, Plot VI and Plot VII choose the pattern of TLR, Plot II, Plot III and Plot V choose the pattern of GLR instead.

## 17.5 Conclusions and Discussion

### *17.5.1 The Difference Between GLR Pattern and TLR Pattern*

1. Different reserve procedures. Relatively speaking, the general reserve pattern is that the government and the land reserve institutions occupy the dominant, and the original rights owners coordinate implementation of land reserve; the TLR pattern is that the original rights owners actively apply for the enterprise land for land reserve.

**Table 17.6** Pattern selection of land reserve (billion Yuan)

| Item | Land area (ha) | Profiting floor area (10,000 m$^2$) | Enterprises income | Government revenue | Patterns selection |
|---|---|---|---|---|---|
| Plot I | 62.84 | 31.26 | 3.746 | 0.778 | TLR |
| Plot II | 49.34 | 30.33 | 1.120 | −0.687 | GLR |
| Plot III | 17.24 | 9.71 | 0.485 | −0.275 | GLR |
| Plot IV | 9.52 | 4.8 | 0.008 | 0.369 | TLR |
| Plot V | 7.92 | 0 | 0.183 | −0.394 | GLR |
| Plot VI | 1.90 | 0 | 0.057 | −0.066 | TLR |
| Plot VII | 0.74 | 0 | 0.023 | −0.026 | TLR |
| Total | 149.49 | 76.1 | 5.622 | −0.301 | – |

2. Different compensation standards. The GLR pattern using the compensation standard is according to the original price of the land use which separates the land purchase compensation and the ground appendages compensation. The compensation includes the cost of fix assets relocation, purchasing land from allopatry and foundation treatment of the industrial land, etc. The price of purchasing land from allopatry and the unit price of foundation treatment of the industrial land are according to the original purpose. The TLR pattern using the compensation standard is according to the compensation of price of land planning purposes.
3. Different land reserve costs. In the land purchase stage, the TLR pattern only needs to pay for the compensation of the public welfare land, then the GLR pattern needs to pay for the compensation of the relocation of the enterprises. During the reserve stage, the enterprises should bear the costs of land consolidation, and the government needs to bear the costs of public facilities construction in the pattern of TLR, then the costs of land consolidation and public facilities construction shall be borne by the government in the pattern of GLR. In the remise stage, if chooses the TLR pattern, the government will gets 40 % of the land revenue, then the government will gets all of land revenue if chooses the GLR. Overall, the circulation funds that the government needs in the TLR are less than that in the GLR. Choosing the TLR pattern, therefore, can reduce the funds pressure of the government so that reducing the financing cost of the land reserve.
4. Different incremental benefits. In the GLR pattern, the land incremental benefits which are obtained by the land reserve institutions have nothing to do with the original rights owners. On the contrary, the government shares the land incremental benefits with the original rights owners in the TLR.

### *17.5.2 Discussion About the Scope of Application of the Two Patterns*

As the compensation standard for the original rights owners is different, the cost and the benefits of the land reserve are different, too. Through the case study, if the enterprises have less areas with more fixed assets, the incomes of the GLR would more than the TLR pattern's. Therefore, the enterprises would not loss when they choose the GLR pattern. If the enterprises have more areas with less fixed assets, the benefits that the enterprises obtain would greater than the cost of actual relocation compensation.

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# Chapter 18
# A Comparative Study of the Measurement Methods of Real Estate Bubbles

**Shenghua Jia and Hang Li**

**Abstract** With the continuous growth and prosperity in domestic real estate industry, researching on real estate bubbles attracted much of public attention and has been one of the hottest issues in the field of economics. There are lots of methods of examination about real estate bubbles, such as economic fundamentals method, asset present value model, etc. This paper reviews these studies on real estate bubbles systematically, and summarizes main strength and weakness of current studies. Finally, based on former analysis, it points out existing problems of current studies, and forecasts the prospect of future domestic studies.

**Keywords** Real estate bubbles • Measurement methods • Economic fundamentals • Asset present value model

## 18.1 Introduction

In recent years, with the development and prosperity of the Chinese real estate market, the problems of overheated investment and housing vacancy are increasingly apparent. Whether there are bubbles in real estate market has attracted public attentions. The debate and study on real estate bubbles have never stopped from the day the conception of bubbles was created. But, are there bubbles in China real estate market? And how to detect real estate bubbles scientifically? The study of real estate bubbles is under continuous improvement, and there are still many issues worth to explore. At present, methods of bubbles measurement mainly from the financial sector, and most from the research of the stock market bubbles. The study of real estate bubbles measurement methods extends the study of stock bubbles.

S. Jia • H. Li (✉)
Center for Real Estate Study, School of Management, Mailbox 2071 of No. 3 West Building, Xixi Campus, Zhejiang University, China
e-mail: lh0791aa@163.com

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To detect bubbles we have to know what they are firstly. Scholars have different descriptions on the definition of bubble. Kindleberger [13] visually depicts the bubbles from generation to burst. He indicates the reason of bubbles formation is speculation and bubbles burst will cause financial crisis. Diba and Grossman [6] think that the market value will change followed the basic value while the asset prices was influenced by the self-realization factors and under the assumption of rational expectations. When market prices deviate from the equilibrium, the bubbles will be generated. Wang Ziming [22] also has his definition of bubbles: bubble is a phenomenon of unbalanced economy. It is an upward shift that asset's price deviate from the theoretical price determined by the economic basic conditions. The mathematical expectation of this upward shift can be used to measure the bubbles. Although scholars have different explanations on bubbles, they all agree that the essence of bubble is the deviation of asset market price and asset basic value no matter the cause is rational and irrational.

Current academic studies tell us that in order to research the existence of real estate bubbles or to calculate the size of bubbles, we have to identify the basic value of real estate. And then we can analyze the bubbles through the comparison of the basic value and the market actual price. So the problem of measurement of the real estate bubble can be converted into a study of the basic value of real estate. There are two approaches to identify real estate's basic value: one is to calculate the basic value by economic fundamentals; the other is based on the asset present value model, using the real estate's future profits to estimate the real estate's basic value. This paper will introduce the two approaches in detail. Each of the detection method will include the existence detection and bubble size measurement. Also, this paper will systematically introduce the real estate bubbles' various detection methods, and compare the advantages and disadvantages of each method. Finally find out the applicability of each method, and provide a reference to the study of bubbles' detection in China real estate market.

## 18.2 Real Estate Bubbles and Economic Fundamentals

As we know real estate industry is an important mainstay of the national economy, its growth is closely connected with the growth of real economy. So lots of studies of real estate bubbles focused on the relation between real estate bubbles and economic fundamentals. There are already many researches approved that housing price was affected by micro economic fundamentals. Income, population, bank interest and other elements decide a country or a region's housing price in long term [3, 7, 18, 21]. A suitable housing price is decided by economic fundamentals, in another way of saying, the economic fundamentals decide the basic value of real estate. So, the part surpass the basic value decided by economic fundamentals in housing price is what we called real estate bubbles. Through the analysis of economic fundamentals and actual housing price, we can judge whether there are bubbles in real estate market.

### 18.2.1 Existence Detection: Index Evaluation Method

Index evaluation method is a common method of study real estate bubbles. It selects a series of economy fundamental index closely connected with real estate market to observe the development of real estate market. And through the analysis of important index of market, whether there are bubbles in the market can be judged. The theoretical basis of index evaluation method is: virtual economy is always based on the real economy, it has high degree of credibility by using real economy's index to measure virtual economy. Index evaluation method is a common method used at early real estate bubbles' research. But due to the difference between Chinese market and foreign market, domestic scholars concluded specific real estate bubbles measurement index system based on foreign scholar's research.

Li Weizhe and Qu Bo [14] divides the real estate bubbles measurement indexes into four categories: the production index, consumer index, trading index and financial index. Production index includes: the percentage of real estate investments in overall fixed asset investments, the growth rate of real estate investment, land and building supply growth, profit rate of real estate investments. Consumer index includes: growth rate of commodity house prices, land price growth, ratio of house price to income. Trading index includes: the growth of commodity houses' sales areas, the growth rate of commodity houses' sales, land pass-through rate. Financial index includes: money supply growth rate, the growth of real estate loans, stock price index, mortgage rate, medium and long term lending rates and so on. They have even designed a synthetic measurement coefficient of real estate bubbles. The formulas are

$$y_i = \frac{x_i - x_i^{\alpha}}{x_i^{\wedge} - x_i^{\alpha}} \times 40 + 60 \tag{18.1}$$

or

$$y_i = 100 - \frac{x_i - x_i^{\alpha}}{x_i^{\wedge} - x_i^{\alpha}} \times 40 \tag{18.2}$$

Where $y_i$ corresponds to $x_i$'s efficacy coefficient, $x_i$ is the actual observation value of index i, $x_i^{\alpha}$ is the value of i can't be. $x_i^{\wedge}$ is the satisfaction value of index i. This method can unify all the indexes by calculating efficacy coefficient of each index through simple arithmetic average or weighted average. Use the calculated comprehensive warning coefficient K we can judge the level of real estate bubbles. Xie Jingrong et al. [24] also designed an index system of real estate industry and real estate circle. The index system mainly has three categories: predictor index, direction index and lagging index. These types of indexes have different time basis to judge real estate bubble. Predictor index, analyzes the changes of the index in a continuous periods so as to predict the trend of real estate and bubbles. It mainly includes the growth rate of real estate loans/total loans, the money supply, and stock price index. Direction index judge the real estate bubbles at real estate market's significant fluctuation period. It mainly includes: land price growth rate/GDP growth rate, the average house price/family income and so on. Lagging index is statistical reflects of the result of real estate price fluctuations. Compared to previous two indexes, it is a lagging index. It can be represented by land price/GDP. They also raised two real estate bubbles alert methods: (1) Set index thresholds and weights and then compare the actual value of bubbles' indexes and the thresholds. If a lot of alerts were generated at warning period, the probability of real estate bubbles will be very high. (2) Delineate the warning section and give different values to different warning section on behalf of the severity degree of bubbles. By comparing the actual value of warning indexes and warning section, get the waning level. Finally summarize the warning levels of all indexes to judge the bubble level.

Methods of using economy fundamentals to judge bubbles are simple and convenient, and the data are easy to obtain. But index evaluation method is indirect, it doesn't adequately reflect the real estate market bubbles. Also, the indexes are referenced on different standards, so the evaluation results would not be unified. Therefore, the index evaluation method is often used as the subsidiary method of measuring the existence of real estate bubbles.

### *18.2.2 Bubble Size Measurement: Statistical Regression Method*

Many scholars believe that the basic value of real estate is composed of economic fundamental elements. The statistical regression method is based on this basic value identification method and use the regression model to calculate the basic value of real estate, and then calculate the size of the real estate bubbles [1, 2, 12].

Zhang Jine and Yang Zongxian [27] establish a linear regression model of the residential price change to estimate the real estate basic value and bubbles. The result shows that before 1987 there is no bubble in Taipei housing market. And the bubbles reached a peek in 1989 after the economic recovery. Shen Yue and Liu Hongyu [19] study 14 cities in China from 1995 to 2002. The result shows that if there is no annual dummy variable, the city's economic fundamentals can explain the change in housing price. But, if the annual dummy variable is put into the model, the explanatory power of the city's economic fundamentals will be greatly reduced, and adaptive expectations have a significant impact on the residential price changes. Deng Xiaorong and Zhang Jine [4] use family income to characterize the economy fundamentals and use State-Space Model to estimate the real estate basic value and bubbles in Taipei and Hong Kong. And then they analyze phenomenon of real estate bubbles in two cities. The result shows that the use of prices of houses and residents' ability to pay are lower than the market real price in Taipei and Hong Kong. The demand for investment is greater than the demand of living.

The statistical regression method which based on economic fundamentals is favored by majority of scholars as it can easily obtain the necessary data and can be operated simply. However, this detection method is also indirect. Using economic fundamentals to evaluate the real estate basic value is also controversial and it still needs a lot of exploration.

## 18.3 Real Estate Bubbles and Asset Present Value Model

Learning the perspective that asset price equals to the asset's future earnings in finance, the real estate basic value equals to the future rental income. So, the future rent can be used to reflect the real estate basic value. We can judge the situation of bubbles in real estate market through the comparison of the basic value capitalized by the rental income and the actual real estate market price.

### *18.3.1 Existence Detection: Indirect Detection Methods*

The indirect detection methods mainly use statistical measurement principles to analyze the changes in real estate prices. Its theory basis is that when there is no bubble in the real estate market, changes in real estate prices and in rents showing a consistent rule. And statistical analysis can find the statistical regularities. When the presence of real estate bubble, the bubble makes the real estate price fluctuate. It causes those statistical regularities disorder. Then we can determine the existence of bubbles. The basic idea of this test method is, based on the changing relationship on actual market prices and rents, using an appropriate model to perform hypothesis testing. Typical indirect detection methods include variance detection method, West's detection method, unit root and co-integration detection method.

#### 18.3.1.1 Variance Detection Method

Variance detection method proposed by Shiller [20] in 1981. The method holds that, while under the assumption that if there is no bubble in the market, the assets' capitalized rational expectation of future income can be used as the correct description of the real market price. The actual price should be equal to the basic value minus a rational prediction error sequence. So the basic value variance should be greater than the variance of the actual price. If the result of the test isn't agree with the preceding, we can refuse to the hypothesis that there is no bubble.

However, the empirical results of variance detection method are not satisfactory because most empirical test results will refuse the assumption so that the bubble may be magnified. So, this method has attracted a lot of criticism. Through analyzing the assumption, we can find out that the hypothesis of rational expectations, no non-rational bubble, and risk-neutral assumption is essentially a joint hypothesis. Any problem from one of these assumptions will lead to refuse the assumption of there is no bubble. Marsh and Merton [15] think that "zero hypothesis" would be falsely refused as the setting error of the basic process.

#### 18.3.1.2 West Set Detection Method

West [23] proposed this detection method in 1987. The basic ideal is: establish two groups of estimate formula to calculate the present value of asset. One group calculates the relationship between the asset price and the asset lag income. The other group calculates the relationship between income and previous period income. If the market is effective, the result of the two groups should be consistent. If there are bubbles in the market, the first group will inconsistent with the second one for missing some important variables (i.e. bubbles), which can be used to determine the existence of the market bubbles.

The first group of estimate formula is

$$\begin{aligned} p_t &= b\left(p_{t+1} + d_{t+1}\right) - b\left[p_{t+1} + d_{t+1} - E\left(p_{t+1} + d_{t+1}/I_t\right)\right] \\ &= b\left(p_{t+1} + d_{t+1}\right) + u_{t+1} \end{aligned} \tag{18.3}$$

The second group of estimate formula is

$$d_{t+1} = m + \phi_1 d_t + \ldots + \phi_q d_{t-q+1} + v_{t+1} \tag{18.4}$$

Where p is asset price, d is future income, m is intercept of the formula, b and ϕ are the regression coefficients, u and v are the remaining items, t = 1, 2, ⋯⋯, n.

Hang Dezong [11] used West's model to test real estate bubbles in Beijing, Shanghai and Shenzhen. The conclusion is: There are bubbles in Beijing housing market, Shanghai housing market and Shenzhen office market; it is unable to determine whether there are bubbles in Beijing office market, Shanghai office market and Shenzhen housing market.

However, West's method also has flaws. When the discount rate is constantly changing or the price is not based on rational expectations, detection will lead to unreliable conclusion by its own setting error. Flood, Hodrick and Kaplan think that the effect of setting test depends on the instrumental variables of the estimate formula, different instrumental variables may lead to different results.

#### 18.3.1.3 Unit Root and Co-integration Detection Method

Hamilton and Whiteman [10], Diba and Grossman [5] all have used the unit root detection method to judge the existence of real estate bubbles. The basic ideal is: If the asset price period series is a non-stationary random process, then the demand for assets include a large number of speculative demand, there are speculative bubbles in the market. Unit root test method can be used to judge whether the asset price sequence is stationary or not. At the same time, Diba and Grossman [5] stress that in order to determine the presence of market bubble more accurately, in addition to the unit root test, co-integration detection is necessary. Yang Zongxian and Zhang Jine [27] find out that real estate bubbles may indeed exist in Taiwan from 1981 to 1996 by using unit root and co-integration detection method. And by using this method, Meng Mian et al. [16] analyze the data of annual house price index and annual rental index from 1998 to 2006 in 35 cities all around China. They conclude that there are bubbles in eastern cities, and there is almost no bubble in western and central cities. But Evans [9] thinks this method is only for a particular form of bubble. When it applies to periodically collapse rational bubble, the co-integration detection will tend to conclude that the bubble does not exist.

Overall, the explanatory power of indirect detection method is relatively weak. It uses “bubbles do not exist” as a zero assumption, rather than directly detect the bubble itself. Once the “zero hypothesis” was refused, it still couldn’t judge whether bubbles exist in the market or not. If it refuse that the bubbles does not exist, we couldn’t ascertain the existence of bubble. Moreover, the mathematical expression under a simplified assumption may deviate from the original intention of detect the existence of bubbles. “Zero assumption” will turn to a “fake” assumption. Finally, the indirect detection method can only judge the existence of real estate bubbles, it can not get the specific size of the bubbles.

### *18.3.2 Bubble Size Measurement: Income Capitalization Method*

Income capitalization method gets the basic value of real estate by capitalizing the future income of the real estate. And compare it with the actual price so as to measure the size of the real estate market bubbles.

The earliest rent discounting method was proposed by Japanese scholar Noguchi Yuukiosu [17]. He calculates the basic land value and compares it with the real land price to measure the bubble level. He believes that the real estate basic value equals to the discounted future real estate net income, the basic value is the sum of the discounted future income. So the calculate formula of bubble level is: Bubble level = (real land price − basic land value)/basic land value. Ye Weiping and Wang Xuefeng [25] use Ramsey model, which calculate basic value by interest, inflation and population growth rate. $p = \theta - \pi + n$, in which p is basic value, $\theta$ is interest, $\pi$ is inflation rate, n is population growth rate. This means that under the economic optimal equilibrium steady state the basic value of an asset depends on the consumer’s psychology, the inflation rate and the population growth rate. They use asset marginal income return rate to calculate the basic value of the assets. They detect the bubbles level from 2000 to 2004 in China by this method. The result shows that in this period China real estate market has experienced a transformation from negative bubble, zero bubble to positive bubble. Zhang Jine et al. [26] establish basic housing value model from the rental income point of view and estimated the bubble size using the state-space mode. The result shows that from 1988 to 1990, Taipei was in the bubble period. In 2008 the bubble showed same rising trend, and the market showed signs of bubble again.

The income capitalization approach is closely linked to the definitions of the bubble. So its result has higher accuracy of detection of the real estate bubble size. However, considering the actual situation of domestic real estate market, it is hard to get the rent income and the discount rate is also difficult to determine. So, the study of using this method has large obstacles.

## 18.4 Conclusion

This paper has introduced several typical real estate bubble measurement methods. Through the analysis, each method has its advantages and disadvantages as in Table 18.1. Therefore, when choosing a method to measure real estate bubbles, it is necessary to consider the actual situation and select the most suitable method. If necessary, it's better to combine variety of methods to measure the bubble.

At current domestic real estate bubble studies are referenced on relatively mature research from abroad. But, the development of China's real estate market has its special background and route. Foreign research results are not necessarily suitable for situation of China. Moreover, the calculation of the real estate basic value has a great deal of difficulty and uncertainty, and there is lack of this area studies in domestic research. In addition, the bubble detection methods described above are more focused on the detection of the rational bubbles, but the reality of the bubbles is not entirely rational bubbles. Bubble caused by irrational investment is an important component of the market bubbles. So, irrational component part of real estate bubbles should also be studied.

Therefore, the study of future real estate bubbles may be concentrated in the following directions: (1) more effective real estate bubble measurement method. From the introduction and analysis above, we can see that all types of real estate bubble detection methods have theoretical and practical obstacles, and therefore have their own defects. So there is still large exploration space in bubbles' measurement. (2) Research the irrational bubbles. Irrational bubbles are a supplement to rational bubbles. It can well explain the phenomenon of abnormal fluctuations of the real estate prices. And it has strong explanatory power to speculative bubbles, more in accord with the actual situation. But at present, very few studies focused on irrational bubbles, research in this area should be strengthened in the future. Through the sophisticated study of irrational bubbles, I believe that it will bring inspiration and breakthrough to the studies of real estate bubbles.

**Table 18.1** Comparison of different bubble measurement methods

| Method | | Focus point | Apply conditions | Advantage | Disadvantage |
|---|---|---|---|---|---|
| Economic fundamental method | Index evaluation method | 1. Macroeconomic match | Large amount of historic data | 1. Emphasis on the coordinated development | Lack of a accepted calculation methods and standards |
| | Bubble size measurement | 2. Balance of people's life | | 2. Calculate is simple | Indirect detection |
| Income capitalization method | Indirect method | Statistical characteristics of housing price fluctuation | 1. Large number of sample data<br>2. Regular price fluctuation | Easy to operate | 1. Can not directly determine the bubble size<br>2. Difficult calculate formula<br>3. Rent data is hard to obtain |
| | Bubble size measurement | The basic value of real estate | 1. Well developed market<br>2. Large number of statistical data | Closely linked to definition of bubbles, high accuracy | 1. Rent data is hard to obtain<br>2. Hard to decided the discount rate<br>3. Calculation is complex |

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# Chapter 19
# Applications of Artificial Neural Networks in the Identification of Real Estate Cycles: Evidence from China

**Yang Li, Hong Zhang, Fei Yang, and Yue Wang**

**Abstract** Deep understandings of the cyclical changes in real estate market have significant meanings for market participants to make appropriate investment decisions. This paper innovatively applied artificial neural networks to identify real estate cycles in China, and accurately predicted its development phases with a well-trained artificial neural network based on 1993–2008 historical training samples. The results indicate that, China's real estate market has oscillational characteristics and the performance of the artificial neural networks reaches high accuracy. In the context of continuously deepening governmental interventions, the volatility in real estate cycles has become more evident since 2008, when the market reached its peak in 2009, but quickly plunged into recession in 2010, and then approached to its trough in 2011. Therefore, a series of governmental macro-control policies since 2008 have tremendous impacts on the duration and frequency of China's real estate cycles, by adjusting the expansion speed of real estate business.

**Keywords** Real estate cycle • Business cycle • Real estate market • Artificial neural network • China

## 19.1 Introduction

As an engine of growth for the national economy, the real estate market is characterized by its cyclical nature over the development process. Deep understandings of the business cycle for the real estate market can provide both

Y. Li (✉) • F. Yang • Y. Wang
Department of Construction Management, Tsinghua University, Beijing, China
e-mail: liy-10@mails.tsinghua.edu.cn; fei-yang11@mails.tsinghua.edu.cn; yueshuyiren@163.com

H. Zhang
Associate Professor, School of Economics and Management Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China
e-mail: highsky_zh@yahoo.com.cn

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theoretical and practical significance for economists and various market participants, so as to grasp the basic law of the real estate market. On the micro-level, real estate market players expect to forecast the ups and downs, make right decision on business investment and operations, therefore entrench their advantageous positions in market competitions. From the macro-level, seizing the cyclical feature of real estate market can accommodate with the requirements for formulating industrial development strategy and national economic planning, as well as providing reference basis for establishing macro-economic regulations of the central government.

As one of the emerging economies, China's real estate market is currently on its initial stage with strong governmental interventions, and the market responds drastically to external factors of macro-economic and political conditions. Distinct from other mature markets in well-developed countries, its cyclical variation and development phases possess evident characteristics. With this in mind, this paper attempts to identify the business cycle of China's real estate market, as a representative sample of the emerging real estate market in the context of a state-moderated economy.

In terms of research methods, existing literature for the identification of the real estate cycle can be categorized into two groups. The first group applies linear models to address the development phases of the real estate market [2, 3]. Such method simplifies the complicated relationships among various indicators, and requires high accuracy for the data, so the error is relatively large. The other is based on nonlinear model analysis, such as fuzzy pattern recognition [5]. However, nonlinear models lack of empirical analysis in the selection process of standard values for the indicators, so the research findings are very likely inconsistent with the development realities of the real estate market.

With respect to the research content, real estate cycles in China possess its own characteristics, given the fact that the real estate market mechanism is still in its fledging period and subjects to intensive macro-control policy intervention. However, much attention has been paid in current studies to the cyclical feature similar to the general business cycle, and the research incorporated with real estate attributes is insufficient. Moreover, due to the difficulties in data acquisition, the majority of current research is merely qualitative description of China's real estate cycle [4, 6]. Accordingly, the empirical research to estimate and identify China's real estate cycle needs to be strengthened. In this instance, this paper consolidates the 1993–2011 annual data of China's real estate market and innovatively introduces the method of artificial neural networks (ANN) to identify the real estate cycle.

## 19.2 Methodology of Using Artificial Neural Networks for Real Estate Cycle Identification

### *19.2.1 Application Process of Artificial Neural Networks*

The process to apply the artificial neural networks for the real estate cycle identification contains three steps:

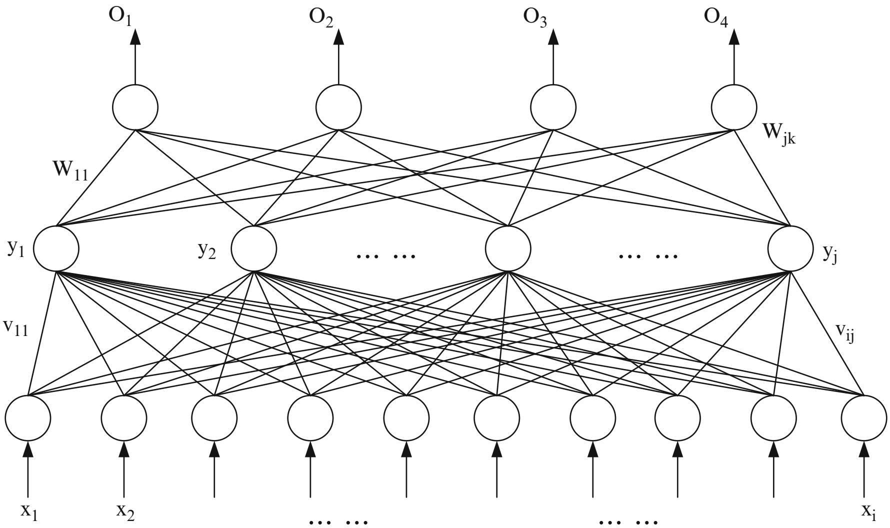


**Fig. 19.1** Topology structure of the BP neural network

1. Use the data value of representative indicators for real estate cycles as the input of the ANN model, encode the terms to identify the phases of the cycle as the output of the ANN, and the basic ANN framework is formed;
2. Summarize the development phases of the real estate market with reference to the past research, generate training samples to train the ANN; when the ANN model is well-trained, the network extracts the characteristic relationships implicit in the sample, and these characteristic information is stored in the weighted vectors of the network;
3. Process the data of representative indicators based on the trained ANN, output the codes of the identification results in the cycle, and the codes correspond to the descriptive term of the phases in the cycle.

### *19.2.2 Architecture of Artificial Neural Networks*

A neural network or so-called ANN is a mathematical model that applies interconnected structure of artificial neurons similar to the brain for the information processing. The neural network is a computational model which consists of an interconnected group of nodes (or neurons), and each node represents a specific output function, called as the activation function. Each connection between two nodes represents a weighted value of the signal through the connection, called the weight, equivalent to the memory of the ANN. The output of the network depends on the types of connections, weight values and activation functions. The network provides an arbitrary approximation mechanism of certain algorithm or function, or an expression of the logical strategy. The network topology structure is established as shown in Fig. 19.1.

In current ANN applications, the back-propagation (BP) algorithm is commonly used for training ANN. The BP method, as the core of the feed-forward network, reflects the essential part of the ANN model. The BP-ANN is constituted by the input layer, several hidden layers and the output layer, each layer contains a number of neurons [1]. As shown in Fig. 19.1, we design a three-layer network with one hidden layer, the nodes on the input layer as $x_i$, on the hidden layer as $y_j$ and on the output layers as $O_k$. The weight of the connection between $x_i$ and $y_j$ is denoted by $v_{ij}$ and the weight between $y_j$ and $O_k$ is $w_{jk}$.

### 19.2.3 Working Mechanism of Artificial Neural Networks

Denote the threshold value of the input layer as $\theta_j$, the threshold value of the hidden layer as $\xi_k$. The transfer function of the output layer is constructed, as shown in Eq. (19.1).

$$O_k = f(net_k) \tag{19.1}$$

Where, $net_k = \sum_{j=1}^{J} w_{jk} y_j - \xi_k,\ k = 1, 2, \cdots K$. The transfer function of the hidden layer is expressed, as shown in Eq. (19.2).

$$y_j = f\left(net_j\right) \tag{19.2}$$

Where, $net_j = \sum_{i=1}^{I} v_{ij} x_i - \theta_j,\ j = 1, 2, \cdots J$. The function $f(\bullet)$ used in the output layer and the hidden layer is used as the ANN transfer function. There are three types of basic transfer models as follows.

The first type is the step function, as shown in Eq. (19.3).

$$f(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x < 0 \end{cases} \tag{19.3}$$

Sigmoid transfer function is set, as shown in Eq. (19.4).

$$f(x) = \frac{1}{1 + e^{-x}} \tag{19.4}$$

Piecewise linear transfer function is set, as shown in Eq. (19.5).

$$f(x) = \begin{cases} 0 & x \le 0 \\ cx & 0 < x \le x_c \\ 1 & x_c < x \end{cases} \tag{19.5}$$

Based on the trial calculation results to identify real estate cycles, the Sigmoid function is superior to the other two, so we set the transfer function type as Sigmoid function.

The training sample is required to train the ANN model. Set the output value of the training sample as $d_k$, calculate the output and known types according to the neural network, then the error of the output layer can be expressed, as shown in Eq. (19.6).

$$\delta_k^O = (d_k - O_k)(1 - O_k)O_k \tag{19.6}$$

According to the theory of back-propagation, the error generated from the output layer to the hidden layer is calculated, as shown in Eq. (19.7).

$$\delta_j^V = \left(\sum_{k=1}^{K} \delta_k^O w_{jk}\right)\left(1 - y_j\right)y_j \tag{19.7}$$

After the errors being calculated, adjust the weights of the output layer and hidden layer, and obtain the adjusted results, as shown in Eqs. (19.8) and (19.9).

$$w_{jk} = w_{jk} + \eta\delta_k^O y_j \tag{19.8}$$

$$v_{ij} = v_{ij} + \eta\delta_j^V x_i \tag{19.9}$$

After each adjustment in weights, the MAE can be calculated as shown in Eq. (19.10).

$$E = \sqrt{\sum_{k=1}^{K} (d_k - O_k)^2} \tag{19.10}$$

Finally, input the training samples one by one, repeat the training process for ANN models until the MAE is less than the predefined threshold value, and the ANN training is completed as a convergent state. Then, the ANN model can be used for the identification and discrimination of the following samples.

## 19.3 Identification of China's Real Estate Cycles Based on Artificial Neural Networks

In this section, the ANN model is established for the identification of real estate cycles in China. First, the representative indicators for real estate cycles are constructed according to the business cycle theory, then related variables of the indicators are selected for data collection; Next, the identification model of real estate cycles is developed based on ANN, and then gets training with previous estimations of real estate cycles in 1993–2008; Finally, the development phases of China's real estate market in 2009–2011 are identified based on training samples.

### *19.3.1 Indexes, Variables and Data*

On the basis of the past studies, four categories of representative indicators for China's real estate cycles are proposed in this paper.

The first category contains the supply index of real estate market, higher value of the supply index represents that the supply side of the market is proactive with confidence, and vice versa. The second category is the demand index of real estate market, higher value of the demand index displays exuberant demand of real estate market and beneficial trend for development. The first and the second category of indexes reflect the supply/demand behaviors inside the real estate market, as well as the market's ability to regulate. The third category of indexes reflects the current socio-economic development situation, in order to measure the coordination level between the real estate market and the economic development. The fourth category of indexes selects the financial indicators in strong correlation with the real estate sector, so as to discriminate whether the financial sector provides development opportunities or threats for the real estate market. The third and the fourth category of indexes stand for the impacts of external factors on real estate market. Ten specific variables are selected in accordance with the categories of supply, demand, socio-economic and financial indexes, and the data is collected in 1993–2008, as shown in Table 19.1. Note that all variables use their relative quantities such as annual growth rates to accurately depict the oscillational changes.

### *19.3.2 Tests of Training Samples*

As mentioned above, ten variables are selected as the input information to identify the real estate cycles, so there are ten nodes on the input layer in the design of the ANN. The hidden layer consists of 20 nodes, and the output layer of the ANN contains six identification types for different phases in real estate cycles. Because

**Table 19.1** Descriptive statistics of variables

| Index | Variable | Year | Max | Min | Mean | SD |
|---|---|---|---|---|---|---|
| Supply index | Real estate investment growth | 1993–2008 | 2.550 | −0.070 | 0.370 | 0.627 |
| | Real estate investment/fixed asset investment | 1993–2008 | 0.580 | 0.140 | 0.422 | 0.136 |
| | Completed construction area growth | 1993–2008 | 0.450 | −0.120 | 0.153 | 0.192 |
| Demand index | Housing sales area growth | 1993–2008 | 0.760 | −0.390 | 0.177 | 0.294 |
| | Housing sales amount growth | 1993–2008 | 1.420 | −0.340 | 0.346 | 0.378 |
| | Housing price/annual household income | 1993–2008 | 0.550 | 0.260 | 0.405 | 0.080 |
| Social-economic index | Annual household income growth | 1993–2008 | 0.450 | −0.310 | 0.150 | 0.154 |
| | GDP growth | 1993–2008 | 0.290 | 0.080 | 0.151 | 0.057 |
| | Employee wage growth | 1993–2008 | 0.450 | 0.110 | 0.194 | 0.086 |
| Financial index | Real estate loan growth | 1993–2008 | 2.250 | −0.310 | 0.381 | 0.577 |

**Table 19.2** Mapping of identification types and codes

| Identification type | Code |
|---|---|
| Recession | 100000 |
| Trough | 010000 |
| Recovery | 001000 |
| Expansion | 000100 |
| Peak | 000010 |
| Contraction | 000001 |

the output information is descriptive, we need encode the six nodes on the output layer, as shown in Table 19.2.

From the existing research, China's real estate market is characterized by the cyclical fluctuations in the past decades. By synthesizing the historical findings with the macro-control policy, we discriminate the development phases of China's real estate market in 1993–2008, as shown in Table 19.3.

Based on the historical classification above, we take the real estate market phase identification in 1993–2008 as the training sample, encode the development phase, and train the ANN model for 5,000 times. Note that the error term is set as 0.2, and the ANN training results have reached expected performance, so it can be used for the identification of real estate cycles. The training results and the actual coding are compared, as shown in Table 19.4.

### *19.3.3 Analysis on Identification Results*

Based on the well-trained ANN model, China's real estate cycle and its development phases can be identified in the 2009–2011 with real estate market data collected. The identification result is obtained, as shown in Table 19.5.

**Table 19.3** Cyclical fluctuations of China's real estate market in 1993–2008

| Year | Market description | Phase |
|---|---|---|
| 1993–1994 | Market developed to its first summit | Peak |
| 1995–1997 | Market slowed down with stable investment and development | Contraction |
| 1998 | Due to low level of housing consumption, the development slows down | Recession |
| 1999 | Market reached its bottom | Trough |
| 2000–2003 | A series of real estate policies were release, the market was stabilized and regulated | Recovery |
| 2004–2005 | The macro-economic development promoted the expansion of the market | Expansion |
| 2006–2007 | The market reached the second peak | Peak |
| 2008 | Affected by the global financial crisis, the market dropped | Trough |

Table 19.5 indicates that, China's real estate market reached its peak of the cycle in 2009, but plunged into the recession phase in 2010, and approached its trough in 2011. Comparing the identification results of the ANN with the performance of China's real estate market, we found that the result is generally consistent with the market reality.

As stimulated by the four trillion investment package as well as the proactive fiscal policy and loose monetary policy by the end of 2008, the real estate sales and prices in China escalated in 2009. According to the National Bureau of Statistics (NBS), China's real estate development investment reached 3.62 trillion *yuan*, an annual growth of 16.1 %; sales area of real estate reached 937.13 million $m^2$, up 42.1 %; real estate sales reached 4.40 trillion *yuan*, up 75.5 %. Behind the surge in real estate sales, the real estate prices also increased suddenly, and the average transaction price of national real estate market reached 4,695 *yuan*/sqm, at a record high in 2009.

After experiencing the real estate boom in 2009, central government of China pronounced a series of macro-control policies to curb real estate prices in 2010 with both economic and administrative instruments, and implemented a full-range regulation on real estate market in terms of inhibiting speculative demand, increasing land supply, and strengthening the supervision. The regulations mainly consist of differentiated credit and tax policies, increased ratio of loan-to-value (LTV) and mortgage interest rate, strict house-purchasing restriction, and etc. The continued launch of these policies had imposed phenomenal impacts on local governments, development companies, commercial banks and home-buyers. Consequently, the severe macro-control policies had gradually plunged China's real estate into the recession phase.

In 2011, the central government of China continued to strengthen the regulation of the real estate market. Some macro-control policies that initiated in 2010 had sustained and refined in 2011. In such highly constrained market environment, the growth rates of real estate investment and new construction area dropped very quickly. The regulatory effects became even more evident in the major cities where the residential turnover witnessed a decrease of 15 % with some cities even lower

**Table 19.4** Training result based on artificial neural networks

| | ANN training result | | | | | | Actual coding | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | $O_1$ | $O_2$ | $O_3$ | $O_4$ | $O_5$ | $O_6$ | $O_1$ | $O_2$ | $O_3$ | $O_4$ | $O_5$ | $O_6$ | Phase |
| 1993 | 0.000 | 0.005 | −0.008 | −0.006 | 0.995 | 0.014 | 0 | 0 | 0 | 0 | 1 | 0 | Peak |
| 1994 | 0.001 | 0.001 | 0.005 | 0.004 | 0.999 | −0.003 | 0 | 0 | 0 | 0 | 1 | 0 | Peak |
| 1995 | 0.006 | −0.001 | 0.004 | −0.009 | −0.008 | 0.994 | 0 | 0 | 0 | 0 | 0 | 1 | Contraction |
| 1996 | 0.008 | −0.030 | −0.003 | −0.001 | 0.001 | 0.944 | 0 | 0 | 0 | 0 | 0 | 1 | Contraction |
| 1997 | −0.004 | 0.001 | 0.005 | 0.001 | 0.003 | 0.999 | 0 | 0 | 0 | 0 | 0 | 1 | Contraction |
| 1998 | 0.958 | 0.009 | 0.051 | −0.013 | 0.037 | −0.037 | 1 | 0 | 0 | 0 | 0 | 0 | Recession |
| 1999 | 0.034 | 0.993 | −0.018 | 0.031 | 0.001 | 0.009 | 0 | 1 | 0 | 0 | 0 | 0 | Trough |
| 2000 | 0.038 | 0.007 | 0.952 | 0.012 | −0.043 | 0.060 | 0 | 0 | 1 | 0 | 0 | 0 | Recovery |
| 2001 | −0.058 | 0.005 | 1.010 | 0.000 | 0.049 | 0.004 | 0 | 0 | 1 | 0 | 0 | 0 | Recovery |
| 2002 | −0.002 | 0.000 | 1.001 | −0.003 | −0.002 | −0.004 | 0 | 0 | 1 | 0 | 0 | 0 | Recovery |
| 2003 | 0.015 | −0.006 | 0.986 | 0.011 | −0.017 | −0.002 | 0 | 0 | 1 | 0 | 0 | 0 | Recovery |
| 2004 | 0.046 | −0.016 | −0.004 | 1.067 | 0.011 | −0.030 | 0 | 0 | 0 | 1 | 0 | 0 | Expansion |
| 2005 | −0.029 | 0.014 | 0.013 | 0.849 | −0.064 | 0.027 | 0 | 0 | 0 | 1 | 0 | 0 | Expansion |
| 2006 | 0.016 | −0.011 | 0.031 | 0.104 | 1.042 | −0.059 | 0 | 0 | 0 | 0 | 1 | 0 | Peak |
| 2007 | −0.037 | 0.029 | −0.016 | −0.033 | 1.022 | 0.078 | 0 | 0 | 0 | 0 | 1 | 0 | Peak |
| 2008 | 0.011 | 1.002 | −0.007 | −0.015 | −0.025 | 0.007 | 0 | 1 | 0 | 0 | 0 | 0 | Trough |

**Table 19.5** Identification results of China's real estate cycles in 2009–2011

| | ANN training result | | | | | | Actual coding | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | $O_1$ | $O_2$ | $O_3$ | $O_4$ | $O_5$ | $O_6$ | $O_1$ | $O_2$ | $O_3$ | $O_4$ | $O_5$ | $O_6$ | Phase |
| 2009 | 0.043 | −0.088 | 0.234 | −0.123 | 0.823 | −0.568 | 0 | 0 | 0 | 0 | 1 | 0 | Peak |
| 2010 | 0.846 | 0.066 | −0.258 | 0.232 | 0.062 | −0.125 | 1 | 0 | 0 | 0 | 0 | 0 | Recession |
| 2011 | 0.492 | 1.288 | −0.14 | 0.334 | 0.092 | 0.519 | 0 | 1 | 0 | 0 | 0 | 0 | Trough |

than 2008. As a result, the average real estate price continued to fell, and the market declined and approached to its trough. Thus, it can be seen that, the cyclical performances of the real estate market have been influenced by the macro-control policies significantly.

## 19.4 Conclusions

This paper creatively incorporated the ANN method into the field of the real estate cycle identification. We established the ANN identification model of real estate cycles, summarized the historical identification results as training sample, and finally applied the well-trained ANN model to identify China's recent real estate cycles. The research found that, China's real estate market also has cyclical characteristics, while real estate cycles fluctuate more frequently after 2008. The market reached its peak in 2009, but plunged into recession in 2010, and approached the trough in 2011. The macro-control policies in China have tremendous impacts on the real estate market, by adjusting the pace of development in the real estate business. In order to maintain the stability and sustainability of China's real estate sector, the government can make the counter-cyclical regulations to reduce the market volatility.

This paper attempts to establish the real estate cycle identification model based on artificial neural networks. The findings show that the artificial neural network can approximate arbitrary complex nonlinear function, possess favorable pattern recognition, and at the same time has the learning ability, with the advantage of continuous learning and training based on the new data. This paper provides empirical results consistent with the real estate market realities, and also confirms that the ANN method is applicable to the analysis of the real estate cycle identification. In the future, the applications of the ANN model can be enriched by extending existing indicators to a more comprehensive real estate cycle evaluation system. International comparisons for real estate cycles based on the ANN can be another potential research area to examine the global real estate cycle.

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# Chapter 20
# Impacts of China's Monetary Policy on Development Investment of Different Uses Properties

**Yue Wang and Hong Zhang**

**Abstract** Subdivide the real estate market according to properties of different uses. Based on the VAR model, use the impulse response function and variance decomposition methods to analyze the impact of China's monetary policy on the development investment of residences, office buildings and business buildings. The conclusions are: (1) the positive impact of money supply on the development investment of residences, office buildings and business buildings is greater than the negative impact of interest; (2) the impact duration of monetary policy on the development investment of residences is shorter than that of office buildings and business buildings; (3) the impact strength of monetary policy on the development investment of residences is greater than that of office buildings and business buildings.

**Keywords** Monetary policy • Residences • Office buildings • Business buildings • Development investment

## 20.1 Introduction

Domestic researches about the relationship between monetary policy and real estate market vary. Recently, major researches focus on two main aspects [1]. On the one hand, researchers analyze the effect of monetary policy tool on real estate investment and price of property [2, 3]. On the other hand, macro transmission mechanism of monetary policy via real estate price is under study [4, 5]. Previous studies

Y. Wang (✉)
Department of Construction Management, Tsinghua University, Beijing, China
e-mail: yueshuyiren@163.com

H. Zhang
Associate Professor, School of Economics and Management Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China
e-mail: highsky_zh@yahoo.com.cn

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suggest real estate market as a unified entirety, whereas the specific characteristics of different types of property were not being taken into consideration. In addition, it is difficult to draw a certain conclusion of quantitative and qualitative researches based on domestic real estate market.

Started from 2010, domestic monetary policy has been tightened properly. Besides, in case of speculation as well as reducing inflation number, the central bank uses various methods of monetary policy, for instant, raising the deposit reserve ratio and the deposit and loan benchmark interest rates. Meanwhile, the price and investment of property are controlled in a certain degree. However, different types of properties react significantly different under the regulation and control of monetary policy. Therefore, investment about the specific influences of macro regulation policy, especially monetary policy, on different types of property markets has more realistic meaning.

This paper is based on development investment of real estate and relies on different types of properties in order to subdivision domestic real estate market. The author analyzes the effect of domestic monetary policy on of real estate from three aspects: the effect on development investment of residences, office buildings and business buildings through studying on real examples. The study is based on theoretical analyses and hypothesis and expects to provide a ground for formulating differential regulation policy.

## 20.2 Theoretical Analyses and Hypotheses

Monetary policy affects macroeconomic by adjusting money supply and regulating interest rate. Therefore, select money supply and interest rate as indicator of monetary policy.

Money supply has a positive effect on real estate development investment. However, interest rate has a negative effect. Because that deposit and loan interest are not completely marketization in China, it cannot guide the rational allocation of funds. Generally, the yield rate of real estate development investment is higher than interest rate. Interest rate regulates real estate development investment by the effect on the cost of loan fund. Additionally, this regulation effect is lower than the influence of money supply which affects scale of credit directly.

In terms of different types of properties, development investment of residences is finish when the property is sold out. Additionally, developing a residence includes following steps: purchase of land, start from begin of construction to complete, sales of the property. Each section requires relatively short time and it is easier to make a new decision to deal with the change of monetary policy. Therefore, the conduction delay effect of monetary policy is weak and the influence of policy on development investment of residences is strong. However, the effect of monetary policy on development investment of office buildings and business buildings is relatively lower. These two types of properties are for business uses which require long-term and sustainable operation to gain profit. As a result of the long and complicate developing process for business properties, the investment decision is affect by more factors and the conduction delay effect of monetary policy is strong.

Above all, following theoretical hypotheses are suggested.

Hypothesis 1: Theoretical hypotheses one: The positive effect of money supply on real estate development investment is higher than the negative effect of interest rate.

Hypothesis 2: Theoretical hypotheses two: The duration of effect of monetary policy on residence is shorter than it on office buildings and business buildings.

Hypothesis 3: Theoretical hypotheses three: The effect of monetary policy on residence is greater than it on office buildings and business buildings.

## 20.3 Methodological Bases

This paper mainly uses the impulse response function and variance decomposition methods to analyze the demonstration and test the hypothesis. Meanwhile, these two methods are based on the VAR model.

### *20.3.1 VAR Model*

VAR model uses every endogenous variable as the function of hysteresis value of endogenous variable to structure the model. This model researches the relationship between numbers of relative time series systems as well as analyzes the dynamic effect of disturbance on variable system. The basic form of VAR model includes p factorial hysteresis is shown as follow:

$$Y_t = \mu + A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + \varepsilon_t \tag{20.1}$$

In Eq. (20.1), $\mathbf{Y}_t$ is system endogenous variable vector. $\mathbf{Y}_t = [Y_{1t}, Y_{2t}, \ldots, Y_{kt}]'$. $\boldsymbol{\mu}$ is constant term vector. $\boldsymbol{\mu} = [\mu_1, \mu_2, \ldots, \mu_k]'$. $\mathbf{Y}_{\mathbf{t}-i}$ is the i factorial hysteresis of $\mathbf{Y}_t$. $\mathbf{Y}_{t-i} = [Y_{1t-i}, Y_{2t-i}, \ldots, Y_{kt-i}]'$ $(i = 1, 2, \ldots, p)$; $\mathbf{A}_i$ is the matrix of hysteresis coefficient.

$\mathbf{A}_i = \begin{bmatrix} \alpha_{11.i} & \alpha_{12.i} & \cdots & \alpha_{1k.i} \\ \alpha_{21.i} & \alpha_{22.i} & \cdots & \alpha_{2k.i} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_{k1.i} & \alpha_{k2.i} & \cdots & \alpha_{kk.i} \end{bmatrix}$, $\boldsymbol{\varepsilon}_t$ is random error vector, $\boldsymbol{\varepsilon}_t = [\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_k]'$.

VAR model requires time series which corresponding every endogenous variable should be stable.

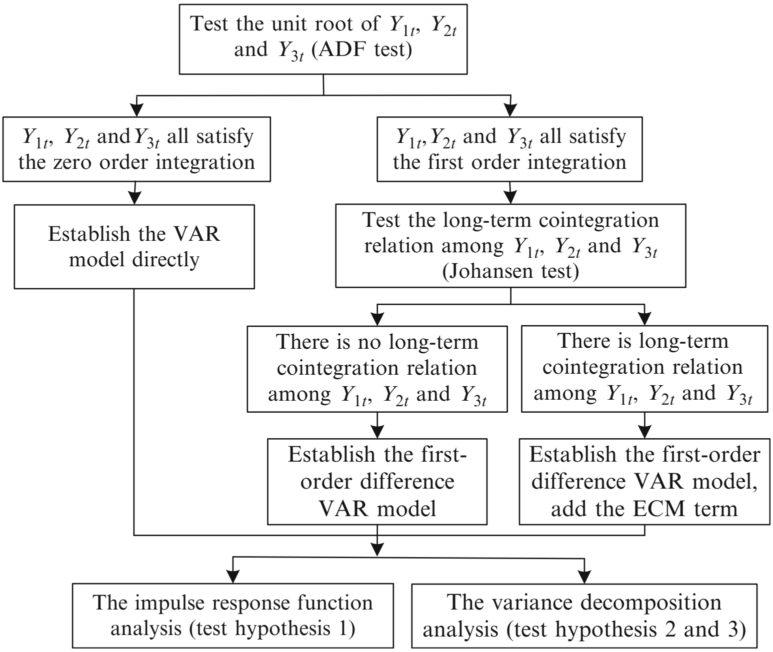


**Fig. 20.1** The technical route of the empirical analysis

### *20.3.2 Impulse Response and Variance Decomposition*

Impulse response function analysis is a method to measure the dynamic effect of system when VAR model impacted by some concussion. Due to the hysteresis structure of VAR model, the concussion on one endogenous variable transmits to other endogenous variables. Impulse response function describes the influence on the current value and future value of every endogenous variable.

Variance decomposition provides relative important information of random information. The relative contribution of the jth endogenous variable concussion variance to the ith endogenous variable variance could be measured through calculating the variance contribution rate. The relative contribution reflects the degree of dynamic impact of the jth variable to the ith variable.

### *20.3.3 Technical Route of the Empirical Analysis*

In the specific empirical analysis of this thesis, the technical route as Fig. 20.1 shows is adopted.

## 20.4 Indicators, Variables and Data

### *20.4.1 Selection of Indicators and Variables*

The analysis of this thesis majorly deals with money supply indicator, interest rate indicator and development investment indictor of different types of properties.

The generalized money supply (M2) is selected to be the money supply indictor. Because the M2 could reflect the condition of total requirement and future inflation pressure more clearly. The interest rate chooses the financial institution 1–3 years RMB loan prime interest rate issued by centre bank in consideration of the development circle of different types of properties. Development investment indictor selects the investment complete value of residences, office buildings and business buildings. Every indictor as well as it corresponding variable are shown in Table 20.1.

### *20.4.2 Data Collection*

In fact, our country started to adopt concentrate policy to regulate real estate market from 2004. Taking this fact as well as availability of data into consideration, total 28 groups' season data from season 1 of 2004 to season 4 of 2010 are selected for analysis and complete by Eviews6.0. The interest rate data is taken from the web site of the People's Bank of China and other data is from CREIS. Besides, the effects of inflation of both generalized money supply (M2) and different types of properties' investment complete value (I_ZHU, I_BAN, I_SHANG) are eliminated via CPI. Moreover, those variables are seasonal adjusted by X11 addition.

**Table 20.1** Indictors and corresponding variables

| Indictor name | Variable name | Variable code |
|---|---|---|
| Money supply | Generalized money supply | M2 |
| Interest rate | 1–3 years loan interest rate | R |
| Development investment | Residence's investment complete value | I_ZHU |
| | Office buildings' investment complete value | I_BAN |
| | Business buildings' investment complete value | I_SHANG |

## 20.5 Empirical Analyses

### *20.5.1 Establishing the VAR Model*

1. Carry out every variable's ADF single integer test. The results show that every variable is first single integer which needs further cointegration test.
2. Carry out cointegration test on development investment value, generalized money supply (M2) and 1–3 years loan interest rate (R) depending on different types of properties. The results show that there is no cointegration relationship between any two of development investment value, generalized money supply (M2) and 1–3 years loan interest rate (R) depending on different types of properties.
3. According to the analysis depending on different types of properties above, every variable is first single integer and there is no cointegration relationship between each other. Therefore, each variable's first difference order is adopted and the VAR model of residence, office buildings and business buildings' market is established separately. After comparing every VAR model comprehensively, all the factorial numbers of hysteresis are 2 (Specific equation of model is omitted).

### *20.5.2 Impulse Response Function Analyses*

Based on the VAR model, analyze the effect of money supply and interest rate indictor on development investment of different types of properties by using impulse response function. Every variable adopts first difference form.

In VAR model, a concussion equals to the value of standard deviation is applied on generalized money supply (DM2) and 1–3 years loan interest rate (DR) separately. The accumulative impulse response results of residence, office buildings and business buildings' investment complete values (DI_ZHU, DI_BAN, DI_SHANG) are shown as Figs. 20.2, 20.3 and 20.4.

According to Figs. 20.2, 20.3 and 20.4, the positive impact of money supply on the development investment of residences, office buildings and business buildings is greater than the negative impact of interest. This is conforming to hypothesis 1.

### *20.5.3 Variance Decomposition Analyses*

We do the variance decomposition analyses about the investment complete values of residence, office building and business building, which reveal the degree of contribution about each variable's variation on the variable quantity of development investment value in terms of different types of properties.

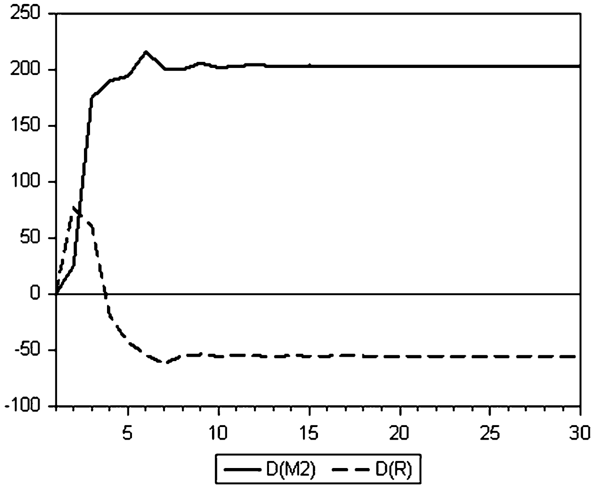


**Fig. 20.2** Cumulative impulse response of DI_ZHU on DM2 and DR

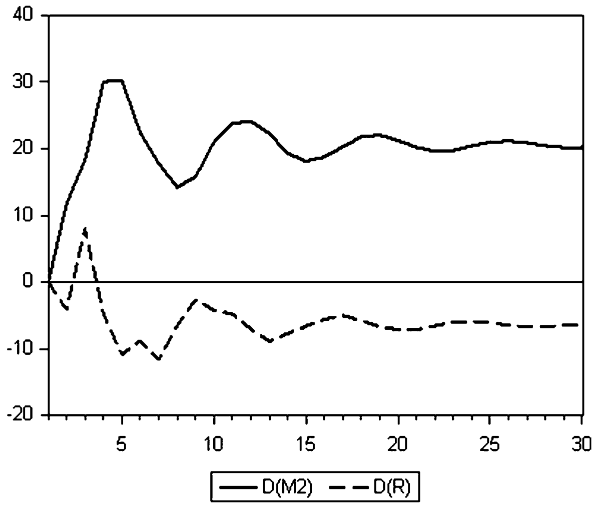


**Fig. 20.3** Cumulative impulse response of DI_BAN on DM2 and DR

The variance decomposition results of residence's investment complete value indicate that the fluctuation of season 7 residence's investment complete value is basically stable. Additionally, about 48 % could be explained by self fluctuation and other 52 % is because of monetary policy.

The variance decomposition results of office building's investment complete value indicate that the fluctuation of season 20 office buildings' investment complete value is basically stable. Besides, about 67 % is due to self fluctuation and other 33 % is because of monetary policy.

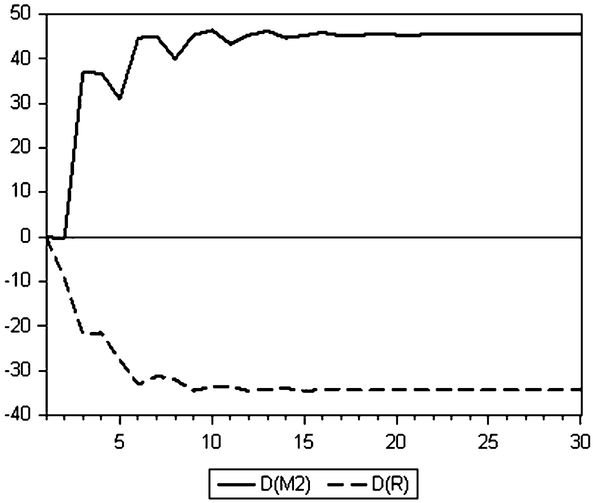


**Fig. 20.4** Cumulative impulse response of DI_SHANG on DM2 and DR

The variance decomposition results of business building's investment complete value indicate that the fluctuation of season 13 business's investment complete value is basically stable, where about 61 % is because of self fluctuation and other 39 % could be explained by monetary policy.

In conclusion, the effect of monetary policy on residence's development investment lasting for seven seasons, which is apparently shorter than the durations of development investment of office buildings (20 seasons) and business buildings (13 seasons). This conclusion is validating the hypothesis 2. Furthermore, more than half (52 %) of the fluctuation of residence development investment is due to the monetary policy, which obviously greater than office buildings (33 %) and business buildings (39 %). This conclusion is validating the hypothesis 3.

## 20.6 Conclusions and Suggestions

In summary, based on theoretical analysis and hypothesis, this thesis builds VAR models of different types of properties separately. Moreover, an empirical analysis about the effect of domestic monetary policy on the development investment of residence, office building and business building is carried out via the method of impulse response function and variance decomposition. The following conclusions are maintained:

(1) The positive impact of money supply on the development investment of residences, office buildings and business buildings is greater than the negative impact of interest; (2) The impact duration of monetary policy on the development

investment of residences is shorter than that of office buildings and business buildings; (3) The impact strength of monetary policy on the development investment of residences is greater than that of office buildings and business buildings.

In terms of policy, the monetary supply is suggested to be the main monetary policy variable for regulating the development investment of real estate by the government. Besides, specific regulative policy should be applied according to characteristics of residence, office buildings and business buildings. In further research, the way of formulating classified regulative policies which suit to different types of properties' market would be investigated.

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# Chapter 21
# Impact of Mortgage on the Housing Market Based on IS-LM Model: Evidence from Shanghai in China

**Fei Yang and Hong Zhang**

**Abstract** The mechanism of mortgage on housing market is theoretically analyzed and IS-LM model including the impact of mortgage and housing prices is developed. On the basis of theoretical model, the marginal effects of mortgage on the housing prices and residential investment are quantitatively examined with the quarterly data of Shanghai in China from the first quarter of 2001 to the fourth quarter of 2010. The results indicate that as far as housing market in Shanghai in China is concerned, the mortgage has significant impact on the housing prices and residential investment. An addition of one billion yuan in total Residential Mortgage Loan in Shanghai will lead to an increase of 3.069 in China Real Estate Index of Housing in Shanghai and an increase of 0.052 billion yuan in Housing Investment in Shanghai.

**Keywords** IS-LM model • Mortgage • Housing market • Shanghai

## 21.1 Introduction

The credit market provides much fund for the development of real estate industry. With the mortgage, the customers can overcome the difficulty of lack of money. The real estate developers could finance for the projects in the credit market. It is of great importance for formulation of macroeconomic policy to study the mechanism and influence of credit market on the real estate market. At present, many researches on this topic are carried out. For example, on the basis of general

F. Yang (✉)
Department of Construction Management, Tsinghua University, Beijing, China
e-mail: fei-yang11@mails.tsinghua.edu.cn

H. Zhang
Associate Professor, School of Economics and Management Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China
e-mail: highsky_zh@yahoo.com.cn

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equilibrium model, Aoki et al. [1] studied the influence of credit policy on the real estate market and found that the mortgage amplified and propagated the effect of monetary policy shocks on the housing prices, residential investment and consumption. VAR models containing variables from credit markets and housing markets in nine European countries were developed by Giuliodori [2] to investigate the transmission mechanism of credit policy in housing market. Goodhart and Hofmann [3] established a fixed-effects panel vector auto-regression model with quarterly data in 17 industrial countries from 1970 to 2006 to examine the inner links among the credit, housing prices and economic activities. The result showed that the three affected each other and credit had significant impact on the housing prices when real estate industry developed rapidly. A dynamic general equilibrium model to study the interactive relationships among housing prices, credit and consumption was built by Iacoviello [5]. Through the theory analysis and empirical study, Iacoviello [6] concluded that the mortgage increased the demand for houses and it showed great influence on the housing prices. Iacovielloa and Minettib [7] utilized a VAR model to analyzed the effect of credit policy on the housing market, with evidences from Finland, Germany, Norway and the United Kingdom. With a SVAR model, Musso et al. [8] comparatively analyzed the different influences of credit policy on the housing markets in the United States and Europe. The relationship between subprime mortgages and residential investment was investigated by Peek and Wilcox [9].

The studies mentioned above investigated the relationship between credit market and real estate market with different theories and methods. This paper aims to discuss the mechanism and influence of mortgage on the housing market. The variables describing housing market are housing prices and residential investment. Proceeding from associations among production, credit and money, the impacts of mortgage on the housing prices and residential investment are examined on the basis of IS-LM model, which is the bridge connecting product market and money market. The research frame is as follows. First, the mechanism of mortgage on housing market is theoretically analyzed and IS-LM model including mortgage and housing prices is set up. Then the paper empirically studies the marginal effects of mortgage on the housing prices and residential investment with the quarterly data of Shanghai in China from the first quarter of 2001 to the fourth quarter of 2010.

## 21.2 IS-LM Model

As shown by Hicks [4], IS-LM model is used to investigate relationship between product market and money market. It is composed of two parts. IS stand for "investment" and "savings", representing product and service market. Both "liquidity" and "money" constitute LM, which reflect supply and demand of money. IS-LM model are listed as follows:

$$\mathrm{IS}: \ Y = C(Y - T) + I(i_r) + G \tag{21.1}$$

$$\mathrm{LM}: \frac{M}{P} = L(i, Y) \tag{21.2}$$

Where, Y is gross income; C(Y − T) is a function for consumption; T denotes tax; $I(i_r)$ represents a function for investment; $i_r$ stands for the real interest rate; $i_r = i - \pi$; i is nominal interest rate, and $\pi$ denotes inflation rate; G is government purchases; M represents supply of money; P reflects price level; $L(i, Y)$ denotes function of demand for money.

Equations (21.1) and (21.2) constitute fundamental form of IS-LM model. In order to study the impact of mortgage on the housing market, it is necessary to introduce mortgage and housing prices into IS-LM model. Because of the direct impact of mortgage on the housing consumption, the consumption in Eq. (21.1) could be divided into housing consumption $C_H$ and consumption for ordinary products (services) $C_{OR}$. Similarly, investment is also divided into residential investment $I_H$ and ordinary investment $I_{OR}$. To simplify the analysis and not to interfere with efficiency of study, an important assumption is put forward that the fiscal policy is assumed as unchanged, which means that the government purchases and taxes are fixed. $G = \overline{G}$ ; $T = \overline{T}$. If M and Y are converted into data with fixed price at a certain time point, then the P stands for unchanged price system. $P = \overline{P}$.

Housing consumption $C_H$ is not only affected by disposable income $(Y - T)$ but also influenced by mortgage $MO$. If the other conditions remain unchanged, the increase of mortgage will lead to addition of Housing consumption. So does the disposable income. That is to say, Housing consumption is an increasing function of disposable income and mortgage. $C_H = C_H\left(Y - \overline{T}, MO\right)$.

In IS-LM model, residential investment is distinguished with ordinary investment. To be specific, ordinary investment is just determined by real interest rate, while residential investment is determined by real interest rate and housing prices. According to Tobin [10], housing prices' rising is associated with increase of residential investment. Therefore, residential investment is also an increasing function of housing prices. $I_H = I_H(i_r, P_H)$.

Mortgage $MO$ is mainly influenced by both money supply $M$ and housing prices $P_H$. For one thing, the increase of money supply means that available number of mortgage in financial market rises. For another, when housing prices keep rising, the homeowner will get more mortgages. In other words, Mortgage $MO$ is an increasing function of money supply $M$ and housing prices $P_H$. $MO = f_1(M, P_H)$. It is seen from Eq. (21.2) that under the fixed price system $\overline{P}$, money supply is function of nominal interest rate i and gross income Y. Taken together, $MO$ could be expressed as a function of i, Y and $P_H$. $MO$ is correlated positively with Y and $P_H$, negatively with i.

According to the theory of supply and demand, housing prices will rise together with the increase of housing consumption. Therefore, housing prices is also an increasing function of housing consumption.

As stated previously, when mortgage and housing prices are taken into account, IS-LM model is shown as follows.

$$\mathrm{IS}: Y = C_{OR}\left(Y - \overline{T}\right) + C_H\left(Y - \overline{T}, MO\right) + I_{OR}(i_r) + I_H(i_r, P_H) + \overline{G} \tag{21.3}$$

$$\text{LM}: \frac{M}{P} = L(i, Y) \tag{21.4}$$

$$MO = MO(i, Y, P_H) \tag{21.5}$$

$$P_H = P_H(C_H) \tag{21.6}$$

The impact of mortgage $MO$ on the housing prices $P_H$ and residential investment $I_H$ can be investigated with the Eqs. (21.3), (21.4), (21.5), and (21.6). In order to explain definitely the progress, two symbols are introduced, "↑" denoting increase of quantity, "↓" meaning reduction. The increase of $MO$ will lead to the changes of investment and consumption. The first round of changes is represented as follows:

according to Eq. (21.3), $MO \uparrow \Rightarrow C_H \uparrow$;
as shown in Eqs. (21.3) and (21.6), $C_H \uparrow \Rightarrow Y \uparrow,\ P_H \uparrow$;
seen from Eq. (21.3), $P_H \uparrow \Rightarrow I_H \uparrow$;
perceived by Eqs. (21.3) and (21.5), $Y \uparrow \Rightarrow C_H \uparrow,\ MO \uparrow$.

A new addition to the $MO$ will drive the second round of changes which is similar to the first one. This change of investment and consumption induced by added mortgage will not stop until the impact of the new added mortgage on the all variables in the model approaches indefinitely in series at 0. At this time, the economic system achieves new balance.

$P_H$ can be denoted as a function of $Y$ and $MO$ with combination of Eqs. (21.3) and (21.6).

$$P_H = f_2(Y,\ MO) \tag{21.7}$$

In order to quantitatively analyze the impact of mortgage on the housing prices, a linear regression equation in which both $Y$ and $MO$ are independent variables and $P_H$ is dependent variable is developed.

$$P_H = \alpha_0 + \alpha_1 Y + \alpha_2 MO + u \tag{21.8}$$

Where, $\alpha_0$ is constant; $\alpha_1$ and $\alpha_2$ are regression coefficients; u is random error. In the same way, $I_H$ could be regressed by $i_r$, $Y$ and $MO$.

$$I_H = \beta_0 + \beta_1 i_r + \beta_2 Y + \beta_3 MO + v \tag{21.9}$$

Where, $\beta_0$ is constant; $\beta_1$, $\beta_2$ and $\beta_3$ are regression coefficients; $v$ is random error.

## 21.3 Indices, Variables and Data

The marginal effects of mortgage on the housing prices and residential investment are quantitatively examined with data from housing market, credit market and macroeconomic.

China Real Estate Index of Housing in Shanghai (HP) is used to describe the housing prices in Shanghai. Residential investment is represented by Housing Investment in Shanghai (INV). The index for reflecting mortgage is total Residential Mortgage Loan in Shanghai (MOR), which is the sum of Commerciality individual loan and housing accumulation fund loan. Gross domestic product in Shanghai (GDP) is considered to be the gross income in Shanghai. The loan interest rate of 1–3 years (including 3 years) is selected as nominal interest rate. The index referring to inflation is Consumer Price Index (CPI), which is the indicator of price changes on the basis of living-related products and services price statistics. Real interest rate ($i_r$) equals to i minus CPI.

The data for the present study is quarterly observations from 2001:1 to 2010:4. The data on Gross domestic product in Shanghai (GDP), Residential Mortgage Loan in Shanghai (MOR) and Housing Investment in Shanghai (INV) is adjusted for the effects of season and inflation.

## 21.4 Empirical Studies

Equations (21.8) and (21.9) will be estimated for quantitatively investigating the impact of mortgage on the housing prices and residential investment. It is worthwhile to note that because all the variables in both equations are data of time series, the first step is to take unit root test with Augmented Dickey-Fuller Test (ADF) before estimation. The estimation is rational only when all the data turn out stationary. If the data is not stationary, co-integration relationship among them should be tested. In such circumstances, a prerequisite for estimation is existence of cointegration relationship.

### *21.4.1 Tests of Unit Root and Cointegration*

The results of tests for SPIH, HI and CPI are represented in Table 21.1.

**Table 21.1** Tests of unit root

| | Level | | | | First difference | | | |
|---|---|---|---|---|---|---|---|---|
| | | Critical values | | | | Critical values | | |
| Objects | ADF | 1 % | 5 % | 10 % | ADF | 1 % | 5 % | 10 % |
| HP | 0.227 | −2.700 | −1.961 | −1.607 | −3.865 | −4.616 | −3.710 | −3.298 |
| INV | 1.808 | −2.718 | −1.964 | −1.606 | −4.321 | −3.920 | −3.066 | −2.673 |
| GDP | 1.370 | −2.728 | −1.966 | −1.605 | −4.768 | −4.571 | −3.691 | −3.287 |
| MOR | 0.103 | −2.700 | 1.961 | 1.607 | −4.024 | −3.887 | −3.052 | −2.667 |
| $i_r$ | −0.453 | −2.692 | −1.960 | −1.607 | −3.513 | −2.700 | −1.961 | −1.607 |

**Table 21.2** The result of cointegration test on HP, GDP and MOR

| Number of cointegration | Eigen value | Trace statistic | Critical values 5 % | 1 % |
|---|---|---|---|---|
| $\leq 0$ | 0.795 | 42.406 | 34.91 | 41.07 |
| $\leq 1$ | 0.521 | 15.481 | 19.96 | 24.6 |
| $\leq 2$ | 0.161 | 2.981 | 9.24 | 12.97 |

**Table 21.3** The result of cointegration test on INV, GDP, MOR and $i_r$

| Number of cointegration | Eigen value | Trace statistic | Critical values 5 % | 1 % |
|---|---|---|---|---|
| $\leq 0$ | 0.902 | 62.242 | 39.89 | 45.58 |
| $\leq 1$ | 0.539 | 20.396 | 24.31 | 29.75 |
| $\leq 2$ | 0.227 | 6.443 | 12.53 | 16.31 |
| $\leq 3$ | 0.096 | 1.815 | 3.840 | 6.510 |

As shown in Table 21.1, all the time series are not stationary, but their first difference have no unit root. That is to say, the cointegrating relationships need to be tested.

The method for testing cointegration test is JJ inspection, which is a useful method of testing cointegrating relationship among multi-variables. The result of cointegration test on HP, GDP and MO is shown in Table 21.2.

It is seen from Table 21.2 that for the trace statistic of "the number of cointegration $\leq 0$" outweighing critical value at 1 % level, the null hypothesis is rejected. And other trace statistics are less than the critical value, so the corresponding assumptions are accepted. That is to say, JJ test indicates 1 cointegrating relationship at the 1 % level. Therefore, Eq. (21.8) could be estimated.

The result of cointegration test on INV, GDP, MO and $i_r$ is listed in Table 21.3.

As shown in Table 21.3, because the trace statistic of "number of cointegration $\leq 0$" outweighing critical value at 1 % level, the null hypothesis is rejected. But the others are accepted. Therefore, JJ test indicates 1 cointegrating relationship at the 1 % level. Therefore, Eq. (21.9) could be estimated.

### *21.4.2 The Marginal Effects of Mortgage on Housing Prices and Residential Investment*

The Eq. (21.8) is estimated with constant item $\alpha_0$, GDP and MOR as explanatory variables. The result is shown in Table 21.4.

It can be perceived by Table 21.4 that the probability of GDP in version I including $\alpha_0$, GDP and MOR as explanatory variables is 0.109. It indicates that the coefficient of GDP is not significant. The probability of MOR is 0.000, which represents MOR has significant influence on HP. In version II, when GDP is deleted, at this time the coefficients of $\alpha_0$ and MOR are significant at 1 % level.

**Table 21.4** Estimation of Eq. (21.8)

| | Version I | | | Version II | | |
|---|---|---|---|---|---|---|
| Variables | Coefficients | T-statistics | P | Coefficients | T-statistics | P |
| $\alpha_0$ | 777.383 | 4.097 | 0.000 | 458.048 | 22.658 | 0.000 |
| GDP | −3.365 | −1.692 | 0.109 | – | – | – |
| MOR | 4.398 | 5.557 | 0.000 | 3.069 | 30.784 | 0.000 |
| $R^2$ | 0.984 | | | 0.981 | | |
| Adjusted- $R^2$ | 0.982 | | | 0.98 | | |

**Table 21.5** Estimation of Eq. (21.9)

| | Version I | | | Version II | | | Version III | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | C | T | P | C | T | P | C | T | P |
| $\beta_0$ | 15.232 | 0.908 | 0.378 | 11.425 | 2.257 | 0.037 | 7.577 | 5.135 | 0.000 |
| GDP | −0.038 | −0.239 | 0.814 | – | – | – | – | – | – |
| MOR | 0.064 | 1.009 | 0.328 | 0.049 | 5.831 | 0.000 | 0.052 | 7.161 | 0.000 |
| $i_r$ | −0.694 | −0.800 | 0.436 | −0.663 | −0.796 | 0.437 | – | – | – |
| $R^2$ | 0.750 | | | 0.750 | | | 0.740 | | |
| Adjusted-$R^2$ | 0.704 | | | 0.720 | | | 0.725 | | |

In terms of fitting effect, in version I, the adjusted $R^2$ is 0.982 and that of version II is 0.980. It illustrates that there is no sensible difference for fitting effect whether GDP is taken into account or not. Because the regression coefficient of GDP is not significant and GDP has little effect of fitting result, the fitting equation can be denoted as follows:

$$\hat{H}P = 458.048 + 3.069MOR \tag{21.10}$$

Where, $\hat{H}P$ is the estimation of HP. Seen from the estimating Eq. (21.10), it will be concluded that the adding 1 billion yuan in MOR, the China Real Estate Index of Housing in Shanghai (HP) will add 3.069.

Similarly, the Eq. (21.9) is estimated with constant item $\beta_0$, gross income in Shanghai (GDP), total Residential Mortgage Loan in Shanghai (MOR) and Real interest rate ($i_r$) as explanatory variables. The result is listed in Table 21.5.

Table 21.5 shows that in version I of Eq. (21.9) there are four explanatory variables, $\beta_0$, GDP, MOR and $i_r$, but none of them is significant. In version II, the probability of $i_r$ is 0.437, which means that this variable is not significant. The two variables of version III have significant effect on the INV at 1 % level.

In terms of fitting effect, the maximum adjusted $R^2$ during the three versions of Eq. (21.9) is 0.725. It denotes that the result can explain 72.5 % of residential investment. The fitting equation can be denoted as follows:

$$I\hat{N}V = 7.577 + 0.052MOR \tag{21.11}$$

Where, $I\hat{N}V$ is the estimation of INV. According to the estimating Eq. (21.11), it will be concluded that the adding one billion yuan in MOR is associated with increase of 0.052 billion yuan in INV.

## 21.5 Conclusions

By the theoretical analysis and empirical research, the conclusions are drawn as follows:

As far as housing market in Shanghai is concerned, mortgage has significant impact on housing prices and residential investment. The balance among housing market, credit market and economic system will be broken by the change of the quantity of mortgage, which will in turn drive a series of variations in housing consumption, gross income, housing prices and residential investment. To be specific, an addition of 1 billion yuan in total Residential Mortgage Loan in Shanghai will lead to an increase of 3.069 in China Real Estate Index of Housing in Shanghai and an increase of 0.052 billion yuan in Housing Investment in Shanghai.

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# Chapter 22
# Study on the Panjin Commercial Real Estate Demand Forecast Based on Grey System Theory

**Yachen Liu and Shuai Zhang**

**Abstract** Based on the 2005–2011 Panjin City commercial business space and its 13 associated factors data, analyze the gray correlation degree of each factor with Panjin City commercial business space. And based on the Panjin City commercial business space selling data of 2008–2011, constructed the Panjin City commercial real estate demand forecasting gray GM (1,1) model, after tested, the model accuracy level is II. Using the gray GM (1,1) built to forecast demand forecast the Panjin City commercial real estate selling area of 2012–2015 and made some proposals to the Panjin City commercial real estate development.

**Keywords** Panjin • GM (1,1) model • Commercial real estate • Forecast

With the improving of urbanization rate and the income level of residents, there will be a sharp growth in the second, third tier cities of the area of commercial real estate property in the next 10 years. The past 5 years, Liaoning province had a strong domestic demand, the province's retail sales rose from 403.01 billion yuan in 2007 to 925.66 billion yuan in 2012. And consumption hot spots became more prominent. With continued strong sales in the urban and rural residents enjoy the type of consumer attitudes shift from subsistence consumption on the basis of the province's market hot commodity. Strong consumer behavior to promote and stratification, it will usher commercial real estate development in a full range. As the integration of reform experienced zone, Panjin will vigorously implement the strategy of urbanization. Optimize the development structure, vigorously develop commercial real estate and industrial real estate, Panjin Liaoning's third largest commercial center to fight the road of new industrialization. Therefore, accurate

Y. Liu (✉) • S. Zhang
Department of Engineering Management, Management School of Shenyang Jianzhu University, Shenyang, China
e-mail: 302623308@qq.com

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estimates of the scale of Panjin City commercial real estate needs, to determine reasonable capacity of Panjin City commercial real estate is particularly important to the healthy development of urban real estate and economic.

## 22.1 Grey Correlation Analysis of Panjin City Commercial Real Estate Influencing Factors

Commercial real estate factors are complex and changing, it is difficult to conduct a detailed analysis of them [1]. Spirit of feasibility, scientific, data can be quantified principle, the paper selected the following indicators to represent commercial real estate factors: per capita GDP, per capita disposable income of urban population density, the tertiary industry output value, output value of tertiary industry Engel coefficient, total retail sales of social consumer goods, the consumer price index, the number of tertiary industry, the per capita savings deposit money, the urban population, per capita consumption expenditure of urban residents, the total tourism income, savings deposits of urban and rural residents (Table 22.1) [2].

Through the gray system software, obtained each factor Grey correlation as Table 22.2 below.

From the correlation calculation results, and Panjin City commercial real estate factors related to the size of the total tourism income, per capita savings deposit paid, the tertiary industry output value, total retail sales of social consumer goods related to a greater degree of gray correlation over 0.75; while per capita disposable income of urban residents per capita consumption expenditure, savings deposits of urban and rural residents, urban population, the number of tertiary industry, urban population density, per capita GDP, the consumer price index, the Engel coefficient also has some influence, the correlation coefficient between 0.74 and 0.75.

First, the impact of tourism revenues came in Panjin City commercial real estate of all the factors in the first one, reflecting that the Panjin City as a tourist city, tourism revenues for the leading role of the local commercial real estate is very obvious. Secondly, the tertiary industry output value of all the factors that came in third place, indicating that the change of urban industrial structure has a greater impact on the scale of commercial real estate, this effect is more reflected in the output value, followed by the tertiary industry employment has on [3]. Third, the per capita savings deposit paid and the total retail sales of social consumer goods, respectively, reflecting the level of wealth of the inhabitants and consumer spending levels, indicating that the continuous improvement of people's income and consumer spending increased for the Panjin City commercial real estate is higher than the influence of the size of the urban population the number and degree of economic growth factors [4].

**Table 22.1** 2005–2011 statistics of each factor

| Influencing factors | Unit | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|
| Commercial business premises selling area | $m^2$ | 3,554 | 6,066 | 16,305 | 35,549 | 66,546 | 170,472 | 285,027 |
| GDP per capita | Yuan/person | 34,128 | 39,313 | 43,000 | 50,433 | 49,634 | 66,976 | 79,584 |
| Per capita disposable income | Yuan | 11,025 | 12,205 | 14,907 | 17,046 | 18,563 | 21,035 | 24,266 |
| Urban population density | People/$km^2$ | 2,169 | 2,201 | 2,291 | 2,415 | 2,751 | 2,460 | 2,606 |
| Tertiary industry | 10,000 yuan | 1,539,595 | 1,751,236 | 2,004,398 | 2,710,019 | 3,495,642 | 4,183,118 | 4,759,728 |
| Engel coefficient | % | 32.4 | 33.8 | 31.6 | 31.8 | 31.4 | 31.3 | 30.9 |
| Total retail sales of social consumer goods | 10,000 yuan | 801,178 | 917,097 | 1,076,456 | 1,325,648 | 1,568,965 | 1,851,055 | 2,178,789 |
| Consumer price index | % | 101.7 | 101.1 | 105.5 | 104.8 | 98.8 | 103 | 104.9 |
| Tertiary industry employment | People | 9.79 | 10.95 | 11.07 | 11.42 | 10.18 | 10.91 | 11.68 |
| Per capita money deposited in savings | Yuan | 1,909 | | | 3,856 | 4,149 | 12,617 | 10,187 |
| Urban population | People | 684,069 | 776,931 | 791,530 | 798,712 | 814,837 | 853,473 | 876,914 |
| Per capita consumption expenditure of urban residents | People | 8,858.99 | | | 12,631.38 | 13,486.39 | 13,923 | 15,213.02 |
| Total tourism income | 100 million yuan | 16.4 | | | 78.7 | 105.7 | 136.4 | 176.4 |
| Savings deposits of urban and rural residents | 100 million yuan | 300.5 | 327.05 | 326.05 | 393.64 | 464.07 | 518.47 | 584.28 |

**Table 22.2** Grey sort table

| Factor | Influencing factors | Grey correlation | Sequence |
|---|---|---|---|
| $X_{12}$ | Total tourism income | 0.780958 | 1 |
| $X_9$ | Per capita money deposited in savings | 0.77083 | 2 |
| $X_4$ | Tertiary industry | 0.751539 | 3 |
| $X_6$ | Total retail sales of social consumer goods | 0.750404 | 4 |
| $X_2$ | Per capita disposable income | 0.749026 | 5 |
| $X_{11}$ | Per capita consumption expenditure of urban residents | 0.748451 | 6 |
| $X_{13}$ | Savings deposits of urban and rural residents | 0.74709 | 7 |
| $X_{10}$ | Urban population | 0.745883 | 8 |
| $X_8$ | Tertiary industry | 0.745344 | 9 |
| $X_3$ | Urban population density | 0.745046 | 10 |
| $X_1$ | GDP per capita | 0.744164 | 11 |
| $X_7$ | Consumer price index | 0.74405 | 12 |
| $X_5$ | Engel coefficient | 0.743845 | 13 |

## 22.2 Panjin City Commercial Real Estate Gray Forecast Model Building

Panjin City, nearly 4 years of commercial space business showed an increasing trend, but also presents the non-linear characteristics, the use of traditional linear regression model predicts that accuracy is not high, gray GM (1,1) model is based on the original data once accumulation generated after 1-AGO sequence established based [5]. 1-AGO sequence data smoothness after processing more accurate depiction of the short-term commercial business space, Panjin City, the variation. This paper selects 2008–2011 Panjin City commercial business premises selling area to build GM (1,1) model for short-term forecasts [6].

### 22.2.1 *Raw Data Processing*

Given the original data sequence

$$x^{(0)} = \left(x^{(0)}(1),\, x^{(0)}(2),\, x^{(0)}(3),\, x^{(0)}(4)\right) = (35549, 66546, 170472, 285027)$$

After a cumulative generated after 1-AGO, the AGO sequence set

$$x^{(1)}(1) = x^{(0)}(1)$$

$$x^{(1)}(k) = \sum_{m=1}^{k} x^{(0)}(m)$$

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), x^{(1)}(4)) = (35549,\ 102095,\ 272567,\ 557594)$$

### 22.2.2 Mean Sequence Generated

Order of the mean (MEAN) sequence, $z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1)$, k = 2, 3, 4. Calculated

$$z^{(1)} = \left(z^{(1)}(2),\ z^{(1)}(3),\ \ldots,\ z^{(1)}(n)\right) = \left(68822, 187331, 415080.5\right).$$

$$Y = \left[x^{(0)}(2), x^{(0)}(3), \ldots, x^{(0)}(n)\right]^T = [35549, 66546, 170472, 285027]^T$$

$$B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \cdots & \cdots \\ -z^{(1)}(n) & 1 \end{bmatrix} = \begin{bmatrix} -68822 & 1 \\ -187331 & 1 \\ -415080.5 & 1 \end{bmatrix}$$

### 22.2.3 Model Building

Accumulation generated after 1-AGO sequence, the trend can be GM (1,1) albino equation

$$\frac{d(x)^{(1)}}{dt} + \alpha x^{(1)} = \beta$$

Where: Parameter estimation by least squares method. Design parameters are listed $\hat{\alpha} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} = \left(B^T B\right)^{-1} B^T Y$, Calculated by the above B, Y data into parameters of the column expression calculated $\hat{\alpha} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} = \begin{pmatrix} -0.613839 \\ 336671.89915 \end{pmatrix}$

Solution of formula corresponds to the time response function $\hat{x}^{(1)}(n+1) = \left(\hat{x}^{(0)}(1) - \frac{\beta}{\alpha}\right)e^{-\alpha n} + \frac{\beta}{\alpha}$ n = 1, 2, 3, 4. Will, in particular Sue liquor into Eq., we obtain Panjin City commercial business premises selling area of GM (1,1) prediction model is:

$$\hat{x}^{(1)}(n+1) = \left(35549 - \frac{336671.89915}{-0.613839}\right)e^{0.613839n} + \frac{336671.89915}{-0.613839}$$

$$\hat{x}^{(1)}(n+1) = 95290.88502e^{0.613839n} - 59741.88502$$

## 22.3 GM (1,1) Prediction Model Accuracy Test

### 22.3.1 Calculation of Analog Values

According to $\hat{x}^{(1)}(n+1) = 95290.88502e^{0.613839n} - 59741.88502$, n = 1, 2, 3, 4. $\hat{x}^{(1)} = \left(\hat{x}^{(1)}(1),\ \hat{x}^{(1)}(2), \hat{x}^{(1)}(3),\ \hat{x}^{(1)}(4)\right) = (35549, 80760.01552, 149204.9681, 275657.7294)$

**Table 22.3** Error checking

| No. | $x^{(0)}$ | $\hat{x}^{(0)}(n)$ | $\xi(n)$ | $\theta(n)/\%$ |
|---|---|---|---|---|
| 2 | 66,546 | 80,760.01552 | −14,214.01552 | −21.36 % |
| 3 | 170,472 | 149,204.9681 | 21,267.03189 | 12.48 % |
| 4 | 285,027 | 275,657.7294 | 9,369.270563 | 3.29 % |

**Table 22.4** Model GM (1,1) accuracy table

| GM (1,1) accuracy class | $P_0$ | W |
|---|---|---|
| Good (I level) | >0.95 | <0.35 |
| Qualified (II grade) | >0.8 | <0.5 |
| General (III level) | >0.7 | <0.65 |
| Unqualified (IV grade) | ≤0.7 | ≥0.65 |

Push guide analog values are:

$$\hat{x}^{(0)} = \left(\hat{x}^{(0)}(1),\ \hat{x}^{(0)}(2),\ \hat{x}^{(0)}(3),\ \hat{x}^{(0)}(4)\right) = (35549, 80760.01552, 149204.9681, 275657.7294)$$

## 22.3.2 Error Checking

$$\xi(n) = x^{(0)}(n) - \hat{x}^{(0)}(n), \mathrm{n} = 2, 3, 4$$

$$\theta = \frac{\xi(n)}{x^{0}(n)}, \mathrm{n} = 2, 3, 4$$

Wherein: the original data and the simulated value of the error; the relative error. Error checking in the following table (Table 22.3).

From the above table shows that the average residual $\theta(n) = \frac{1}{3}\sum_{n=2}^{4}\theta_n = -5.60\ \%$.

## 22.3.3 Later Error Checking

Given $\bar{x}^{0}(k) = \frac{1}{k}\sum_{n=1}^{k} x^{0}(k)$ g, The variance of the original data were $\sigma_1 = \sqrt{\frac{1}{4}\sum_{n=1}^{4}\left(x^{0}(k) - \bar{x}^{0}(k)\right)}$

$\bar{\xi}^{0} = \frac{1}{k-1}\sum_{n=2}^{k}\xi(k)$, The mean square error term formula (Table 22.4)

$$\sigma_2 = \sqrt{\frac{1}{k-1}\sum_{n=2}^{k}\left(\xi(k) - \bar{\xi}^0(k)\right)}$$

$$W = \frac{\sigma_2}{\sigma_1} = 0.411 < 0.5$$

It can be judged that Panjin City Commercial real estate the scale of demand forecasting model accuracy rating is II grade, which has a high accuracy, can be used to predict 2012–2015 Panjin City commercial real estate the scale of demand [7].

## 22.4 Conclusions and Recommendations

### *22.4.1 Predictions*

Construction of Panjin City, according to commercial real estate demand model (Table 22.5): $\hat{x}^{(1)}(n+1) = 95290.88502e^{0.613839n} - 59741.88502$ n = 4, 5, 6, 7.

Forecasts show that by 2015, Panjin City commercial business premises selling area will reach 3.2 million square meters, the entire real estate industry structure tends to balance, to achieve the "Twelfth Five-Year Plan" development goals, Panjin City commercial real estate growth will into the stationary growth phase.

### *22.4.2 Panjin City Commercial Real Estate Development Proposal*

1. Depending on tourism to develop commercial real estate

Through gray correlation analysis, commercial business premises selling area of the strongest correlation with tourism revenue. Panjin should play its advantages in resources, integration of Red Beach Resort and Liaohe mouth Ecological Economic Zone, and the Liaohe River, Daliaohe, Daling three estuaries and other tourist resources. Encourage the development and construction of restaurants, attractions, hotels, business, convention and exhibition industry and other commercial real estate. Create a set of ecological, cultural, leisure and shopping multifunctional commercial real estate, the formation of commercial real estate, tourism, real estate development in parallel mode.

**Table 22.5** Panjin city 2012–2015 commercial business premises selling area forecast results

| Years | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| Commercial business premises selling area ($m^2$) | 492,869 | 940,890 | 1,737,811 | 3,212,086 |

2. Create a diversified, integrated shopping center

Panjin higher per capita savings deposits, wealth levels higher than ordinary third-tier cities, strong purchasing power, especially of social consumer goods retail sector there is a big space for development. Should build classification, diverse, personalized, friendly, and specialty-type shopping centers, innovative business models, adjusting the industrial chain, to meet strong consumer demand as well as residents of hierarchical consumer behavior.

3. Commercial real estate development and adaptation of population size

Third-tier cities commercial real estate development must size with urban population urban development stage and level of coordination, forecasting results show that over the next 3 years, Panjin City area commercial business premises selling basic grown exponentially rapid growth rate. The small population base of Panjin City, Panjin City should maintain the size of the urban population continues to grow, adapt to the pace of development of commercial real estate.

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# Chapter 23
# The Problems and Solutions Facing Land Supply of Affordable Housing in China

**Yachen Liu, Jian Ma, and Siqi Niu**

**Abstract** Housing security is an important issue for the development of the relationship between people's livelihood and the most important task in "Twelve Five" period. In the context of housing prices continuing to rise, affordable housing system as a means of national macro-control plays an important role. However, people still face serious problems of the housing difficulties, the construction of affordable housing is not as effective as expected, there are still many problems. Land supply is the primary reason behind the problem. This article will start from the affordable housing land supply situation, the problems and the solutions of the supply of land. This paper will overview and analysis the problems faced by the affordable housing land supply in China and contribute better to the construction of affordable housing for China.

**Keywords** Affordable housing • Land supply • Problem • Countermeasures

## 23.1 The Status Quo of China's Affordable Housing Land Supply

With the country as solving the problem of low-income housing as important areas of livelihood projects, and vigorously promoting the construction of affordable housing is an important measure of the central and local levels of government. According to the national "12th Five-Year" national new build affordable housing transformation of 36 million sets of development planning and affordable housing, shanty towns and small and medium-size commercial land not less than 70 % of the total amount of land for housing construction, housing land use planscan be expected, affordable housing will become urban housing construction in the

Y. Liu (✉) • J. Ma • S. Niu
School of Management, Shenyang Jianzhu University, Shenyang, China
e-mail: 296465378@qq.com

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large [1]. As 2010 and 2011 for an example, in 2010 the actual supply of the national affordable housing land is 32,400 ha, the country plans to supply affordable housing land 77,400 ha in 2011, accounting for housing land supply plan 35.5 %. Compared to actual for 2010, the amount of increase is 138.9 % closing to two times the increase of the overall residential land supply plan. Large-scale construction of affordable housing needs of land resources to carry.

The central government has issued a series of policies on the construction of affordable housing land supply and have the systematic plan for land supply. Due to the structural adjustment of China's housing patterns, as well as the expected long-term maintenance of the housing security system, China's urban housing supply "dual track" pattern has been formed [2]. To be sure, the "dual track" era of China's urban housing real estate and the security room not only will arrive, is also expected to maintain, regulate and coordinately develop in a longer period of time. However, a lot of problems in the actual implementation process are still exposed, leading to the relative chaos of affordable housing land supply system. Therefore, China's urgent need to regulate the construction of affordable housing land supply, perfect the system of affordable housing land supply in reason in order to ensure the successful completion of objectives and tasks of the construction of affordable housing [3].

## 23.2 The Basic Characteristics of the Construction of Affordable Housing "Dual Track"

Overall, the operational aspects of the protection of housing supply in China have two major problems, including protection of housing construction and allocation of affordable housing. The urgent need to address the main problem is the protection of housing construction. To this end, we have a profound understanding of the basic characteristics of the protection of housing construction presented [4].

First, the construction of affordable housing under market mechanisms of the supply in the real estate and administrative mechanisms of the housing advances in parallel. Affordable housing system as one of the government's social security, the premise of the concept of policy design: Due to the huge disparities of income and housing prices, the housing problems of the social low-income and low-income groups basically through the market mechanism can not be resolved. For the realization of the "Housing" people's livelihood requirements, and it should be included in the social security system, protection of housing supply by non-market dominated by administrative arrangements can be solved. There are significant differences between protection of housing and commercial housing supply system, including the function of the between the two system is different, the supply of objects is different, from the capital to raise, land configuration and other construction aspects of to the pricing to the last housing, different from the allocated the operating mechanism [5]. It will inevitably lead to a conflict especially in prices, income disparity. At present, the Government takes the system of the protection of housing allocated to build a certain proportion of the commercial housing, restricting developers in the behavior of the aspects of the land supply is the manifestation of the operation of the dual-track system the contradiction [6].

Secondly, the construction of the protection of housing involves a multiple of the interests of the main body, facing on the complex Game Theory relationship. First of all, it is reflected in the actions and the proportion of investment relations between the central government and local governments [7]. In the early of 2011, with the provincial government signed a housing construction target responsibility documents, the building housing security was to rise to the height of the political, and the progress of construction was included in the assessment of the local government accountability system. The local government-led construction of affordable housing have a significant progress in the pressure of the administrative examination and general effect. But it also implies the negative attitude of some local governments and the reality of lack of motivation behind the rigid administrative arrangements and it needs improvements and adjustments in the incentives and interest [8]. There is the game of the government and the real estate business, large enterprises and small and medium-sized enterprises, banks and government, corporate and government benefit unit, family and personal rights, responsibilities and obligations.

Third, the whole affordable housing projects by multiple levels of government and multisectoral forge ahead together. Protection of housing construction as a political task makes top-down administrative arrangements. Protection of housing construction scale targeted by the central government, down to every level place. The division of work of the security room: Led by the urban and rural housing construction sector, the guidance and supervision of the national and local protection of housing construction work; Development and Reform Commission is responsible for the introduction of the reform of the housing system, the construction of affordable housing projects to promote the development of standards of advice and prices; Ministry of Land and Resources Department is responsible for the land supply of the protection of housing; responsible for the security room to review the qualifications of the beneficiary groups identified by the civil affairs department; Supervision departments conduct supervision and inspection to the low-rent housing security [9]. And the supervision and inspection results are published: The financial sector provides public finance expenditure for the protection of housing, and raise funds for the construction of affordable housing.

## 23.3 The Problems and Challenges Faced by the Construction of Affordable Housing Land Supply

The core mechanism of China's urban supply of affordable housing is the implementation of the administrative pricing mechanism for land and housing. Firstly, the way of he protection of room takes administrative allocation and tender mode, which is that the protection of housing construction by unpaid limit the supply of land can reduce the level of investment for affordable housing and control the level of protection of housing rents and housing prices. Secondly, the profit of the developers involved in the protection of housing construction imposes restrictions, and at present regulations are controlled at below 3 %. The profit-building activities which is limited range even at low earnings by the government may be operating at a loss [10]. In the context of the urban housing dual supply system, construction of affordable housing land supply is facing a series of problems and challenges:

1. Because of the local government “land finance” institutional constraints, some local governments which has the financial difficulties are not enthusiastic about allocating land protection of housing land supply.

Fiscal revenue situation of the land of the local government is a special product of China’s land property rights system and financial system restraining each [11]. Only the elasticity of the land tax is the largest in the source of revenue for local government. According to the data, the land revenues of local governments in China are generally more than 20 % of the local budget revenue, in some places even up to 40–60 %. Some tax revenues which are related to land development and real estate development are also more than 60 %. Local governments generally pass through city management to increase the proportion of commercial land auction land market, to get government revenue and to meet the expenses of the government, including the expenditure of a large number of livelihood projects. It is estimated that over 10 million units of affordable housing construction require approximately 1.3–1.4 trillion yuan, of which about 50 billion will be funded by the central government and local governments to raise resolved, the remaining about more than 8,000 billion yuan of funds raised by social institutions and the protection of objects and the enterprise. Local governments need to raise the construction funds of about 400 billion yuan, the main source of funds is not less than 10 % of the land premium and the part of housing fund value-added benefits. But with the year-on-year reduction of the amount of land transfer, land premium dropped, the local government under the weight of its own debt directly put in the extremely limited amount of money [12].

2. Under the premise of ensuring the country’s 18 million mu of arable land red line and strict implementation of land use planning, long-term sustainability of providing a lot of the protection of housing construction sites is faced with challenges.

At present, all levels of government on the principle of “cities”, “stock” as a political task required to complete the land supply is the main. But with the protection of housing construction to further promote the increase in the cost of land acquisition, new land supply, there will be many obstacles and bottlenecks. The cost of the protection of housing construction must be reduced in order to save the cost of protection of housing construction, land acquisition relocation claims and so on [13]. At present the relevant departments have been asked to provide more “pure land”, but the lower “net” sources of land costs tend to occupy the new land, or government invested heavily in pre-development waiting for the auction reserve land. If you do not open up a new reliable source of land supply, under the impact of high-yield in the housing land supply, the sustainability of affordable housing land supply is questionable.

3. Integrated support of affordable housing construction land is low affected land dual pricing system. When local government allocated land "hard" indicators, for cost-benefit considerations, local government often want to transfer income at the central city land auction to compensate for the decreasing loss of allocated land transfer net. Therefore, the distribution of protection of housing construction is often located in the suburbs of the city, the conditions of transportation and other social support services are poor. Although the beneficiary population and family get housing security, but employment, education, health care, pension and other security level and quality of life have been not necessarily increased.
4. The design of the target beneficiaries of the government on the protection of housing construction is fuzzy which makes the scale of land supply may exceed reasonable limits. Governments for the town affordable housing still lack a comprehensive, scientific, fully research and demonstration, there is a demand object not uniform supply standards not clear, reporting conditions inaccurate. The ability to pay of affordable housing distribution system and mechanism and beneficiaries and the actual needs is lack of organic links. So it directly, indirectly affect the efficiency of the construction of affordable housing.

## 23.4 Measures and Policy Recommendations to Improve the Protection of Housing Construction Land Supply

1. Quickly formulate and revise relating to the rule of law and policy of the allocation of land and protection of housing construction. When improving the current affordable housing policies, regulations, first of all, housing security explicitly is included in the scope of the "Social Security Act", the housing security get the equal system legal status to the basic life, basic education, employment, comprehensive, basic medical care, basic old-age social security. To correctly handle the relationship between administrative mechanisms leading affordable housing in the housing under the "dual track" and real estate-oriented market mechanism. Rationally define target beneficiaries of affordable housing and determine the necessary exit mechanism to reasonably control the protection of housing construction scale.
2. Scientifically determine the target beneficiaries of the security room, security standards and out of the mechanism, reasonably supporting the supply of land for construction. In the system strictly restrict that individuals, families and units take advantage of price differential under the two-track housing to gain an unfair advantage, reasonably, scientifically determine the size and proportion

of protection of housing land supply, thereby reducing the blindness of the protection of housing land supply. Relevant policies should take full account of the relationship between the interests of all stakeholders in the protection of housing construction, make use of economic instruments and reduce the administrative means to the smooth progress of the construction of affordable housing [14].

3. Innovative protection of housing construction fund-raising channels and expand funding sources to reduce the impact of the construction of affordable housing funding gap for local government land finance sources. In order to ensure capital investment in the cycle of the protection of housing construction, it is recommended to promise the income investment proportion of 10 % of place land premium and while the added income of housing funds putting into the protection of housing construction, the government guide part of the housing fund funds, social security funds into the construction of affordable housing. It suggested that the state invests banks to establish special protection of housing policy interest subsidy fund, supporting commercial banks and community groups, charitable organizations involved in affordable housing, limit housing credit activities.
4. Optimize mechanism of the protection room for the land, improve the utilization efficiency of land and establish long-term mechanism of affordable housing land supply. On the basis of the protection of housing land supply "Yingbaojinbao" policy, the government actively introduced the policy document, rationally planned the medium and long term land supply plan, handled the ratio relationship between the stock of land and new land: optimize the layout of land supply location, establish dynamic supply mechanism to make protection of housing and urban development for coordination [15]. Adhere to the housing construction with the construction of public housing land supply policy, make public rental reasonably distributed in urban communities. In order to expand effective supply of land of affordable housing, to meet the long-term trend of the rural population to move into urban employment and settlers, according to the expected size of the urban population growth, it allows local governments to take advantage of policy which is linked to changes of urban and rural construction land, expands the incremental land scale of urban construction, create long-term mechanism of affordable housing land supply.

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# Chapter 24
# Public Rental Housing Exit Mechanism Policy: Experience and Its Implications for China

**Feng Zhao**

**Abstract** This article analyzes the problem that might be encountered when people lose the right of having public rental houses and points out the difficulties in the pre-lease application and in the post-exit mechanism in the large-scale implementation of public rental verification. Analyzing successful implementation of public rental management practices in Hong Kong and several other regions, I think that public rental operations should be supported by local government. This article also provides some suggestions on avoiding potential problem when people lose the right of obtaining public rental houses, on some applicable policies and systems, to form a recyclable and healthful environment of public rental housing.

**Keywords** Public rental housing • Exit mechanism • Countermeasures

## 24.1 Introduction

China in 2010 issued the guidance on accelerating the development of public rental housing proposed to accelerate the development of public rental housing has an important significance. Public rental is another affordable housing following the affordable housing and low-rent housing, the government provided public rental policy and financial support, limit dwelling size and the preferential rent standards, protection to the supply of eligible families housing. How to make scarce resources meet the need of the community, ensure greater social equity, as the aims and objectives of public rental housing to set the exit mechanism.

In this paper, the management of public rental housing, especially problems that might arise from exit process analysis, drawing on the experience of developed

F. Zhao (✉)
Zhejiang College of Construction, Zhejiang, Zhejiang Province, China
e-mail: thini23@163.com

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countries, proposed exploratory responses to ensure equitable distribution and rational use of the protection of housing.

## 24.2 Analysis the Public Rental Housing Exit Mechanism

Public rental housing is a transitional solution, a definitive solution can not be the difficulties of urban “sandwich layer” for market, by the help of the Government’s policy of public rental relatively stable living environment, general lease period is 3–5 years. When this people have the ability to pay, they should leave the public rental market and buy one or lease housing. Especially when the high prices appear some large cities, high rents prompted a number of university graduates and migrant workers to give up development in developed city. This is not healthy for development of the city, hinder the steady progress of society. Government provides sufficient public rental houses to protect the urban labor force, to activate urban economy and to promote the city’s prosperity and development.

### *24.2.1 Experience of Shenzhen*

Shenzhen provides that public rental housing, the lessee has one of the following acts by the administrative department to cancel the lease contract, to recover its lease of public rental housing:

(1) misrepresentation, concealment or falsification of relevant supporting access to public rental housing of household registration, household size, income, assets and housing; (2) does not meet the conditions of public rental housing application; (3) under the lease contract or legal public rental housing provision should recover. The above acts shall be ordered by public rental housing management departments with similar regional housing market, real estate guidance rent, pay rent, and load its poor record of personal integrity, within 5 years may not apply for housing support.

### *24.2.2 Experience of Chongqing*

Chongqing public rental exit police, including three aspects: First, the tenant income is no longer satisfied with public rental eligibility criteria, the tenant in the lease during the non-compliance with lease provisions or tenant to improve the demand for housing, and voluntary retirement rent of public rental; second, the tenant rent for a certain period, apply for the purchase of public rental [1].

### 24.2.3 *Experience of Qingdao*

Qingdao public rental lease term is for 3 years upon the expiry of the lease, the tenants will be re-audit. If the condition does not meet the public rental housing conditions, will be advance notice of tenants allowed to exit the schedule. Hangzhou provisions of public rental housing lease term of 3 years, to re-apply prior to the expiry of the lease and rental housing audit, audited in line with the time, access conditions, and continued to sign the lease contract; when access conditions, in accordance with relevant regulations and contracts agreed to back the house.

## 24.3 The Developed Countries and Regions of Public Rental Housing Exit Mechanism Experience and Reference

### 24.3.1 *Hong Kong Public Rental Housing Exit Mechanism Experience*

Hong Kong public rental housing exit mechanism established, all income and net asset value than annually revised upper or do not declare income and net assets of the tenants, must pay the rental market and within 1 years, from the live in flats. It is more effective to achieve the limited public housing resources allocation. The Housing Department has successfully recovered approximately 3,140,000 public housing units, relocated to the needy in the. At the same time, has about 1,160,000 public housing tenants pay additional rent amount each year, about 11,700,000,000 Hong Kong dollars

In order to safeguard the public rental housing exit mechanism, to carry out effective, beginning from 2004, Hong Kong housing department, which are households if provided false information, is illegal, HA may immediately terminate the lease, and according to the law, the prosecution tenants, convicted, sentenced to a fine of $20,000 and to imprisonment for 6 months. Hong Kong public housing exit management gradually strict, the existing tenants generally every 2 years the audit once, family income exceeds a certain limit, the first is to raise the rent, and then asked for public housing, and given a 1-year transition period.

### 24.3.2 *Singapore Public Rental Housing Implementation Experience*

The government of Singapore through the HDB, provide high housing subsidies (mainly in the low land), in severe housing shortage period to provide a large number of cheap public rental housing rental to residents, to resolve the housing shortage, the public rental housing for sale, the establishment of a set of public rental housing exit mechanism, saving society resource. Public housing applicants must meet the following four standards can be eligible for citizenship, i.e., private property, income level and family composition. Civil rights, private property is easily defined, and income level is with the development of economy is dynamic, in actual operation, according to the housing shortage degree and the change of income to dynamically determine the income ceiling [2].

## 24.4 Experience and Learn From Developed Countries and Areas of Public Rental Housing Exit Mechanism

### *24.4.1 To Ensure Fair, Intensify the Exit Management System and Legal Guarantee of Sound*

For the protection of public rental housing fair implementation, must strengthen the public rental housing development from system construction, normative whole process supervision and handling of violation. From the system of the public rental housing acts in violation of the management to make the entity and procedure stipulated. Formulate and improve laws and regulations for public rental housing to ensure public rental housing system implementation, to ensure that the public rental housing security functions, first, must be developed a higher level law to guide the local “public rental housing management approach”, in the formulation and implementation of. Second, make laws and regulations clear the duty of the government and the government should undertake the legal liability, in order to strengthen the unified management and public supervision. Third, public housing law should formulate specific procedural norms, regulations, publicity, public rental application review, waiting, review procedures, attention to security door when the audit to avoid privacy. Sound public rental housing system legislation, improve the public rental housing implementation effect.

To strengthen the public rental housing development system construction, to normative whole process supervision and handling of violation, related department forms the system of the public rental housing acts in violation of the management to make the entity and procedure stipulated. This also can draw lessons from the practice of Hong Kong, the public housing policy making and execution mechanism by separation, civil society representatives and other representatives from all walks of life and political group decision-making body of the housing committee, and the government’s Housing Department Representative Executive, ha has to criminal prosecution for the application process by resort to deceit behavior of law enforcement power.

### *24.4.2 Establishment of Dynamic Tracking Management Mechanism, the Implementation of the Mandatory Reporting of Personal Information*

In public rental housing exit mechanism construction for tenants, the income and assets of recurrent review is critical. Each country almost all tenants' income and asset limits as a necessary condition of application, in the application of the preliminary review of more stringent, but in the 3 year of the lease period how to determine factors, at lease process assets change is difficult to control. Public rental housing must establish the access and exit mechanism, to meet the conditions of the people enjoy the welfare, let no longer eligible people timely exit. Need to consider the establishment of a national multi-pectoral linkage information system, much channel to verify the public rental housing applicant's income and assets, discern true eligible applicants and no longer meet the conditions of the lease. Recommended settings for individual household income annual reporting system: the figure of a self-help information platform was forced to declare, if the declaration without independent ability to declare to be registered in the District Construction Bureau submitted (housing). If the income of more than to declare their assets limit, can be used 2–3 times the rent live full time remaining, but not make it rigidly uniform "adopted in 2 years has no public housing and affordable housing eligibility; the occurrence of other illegal behavior, then in 5 years had to apply for public rental housing and affordable housing eligibility" such severe punishment means.

## 24.5 Conclusions

China's affordable housing construction has just started, the implementation also has just started, the implementation of policy cannot avoid some loopholes, at the same time, the original intention produced inconsistent results. But affordable housing to solve the housing problems of low-income families is very important, cannot be ignored the right move, this requests us in the management of the timely detection of problems, combined with the actual situation of our country and work out a reasonable solution to the problem, ensure affordable housing health, efficient, rapid development, eventually to achieve the goal of home ownership housing, really want to achieve the public rental housing lease fair.

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# Chapter 25
# Study on Effects of Land Supply System on Old-Age Care Institutions Developing in China

**Dapeng Xiu and Wenjia Zuo**

**Abstract** China has already entered an aging society with aging population increasing rapidly. Currently, the contradiction between supply and demand of old-age care institutions is daily outstanding. One of the most critical issues is the matching land supply for housing of old-age care institutions. It logically follows then that efficiency of land resource allocation influences construction of old-age care institutions. And this study focuses on analyzing the effect of land supply system on the development of old-age care institutions. A single central city model of bid-rent theory and theory of government behavior were used in the study. Furthermore, data of transfer land from 2009 to 2011 and relevant information on old-age care institutions in Beijing was collected for empirical analysis. Preliminary results indicate that: (1) the probability is small for old-age institutions accessing to the land by the paid transfer market; (2) accessing to free allocated land is less likely in regions of the higher population density. The main conclusion of the study is that the existing urban land supply system has an adverse effect on construction of old-age institutions in China.

**Keywords** Land supply • Old-age care institutions • Housing policy • China

## 25.1 Introduction

Since 1999, China had entered an aging society. Based on the great scale of the aged, the aging population is increasing rapidly. As a result, the phenomena of aging and empty-nested have become increasingly evident, along with the rapid growth of disabled and semi-disabled old people. The sixth national population census indicates that the elderly population will reach 221 million, accounting for

D. Xiu (✉) • W. Zuo
Department of Land and Real Estate, Renmin University of China, Beijing, China
e-mail: xiuda1010@126.com; dwt891118@163.com

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**Table 25.1** Demand gap of endowment institution beds

| | Number of elderly population ($10^4$) | Proportion of endowment institution beds in elderly population (%) | Demand of endowment institution bedspread ($10^4$) | Supply of endowment institution beds ($10^4$) | Supply gap ($10^4$) | Gap rate (%) |
|---|---|---|---|---|---|---|
| China | 17,800 | 5 | 890 | 270 | 602 | 67.6 |
| Beijing | 235 | 5 | 12 | 7 | 5 | 41.7 |

The data is from Qiufang Zhang [10]

16 % of the total population in 2015. And it will reach 243 million, accounting for 18 % of the total population in 2020. China is the only country in the world that has a population of aged more than 100 million. What's more, the elderly population is increasing every year with a growth rate of 3 %, which is five times more than the total population growth rate in the same period. Currently, the number of disabled and semi-disabled is about 33 million in our country, accounting for 19 % of the elderly population. Accordingly, it's an arduous task to strengthen the social endowment service system.[1]

The state and government attach great importance to the aging problem. For example, the 17th CPC National Congress established the goal of security in old age. The fifth plenary session of the 17th CPC Central Committee put forward the requirements to give priority to the development of the social endowment service. The 12th Five-Year Plan of economic and social development required an actively respond to the aging population and accelerating the development of social endowment service that per 1,000 elderly should have at least 30 nursing home beds. Social endowment service system construction plan (2011–2015), introduced by the end of 2011, also promoted and supported the development of old-age care institutions.

However, the development of old-car institutions is facing the reality of a serious shortage of nursing home beds and great contradiction between supply and demand. The facilities of most old-care institutions are humble and simple-functioned so that it's difficult for the institutions to provide nursing care, medical rehabilitation, mental consolation and many other services [1]. What's more, the layout of old-car institutions is irrational, leading to regional inequality and unbalanced development between urban and rural areas. The government investment is also lacked, while private investment is in limited scale. Even without considering the quality of old-age care institutions, there is a large gap in the number of nursing home beds between China and the average level of developed countries (Table 25.1).

In accordance with the world's average percentage of endowment institution beds, which is 5 % in elderly population, the supply gap is about 6.2 million and the

[1] Social endowment service system construction plan (2011–2015).

gap rate is about 67.6 % in China. In Beijing, the supply gap is about 0.5 million and the gap rate reaches 41.7 %. However, the data we use for calculation in Beijing is the registered number of elderly population, which is less than the actual number. Thus, the actual gap rate will be greater than the calculated values. The aging population calls for a growing demand for endowment institutions and endowment real estate, leading to a serious contradiction between the supply and demand of endowment services. With the strong demand of endowment institutions, endowment polices and plans have been released successively. In the meanwhile, the willingness of private investment is getting stronger and stronger. But why do the endowment institutions still develop in a low speed? As is said by Marshall, any industrial cannot develop alone without the help of land [2]. The essay explores the influence of land supply system on the development of endowment institutions in China. Assuming that, (a) China ‘s construction land supply system does affect endowment institutions; (b) endowment institutions, especially new-built institutions are built mostly in collective construction land; (c) in areas where house price or land price are higher, there will be less endowment institutions.

## 25.2 The Definition and Classification of Endowment Institutions

### *25.2.1 Definition of Endowment Institution*

In the existing literatures, there is no strict definition of endowment institution or endowment real estate. The concept is not clear, with a broad but uncertain meaning. “Regulation for pension agency in Shanghai” defines it as integrated service agencies provided residual and caring for the elderly. While “Regulation for pension agency in Beijing” defines it as agencies provided caring and rehabilitation. Pension institutions, which relies on the government fund, relatives’ aid and the elderly self’s fund, gather the elderly together to provide them comprehensive services [3]. The elderly can live and enjoy varying degrees of service in pension institutions. The institutions can be operated by private, public or hybrid [4]. In addition, some literatures define pension institutions as any housing construction and related operation service meeting the living demand of the aged, including community care, commodity houses aimed at the elderly population.

This essay considers endowment institutions as property that providing continuous nursing care services and long-term operated. Unlike residential houses for one-time sale, nor medical services provided by hospitals to treat patients, endowment institutions are supposed to meet the elderly’s living needs, the extended health needs, the psychological needs and the hospice care, such as old-age care institutions, rental apartments providing pension service, nursing homes, etc.

### 25.2.2 Classification Based on Government and Market Boundary

Endowment institution, which is related to a series of public and market services like housing, medical care, rehabilitation, housekeeping, urgent aid, nursing care and social management, needs policy support, social participation and efficient allocation of market resources, including capital, land and human resources. In the field of endowment service, some countries provide the service through market, others through government. However, in most cases, the market and the government complement each other to meet the endowment service needs. European countries practice "the universal warfare" policy. The governments invest a lot in the area of income security, housing construction and community services in the elderly, but have to withstand the heavy fiscal burden. The American policy is more flexible. The government introduces the participation of private sector; provides preferential policies in the development and operation process of endowment institutions. The government itself is committed to the community management and assistance for the low-income. Currently, China mainly provides endowment services for low-income elderly by the government, and encourages the participation and funding of private sector. But it's not clear when asking the question that which part of endowment service should be provided by the government and which by the private.

Due to the elderly's different abilities of self-security, the government and the market need to provide multi-level endowment services to make sure that all elderly will be looked after properly. The responsibility of the government and the market should be defined clearly. On the one hand the market should allocate resources efficiently through the invisible hand; on the other hand the government should complement the market failure through the visible hand. From the perspective of the government and market responsibility boundary, this easy defines the type of endowment institutions and analyzes the land use conditions of different types.

Type I – warfare endowment institution. The government takes primary responsibility for this type. This type of endowment institution is run and invested by the government. It can be operated either by the government or the community. And it aims at low- and middle-income elderly primarily. This type includes warfare institutions under the management of civil affair departments, such as nursing home, daycare center, etc. Since the founding of People's Republic of China in 1949, warfare endowment institutions have been constructed one after another constantly that the stock of this type has reached a great amount at present. They are mainly managed by the community office, the township government or the village collective.

Type II – commercial endowment institution. The companies take primary responsibility for this type. This type of endowment institution is run, invested and operated by the society, aimed at middle- and high-income elderly with the corresponding ability to pay. It provides a fully market-oriented endowment

**Table 25.2** Classification of endowment institution

| | Type I | Type II | Type III |
|---|---|---|---|
| | Warfare endowment institution | Commercial endowment institution | Limited-price endowment institution |
| Funds sources | Government | Society | Society/government offers subsidies |
| Service target | Low-and middle-income elderly | Middle-and high-income elderly | Middle-income elderly |
| Service pricing | Government | Market | Market/government |

services through price mechanism. The good thing of this type is that it can decentralize the endowment burden of society and the family. The investors of commercial endowment institutions provide different kinds of endowment services according to the consumer's demand. The government's task is to regulate the industry, reduce market regulation, and provide policy support and supervision.

Type III – limited-price endowment institution. This type is between type I and type II. The government and market complement each other for the responsibility of this type. Limited-price endowment institution is run, invested and operated by the society and subsidized by the government, aimed at the middle-income elderly. It not only achieves high quality and efficiency of endowment services through market allocation of resources, but also gets sustainable development through the government's provision of land policy and financial support. The government has the right to manage the service targets and service price (Table 25.2).

## 25.3 The Existing Land Supply System and Endowment Services

The essence of system is an incentive institution [5]. This incentive has a special and foreseeable impact on human behavior, thereby affecting the allocation of resources and the innovation process. As an important land system, land supply system creates incentives for the efficiency of land use. However, it also inhibits the development of relevant industries due to the regulations of planning and the management of land use, and then changes and affects the welfare distribution.

Under the current urban and rural land system, the supply of construction land is divided into state-owned construction land supply and the collective construction land supply in China. State-owned construction land has a relatively complete property rights. And there is no restriction for the users of land use right. Foreign companies operated in China, institutions and individuals can be users of the state-owned land. The remising, transfer, leasing and mortgage rights of the use of

**Table 25.3** Land supply mode of endowment institutions

| Classification of endowment institutions | Land supply mode | Land supply rules |
|---|---|---|
| Type I | Allocation of state-owned construction land | Agreed by the government |
| | Collective construction land | Agreed by the rural collective organizations |
| Type II | Compensated transfer of state-owned construction land | Market competition |
| | Collective construction land | Agreed by the rural collective organizations |
| Type III | Compensated transfer or allocation of state-owned construction land | Market competition/agreed by the government |
| | Collective construction land | Agreed by the rural collective organizations |

collective land are strictly limited. Legitimate land users of collective construction land are special civil subjects, mainly collective economic organizations and their members.

The state-owned construction land is supplied mainly by compensated transfer, supplemented by free allocation of land in China. The law of land administration provides that the "the state introduces the system of compensated use of land owned by the state except the land has been allocated for use by the state according to law". Allocation of land for the directory, which is published by the Ministry of Land and Natural Resources in 2001, provides that welfare endowment institutions can obtain free land supply in the name of land for non-profit social welfare facilities.

Therefore, there are three modes for the acquisition of land-use-right for the construction of endowment institutions. The first mode is compensated transfer of land through bidding, auction and listing. The second mode is free allocation of state-owned construction land through consultation with the government. And the third mode is the access to the collective construction land in the form of rent or rent to buy despite of property missing through consultation with rural collective organizations.

The first and second land supply mode is in line with laws and regulations and conforms to the city's land supply system. The land use rights are relatively complete; therefore it is a legitimate way of the endowment institutions to acquire land. In the third way, land use right subject of the collective construction are special civil entities, thus members out of the collective organization cannot be fully protected by law when using their land. The transfer, mortgage and rental and other property rights of collective construction land is incomplete, and long-term use of the pension agency's and sustained investment have risks and uncertainties. What's more, there are different policies for pension institutions building on collective construction land between national and local governments, which lead to certain risks when using collective construction land (Table 25.3).

## 25.4 Theoretical Analysis of the Influence of Land Supply System on Pension Institutions

### *25.4.1 Crowding-Out Effect of Compensated Transfer System of State-Owned Construction Land on the Construction of Endowment Institution*

In the compensated transfer system of state-owned construction land, the highest bidder or the highest bidder under limited conditions gets the land use right through market competition, namely bidding, auction and listing. In order to analyze the impact of state-owned construction land transfer system on the construction of endowment institutions, this section expands the single central city model [6] to analyze the possibility of access to land for endowment institution through market competition.

Main assumptions:

1. The government's goal of land transfer is to maximize the local fiscal revenues in local policies and land use planning conditions.
2. There are no mandatory land use indicators for endowment institutions in land use planning of transfer land.
3. There are supporting services in the target land or the surroundings to meet the needs of endowment institutions.
4. Compared to other residential living groups, the group living in endowment institutions is less sensitive and has a lower aversion to the transport distance.
5. The land is used by the group which is willing to pay the highest rent, and the allocation of land resources reflects the principle of maximizing land rent.
6. The buildings are able to meet the needs of the living group and all buildings have the same quality.

Household income y is for transport cost kd (k is the opportunity cost of travel time for unit distance, d is the distance from the city center or the employment center), other commodities spending x and housing consumption R, which is the function of transport distance d.

$$y = R(d) + kd + x \tag{25.1}$$

Assuming that the housing consumption of general living group is R(d)g, the traffic consumption is kgd, and other consumption is x0.

$$R(d)_g = y_g - k_g d - x^0 \tag{25.2}$$

Assuming that the housing consumption of the group living in endowment institutions is R(d)o, the traffic consumption is kod, and other consumption is x0.

$$R(d)_o = y_o - k_o d - x^0 \tag{25.3}$$

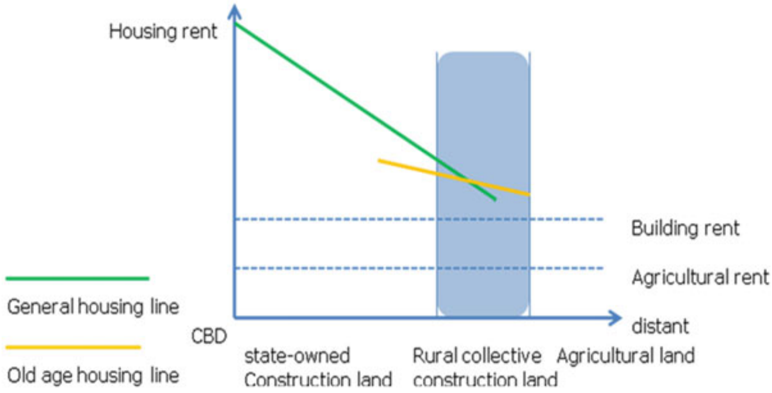



**Fig. 25.1** Schematic diagram of central city model

The groups living in endowment institutions are elderly retirees and they are the least sensitive groups to the transport distance and cost of their residential location to the city center. As a result, kg > ko. Single central city model indicates that, the closer the distance between residential location and the city center is, the higher rent the living group has to pay. On the contrary, the farther the distance, the lower rent the living group should pay. The saved rent can be used in the consumption of other goods or services.

In the condition of assumption c, because of kg > ko, the residential area in accordance with rent which endowment living group is able and willing to accept is close to the theoretical edge of the city. Setting the theoretical city edge line b. In the theoretical edge of the city, residential rent is minimum and the minimum rent is determined by the opportunity cost of agriculture land and new housing construction. However, China has adopted the urban and rural land system. Under the control of land use planning, the scope of state-owned construction land do determine the actual edge of the city. Setting the actual city edge c. Because there will be competition in the expropriation process of collective construction land, high value land will be requisitioned prior. In the single central city model, the higher the land value is, the closer the distance from residential location to the city center is. Therefore, the distance from the theoretical city edge line b to CBD of the city is farther than the distance from the actual city edge line c to CBD of the city (Fig. 25.1).

Corollary one: the state-owned construction land is only transferred between the city center and the actual city edge, namely the scope between CBD and b. According to the competition rule that the higher bidder or the highest bidder under limited conditions gets the land, it is difficult for endowment institutions to bid for the land resources, because their willingness to bear the rent is lower than other housing groups. Only type II of endowment institution, which servers the high-income elderly, is possible to get the land.

### 25.4.2 Impact of the Allocation System of State-Owned Construction Land on the Construction of Endowment Institutions

Type I, which has the public welfare nature, can obtain land through government allocation. Similar to education, health care and postal agencies, welfare endowment institution is non-profit social agency. However, in urban planning, there are mandatory requirement to set aside land for education, health care and postal agencies in accordance with the urban population density ("Urban Residential Area Planning and Design Standard" GB50180-93). Due to the special supply of land, it is easy to meet the land scope needs of such institutions.

There are many literature about local government choices in urban land market behavior [7–9]. They all think that the local government of the city, by virtue of its control of the land market, have the capacity to maximize the utility to allocation of land resources, whether by adjusting the land premium or taxes, increasing investment in infrastructure or strengthening public services, improving the investment environment, or promoting the construction of real estate or to increase support services. The ultimate goal is to achieve the maximization of economic growth or revenue.

There are no mandatory requirements for endowment institutions in urban planning. As a result, the local government is facing selection dilemma when deciding whether to allocate the land to endowment institutions despite of the endowment service planning made by the central government. The government behavior theory generally analyzes the motives of local government and officials from three perspectives, namely economic growth (the growth of GDP), the interests of the original city inhabitants and the maximum of fiscal revenue.

Welfare endowment institution (type I), which has the nature of public welfare, is able to meet the interests of a small part of the original city inhabitants, but neither its investment can promote economic growth nor increase fiscal revenue. What's more, welfare endowment institution is different from education or medical institutions, which have positive externalities and can promote economic growth and maintain social stability indirectly. Therefore, in such administrative system which measuring government performance by economic and fiscal revenue growth, there is less possibility that the local government allocates land for endowment institution on its own initiative.

The higher the population density is, the higher the land price is. Although areas of high population density have the needs for a great amount of endowment institutions, the opportunity cost of allocating land by local government is relatively high. In the absence of mandatory endowment land supply policy and related urban planning, it can be inferred that endowment institutions can hardly obtain free allocated construction land in regions with high population density and high land price.

Corollary two: the site of endowment institution will be between the theoretical city edge and the actual city edge, namely the scope between b and c. The land within the scope is either collective construction land or state-owned construction land of outer suburb in township.

### *25.4.3 Main Problems of Developing Endowment Institutions on Collective Construction Land*

According to the above analysis, due to the crowding-out effect of the current land supply system, it is difficult for new pension agency to obtain land in urban areas where land price is high. Endowment institutions are mainly distributed between the actual city edge and the theoretical city edge, where the land is mainly suburban collective construction land.

This zone is a gray area of land control with both economic rationality of housing construction and illegality of land regulation. Thus, this region has produced all kinds of reasonable but illegal housing or buildings with unclearly defined property rights, including the premises for endowment institutions. There are following problems to promote the development of pension institutions in collective construction land:

1. Information opacity, high transaction costs. Collective construction land use right of rural collective is organized by different agents. So there is no unified information market and no clear trading rules. Buyers and sellers negotiate and sign contracts lack of procedural and normative, which led to relatively high costs of transaction in the investment of pension institutions.
2. Ownership unclear, low ability to accumulate wealth. Pension institutions have potential assets of the estate, but most cannot get the full recognition of property rights. Lack of property rights gives investors risks and uncertainties that affect the investors with the scale, sustainable investment.
3. Weak financing capacity, difficult to carry out large-scale construction. Lack of property rights limits the financing capacity of pension agency, affects banks, funds and other financial institutions, pension funds into the industry to promote its development, and inhibits pension institutions to enhance the scale and quality of service (The Mystery of Capital p21).

Corollary three: pension institutions, especially newly built pension institutions are more constructed in the collective construction land.

Corollary four: land supply system of our country affects the development of the pension agency.

## 25.5 Empirical Analysis: Take Beijing as an Example

This paper uses data of publicly traded land in Beijing from 2009 to 2011, annual sub-district statistics in Beijing and data of endowment institutions from the Bureau of Civil Affairs in Beijing to analyze land supply system's effect on the construction of endowment institutions.

### 25.5.1 Analysis of Compensated Transfer of State-Owned Construction Land

From 2009 to 2011, the land market in Beijing granted 770 pieces of land publicly.[2] After synthetically analyzing the uses of every pieces of land, the corporation nature of the winner and the reports of the project approval, only one of 770 is intended for pension apartment, set the elderly who are able to live independently as target customers. And the original land use is for public rental housing.[3] Analysis on Beijing's data shows that endowment institutions cannot acquire inadequate land resources for development under the land supply policy of state-owned construction land, which happens to coincide with the Bid Rent Theory.

### 25.5.2 Statistical Analysis of Existing Endowment Institution Distribution

According to the annual sub-district statistics in Beijing in 2010, we descriptively analyzed the number of endowment institution beds in Beijing, the number of adopting institutions, the number of beds per installation and the number of beds per capita in 16 districts in Beijing. In convenience, we separate Beijing into four functional districts, namely core district including Dongcheng and Xicheng,[4] functional widening district including Chaoyang, Haidian, Fengtai and Shijingshan, newly developing district including Tongzhou, Shunyi, Daxing and Changping, and eco-friendly district including Mentougou, Fangshan, Pinggu, Huairou, Miyun and Yanqing (Fig. 25.2). These four districts expand from the center to the margin and the prices of land and house share a trend from high to low correspondingly.

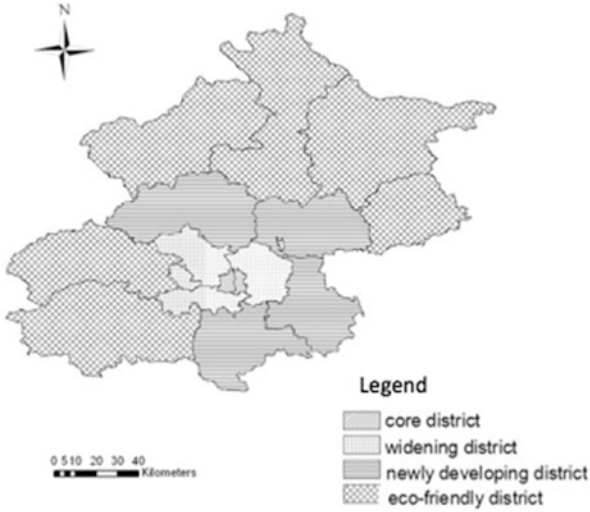
The number of endowment institution beds in Beijing, the number of adopting institutions, the number of beds per institution and the number of beds per capita share a nadir in Dongcheng District, a part of the core district. Moreover, the number of beds per capita is less than 12 % of the average and the number of beds per institution is less than 33 % of the average. And this area shares the highest land and house prices. However, these indexes reached a summit in Changping

[2] A-001-A-005, Changying living area, Chaoyang Dist., auctioned by Beijing Tong RuiWanhua Properties Limited in February 24, 2010. In conditions of public rental purposes, the revenue of pension apartment would be higher than public rental income. Thus, it is reasonable for pension institutions to take place of public rental houses.

[3] This land is located in Changying residential area, Chaoyang District, land number of which is A-001-A-005 and sold on February 24, 2010. Under public rental use limitations, the construction revenue of endowment institutions and related services income is higher than the income of public rental lease. Therefore, it is rational for endowment institutions to replace public rental houses.

[4] In 2009, Beijing government merged Dongcheng District and Chongwen District into Dongcheng District, and Xicheng District and Xuanwu District into Xicheng District.

**Fig. 25.2** Function zoning map of Beijing




District, a part of the newly developing district. The number of beds in total is thrice as many as the average level, and the number of adopting institutions is twice. In this district, the natural environment is better and locating between theoretical urban fringe and practical one (Table 25.4).

Viewing from the functional aspect, these four districts expands from inner to outer and the corresponding land price and house price gets down, but beds per capita and number of institutions per capita hold an opposite trend (Table 25.5).

Although China started building welfare pension institutions in local governments at all levels since 1949. They located in the city district offices and the township government, but there's no effect on the distribution of pension institutions.

We can see form the above data, the higher housing prices, the fewer the number of pension institutions, the fewer beds per capita.

### *25.5.3 Regional Distribution of Pension Institutions*

Using the operating address and business entities of 356 endowment institutions in the 16 districts in Beijing shown on the website of Beijing Municipal Bureau of Civil Affairs, we analyzed the land usage character of endowment institutions. Even though the statistics on the website is not the same with the one from Bureau of Statistics, it affects little to the result of analysis.

Two hundred and nineteen out of the three hundred and fifty six endowment institutions are opened by the government, which includes local governments, neighborhood offices, the township government, accounting for 61.5 % of the total number. The rest are opened by private institutions. Some of them are

**Table 25.4** Descriptive statistics

| | N | Min | Max | Mean | SD | Var |
|---|---|---|---|---|---|---|
| Number of endowment institution bedspread | 16 | 493 | 11,644 | 3,997.25 | 2,698.147 | 7,279,994.733 |
| Nature of adopting institutions | 16 | 9 | 52 | 25.31 | 10.499 | 110.229 |
| permanent population | 16 | 29.0 | 354.5 | 122.575 | 99.7468 | 9,949.427 |
| number of beds per institution | 16 | 54.78 | 401.52 | 180.7015 | 95.84630 | 9,186.514 |
| Number of beds per capita | 16 | 5.36 | 91.66 | 43.4993 | 25.57811 | 654.240 |

**Table 25.5** The number of beds and the average housing price of Beijing sub-function area

| | Proportion of adoption unit per 10,000 people (%) | Number of beds per capital | Average housing price in 2010 (RMB per square meter) |
|---|---|---|---|
| Core functional district | 15.26 | 9.20 | 29,160 |
| Functional widening district | 9.94 | 22.58 | 21,072 |
| Newly developing district | 24.57 | 46.68 | 14,056 |
| Eco-friendly district | 54.11 | 59.28 | 10,284 |

Note: The average housing price uses residential sales/residential sales volume from sub-counties Statistical Yearbook. The average price differs from the actual one, but does not affect the analysis results

transferred from public ones, which means turning from type I endowment institutions into type III.

Viewing form the construction land, 66.6 % of endowment institutions are constructed on collective construction land, and the rest on state-owned construction land. Furthermore, 53.4 % of the later are distributed in villages and towns outside the 5th Ring Road, far from the core district. Viewing form the construction land of private endowment institutions of type II and III, 89.1 % are on collective construction land.

From the perspective of the distribution of endowment institutions, 292 are outside the 5th Ring Road, which have a proportion of 82.02 %. In the above analysis, the 5th Ring Road is regarded as the practical fringe of Beijing empirically. While 3.93 % and 14.04 % are respectfully distributed between the 4th and the 5th Ring Road and inner the 4th Ring Road. Those that are inner the 4th Ring Road follow historical continuity of municipal endowment institutions and sub district ones (Fig. 25.3).

Moreover, we will take Haidian District as a typical example for it covers a wide area from the 2nd Ring Road, the city center, to the 6th Ring Road, the outer suburbs and its private endowment institutions are developing rapidly. There are 30 endowment institutions in Haidian District, and 12 are newly opened after the year of 2005, 11 of which are private ones. However, 10 of 11 are on collective construction land outside the 5th Ring Road, the other one is in the 4th Ring Road, which has medical cooperative relations with People's Liberation Army General Hospital, one of the top hospitals in China.

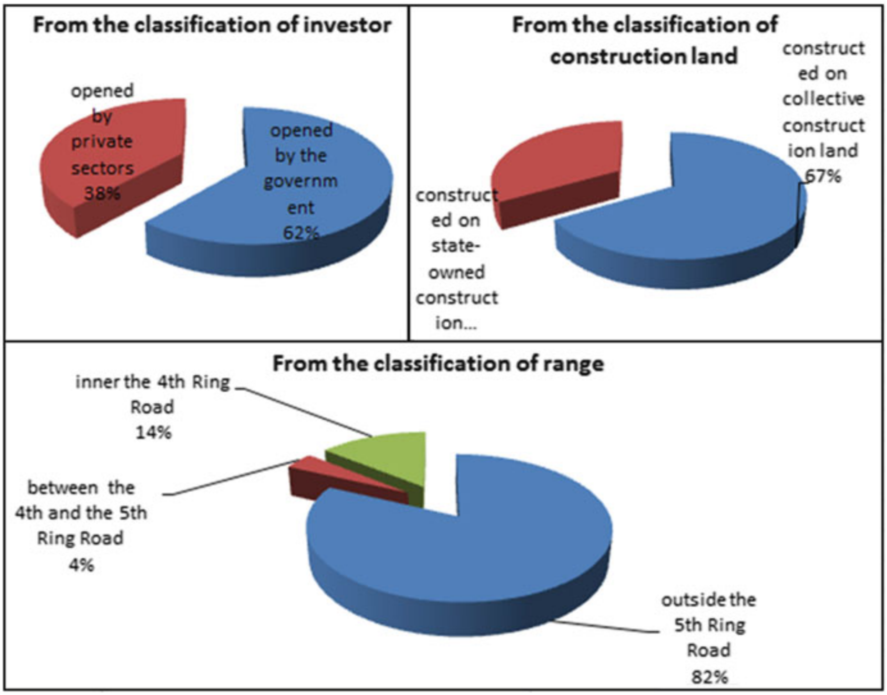



**Fig. 25.3** Regional distribution of old-aged care institutions in Beijing

The data of Beijing pension agency consistent with the inferences above, namely pension institutions, especially the newly built pension institutions are located in the collective construction land.

## 25.6 Conclusion and Suggestion

### *25.6.1 The Existent Land Supply System Has a Retarding Effect on Endowment Institutions*

State-owned construction land supply system that putting emphasis on compensated transfer and taking allocation as auxiliary, along with domain urban and rural land system, has a retarding effect on endowment institutions. In the land market with compensation, habitants that endowment institutions serve have a lower level than those in dwelling house projects on the capacity and willing of leasing. So it is difficult for endowment institutions to contend for land in overt ways. On the other hand, it is clear that the higher density of population, the more demand for endowment services. Considering the governmental measurable indicators that economic and revenue growth are in the first place, it is less possible to allocate land since the opportunity cost will rise at the same time.[5] The crowding-out effect that land supply system lays on endowment institutions forces a number of endowment institutions, especially type II and III, choose collective construction land as priority, and distribute between theoretical urban fringe and practical one.

### *25.6.2 Adding Mandatory Indicators and Making Special Plan for Land Supply of Endowment Institutions in Urban Planning*

In large and medium-sized cities, mandatory planning targets should be put forward to meet the need on endowment institutions of those with low and middle income level. In the process of land public granting, to supply endowment land in planned manner will satisfy the endowment needs of those with high and middle-income level.

### *25.6.3 Permitting to Construct Endowment Institutions on Collective Construction Land with Suitable Location and Fine Environment*

The operating way of endowment institution is holding it with long-period cash flow. Only by matching it with favorable financing structure can endowment institutions develop. Lacking of land control, collective construction land has a serial of negative effects on endowment institutions, such as partial property rights, difficulty on capitalization, narrow financial channels and high cost of capital, which obstruct capital flows into endowment. Meanwhile, this phenomenon keeps trust capital and insurance fund off, which becomes a critical problem restricting the development of endowment institutions.

Therefore, China's land supply system not only inhibits the development of pension institutions from the land resources, but also inhibits a variety of private funds into the pension industry for investment, thus is one of the key issues to affect the development of pension institutions. This essay suggests the government should work out regulations, encourage and regulate the development of endowment institution built on collective construction land with appropriate location and good environment. The property rights of land and housing should be defined clearly and the financing capacity of land and housing for endowment institution should also be improved, thus promoting the development of market-oriented.

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[5] To a certain extent, it explains the question that the development level of urban endowment institution is lower than that in rural areas raised by Zhou Yun in 2007.

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# Chapter 26
# Study on Path Dependence in Reform of Housing System in China

**Taozhi Zhuang, Guiwen Liu, Pengpeng Xu, and Guichong Chen**

**Abstract** With the deepening of Chinese Reform and Opening-up, the old housing system impeded the development of society. All the time, the urban housing problem is one of the most critical social problems in China. In order to conquer the problem, a series of housing system transformation have been adopted since the 1980s in China. However, the problem of path dependence emerged during the process of housing system Reform. This paper uses path dependency theory of New Institutional Economics to discuss the transformation process of Chinese housing system and analyze the path dependence problem in housing system transformation in different periods, then puts forwards a set of corresponding countermeasures to avoid path dependence in the future housing system transformation.

**Keywords** Path dependence • Housing system reform • Institutional change

## 26.1 Introduction

As a basic surviving condition, housing is the foothold and habitat for human. Housing system is a fundamental policy and measure for solving the problem of urban and rural residents housing, being an important part of national economic system reform. Over the past 20 years, reform of housing system in China has made a great achievement and progress. However, as a result of path dependence existing in institutional change, reform of Chinese housing system is far from achieving the ultimate goal of "residents own houses". Based on the status quo, the writer applied the path dependence theory in the new institution economics, inquired into

T. Zhuang (✉) • G. Liu • P. Xu • G. Chen
School of Construction Management and Real Estate, Chongqing University,
Chongqing 40045, China
e-mail: zhuang.tz@foxmail.com

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the reform process of housing system, analyzed the problem of path dependence in China urban housing system, providing the countermeasures against path dependence in the future reform process.

## 26.2 Process of Housing System Reform in China

Housing system reform is started against the background of China economic system reform. In the period of planned economy, housing is an essential element of socialism welfare system [1]. But in the year of 1978, housing floor area per capita in China was only 7 square meters while 47.5 % of urban resident families were short of or even had no houses [2]. Obviously, the old housing system failed to meeting all housing demands. Therefore, Chinese housing system began officially. According to different characteristics appearing in housing systems in different periods, so far, housing system reform is classified into four stages as follows:

### *26.2.1 The Initial Stage of Housing System Reform (1978–1992)*

The core of this reform stage is to sell new and old public houses to individual residents, and make a reasonable adjustment to public house rent to relieve government financial pressure, promoting housing commercialization.

Since 1978, the State Council began to issue documents constantly, proposed a concept of housing system reform and made experiments in some cities at the same time. In June 1980, *The National Basic Construction Work Conference Outline Report* was authorized by the State Council to implement the housing commercialization policy officially. In 1982, China putted forward the thought of subsidy for sale and conducted tests at selected four cities at different times. In January 1988, the State Council printed and distributed *About the National Urban Housing System Reform Plan Implementing by Stages and in Groups*. This was the first housing reform document in China which indicated that housing system reform has come into the overall scheme design period, and experiments was expanded in full swing.

The initial housing system reform basically could not move the old system, failing to solve the problem of deficiency in the amount of housing construction. There was no change in rent of large amount of public houses while the new-made ratio of rent and purchase was unreasonable, and the funds for housing construction was not capable to self-cycle. Consequently, it was difficult for the country and enterprises to undertake. In 1988, the general retail price index raised 18.5 %, which caused that a number of cities sold public houses at a discount, on the basis of normal price, for throwing the burden of housing policies away. The matching reform, taking selling public houses at a lower price as welfare instead of renting with selling, was the reverse of the policy aims of housing mechanism transformation, bringing massive consequences. In addition, owing to the poor implementation of local governments, the price of houses could not jump out of the circle that renting and selling at a low price.

### *26.2.2 The Propulsion Stage of Housing System Reform (1993–1997)*

The core of this stage is learning a lesson from the previous stage to establish a new housing system aiming at speeding up the reform progress.

The convocation of the third national housing reform work conference in 1993 contributed to the establishing of the framework of urban housing system reform. The conference proposed a new housing reform plan that "putting emphasis on the sale of public houses; develop sale, rent and construction simultaneously" and soon fully implemented. In July 1994, *Decision about Deepen the urban housing system reform* was issued and implemented by the Stated Council, suggesting that the objective was to build a new housing system. In August 1996, the State Council published *the Suggestion about Reinforce Housing Fund Management* which developed housing fund for financial instrument. By means of a series of housing system reform, housing construction came into an extraordinary growth period.

According to this reform, different districts began to make housing reform performance plan in succession, progressing in the aspects of housing fund construction, rent raising of public houses, public houses sale, etc. By 1988, the percentage of China urban population possessing houses had passed 50 %, which improved greatly when compared with the past.

### *26.2.3 The Monetization of Housing Distribution Stage of Housing System Reform (1998–2002)*

In this phase, the core of the housing system reform is to establish the operation mechanism based on the monetization of housing distribution in the housing market.

Chinese housing system has entered into a new stage of comprehensive socialization, commercialization and marketization in 1998 [3]. In 1998 July, The State Council promulgated the *Notice to further deepen the urban housing system reform and speed up housing construction notice*, declaring the end of the welfare housing distribution system. The issue of the document symbolized the abolishment of welfare housing distribution system which maintained for a decade, and the establishment of the new monetization and privatization policy. At the same time, the document also proposed to establish a multi-level urban housing supply system and housing security system.

Between 1998 and 2002, the real estate development investment in China experienced a remarkable growth from 317.84 billion Yuan in 1997 to 498.41 billion Yuan in 2002, an average annual growth rate of 9.41 %. Nevertheless, the upward housing price and scarce of indemnificatory housing was not able to realize social fairness brought by reform. Even this enormous investment did not meet the distribution of housing subsidy and housing demand. What is worse, housing inequality has become to a serious issue with the increasingly soaring house prices. Distribution of indemnificatory housing turned to out of control due to the lack of clear policy goals and improper execution. Between 1998 and 2002, nationwide area of buildings completed involved marketable houses reached 1,268 million square meters, while that of economically affordable houses was only 230 million square meters. Apparently, indemnificatory housing did not turn to be the main channel of supply, and was difficult to handle the housing demand related to a great deal of low income population after cancel housing distribution in kind.

### *26.2.4 The Market Regulation and Housing Security Stage of Housing System Reform (2003–)*

In this phase, the core of the housing system reform is to stabilize the prices of commercial houses and to increase the construction of indemnificatory housing.

In 2003, the State Council issued the *Notice to promote the sustained and healthy development of the real estate market*, clarifying the future housing system reform should be adjusted to changes during the housing system reform process and the resident income level. The government aims to assure that ordinary families are able to buy or rent commercial residential building, and low-income families are able to purchase or rent indemnificatory houses through the improvement of housing supply policy and supply structure reasonably determine the division standard of housing security object, the implementation of goals. Then, a series of policies that emphasized the importance of price regulation and indemnificatory housing construction have been introduced.

This stage of the reform of the housing system is based on the market system. Although a series of policies has been effective, there is still a serious problem exist in real estate development [4]. National commercial housing prices experienced a growth of 8.3 % between 2000 and 2010. And the number of real estate enterprises rose from 24,378 in 2002 to 85,218 in 2010, namely an average annual growth rate of 16.9 %. At the same time, Real estate operating income rose by about 707.8 billion Yuan to about 4,299.6 billion Yuan between 2002 and 2010, an average annual growth rate of 25.3 %. As a national project, the construction process of indemnificatory housing is slow. In 2008, the coverage rate of indemnificatory housing was less than 4 % then reached to only 11 % 3 years later. However, such statistics include the number of high-income groups who take advantage of loopholes in the policy to access the ownership of indemnificatory housing.

## 26.3 Analysis of Path Dependence in Chinese Housing System Reform

The concept of path dependence was first created by W. Bryant. Arthur to describe inertia characteristics in technical evolution that similar to physics. And Douglass C. North was the first to apply the theory of path dependence from technological change on institutional change. As he pointed out, similar to technological change, institutional change could enter virtuous circle but could also fall into 'lock-in' state of low efficient vicious circle. Meanwhile, institutional innovation could be directed towards old track by path dependence. The result is to make new system mixed with traditional elements or even become the variety of the old system [5].

The path of institutional change is determined by two forces: the mechanism of increasing return and market imperfection due to high transaction cost [5]. Firstly, institutional change is constrained by increasing return. Increasing return is the result of scale effect, learning effect, alignment effect and adaptive expectation that caused by interdependence within the institutional matrix. Secondly, institutional change is constrained by the imperfect market. Market failures that associated with asymmetric information and high transaction cost means that actor were reluctant to undertake system innovation and reform.

The following section of this paper uses the path dependency theory to analyze the problems that exist during each phase of the reform of Chinese housing system.

### *26.3.1 The Binding of Ideology*

The theory of path dependence states that "history is vital that the choice people made in the past determined the possible choice they will make now" [5]. Methods selection of institution change mainly depends on preference of the institution actors. Meanwhile, what profoundly affect the preference of actors related to housing system reform is their ideas. In the historical context, human being built the recognition of the established system based on their experience. The recognition tends to exist in the long term and limit their willingness to make choice of the new system. Traditional system played a vital role in shaping the building of socialist market economy. This was demonstrated by the repeatedly changing of goal model as well as the lasting argument about ideology and economic theory since the "reform and opening-up policy" was implemented [6].

At the beginning of new China's foundation, the development of the housing system was strictly controlled by the government and the market played little role. It was a need for national conditions at the time and social stability. However, with the coming of reform and opening-up, demand for housing increased considerably as a result of the extraordinary growth of economy and urbanization, generating that housing problem was totally solved by country and enterprises under the planned economy system and welfare distribution did not work. Since the reform and opening-up, China gradually transformed from socialist planned economy to socialist market economy. It's widely known that there was much difference between them, and the huge change necessarily required the actors to abandon the ultra-left thought in old times. At that period, the idea of the traditional system that deeply rooted in the society was challenged by the marketization of the housing system. As the society struggling to break away from the shackles of the ultra-left ideology, the reform failed to achieve substantive breakthrough at the early stage. It was not until a decade after the reform started that the traditional way of housing distribution was replaced. The shackles of the ideology finally faded away.

### *26.3.2 The Low Cost Choice*

It is no doubt that institutional innovation associates with high cost and risk. On the contrary, to reform through traditional path is less costly and less risky. The long reform cycle (average tenure of each government level is 5 years) means that the actors at that time should bear majority of the cost. As a result, the traditional path was preferred by the reformer despite its low efficiency. Only when the path dependence of the traditional system brings more benefits than the cost, the actor would chose to innovate and change.

At the early stage of the reform, the scaling effect means that to replace the old system requires significant initial cost. For actors, it was a huge challenge for them to face and risk for them to take. Therefore, the reform simply altered the way of physical distribution of houses but did not change the foundation of the system. Furthermore, the main emphasis of reform was restraining housing demand but did not point out the material direction. However, at early 1990s, the rapid growing Chinese economy means that the government and enterprises could no longer be able to satisfy the increasing rigid demand through traditional way of housing distribution. That means, for actors, the cost of carrying out institutional change through traditional path had outweighed the benefit. In this context, to conduct a new kind of reform was inevitable. In the twenty-first century, as the last phase of the reform deepened, the unit cost and additional cost of policy making decreased significantly. The preference for traditional path due to its low cost could not coexist with the goal of the next phase of the reform, which is to conduct price control and to provide indemnificatory housing.

### *26.3.3 The Strengthen of Entities' Interest*

China has come a long way in reforming the housing system. The actors attempted to find out benign path dependence in the progressive institution change mode, aiming at increasing the positive benefit by degrees with a low cost. During the process of institutional change, the actors failed to explore the optimum path dependence.

Instead, the institutional change self-reinforced through inefficient path and deviated from the goal of the reform. The process of self-enforcing caused learning effect and organizations that emerged by adapting the system seized the opportunity of profiting from the institutional framework [7]. At the meantime, there was the alignment effect that produced mutually benefiting entities. The entities further invest in the system, and then make the generation of a formal rule derive another formal rules and a series of informal rules to supplement this formal rule [7]. The result of the above effects was to strengthen the interest of the entities that related to reform.

During the last three decades, the process of the reform created divergence of interest that exists between the central government, local government, relating enterprises and the masses. Since the stage of housing capitalization, market mechanism of housing has reinforced and crystallized finally. Moreover, central authority, local government and relating enterprises succeeded to realize group interest through these policies. Without participating in the policy making and supervising, Chinese people could not express their own interest. During the last 10 years, housing price of China has surged. In order to stabilize the society, the central government introduced a serious of policies. However, to keep GDP growing, China has to increase domestic demand, especially fix asset investment and consumption that relating to property and infrastructure. Base on the principle of self-interest maximization, the policies made by the central government were merely to limit purchase, mortgage lending and the price. In fact, the policies were still depending on the traditional path. By reasons of the introduction of land appreciation tax, land use tax and property tax, local governments largely benefited from the marketization of housing industry. In some areas, revenue from land has become the "second source of finance" and accounts for over 70 % of the revenue beyond the budget [8]. When the central government introduced policies to control the housing price, it is likely that local government response by making complementary policies or informal rules. Enterprises that are optimistic about the prospect of the Chinese housing industry became the mutually benefiting entities with the government and they profited from the imperfect market. Based on the above factors, the change of the housing system self-reinforced through path dependence with low efficiency. The ordinary citizens were the ones who ultimately bear the losses. Under this circumstance, the current housing system reform failed to transform the rigid demand into effective demand. Especially the housing problem of low-income population was not addressed without effective policies.

## 26.4 Conclusions and Suggestions

Since the reform and opening-up, China has experienced four stages of housing system reform, including initial stage, propulsion stage, monetization of housing distribution stage and market regulation and housing security stage. Meanwhile, problems of residents housing transformed from undersupply, low rent and uneven distribution at the beginning of the reform to plenty supply of marketable houses, rising prices as well as huge gap of indemnificatory housing nowadays. Obviously, housing system reform failed to solve the problems effectively. Applying path dependency theory, which is first advanced by Douglass C. North, the author analyze that there exist three main path dependence problems leads to low efficiency of institutional change: firstly, the ultra-left thought of socialist planned economy period brought the early stage of housing system reform into binding of ideological; Secondly, there is a tendency that actors adopt the traditional path because of its low cost in the institution change process; Thirdly, in the long way of housing system reform, constant strengthening of interest entities prevented institutional innovation.

As statements mentioned above, Chinese housing system depends on non-benign path changes. Any policy which is trying to change the status quo has inevitably to face with difficulties result from the mechanism to strengthen existing situation [9]. If things go on like this, the housing system reform will fall into 'lock-in' state of low efficiency, intensifying social contradictions. But it is not easy to solve this problem. In order to conquer the problem of path dependence, the actors should be conscious to correct their own mistakes, and at the same time, external effect and introduction of exogenous variables are also needed. Only in this way, the actors can reverse original path.

For the sake of jumping out the non-benign path dependence, the reform of the housing system can be improved from the following aspects: firstly, the actors must establish a people-oriented idea, the willing to serve society and fair administration. Secondly, to strengthen the construction of democracy, so that the masses can express their interests then participate in the reform. Thirdly, to build up the supporting financial system, performance evaluation system, other industry support system and social management, such as political system. Fourthly, to formulate laws to protect the housing rights of Chinese citizens, standardizing the authority, obligation and behavior of government, enterprises, the masses of the people in the real estate industry.

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# Chapter 27
# House Price Fluctuation Spillover Effects-Evidence from 35 Chinese Large and Medium-Sized Cities

**Gang Wu and Guoliang Ou**

**Abstract** Using quarterly house price index of the 35 Chinese large and medium-sized cities during the period 2000Q2–2012Q3, applying Block-exogeneity test on the estimates from a multi-variable VAR model, we found that the transmission of house price fluctuations between cities is multi-directional and do not depend on geographical contiguity. And the wider spillover effects come from cities with higher land scarcity.

**Keywords** Spillover effect • Large and medium-sized cities • VAR

## 27.1 Introduction

In the existing literature on housing price fluctuations study, there are lots of papers focus on the housing price volatility spillover effect. That is whether if a regional house prices fluctuation can be transmitted to other peripheral areas. But in specific name, some called it ripple effect, some called it spillover effect. China government has cancelled the housing distribution system since 1998. Hence housing prices has increased greatly. Especially in recent years some "hot cities" have seen their house prices continued to double, the housing problem has become the most concerned problem. Since 2003, in order to curb the rapid rise in prices, China's central government has introduced a lot of macro-control policies, but the effect is very poor. The policies gives an overall feeling that they are neither issued in time, nor graph the critic problems. If we can study the housing price problems from the perspective that house price fluctuations have spillover effects, and then analyze the reasons why all the macro-control policies are not ideal, we believe that it is helpful for the government to make proper real estate macro-control policies in the future.

G. Wu (✉) • G. Ou
School of Construction and Environmental Engineering,
Shenzhen Polytechnic, Shenzhen, China
e-mail: szwug@163.com; ouyangszpt@126.com

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We use Block-exogeneity test to analyze the housing prices interaction between 35 big and medium-sized cities to find multi-directional spillover effects. Cities with higher land scarcity such as Beijing and Shenzhen have wider influence in house price transmission.

The paper is constructed as follows: second part, literature review of housing price fluctuations; third part, econometric analysis; forth, conclusion and policy suggestions.

## 27.2 Literature Review

There are three main ways on the research of housing price fluctuation spillover effect. One is to use co-integration theory to test the regional housing prices Granger causal relation. For example, Giussani and Hadjimatheou [5], McDonald and Taylor [9], Alexander and Barrow [1] use this method to analyze UK housing market, Pollakowski and Ray [13] use this method to study on United States housing market, Stevenson [14] use it on the Irish house prices to test the existence of a long-term stable relationship between the regional housing prices, then use Granger causality method to test which region fluctuate earlier than others. Gupta and Miller [6, 7] also use this method to analyze the ripple effect of Las Angeles, Las Vegas and Phoenix housing prices, and the housing prices Granger causality between the eight southern California metropolitan areas. Zhang [19] applied this method to find a weak ripple effect between different regions' housing prices in China. While Wei and Yang [17] use find strong ripple effect between Shanghai, Nanjing and Hangzhou.

The second approach is to test if the ratio between regional prices and the national average house price is stationary. The essence idea of this method is to simplify ripple effect test into a unit root test. Meen [10] believe that housing price spillover means there is a long-term stable relationship between regional house prices and national house prices, therefore it is only necessary to test if the time series of the ratio between regional housing prices and the average national house prices are stationary. He use ADF unit root test to do it, found that there are significant ripple effect on British house prices. Cook [2] use asymmetric unit root test to find that there is house prices ripple effect in parts of the UK. Holmes and Grims [8] and Cook [3] also use this method to find a house prices spillover effects in the UK. Cook [3] applied an asymmetric adjustment process to do co-integration test on UK housing prices, he found that there is obvious differences in the rate of price adjustment to its equilibrium between house price rise and decrease process.

The third approach is Global Vector Autoregressive (Global VAR) model originated from Pesaran. The two classical papers, Pesaran et al. [12] and Dees et al. [4] are widely cited by other scholars. The basic idea of this approach is: take all the countries and regions as a whole unit, use some economic relationship to connect them together, build a global vector autoregressive model. The main difference between this theory and other traditional vector autoregressive model is that they added a connection variable between all the cities. It is precisely because of this reason, that the variable to be estimated has been doubled. Vansteenkiste [15] simplify the model when she use Global VAR model to test the spillover effects of the United States housing markets. In the process of building external variables, she uses geographic distance to connect all the states. Vansteenkiste et al. [16] also use this method to analyze the spillover effect of Euro area countries house prices. While Wu et al. [18] use VAR and GARCH model, do not find monetary supply have any spillover effect on China's house prices.

No matter what kinds of methods were used, there are regional housing prices volatility spillover effects. China's experience shows a hot area's price changes often leads to changes of other regions. For example, before 2003, Shanghai housing prices lead the national which brought about the first round of real estate control policy, but still can not stop the rising trend. During 2009–2010, Shenzhen and Beijing leads another round of nationwide housing prices rising. All the macro-controlling polices are either time lagged or weak in effects. If we can find out the source of housing price fluctuation which leads other cities to follow, then it is possible to supervise these source cities. When there is unusual house price change in source cities, the government should take actions duly. This paper aims to find the source of fluctuation through empirical research, and then put forward corresponding control measures.

## 27.3 Econometric Analyses

### *27.3.1 Descriptive Statistics*

From Tables 27.1 and 27.2, we can see that Beijing, Fuzhou, Zhengzhou, Xian and Yinchuan have least house price volatility with standard error less than 0.002, while Taiyuan, Ningbo, Hefei, Shenzhen, Chongqing and Kunming have a standard error greater than 0.004.

**Table 27.1** Statistics for five cities with least volatility

| Variable | Obs. | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| BJ | 50 | 0.0110 | 0.0197 | −0.0281 | 0.0457 |
| FZ | 50 | 0.0070 | 0.0159 | −0.0284 | 0.0374 |
| ZZ | 50 | 0.0092 | 0.0121 | −0.0230 | 0.0440 |
| XA | 50 | 0.0096 | 0.0194 | −0.0446 | 0.0741 |
| YC | 50 | 0.0106 | 0.0182 | −0.0234 | 0.0611 |

**Table 27.2** Statistics for six cities with biggest volatility

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| TY | 50 | 0.0072 | 0.0465 | −0.0847 | 0.1221 |
| NB | 50 | 0.0184 | 0.0413 | −0.0805 | 0.1040 |
| HF | 50 | 0.0111 | 0.0438 | −0.1390 | 0.0815 |
| SZ | 50 | 0.0106 | 0.0450 | −0.0932 | 0.0978 |
| CQ | 50 | 0.0165 | 0.0622 | −0.1368 | 0.1275 |
| KM | 50 | 0.0071 | 0.0408 | −0.1211 | 0.0602 |

Among the first-lier cities, Shanghai and Shenzhen have a much wider house price fluctuations than that of Beijing and Guangzhou. While Shanghai leads national housing price before 2003, and Shenzhen leads National house prices during 2004–2007.

### 27.3.2 Block-Exogeneity Test

Follows Nneiji [11], we use quarterly house price return as explained variable, then the fluctuation of a city depend on both its lagged values and on other cities lagged variables. The model is as follow:

$$R_{t,k} = \beta_{0,k} + \sum_{k=1}^{35} \beta_{i,k} R_{t-1,k} + u_{t,k} \tag{27.1}$$

Among which, k stands for the number of 35 cities.

To test if there is significant effect between each city's housing price fluctuations, we can simplify the test as:

$$H0 : \beta_{i,1} = \beta_{i,2} = \ldots = \beta_{i,k} = 0$$

If H0 hypothesis is valid, there this is no spillover effects. Otherwise, there are no spillover effects. Unit root test results shows that each time series are stationary. We use Eviews to do the estimation. Block-exogeneity test can be used to estimate the Chi-squared value p value. And p values are used to decide if there is significant spillover effect. Shijiazhuang and Haikou have outliers, so these two cities were eliminated. Then 33 cities were left. As there is maximum limit of 30 variables, we eliminated the capital cities of Xinjiang, Inner Mongolia and Qinghai in that there is fewer economic connect between there cities and other inner land cities.

Appendix Table 27.7 and Table 27.3 shows that house prices of Ningbo and Shanghai were not affected by other cities, house price of Chongqing and Shenzhen can be affected by one city. While house price of Changsha, Guiyang, Hangzhou and Harbin can be affected by more than ten other cities. The greatest spillover effect arise from Beijing, Hefei, Jinan, Yinchuan and Guiyang, while Chengdu, Harbin, Wuhan, Zhengzhou , Hangzhou and Lanzhou have least spillover influence.

In order to avoid possible defects brings by the full sample, we divide it into two sub-samples. Subsample one consists the first-tire cities, namely, Beijing, Shanghai, Guangzhou and Shenzhen. The second sample include all the rest cities, we call it 29 cities sample. The full sample is called 30 cities sample. For sub-sample one, the AIC and FPE index show that the lag order 4 is the optimal lag order. The p values in the Block-exogeneity test for H0: $\beta 1 = \beta 2 = \ldots = \beta k = 0$ is less than 0.05.

**Table 27.3** Spillover effects between main cities

| | CS | GY | HEB | HZ | JN | KM | SY | WH |
|---|---|---|---|---|---|---|---|---|
| BJ | 10.3$^{**}$ | 30.1$^{**}$ | 24.8$^{**}$ | 11.1$^{**}$ | 9.59$^{**}$ | 3.219 | 1.475 | 4.67$^{*}$ |
| DL | 1.086 | 5.97$^{*}$ | 4$^{*}$ | 9.8$^{**}$ | 0.067 | 1.512 | 3.259 | 11.3$^{**}$ |
| GY | 9.41$^{**}$ | | 13.6$^{**}$ | 16.5$^{**}$ | 4.47$^{*}$ | 9.13 | 4.41$^{*}$ | 12$^{**}$ |
| HF | 7.74$^{*}$ | 20.8$^{**}$ | 4.06$^{*}$ | 5.29$^{*}$ | 2.897 | 0.035 | 19.5$^{**}$ | 0.612 |
| JN | 5.18$^{*}$ | 14$^{**}$ | 32.9$^{**}$ | 4.14$^{*}$ | | 15.2 | 3.98$^{*}$ | 1.138 |
| NB | 6.37$^{*}$ | 1.452 | 2.281 | 2.515 | 2.840 | 6.93 | 0.459 | 0.153 |
| QD | 5.33$^{*}$ | 4.79$^{*}$ | 11.4$^{**}$ | 0.531 | 4.37$^{*}$ | 8.11 | 17$^{**}$ | 16.8$^{**}$ |
| XM | 4.11$^{*}$ | 6.34$^{*}$ | 18.4$^{**}$ | 0.388 | 0.865 | 6.018 | 0.209 | 0.004 |
| YC | 5.48$^{*}$ | 7.06$^{**}$ | 21.2$^{**}$ | 0.059 | 1.926 | 17.1 | 6.75$^{**}$ | 2.754 |

Note: Row variables indicate explained variable, column variable indicated lagged value of house price volatilities

$^{*}$, $^{**}$ stands for 5 % and 1 % significance respectively

**Table 27.4** Spillover effects between four first-tier cities

| | BJ | SH | GZ | SZ |
|---|---|---|---|---|
| BJ | | 6.519(0.164) | 14.557(0.006) | 15.094(0.005) |
| SH | 5.405(0.248) | | 6.757(0.149) | 2.625(0.622) |
| GZ | 6.070(0.194) | 7.519(0.111) | | 2.546(0.636) |
| SZ | 18.081(0.001) | 7.054(0.133) | 18.265(0.001) | |

Note: value before the brackets represent Chi-squared value, P value in parenthesis

**Table 27.5** Interaction of fluctuations between main cities of 29-City sample

| | CQ | HEB | NN | SY | WLMQ | XN |
|---|---|---|---|---|---|---|
| GY | 0.599 | 4.915(0.027) | 5.998(0.014) | 4.282(0.038) | 0.004 | 3.655 |
| HF | 5.112(0.023) | 0.283 | 0.667 | 13.622(0.000) | 14.628(0.000) | 1.664 |
| JN | 0.114 | 10.88(0.001) | 9.008(0.002) | 2.739 | 4.461(0.034) | 5.163(0.023) |
| SY | 0.009 | 7.283(0.007) | 1.893 | 16.504 | 9.583(0.002) | 2.986 |
| TJ | 0.023 | 16.356 | 0.882 | 16.504(0.000) | 1.106 | 2.179 |
| YC | 0.071 | 17.352(0.000) | 10.309(0.001) | 10.663(0.001) | 12.352(0.000) | 1.307 |

Note: only cities with most influence and those be effected most were presented. Row variable represent the 6 cites most volatile, column vector represent cities with most influence on others. Inside () is P value, only those less than 0.05 were marked

It is seen from Table 27.4, relationship between first-tier cities' house price fluctuations is multi-directional. There is mutual influence between Beijing and Shenzhen in house price fluctuations; Shanghai's housing price volatility is not affected by the other three cities, while Guangzhou was affected both by Beijing and Shenzhen.

From Table 27.5, we can find that cities with less influence on the other city's house prices are as follows: Zhengzhou, Hangzhou, Kunming, Changchun, Chengdu, Chongqing, Nanchang and Huhehot. Among which, Zhengzhou and Hangzhou have no effect on others. Cities with most affects on others are Yinchuan, Hefei, Shenyang, Tianjin, Jinan and Guiyang. Compared with the 30 city sample results, Yinchuan, Hefei, Guiyang and Jinan were shown to have significant effects on a number of other cities.

On the aspect of been affected, Huhehot, Ningbo and Yinchuan were not affected by other cities. Those affected most were Shenyang, Chongqing, Nanning, Xining, Urumqi and Harbin. Similar to the 30 city sample conclusion, Ningbo's house prices are not affected by any other cities, Harbin was most affected by other cities.

Based on the above analysis, we can find the following rules.

Rule 1: the more developed in economy, the less influenced by other cities' house price fluctuations; conversely, the less developed, the more influenced. It is seen from Table 27.6 that Shanghai, Shenzhen, Ningbo, Qingdao and Huhehot are not easy to be influenced by others. The common features of these cities are relatively more developed economies. Most of them belong to the richest coastal provinces. In 2012Q2, the per capita disposable incomes of these cities are between 7,300 Yuan and 10,040 Yuan. The most influenced cities are Guiyang, Harbin, Wuhan, Nanning, Changsha, Hangzhou and Jinan. Except for Hangzhou and Jinan, other cities belong to economically underdeveloped regions. Per capita disposable income in 2012Q2 is less than 5,500 Yuan.

Rule 2: weak house price spillover effect comes mainly from cities with lower levels of land scarcity. They are Hangzhou, Lanzhou, Zhengzhou, Huhehot, Changchun, Chengdu, Harbin, Xining, Nanning and Kunming. The common features of these cities are relatively low population density. With the exception of Zhengzhou and Chengdu have population density of more than 1,000 people/km$^2$, other city's population density are basically less than 350 people/km$^2$, belonging to the lowest land scarcity among 35 large and medium-sized cities.

Rule 3: Beijing, Guiyang, Hefei, Jinan, Yinchuan, Ningbo, Xiamen, Dalian, Guangzhou and Shenzhen have greater house price impact on other cities. These cities are located in the capital city and coastal areas, which are economically, developed cities with greater degree of land scarcity.

Rule 4: house price spillover effect is multidirectional, geographical position do not play a main role in price transmission. Taking Ningbo as an example, its price fluctuation spillover effects can affect Changsha, Kunming, Lanzhou, Qingdao, Taiyuan, Yinchuan and Zhengzhou, but has no effect on the neighboring cities such as Shanghai, Hangzhou and Nanjing.

## 27.4 Conclusions

From the above econometric analysis, it is not difficult to find that among 35 large and medium-sized cities, there are obvious house price spillover effects. Government can take timely and effective measures according to its transmission characteristics.

**Table 27.6** Number of cities affect and affected on house prices

| | Affect | | Affected | | | Affect | | Affected | |
|---|---|---|---|---|---|---|---|---|---|
| City | Sample1 | Sample2 | Sample1 | Sample2 | City | Sample1 | Sample2 | Sample1 | Sample2 |
| BJ | 12 | Na | 4 | | NC | 5 | 2 | 2 | 5 |
| CC | 4 | 2 | 4 | 6 | NJ | 6 | 5 | 5 | 2 |
| CD | 2 | 2 | 4 | 1 | NN | 3 | 4 | 6 | 8 |
| CQ | 6 | 2 | 1 | 8 | QD | 8 | 3 | 2 | 3 |
| CS | 4 | 5 | 12 | 5 | SH | 6 | Na | 0 | Na |
| DL | 7 | 3 | 7 | 6 | SZ | 5 | Na | 1 | Na |
| FZ | 5 | 5 | 2 | 4 | SY | 3 | 8 | 8 | 11 |
| GY | 14 | 7 | 14 | 6 | TJ | 6 | 9 | 3 | 5 |
| GZ | 6 | Na | 5 | Na | TY | 4 | 4 | 5 | 4 |
| HEB | 2 | 4 | 15 | 7 | WH | 1 | 3 | 10 | 6 |
| HHHT | Na | 2 | Na | 0 | WLMQ | Na | 6 | | 8 |
| HF | 11 | 11 | 6 | 4 | XA | 2 | 7 | 5 | 3 |
| HZ | 0 | 0 | 11 | 4 | XM | 7 | 5 | 3 | 3 |
| JN | 12 | 7 | 8 | 4 | XN | Na | 3 | | 8 |
| KM | 5 | 1 | 9 | 3 | YC | 12 | 14 | 4 | 0 |
| LZ | 0 | 3 | 6 | 5 | ZZ | 1 | 0 | 4 | 6 |
| NB | 7 | 6 | 0 | 0 | | | | | |

Note: Haikou and Shijiazhuang were removed for outlier. Due to the VAR variable number limit of 30, sample includes the remaining cities except Urumqi, Huhehot and Xining, sample 2 includes cities without 4 first-lier cities

1. There is multi-directional housing price fluctuation spillover effect between all the cities. Take the first-tier cities, namely, Beijing, Shanghai, Guangzhou, Shenzhen as an example, there is two-way spillover effects between Beijing and Shenzhen; both Beijing and Shenzhen have spillover effect to Guangzhou; Mutual influence between other cities are much more complex.
2. House prices fluctuation spillover effect is more obvious in areas with higher land scarcity degree. The full sample regression results shows that economically developed city with higher land scarcity degree such as Beijing, Shenzhen, Ningbo, Xiamen et al, have significant spillover effect on other cities. While cities with lower degree of land scarcity have fewer spillover effect.
3. House price spillover effects do not depend on geographical contiguity. Take Ningbo as an example, it does no have any significant affect on neighboring cities such as Hangzhou, Shanghai and Nanjing, but have significant effect on Changsha and Kunming which are much more faraway than the neighboring cities.
4. Policy suggestions. As there is significant spillover effects between all the cities, and the transmission is multidirectional, so any single city's housing price unusual changes should attach great importance to the government. More attention should be especially paid to price changes in Beijing, Shenzhen, Guangzhou and Shanghai. When there are any unusual changes in housing prices or land prices, government should take timely measures to prevent it from going too fast and too far, so as to avoid other places to follow, which may result in a mess.

The main limitation of this study is that house price data may be conservative. Because we cannot collect full sample data from real market, so a price index from National Statistics Bureau is used. We use chain index of 2012 and index of other years to deduce the time series. There may unavoidably have some error transfer problems. From the rate of increase in housing prices, our data is a bit smaller than it should be. But because each city have the same problem, it is credible to find common trend in house prices.

# Appendix

**Table 27.7** Block-exogeneity test result between 30 cities

| | BJ | CC | CD | CQ | CS | DL | FZ | GY | GZ | HEB |
|---|---|---|---|---|---|---|---|---|---|---|
| BJ | | 7.185** | 4.415* | 0.145 | 10.298** | 3.122 | 2.949 | 30.117** | 3.099 | 24.773** |
| CC | 0.494 | | 0.000 | 0.737 | 0.227 | 2.102 | 0.098 | 1.825 | 0.515 | 1.865 |
| CD | 1.405 | 2.896 | | 0.478 | 0.170 | 0.054 | 0.832 | 0.322 | 0.131 | 9.767** |
| CQ | 7.467** | 0.353 | 0.022 | | 7.346 | 17.378** | 0.287 | 0.022 | 5.576* | 2.646 |
| CS | 10.309** | 1.013 | 0.937 | 2.510 | | 0.895 | 0.249 | 1.490 | 2.875 | 0.031 |
| DL | 1.026 | 1.439 | 12.446** | 4.932* | 1.087 | | 0.319 | 5.972* | 0.688 | 4.002* |
| FZ | 0.536 | 3.649 | 0.779 | 0.211 | 5.571* | 7.207** | | 12.458** | 0.151 | 0.500 |
| GY | 4.267* | 3.931* | 3.718 | 1.140 | 9.413** | 8.568** | 1.510 | | 3.142 | 13.604** |
| GZ | 2.539 | 1.983 | 1.394 | 0.007 | 1.140 | 0.657 | 1.258 | 10.55** | | 13.101** |
| HEB | 2.164 | 0.645 | 1.328 | 3.112 | 6.101* | 2.838 | 0.186 | 0.037 | 5.296* | |
| HF | 2.910 | 3.584 | 9.730** | 2.914 | 7.738** | 0.136 | 4.011* | 20.788** | 8.237** | 4.063* |
| HZ | 0.497 | 0.019 | 0.869 | 0.576 | 0.464 | 3.149 | 0.004 | 0.527 | 0.001 | 1.037 |
| JN | 0.041 | 0.358 | 0.044 | 0.139 | 5.176* | 5.164* | 0.669 | 14.036** | 4.011* | 32.8919** |
| KM | 1.028 | 0.330 | 0.072 | 0.373 | 3.475 | 0.191 | 0.828 | 0.430 | 5.718* | 1.232 |
| LZ | 0.204 | 1.629 | 0.062 | 0.149 | 1.284 | 0.008 | 0.988 | 0.858 | 0.129 | 3.039 |
| NB | 0.616 | 0.222 | 0.078 | 2.144 | 6.372* | 1.092 | 0.022 | 1.453 | 1.896 | 2.281 |
| NC | 1.356 | 0.497 | 0.121 | 1.779 | 1.054 | 0.232 | 0.003 | 3.995* | 0.882 | 5.636* |
| NJ | 0.876 | 2.460 | 0.236 | 1.319 | 8.987** | 0.165 | 0.532 | 4.852* | 0.718 | 1.391 |
| NN | 0.265 | 3.023 | 1.887 | 0.028 | 1.058 | 0.151 | 0.003 | 1.766 | 0.876 | 10.624** |
| QD | 0.015 | 0.370 | 0.110 | 0.456 | 5.327* | 0.010 | 0.079 | 4.793* | 0.722 | 11.438** |
| SH | 0.283 | 6.174** | 1.350 | 0.424 | 2.442 | 0.208 | 0.249 | 9.369** | 0.063 | 15.323** |
| SY | 0.105 | 2.026 | 0.048 | 0.330 | 0.045 | 4.813* | 0.977 | 1.327 | 0.086 | 0.405 |
| SZ | 6.143** | 0.036 | 4.355* | 2.370 | 0.482 | 1.608 | 0.625 | 8.220** | 0.043 | 0.127 |
| TJ | 2.367 | 1.002 | 2.884 | 0.327 | 3.150 | 0.782 | 0.699 | 0.171 | 0.690 | 5.079* |
| TY | 0.682 | 4.902* | 0.673 | 1.327 | 0.312 | 0.207 | 0.259 | 4.509* | 4.680* | 11.691** |
| WH | 0.570 | 0.035 | 0.261 | 0.002 | 0.984 | 5.194* | 0.523 | 0.083 | 0.001 | 1.736 |
| XA | 0.536 | 0.244 | 0.356 | 0.070 | 0.436 | 0.800 | 0.260 | 2.044 | 0.000 | 2.201 |
| XM | 2.848 | 3.090 | 0.538 | 0.002 | 4.109* | 3.180 | 0.118 | 6.337* | 1.056 | 18.363** |
| YC | 1.204 | 2.908 | 2.597 | 0.014 | 5.483* | 8.523** | 11.862** | 7.059** | 2.716 | 21.159** |
| ZZ | 0.015 | 0.245 | 2.133 | 0.093 | 0.709 | 0.018 | 0.683 | 0.087 | 0.568 | 0.141 |

(continued)

**Table 27.7** (continued)

| | SH | SY | SZ | TJ | TY | WH | XA | XM | YC | ZZ |
|---|---|---|---|---|---|---|---|---|---|---|
| BJ | 0.011 | 1.475 | 0.235 | $9.725^{**}$ | 1.885 | $4.667^{*}$ | $4.904^{*}$ | 1.124 | $7.529^{**}$ | 0.588 |
| CC | 0.092 | 0.137 | 0.168 | 3.158 | 0.016 | 2.857 | 0.286 | 1.084 | 0.054 | 0.692 |
| CD | 0.027 | 0.412 | 0.986 | 1.176 | 0.094 | 1.903 | 0.890 | 1.098 | 0.443 | 0.198 |
| CQ | 0.033 | 3.772 | 2.522 | 3.471 | 1.431 | $5.812^{*}$ | $7.433^{**}$ | 0.303 | 2.094 | 0.975 |
| CS | 0.441 | 0.000 | 0.473 | 1.598 | $10.407^{**}$ | 1.372 | 0.080 | 0.067 | 0.494 | $5.775^{*}$ |
| DL | 3.196 | 3.259 | 0.495 | 3.429 | 0.298 | $11.292^{**}$ | 0.507 | 1.969 | 0.150 | 1.911 |
| FZ | 0.004 | 0.190 | 0.061 | 0.589 | 1.827 | $4.943^{*}$ | 3.022 | 0.000 | 3.325 | 0.798 |
| GY | 1.180 | $4.411^{*}$ | 1.471 | $15.135^{**}$ | 0.063 | $12.004^{**}$ | 1.672 | 1.411 | 3.475 | 1.783 |
| GZ | 0.004 | 1.388 | 0.104 | 1.698 | 0.012 | 0.001 | 0.561 | 0.578 | 1.364 | 0.285 |
| HEB | 0.060 | 1.695 | 1.996 | 0.003 | 0.440 | 0.165 | 2.919 | 0.004 | 0.008 | 0.029 |
| HF | 0.846 | $19.499^{**}$ | 2.002 | 0.111 | 0.130 | 0.612 | $7.602^{**}$ | 2.885 | 0.503 | $15.188^{**}$ |
| HZ | 0.705 | 0.048 | 1.634 | 0.392 | 2.324 | 1.249 | 0.141 | 0.149 | 0.328 | 0.000 |
| JN | 0.168 | $3.979^{*}$ | 0.000 | 0.388 | $7.590^{**}$ | 1.138 | 1.445 | $4.936^{*}$ | 1.506 | 1.362 |
| KM | 0.411 | 0.127 | 0.003 | 0.495 | $4.612^{*}$ | 2.231 | $5.409^{*}$ | 0.083 | 1.614 | 0.554 |
| LZ | 0.129 | 0.000 | 0.260 | 1.143 | 0.000 | 0.855 | 2.603 | 1.104 | 0.064 | 1.689 |
| NB | 0.014 | 0.459 | 0.710 | 0.835 | $5.517^{*}$ | 0.153 | 3.051 | 0.019 | $4.250^{*}$ | $7.479^{**}$ |
| NC | 0.127 | $6.217^{*}$ | 0.049 | 0.301 | 0.122 | 0.026 | 1.611 | 0.593 | $4.931^{*}$ | 0.035 |
| NJ | 1.889 | 1.107 | 0.204 | 0.372 | 2.281 | $9.152^{**}$ | 1.825 | $6.669^{*}$ | 0.186 | 0.692 |
| NN | 0.074 | 1.502 | 0.051 | 3.183 | 0.001 | 0.009 | 0.069 | 0.358 | 0.550 | 0.325 |
| QD | 2.224 | $16.987^{**}$ | 0.009 | 0.423 | 0.015 | $16.784^{**}$ | 1.437 | 1.066 | 3.355 | 0.006 |
| SH | | $6.500^{*}$ | 1.924 | $6.388^{*}$ | 0.795 | 2.027 | 0.980 | 0.227 | 1.512 | 3.162 |
| SY | 0.479 | | 0.403 | 0.165 | 1.328 | 1.611 | 0.000 | 0.381 | 1.841 | 0.299 |
| SZ | 0.009 | 0.582 | | 1.737 | 0.265 | 0.832 | 0.280 | 0.764 | 1.062 | 0.154 |
| TJ | 0.019 | $13.613^{**}$ | 3.592 | | 0.279 | $5.376^{*}$ | 0.521 | 0.474 | 1.242 | 3.080 |
| TY | 0.101 | 0.664 | 2.020 | 2.149 | | $4.118^{*}$ | 0.289 | 1.497 | 0.212 | 0.352 |
| WH | 0.116 | 0.106 | 1.528 | 0.382 | 2.662 | | 0.452 | 0.048 | 0.183 | 1.891 |
| XA | 0.055 | 0.089 | 1.921 | 1.100 | 0.066 | 0.039 | | 0.001 | 2.567 | $8.321^{**}$ |
| XM | 0.039 | 0.209 | 0.273 | $4.156^{*}$ | 0.544 | 0.005 | $6.079^{*}$ | | 2.541 | 0.169 |
| YC | 0.542 | $6.750^{**}$ | $8.193^{**}$ | 2.791 | $4.258^{*}$ | 2.754 | 1.106 | $4.924^{*}$ | | 2.664 |
| ZZ | 0.001 | 2.353 | 0.814 | 1.456 | 0.109 | 0.030 | 0.663 | 0.141 | $3.937^{*}$ | |

| | HF | HZ | JN | KM | LZ | NB | NC | NJ | NN | QD |
|---|---|---|---|---|---|---|---|---|---|---|
| BJ | 2.52 | 11.13** | 9.59** | 3.22 | 3.69 | 0.22 | 0.02 | 4.04* | 5.098* | 0.00 |
| CC | 4.31* | 0.03 | 4.99* | 1.26 | 4.90* | 0.22 | 1.03 | 0.21 | 2.23 | 0.09 |
| CD | 0.63 | 6.25* | 1.52 | 2.23 | 0.31 | 0.16 | 0.07 | 0.97 | 0.24 | 0.39 |
| CQ | 3.72 | 0.00 | 0.26 | 0.38 | 0.74 | 1.39 | 1.86 | 1.71 | 0.48 | 1.48 |
| CS | 0.66 | 0.63 | 0.20 | 0.79 | 2.79 | 0.15 | 0.94 | 3.12 | 1.47 | 4.23* |
| DL | 3.48 | 9.79** | 0.07 | 1.51 | 3.28 | 1.58 | 2.25 | 4.70* | 0.18 | 0.00 |
| FZ | 0.79 | 5.80* | 0.04 | 0.14 | 0.80 | 0.04 | 0.84 | 0.00 | 1.88 | 0.02 |
| GY | 3.34 | 16.48** | 4.46* | 9.12** | 3.59 | 0.77 | 6.98** | 5.291* | 12.86** | 2.09 |
| GZ | 6.48* | 3.33 | 2.37 | 5.45* | 0.52 | 0.51 | 0.21 | 6.047* | 4.50* | 2.33 |
| HEB | 0.58 | 2.00 | 0.44 | 1.77 | 0.16 | 0.03 | 0.91 | 0.37 | 0.00 | 0.63 |
| HF | | 5.29* | 2.90 | 0.04 | 2.43 | 0.27 | 4.02* | 0.09 | 1.85 | 3.78 |
| HZ | 3.08 | | 0.26 | 2.16 | 1.53 | 1.23 | 0.00 | 0.11 | 0.42 | 1.70 |
| JN | 7.50** | 4.14* | | 15.22** | 2.72 | 1.92 | 0.91 | 0.16 | 15.01** | 2.69 |
| KM | 1.05 | 0.00 | 6.19* | | 3.92* | 0.46 | 0.27 | 0.36 | 1.80 | 1.79 |
| LZ | 0.00 | 0.00 | 0.51 | 0.51 | | 0.00 | 0.72 | 1.13 | 1.11 | 0.44 |
| NB | 0.02 | 2.52 | 2.84 | 6.93** | 14.56** | | 1.51 | 0.16 | 0.59 | 9.90** |
| NC | 2.89 | 4.58* | 0.24 | 0.07 | 2.08 | 1.30 | | 0.06 | 0.08 | 1.05 |
| NJ | 0.85 | 0.01 | 3.34 | 5.85* | 18.40** | 0.32 | 0.10 | | 2.12 | 0.01 |
| NN | 4.86* | 0.00 | 2.04 | 7.55** | 0.11 | 0.51 | 0.32 | 0.55 | | 0.06 |
| QD | 0.27 | 0.53 | 4.36* | 8.10** | 3.96* | 0.68 | 0.55 | 1.33 | 2.82 | |
| SH | 1.52 | 4.85* | 2.86 | 0.87 | 0.01 | 0.50 | 0.40 | 1.43 | 2.93 | 0.08 |
| SY | 2.59 | 1.68 | 10.06** | 1.06 | 10.33** | 0.26 | 0.85 | 0.28 | 0.02 | 2.06 |
| SZ | 0.00 | 3.97* | 6.67** | 1.88 | 0.76 | 0.71 | 0.48 | 0.18 | 0.69 | 2.89 |
| TJ | 14.69** | 0.11 | 2.55 | 6.37* | 1.39 | 0.11 | 0.12 | 2.83 | 0.09 | 0.05 |
| TY | 0.93 | 2.01 | 4.20* | 2.71 | 0.18 | 0.22 | 0.27 | 2.72 | 1.87 | 1.15 |
| WH | 0.79 | 1.52 | 0.39 | 0.00 | 1.03 | 0.03 | 3.26 | 1.62 | 1.58 | 0.68 |
| XA | 0.51 | 4.78* | 2.71 | 0.06 | 0.80 | 0.57 | 0.00 | 0.00 | 3.23 | 0.37 |
| XM | 12.06** | 0.39 | 0.87 | 6.018* | 0.76 | 1.08 | 0.67 | 2.90 | 10.53** | 2.88 |
| YC | 0.02 | 0.06 | 1.93 | 17.05** | 1.19 | 0.62 | 1.08 | 6.592* | 9.87** | 1.45 |
| ZZ | 1.01 | 0.38 | 0.02 | 0.06 | 1.26 | 0.00 | 1.07 | 0.68 | 0.93 | 1.00 |

Note: H0: $\beta1 = \beta2 = \ldots = \beta k = 0$

Row variables as dependent variables, indicating a city's price fluctuations, column variables are the lag variables of each city's house price fluctuations. The figures in the table stands for the Chi-squared value

*, ** stands for 5 % and 1 % significance respectively

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# Chapter 28
# Policy Change from Affordable Housing to Public Rental Housing: A Comparative Analysis Based on IAD Framework

**Jiahui Shen, Yuzhe Wu, and Xiaoling Zhang**

**Abstract** At a time when affordable housing gradually withdraw from the stage of history and public rental housing instead become the main part of indemnificatory housing, in order to explore the efficiency of the policy change, as well as social welfare and housing affordability, this paper first combs the policy change of indemnificatory housing. Learning from the Institutional Analysis and development Framework put forward by Ostrom, this paper then builds the IAD framework of the indemnificatory housing policy change analysis. After that, it analyzes the short-term changes in efficiency and long-term changes in social welfare using econometric models. In the empirical part, this paper compares the reasonable price for the target groups and the current benchmark price of indemnificatory housing, taking Hangzhou for example. It can be concluded that policy change from affordable housing to public rental housing has enhanced the affordability of housing for middle- and low-income families, meanwhile, policy efficiency and social welfare have been increased, which is beneficial to the whole society.

**Keywords** Affordable housing • Public rental housing • Policy change • IAD framework • Social welfare

## 28.1 Introduction

Nowadays, with the rapid improvement of China's urbanization level, the concept of "home ownership" is further strengthened in everyone's heart. However, since the system of welfare housing has been abolished and replaced by the commercial

J. Shen • Y. Wu (✉)
Department of Land Administration, Zhejiang University, Hangzhou 310029, China
e-mail: shenjiahui@zju.edu.cn; wuyuzhe@zju.edu.cn

X. Zhang
Department of Public and Social Administration, City University of Hong Kong, Hong Kong, China

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residential building from 1998, the price of commercial residential building increased significantly. The issue of housing security for the middle- and low-income families has become a focused topic.

In fact, "the notice on further deepening the system reform of urban housing and speeding up housing construction" issued by the State Council in 1998 had made it clear that families of different income levels should be implemented with different housing supply policies. That is, high-income families should buy commercial housing according to the market price; middle-income families should buy affordable housing and low-income families should rent low-rent housing.

The concept of affordable housing was initially proposed in the 1990s and the "Twelfth Five-Year Plan" made it clear that within the next 5 years China will build 36 million units of indemnificatory housing. However in the past years, affordable housing hasn't formed a perfect mechanism. It has advantages such as more favorable price than commercial housing and full ownership comparing to public rental housing, which makes corruption and irregularities common occurrences in recent years.

It is precisely because that affordable housing has all kinds of problems, Zhengzhou stopped new affordable housing project in 2012; Shenzhen launched the last batch of affordable housing in February 2013 and Guangzhou suspended the application for affordable housing since April 2013 and included the new qualified people into the scope of protection of public rental housing...... Thus, it has become a general trend that public rental housing will replace affordable housing to be the main part of indemnificatory housing.

## 28.2 Literature Review

On the issues of housing security, foreign scholars mainly focused on two aspects. The first one is the link between indemnificatory housing policy and social justice. Charles, Sinan and Kuzey developed a general equilibrium model of residential choice and study the effects of two housing aid policies, public housing units and housing vouchers [1]. Anniz and Mazlin addressed the challenge of finding innovative ways to reduce the cost of building houses making it affordable for every family and then provided a theoretical alternative – the Affordable Mosaic Housing concept as a possible inventive solution [2]. Another aspect is how to balance the relationship between indemnificatory housing policy and market economy. Bruce and Alex studied the new indemnificatory housing policy in the UK which claimed the rent of public housing should be determined with reference to those obtaining in the local private rented sector [3].

As China has been implementing a welfare housing system for a long period, the research on indemnificatory housing started late. In the areas of macro research, Su Duoyong and Zhang Yuxiang analyzed the reasons for the shortage of indemnificatory housing supply from deficiencies in the system, land finance and other perspectives [4]. Ren Pengchong and Ren Fanxing concluded the experience for the sustainable development of indemnificatory housing after comparing the indemnificatory housing policies in Germany, the U.S. and Singapore [5].

In the areas of micro research, scholars focused on the price of affordable housing and public rental housing, using many models to conduct quantitative study. Zhang Shuangtian and Luo Xiaogeng built the autonomous decision-making model of local government and incentives model of central government to research the price of indemnificatory housing [6]. Using system dynamics model, Fu Hongyuan, Chen Yuhong and Liang Huaiqing predicted per capita annual income of middle- and low-income families and then measured the reasonable price of indemnificatory housing, taking Chongqing for example [7]. Wu Di, Gao Peng and Dong Jichang established the Comprehensive regional cost pricing model for public rental housing in order to find the reasonable price that people could afford [8].

## 28.3 Conception of IAD Framework for Housing Policy Change in China

### *28.3.1 Policy Review*

Chinese indemnificatory housing policy has been dramatically changed for 15 years since it is first developed in 1998. Let us look at these changes in retrospect.

In 1998 the State Council issued "on further deepening the system reform of urban housing and speeding up housing construction," which defined to provide different housing policy for families with different income and proposed to establish affordable housing based multi-level urban housing supply system.

In 2003 the State Council established the real estate industry as a pillar of the national economy and emphasis was to be placed on the commercial housing, which resulted in inadequate supply of indemnificatory housing and made the housing problems of "sandwich-layer" groups even tougher.

Housing policy after 2007 returned to indemnificatory housing based livelihood security policy orientation and in 2009 central government made it clear that public rental housing will become the main form of indemnificatory housing in the future. Under this policy guidance, the country's various types of affordable housing construction volume changed significantly.

Early in 2011 released of economic and social development Twelfth Five-Year Plan clearly emphasized the importance of the development of public rental housing. At the same time, as affordable housing is susceptible source for corruption, irregularities and difficult to meet the affordability of target groups, from 2012 to early 2013, Zhengzhou, Shenzhen, Guangzhou and many other regions have clearly announced the exit of affordable housing and public rental housing will become the main part of indemnificatory housing.

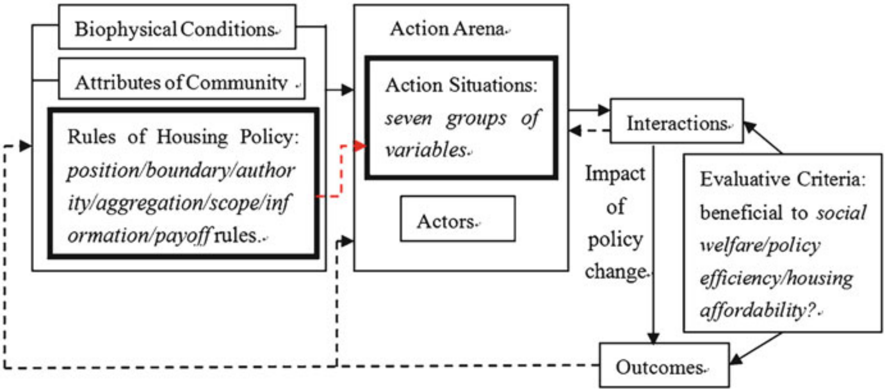


**Fig. 28.1** Schematic of IAD framework on indemnificatory housing policy analysis

### *28.3.2 Building of IAD Framework on Housing Policy Analysis*

Institutional Analysis and Development framework (IAD framework for short) is proposed by Ostrom, who won the 2009 Nobel Economics Prize. The framework is a generic term about rule, natural and physical conditions how to affect the action situations and outcomes. It is widely used in governance of common pool resources. This paper introduces IAD framework into analysis on policy change of indemnificatory housing, building of IAD framework on housing policy analysis is shown as below.

In general, biophysical conditions, attributes of community and rules-in-use act as exogenous variables. Action arena, a kind of social space where the interaction between stakeholders groups happen, including two variables: action situations and actors. And action situations act as endogenous variable.

In the policy change from affordable housing to public rental housing, regime change of housing policy, which refers to government selling affordable housing to middle- and low-income families in the past but now renting public rental housing to them, is the independent variable. Biophysical conditions and attributes of community are unchanged overall and there are seven groups of variables in action situations which can affect on the outcomes: (1) Set of participants, (2) participants' identities, (3) allowed collection of behaviors, (4) association with the outcome, (5) decision-making control, (6) available information, (7) cost and benefit. Meanwhile, Ostrom also divided the rules which restrain participants' action into seven categories, that is (1) position rules, (2) boundary rules, (3) authority rules, (4) aggregation rules, (5) scope rules, (6) information rules, (7) payoff rules. It is believed that each category of rules corresponds to a set of variables in action situation and change of rules could affect on one or more variables.

Figure 28.1 also shows how rules affect variables in action situation in the policy change of indemnificatory housing. Our research emphasis is what on earth happens to social welfare, housing affordability and benefit coverage of housing policy after the interaction of rules and action situation.

## 28.4 Comparative Analysis Between Affordable Housing and Public Rental Housing Based on IAD Framework

### *28.4.1 Changes of Rules*

Boundary rules declare the conditions and criteria required for those who want to apply for indemnificatory housing should have. Only when people are qualifying, could they become the participants. In the process when public rental housing replace affordable housing to be the main part of indemnificatory housing, changes of boundary rules expand the scope of security object. Apart from the middle- and low-income families with local household registration, the new employments of university graduates and migrant workers who have a stable job also have the right to apply for public rental housing.

Payoff rules are about rewards and sanctions. In this paper, the focus of payoff rules is the exit mechanism of indemnificatory housing. In the past, after symbolically paying land premium, affordable housing buyers can obtain full property rights of the house and then enter the market. That is to say, the lack of exit mechanism allowed buyers to continue having affordable housing even after their economic strength increased. As a result, the sustainability of affordable housing greatly reduced and power corruption occurred. However, public rental housing holders should submit an application to renew the lease and only when they pass the qualifications re-examined by the government department in charge of housing security, could they continue renting the house. So the changes and perfections of payoff rules better achieve the value of indemnificatory housing and make it transform from disposable indemnificatory housing to transitional one.

### *28.4.2 Comparative Analysis on Social Welfare*

#### 28.4.2.1 Short-Term Changes in Efficiency

As shown in the Fig. 28.2, assuming at the initial stage, the supply curve of affordable housing is *s*, the demand curve is *d*. Because the lack of affordable housing exit mechanism, after a certain time, buyers who pay a nominal land premium can obtain full ownership of affordable housing, which makes affordable housing enter the market and has the same general nature as real estate. In the short term, it is difficult for governments and developers to respond to market conditions, so the affordable housing supply suffers a shortage. Therefore, the supply curve translates inward to $s1$. On this occasion, the equilibrium point is $a$, the equilibrium price is $p1$and the equilibrium quantity is $q1$. We could see the consumer surplus is the area of $\triangle ep1a$, the producer surplus is the area of $\triangle cp1a$ and social welfare is the sum of both, that is the area of $\triangle eac$.

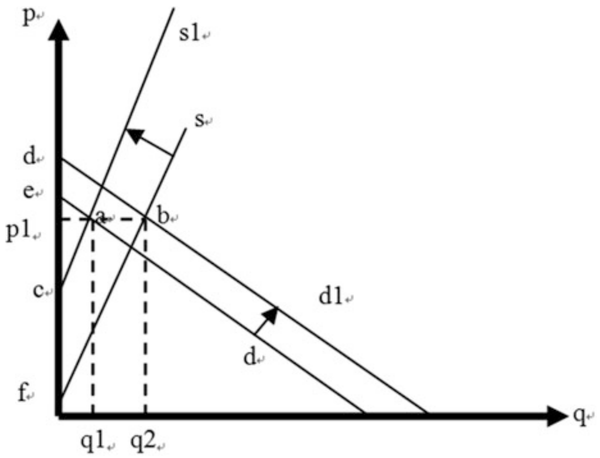


**Fig. 28.2** Supply and demand curves in short-term

As the application of public rental housing exceeds residence restrictions, its demand increases comparing to affordable housing and the demand curve translates outward to *d1*. Since the exit mechanism of public rental housing is better, householders are required to vacate their house when their economic strength increases and no longer belong to the "sandwich- layer" group. In the short term, the amount of public rental housing supply won't be in a significant reduction, so the supply curve can be considered unchanged, still be as *s*. On this occasion, the equilibrium point is *b*, the equilibrium price is *p1* and the equilibrium quantity is *q2*. We could see the consumer surplus is the area of $\triangle dp1b$, the producer surplus is the area of $\triangle fp1b$ and social welfare is the sum of both, being as the area of $\triangle dbf$.

Through the analysis above, it is noticeable that the policy change from selling affordable housing to renting public rental housing keeps the equilibrium price almost unchanged, while the equilibrium quantity is increased from *q1* to *q2*. Obviously, the area of $\triangle dbf$ is larger than that of $\triangle eac$, which means policy change have increased both the social welfare and efficiency of housing policy.

#### 28.4.2.2 Long-Term Changes in Welfare

In the long term, the indemnificatory housing supply from government and developers needs to be considered. Government reduces the land-transferring fees and related taxes to reduce the construction cost of affordable housing in order to achieve the housing security for middle- and low-income families indirectly. In contrast, the property of public rental housing is owned by government or public bodies and lessee get public housing at a price cheaper than market rent. If lessee's income is under local standards, rental subsidies will be provided by the government. To sum up, when it comes to the government subsidies in the long term, for affordable housing it is subsidies per brick and for public rental housing it is subsidies per person.

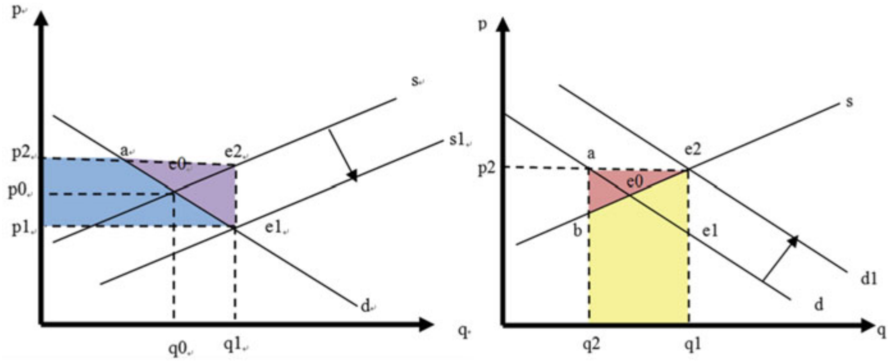


**Fig. 28.3** Supply and demand curves of subsidies per brick and subsidies per brick

The left one in Fig. 28.3 shows the supply and demand curves of subsidies per brick for affordable housing. The supply curve is *s*, the demand curve is *d*, the equilibrium point is *e0*, corresponding to the equilibrium price *p0* and the equilibrium quantity *q0*. Because of the subsidies per brick, the reduction of the construction cost results in the supply curve's moving outwards to *s1*, intersecting the demand curve at *e1*, corresponding to the new equilibrium price *p1* and the new equilibrium quantity *q1*. It can be seen that under the action of subsidies per brick, the positive effects is the prices of affordable housing decreases while the quantity increases.

Assuming without subsidies per brick provided by government, in order to achieve supply quantity *q1*, the actual price developers could get is *p2*. The area of quadrilateral *p1p2e2e1* is the housing subsidy government paid for middle- and low-income families, among which the area of quadrilateral *p1p2ae1* is obtained by purchaser, namely consumer surplus, but the area of $\triangle ae1e2$ is neither obtained by consumer nor by provider. The loss of social welfare shows its low efficiency.

The right one in Fig. 28.3 shows the supply and demand curves of subsidies per person for public rental housing. Assuming in order to achieve the same supply quantity *q1* as affordable housing, the demand curve translates outward to *d1* in the condition of subsidies per person, intersecting the demand curve at *e2*, corresponding to the new equilibrium price *p2* and the new equilibrium quantity *q1*.

Without the subsidies per person, when the price of Public rental housing on the market reaches *p2*, the actual demand is only *q2*. The area of quadrilateral *q1q2ae2* is the currency subsidy paid by government, among which the area of $\triangle abe2$ is obtained by provider, namely producer surplus while the area of quadrilateral *be2q1q2* is obtained by consumer, namely consumer surplus. It is sure that the policy of public rental housing is of high efficiency because social welfare is all obtained by suppliers and consumers.

## 28.5 Empirical Analysis

This paper studies the policy change of indemnificatory housing and its impacts from an affordable housing based mode to a public rental housing based mode. It is in 2009 that the national government clearly stated that public rental housing will be the main part of indemnificatory housing, so at present, many cities' public rental housing projects are still in the construction phase, which makes empirical analysis on social welfare difficult to carry out. In this part, taking Hangzhou as an example, policy change's impacts on housing affordability will be the focus.

### *28.5.1 Study on the Affordability of Affordable Housing's Price*

Firstly, effective demand price model is built as $P = \frac{bY[(1+i)^n-1]}{12aMi(1+i)^n}$. Where, $b$ is the ratio of housing consumption, $Y$ is the average annual disposable income, $i$ is the monthly interest rate, $n$ is the number of months, $a$ is the loan-to-value ratio and $M$ is the housing area. Secondly, try to determine the value of these parameters according to Hangzhou Statistical Yearbook for 2012 and other related data. Then plug the above values into the effective demand price model for housing, we could get the reasonable housing price for middle- and low-income families is $P = 2{,}651.44$ yuan/square meter. By looking up the price of the 24 different properties for affordable housing in Hangzhou and sorting them by geographic location, we could get the average price of affordable housing prescribed by Hangzhou government regulation is $P0 = 3{,}022$ yuan/square meter. It is obvious that $P0 > P$, and the gap between the two is 13.98 %. This means that under the existing affordable housing policy system, middle- and low-income households still have big difficulty buying affording housing, and there are still difficulties achieving housing affordability.

### *28.5.2 Study on the Affordability of Public Rental Housing's Price*

Public rental housing is primarily designed for sandwich-layer groups, including low-income, middle- and low-income, middle-income groups. Still according to the data from Hangzhou Statistical Yearbook for 2012, the reasonable housing rents they could afford are shown in Table 28.1.

From May 2012 onwards, considering the costs and administrative expenses as well as the lessees' economic capacity, Hangzhou Price Bureau announced the prescribed rents of public rental housing. The rents are different according to the

**Table 28.1** Rent for different income groups can afford (yuan/month/sqm)

| Income groups | Low-income | Middle-and low-income | Middle-income |
|---|---|---|---|
| Affordable rent | 20.99 | 34.56 | 44.55 |

**Table 28.2** Prescribed rent of public rental housing in Hangzhou (yuan/month/sqm)

| Land grade | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Normal rent | 36 | 32 | 29 | 27 | 21 | 16 | 12 | 10.5 |
| Reduced rent | 25.2 | 22.4 | 17.4 | 16.2 | 10.5 | 8 | 6 | 5.25 |

grades of land, and low-income families that meet the standards of urban minimum living guarantee could enjoy a certain rent relief on this basis. Specific amount of rents are shown in Table 28.2.

We know that siting of Hangzhou public rental housing are relatively peripheral due to urban planning, and most of them are located on land on or under the 3rd grade. Compare the data from Table 28.1 and Table 28.2, we find that for low-income families, the reduced rent according to the policy is lower than the actual rents then can afford; for middle- and low-income and middle-income groups, the prescribed rent is much lower than the affordable rent. In other words, large scale of families benefit from the existing public rental housing policy, and the income of the target groups could afford the rent. To sum up, the policy changes is useful for enhancing housing affordability of disadvantaged groups in Hangzhou.

## 28.6 Conclusions

This paper builds the IAD framework on policy change of indemnificatory housing to investigate the effects of it. The conclusions can be draw as follows.

1. The most intuitive phenomenon is that indemnificatory housing policy changes from selling rooms to renting housings to people, which makes more people's housing problems, especially the sandwich layer group, be guaranteed.
2. The mechanisms of entry and exit become more rigorous and comprehensive, which ensures the liquidity of public rental housing market, making affordable housing sustainable.
3. The policy change further eliminates corruption and reduces monitoring costs.
4. The policy change makes the equilibrium price remain unchanged and the equilibrium quantity increased, as well as social welfare and policy efficiency improved in the short-term. Meanwhile, In the long-term, it makes both the equilibrium price and quantity increased but avoid the loss of social welfare.
5. In Hangzhou, the benefit of the policy change is that the housing affordability greatly enhanced and group of housing security extended, which show the policy change is giving superiority.

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# Chapter 29
# The Fluctuation Research of the Real Estate Cycle in China

**Yachen Liu, Siqi Niu, and Jian Ma**

**Abstract** The effect of current fluctuations in the real estate cycle for national economy has become increasingly salient, so the fluctuation research in the real estate cycle will become the core issue of the real estate research. Because the real estate industry is affected by endogenous factors and external factors, thus it created a certain cycle fluctuations, fluctuations is beyond a certain range, macroeconomic will cause great harm. This paper overview research progress and method of domestic theoretical circles in recent years about the real estate cycle. It starts from the study of the concept of the real estate cycle, the choice of the evaluation, measuring method and others' several aspects. It proposes the problem of the study and the direction needing to expand.

**Keywords** Real estate • Real estate cycle • Fluctuations

## 29.1 Overview of Real Long Cycle Fluctuations

### *29.1.1 The Concept of Fluctuations in the Real Estate Cycle*

For the real estate cycle, the concept of the real estate cycle fluctuations, mainly the following six perspectives:

(a) Real estate cycle, fluctuations in the real estate cycle (Ho Kwok Chiu et al. 1996). In this view, the real estate industry in the development process of the fluctuations shows periodic cycle fluctuations of the four stages of the recovery, prosperity, recession and depression, thereby it forms a real estate cycles or fluctuations in the real estate cycle [1].

Y. Liu • S. Niu (✉) • J. Ma
School of Management, Shenyang Jianzhu University, Shenyang, China
e-mail: nsq0920@126.com

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(b) Real estate fluctuations in the economy, real estate economic cycle (Liang Gui 1996). In this view, under the premise of the general market economy, real estate aggregate supply and demand fluctuations shows a characteristic of cyclical fluctuations [2]. Thereby forming a real estate business cycle, it is classified into real imbalance between supply and demand – the market to become more active – prosperity – tightening – depression five stages.

(c) Fluctuations in the real estate cycle (Tam 1993, 1994). In this view, the real estate development that is similar to the macroeconomic cyclical fluctuations also exists the phenomenon of cyclical fluctuations. Although the length and amplitude of the fluctuations of the real estate cycle is different, but it is the same as the macroeconomic cycle fluctuations. It also includes four stages of recovery and growth, the prosperity crisis and recession, depression.

(d) The real estate boom, real estate business cycle [3]. This view is popular mainly in Taiwan, Hong Kong scholars. The so-called business cycle is that the rise of economic activity (the economy) and recession (recession) is delivered to each other recurring. Similarly, the real estate business cycle is the real estate activities of the various stages of real estate development, construction of housing, real estate marketing, use, maintenance and services, retirement phases or aspects.

(e) Real estate economic operation cycle or real estate economic cycle operation process (Chen Baidong and Zhang Dong 1996). Point of view, the real estate economy operating cycle is that the real estate economy in a cycle of continuous circular motion passes the process of all phases and aspects. As a starting point to the production of real goods, it includes real estate development, construction of housing, real estate marketing, use, maintenance and services, retirement stage or links [4].

(f) Real estate life cycle. Being similar to a three-stage (investment – production – using) of any product life cycle, the life cycle of real estate displays the cycle of repetitive processes of the four stages. More than six views can actually be grouped into two categories. The first four view is defined from the point of view of the economic cycle in the real estate cycle or real estate cycle fluctuations, and the real estate cycle is basically divided into expansion and contraction in the stage of recovery – prosperity – recession – depression four processes. What makes it different is only the economic cycle or business cycle, real estate or real estate uses a different formulation. The latter two views are defining the real estate cycle in the light of the operation of the real estate industry. Only the selected formulation is different, one is called the real estate life cycle, all belong to the objective process of the operation of the real estate industry, or a necessary stage of the real estate activities. Taken together, the six point of view, two categories view above-mentioned, it reveals the real estate cycle to some extent, but there are still the place to be improved. For example, some real estate cycle is equivalent to the running of the real estate industry, in fact, it is beyond the scope of the economic cycle; some are not from the real estate cycle, it is easy to lead to conceptual confusion or ambiguity. In addition, most of these definitions is not clearly distincted and defined the for the concept of the real estate fluctuations, the real estate cycle, real cycle fluctuations and so on, it may lead to conceptual confusion [5].

### 29.1.2 Characteristics of the Fluctuations in the Real Estate Cycle

According American scholar Stephen E. Roulac discussed in his classic paper, "real estate business cycle and the meaning of its investors and portfolio managers in the global economy", the basic characteristics of the real estate business cycle and its cycle [6]:

(a) In a growth-oriented economy, the rise and boom phase of the cycle occupied a dominant position, its duration is longer than the downturn and the bottom.
(b) The long-term trend of the supply and demand in the growth-oriented economy was positive slope, the peak of a cycle is always higher than the last time, it is on the contrary in a recession-based economy.
(c) The fluctuations in the supply are often more intense than the fluctuations in the demand. In the real estate boom phase, the excessive optimism of the lending banks and developers tend to increase in the supply greatly beyond the demand, in a recession phase, the excessive pessimism of the lending banks and developers tend to make the supply excessive decline less than the level of the decline in the demand.
(d) The demand cycle is often ahead of the supply cycle in some time. Planning and design, financing and construction time (i.e. the time lag effect) often enable exploitation not to keep up with changes in the demand.
(e) The best cycle indicator is vacancy rate. At the peak of the cycle, the vacancy rate reached its lowest point, and then slowly rised; In the bottom of the loop, the vacancy rate reached a peak and then slowly declined.

## 29.2 The Evaluation Index of the Real Estate Cycle

### 29.2.1 Type of Evaluation of the Real Estate Cycle

Currently, the real estate cycle model that the domestic judged is still immature, there is no uniform method [7]. But summed up in three ways: single-indicator approach, the diffusion index (DI) and the composite index (CI).

For single indicators, domestic scholars held different views. Some people think it should be the residential annual sales (Lianggui 1996), some people think it should be the real estate sales (Zhang Yuan end 2002; Bo Shengjuan 2006) for evaluation indicators, as well as people think it should use real estate sales prices [8]. The different scholars choosing the single indicators have their own point of views, no scholars have done a very scientific or authoritative argument so far. The advantages of the single indicator approach is simple, there-use of research results is good and horizontal comparability is strong. The drawback is that the real estate cycle fluctuations in the economy of the entire real estate cycle, the fluctuations process of any one economic variable itself is not sufficient to represent all of the fluctuations process.

The diffusion index is the most used method that can more accurately determine a turning point in the economic cycle. A typical representative of He Guozao et al. (1996) select the price of commercial housing, new urban residential area, completed in the area of urban residential real residential construction area, real housing construction area of urban residential investment, practitioners, real estate transaction area of eight indicators, the diffusion index for data processing, the result for an overall measure; The other is when Tan Gang [9] studied the Shenzhen real estate cycle fluctuation, he selected 6 categories and 16 indicators, followed by aggregate indicators of the real estate industry, real estate investment categories of indicators, indicators of real estate production class categories of indicators of real estate transactions, real estate financial indicators, categories of indicators of real estate prices. The diffusion index method is a comprehensive variety of time series, but did not take the amplitude of the fluctuations into account and did not reflect the depth of the contraction and strength of the recovery. In addition, in recent years, China's real estate industry develops rapidly, all of the indicators value almost increase. In this case, the method can not clearly depict the state of development of China's real estate industry, can not be accurately divided into different stages of cyclical fluctuations. Therefore, further analysis of the economic cycle need such an index, the index can not only match different time series together, but also the amount will be reflected. Synthetic index method can overcome the deficiencies of the first two, can well reflect the turning point and volatility, but its choice of indicators and determining the weights is more difficult.

Synthetic index method can specifically use Analytic Hierarchy Process (AHP) or principal component analysis to solve weight problems, or simply use the simple arithmetic average method. For example, Huang Liming [10] using the composite index method (principal component analysis) analysis the real estate cycle of Guangzhou 1998–2005. The selected indicators are: real estate value added growth, the growth rate of real estate housing construction area, the growth rate of completion of the housing area, real estate sales area growth rate, the growth rate of the actual sales price of the real estate, real estate development and investment growth rate, GDP growth rate.

### *29.2.2 China's Current Real Estate Market Comprehensive Evaluation Method to Select*

Cluster analysis is also known as group and class analysis, it is a multivariate statistical method in accordance with the intimacy of nature and the degree of similarity of the individual (variable or sample) to classify. Luo Yue and Zhang Xinli (2006) use Q (samples) of system clustering method to calculate the China's real estate cycle, the results consistent with the objective reality of the real estate development in China. Cluster analysis on the basis of the combination of historical data, the understanding of the clustering results can enhance system knowledge, insight and judgment speed of the decision-maker. Using this simple and easy to use, accurate clear multivariate statistical tools for analysis, cluster analysis method has the advantage with respect to other methods: more fully than the diffusion index method to use sample data, to improve the real estate development phasing and defined scientific and accurate; through the analysis of the clustering results between different unit size, it determines the strength of the fluctuations in the economy and thus overcomes the limitations of the diffusion index method that it can not determine the strength of the economic fluctuations.

### *29.2.3 Real Estate Cycle Identification Based on Artificial Neural Network*

The basic idea of recognition model of the real estate cycle based on artificial neural network: Firstly, to take reflecting the value of the real estate cycle indicators as the input of the artificial neural network, it will be used to describe the output cycle stages of development terminology encoded to form the basic framework of artificial neural network; Secondly, time series analysis method studies the stage of cycle development of the real estate market in the past calendar year, using this training samples to train the neural network. When artificial neural networks are well-trained, the network can extract the sample implicit characteristic relationships, these feature information stored in the weight vector of the network; Finally, using the trained neural network handle the need to identify the index data, output cycle will identify result with a code that corresponds to the description of the term of a cycle stages of development. Jun Zhu and Zhang Quan [11] establish the Beijing real estate market cycle recognition model based on artificial neural network, and the use of time series analysis method distinguish cycle stages of learning samples. The selection of identify indicators of the real estate cycle is the key to establish artificial neural network cycle recognition model, only the formation of a certain index structures and systems can reasonably reflect the real market situation, the model can be reasonable and effective. At the same time, the number of training samples is the key to improve the accuracy of the model, these two aspects are the bottleneck of the domestic real estate cycle [12].

## 29.3 Problems in the Study of the Domestic Real Estate Cycle

### *29.3.1 Theoretically Weak*

The theoretical foundation is weak, which is a common problem for China's economic class, it is difficult to quickly improve in the short term; The poor research mainly refers to that under the specific historical conditions and institutional conditions, data collection, practical research is difficult, which resulted in setting and study of the indicator system often failed due to data collection difficulties; The analysis of the characteristics of the real estate cycle and policy ideas constitute a major feature of domestic research of the real estate cycle, this research method that combines practice and policy is able to adapt to the needs of China.

### *29.3.2 The Research of Domestic Real Estate Cycle Is Little*

It only notices the real estate industry with the similar period of the general business cycle fluctuations in the empirical analysis of China's real estate cycle, the unique combination of industry and product in the research of the real estate cycle fluctuations need to be strengthened. Research index system is disordered, chaotic oriented, no one is more authoritative indicators to measure the development of the real estate cycle, the current housing index and national housing can not be generally used by institute because of the complexity of indicators [13, 14].

We should further investigate the microscopic effects and counter measures in the real estate cycle fluctuations. The "real estate cycle microscopic explanation: Behavioral Economics and Empirical Methods" of Guan Tao [15] explains the causes of the real estate cycle from the individual microscopic point, creating its kind of a domestic real estate cycle with behavioral economics studies, but its effect has not fully developed. This cycle should be mainly from the perspective of real estate development enterprise strategic planning and investor's investment strategy, studying different stages of the real estate cycle, development companies and investors should take what measures to deal with.

In recent years, the research of the emerging regional real estate market cycle fluctuations make up the blank that the whole of the real estate cycle fluctuations dominated. But the research of the city's real estate fluctuations is very different, Either the selection of evaluation index or cycle measurement is different, which increases the difficulty of the real estate cycle in different cities to make comparisons, the literature that the form and causes of the cycle between different cities were analyzed and compared has almost none.

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# Chapter 30
# An Analysis on the Important Factors Affecting the Housing Price—Based on a Five-Party Game Model

**Li Ye, Xinmei Zhang, and Suhong Li**

**Abstract** Currently, China's real estate market relies on direct financing driven by market demand, and is affected by multiple stakeholders, therefore, regulations of real estate market can easily encounter dilemmas. In order to keep the fluctuation of housing prices under control and to avoid impeding macro-economy development by the regulations, all stakeholders should be included into the analysis framework. In the present article, analyzing from the views of stakeholders, we established a five-party mixed game model, including central government, local government, banking institutions, real estate developer and evaluating institutions into the framework, to calculate the equilibrium solution from different alliances and searched for the most important factors affecting housing prices in China. Accordingly, we explored the direction and strength of the optimal regulation to housing price and provided policy recommendations for the government.

**Keywords** Price fluctuations • Five-party mixed game • Price control

## 30.1 Introduction

China's real estate industry relies on direct financing driven by market demand. Ostensibly, housing price is affected by the balance between supply and demand, while in reality, it fluctuates according to the combined effects of the different stakeholders in the real estate market. However, the effects on the price are varying between the key factors, such as central government, local government, financial

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L. Ye (✉) • X. Zhang • S. Li
School of Economics and Management, Hebei University of Technology, Tianjin, China
e-mail: yeli_cn@163.com; zhangxinmeizhao@126.com; lisuhong@hebut.edu.cn

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institutions, real estate developers and evaluating institutions during the process of game. What's more, the regulation of the housing price in China is currently entering its bottleneck period. It is essential to exploit the most important factors affecting the price fluctuation in the regulations, so as to avoid impeding macro-economy development or giving up our early efforts before the regulations are nearly completed. For this issue, the results of previous studies provided a solid theoretical foundation for this article.

Unreasonable price fluctuations will affect the running of the macro-economy, and even lead to financial crisis [1]. So, central government should necessarily control the prices appropriately to weaken the adverse impacts of the price fluctuations on the macro-economy. The price fluctuations are influenced to varying extents by different stakeholders in the real estate market, therefore a number of researchers explored the factors that affect the prices based on a game model, and provided the corresponding recommendations for the central government's policy. Jingkui Zhou et al. [3] analyzed the impacts of different game behaviors of the commercial banks and evaluating institutions on the housing prices by constructing a two-party game model including commercial banks and evaluating institutions, and eventually pointed out that central government should facilitate the establishment of a cooperative alliances between commercial banks and evaluating institutions; whereas, Qiang Qiao et al. put central government and local governments—the most important two stakeholders in the real estate market—into the model for analyzing, and drew a conclusion that the pursuit of profit by local governments in the game have an important impact on the housing price. Consistently, Jianrong Yang et al. [5] introduced developers and consumers into the game model, establishing a tripartite game model involving local government, developer and consumer, eventually got the similar results with Qiang Qiao et al., that local government plays a considerably important role in the course of the game, so central government should give the full consideration of the interests of local governments to develop a reasonable policy to mobilize their enthusiasm, and promote their active participation in regulating the prices; With the development of the international economic integration, international speculators become an important subject in the real estate market. Therefore, Lingling Mu et al. [7] introduced international speculators as one of the factors into the game model, drew a conclusion by their analysis, that the alliance between local government and international speculators or real estate developers can affect the fluctuations of housing price in China's real estate market, which can be aggravated by the information asymmetry. Hence, central government should pay more attention to the role of information during the regulatory process.

In summary, the results of previous researches underlay the development of game model for the present study. Meanwhile, it should be noted that previous studies focused on only one or several of the stakeholders in the real estate market, instead of taking all factors into account, resulting in that (1) not all the major stakeholders of the chain in the real estate market are included; (2) different degrees of market development are not including in the framework of analysis; (3) no specific quantifiable policy recommendations can be provided for the government.

Therefore, we built a mixed game model for the real estate market by including major stakeholders, such as central government, local government, banking institutions, real estate agents as well as evaluating institutions into the analysis framework. Based on this model, we got the solution under the conditions of different alliances of the factors, defined the most important factors affecting the price, and provided quantifiable policy recommendations for the government.

## 30.2 The Five-Party Mixed-Game Model

### *30.2.1 Factors in the Game and Assumptions of the Model*

Central government, local government, real estate developers, banking institutions and evaluating institutions are the participants in the five-party game model, their objective functions are set as $M_C$, $M_L$, $M_H$, $M_B$ and $M_E$, respectively.

#### 30.2.1.1 Central Government

During the courses of the game, central government decides the proportion of housing price contributing to the revenue of the central government, indicated as $b_1$; the proportion of the financial support from central government accounted for the total investment of affordable housing, indicated as $\gamma$, and the regulatory costs of central government, indicated as $n_1$ [8].

#### 30.2.1.2 Local Government

Local government decides the proportion of housing price contributing to the revenue of the local government, indicated as $b_2$, the investment of affordable housing, indicated as $m$ and the regulatory costs of local government, indicated as $n_2$ [8]. Revenue of local government includes: the revenue of land sales, tax revenue, as well as the financial support from central government for the construction of affordable housing. Therefore, the objective function of local government is: $max\ M_L = b_2P + \gamma m - \alpha_1 m^2 - \alpha_2 n_2$.

$\alpha_1 m^2$ represents the local government's cost of the construction of affordable housing, $\alpha_1$ is the coefficient of local government's cost in the construction of affordable housing, $\alpha_2$ is the cost coefficient for the supervision of local government, and $0 < \alpha_2 < 1$.

**Table 30.1** Banking institutions and evaluating institutions game matrix

| | Banking institutions | | | |
|---|---|---|---|---|
| | Market booming | | Market downturn | |
| Evaluating institutions | Employed | Not employed | Employed | Not employed |
| Over evaluation | r + βl, r + hA | 0, −flr | 0, −flr | 0, −flr |
| Normal valuation | r, −lr | 0, −flr | 0, −lr | 0, −flr |

#### 30.2.1.3 Real Estate Developers

In real estate market, developer decides the housing price, indicated as $P$, following the principle of profit maximization, the objective function is: $max\ M_H = (1 - b_1 - b_2)(1 - r)p - \alpha_3 p^2$.

By removing the revenue paid to the central government and local government as well as reimbursement of interest on loans, we get $(1 - b_1 - b_2)(1 - r)p$, which represents the income of the developers in real estate market; $\alpha_3 p^2$ represents the cost of construction. $\alpha_3$ represents the cost coefficient for developers.

#### 30.2.1.4 Banking Institutions

Banking institutions determine the level of interest rates, indicated as $r$, following the principle of profit maximization, the objective function is: $max\ M_B = k\alpha_4 r^2 - \alpha_5 r_e$.

$k$ represents the asset quality factor of real estate developers, ranging from 0 to 1; $r_e$ represents the assessment cost of banking institutions for employing evaluating institutions, it is associated with the interest rate $r$.

#### 30.2.1.5 Evaluating Institutions

Evaluating institutions choose the normal valuation or over-valuation for real estate developers. Game payoff matrix is shown in Table 30.1.

When local governments increase efforts to support the affordable housing, real estate market appears downturn, we assume: $\theta = e^{-\delta m}$ ***i.e.*** the real estate industry shows slump with the local government increasing the support to affordable housing.

### *30.2.2 Equilibrium Solution of the Game*

As in other markets, there is also a gradually maturing process in the real estate market. The competition is not sufficient in an immature real estate market, so various stakeholders have to establish alliances to ensure their rights and interests. Whereas, in a mature real estate market, various stakeholders will be in full compliance with the rules of the market, and form a fully competitive state without establishing an alliance. At present, China's real estate market is in an immature stage, showing three different types of alliances: (1) local government, real estate developers and evaluating institutions, (2) central government, local government and evaluating institutions, (3) central government, banking institutions and evaluating institutions. Accordingly, we start our game process as following.

#### 30.2.2.1 Alliance 1—Local Government, Real Estate Developers and Evaluating Institutions

① If local governments, real estate developers and evaluation institutions build alliances, in any case, local governments and real estate developers require evaluating institutions to select over-valuation, therefore, the assessment cost of banking institutions is: $r_e = flr$. Taking the converse solution method, we get: $r* = \frac{\alpha_5 lf}{2k\alpha_4}$.

② If local government and real estate developers build alliances, local government will not take the proportion of house income $b_2$ into its revenue, meanwhile, the objective function of the real estate developers is: $max\ M_H = (1 - b_1)(1 - r)p - \alpha_3 p^2$, putting $r* = \frac{\alpha_5 lf}{2k\alpha_4}$ into $M_H = (1 - b_1)(1 - r)p - \alpha_3 p^2$, and doing the derivation of $p$, we get $p* = \frac{(1-b_1)(1-r)}{2\alpha_3}$; Similarly we have: $y* = \frac{\gamma}{2\alpha_1}$.

③ When local governments, real estate developers and evaluating institutions build alliances, the goal of central government is to maximize central tax revenue and to encourage the local government to maximize the support for the construction of affordable housing and minimize regulatory costs. Therefore, the objective function of central government is: $max\ U_C = b_1 p + (1 - \gamma)m - \alpha_6 n_1$. Putting $p* = \frac{(1-b_1)(1-r)}{2\alpha_3}$, $y* = \frac{\gamma}{2\alpha_1}$ to $U_C = b_1 p + (1 - \gamma)m - \alpha_6 n_1$, and doing derivation of $b_1 \gamma$ respectively, then we get $b_1{}^* = \frac{1}{2}$, $\gamma = \frac{1}{2}$. Furthermore, we do derivation of $P$, $m$, then we get the Nash equilibrium solution as: $p* = \frac{1-r}{4\alpha_3}$; $m = \frac{1}{4\alpha_1}$.

#### 30.2.2.2 Alliance 2—Central Government, Local Government and Evaluating Institutions

① As long as central government, local government and evaluating institutions build alliances, evaluating institutions can only select normal valuation under pressure by central government, therefore, the assessment cost of banking institutions is, $r_e = lr$. The reaction function of banking institutions during the fourth stage is: $r* = \frac{\alpha_5 l}{2k\alpha_4}$.

② If central government and local governments build alliances, they will no longer consider the tax distribution and the investment for affordable housing. Therefore, the objective function of the government coalition is: $max\ U_G = bp + m - \alpha_1 m^2$.

Among them, $b = b_1 + b_2$, represents the government coalition extracted the proportion of taxes from the price.

③ Accordingly, the objective function of the real estate developers becomes *max* $U_H = (1-b)(1-r)p - \alpha_3 p^2$. Putting $r^* = \frac{\alpha_5 l}{2k\alpha_4}$ into $U_H = (1-b)(1-r)p - \alpha_3 p^2$, and then doing the derivation of $P$ and setting derivative to zero, we have: $p^* = \frac{(1-b)(1-r)}{2\alpha_3}$.

④ $p^* = \frac{(1-b)(1-r)}{2\alpha_3}$ will be substituted into $U_G = bp + m - \alpha_1 m^2$. By doing derivation of $b$, $m$ respectively, we get $b = \frac{1}{2}$; $m = \frac{1}{2\alpha_1}$. $b = \frac{1}{2}$ is substituted into $p^* = \frac{(1-b)(1-r)}{2\alpha_3}$, we get the equilibrium solution in this target: $p^* = \frac{1-r}{4\alpha_3}$.

#### 30.2.2.3 Alliance 3—Central Government, Banking Institutions and Evaluating Institutions

① When the alliances are built by central government, banking institutions and evaluating institutions, central government will demand that banking institutions employ the evaluating institutions when they select normal valuation. The assessment cost of banking institutions is: $r_e = lr$.

Ditto, with the converse solution, the reaction function of a fourth stage of banking institutions is: $r^* = \frac{\alpha_5 l}{2k\alpha_4}$.

② Similarly, the reaction function of the third stage of the real estate developers is: $p^* = \frac{(1-b_1-b_2)(1-r)}{2\alpha_3}$. Putting $p^* = \frac{(1-b_1-b_2)(1-r)}{2\alpha_3}$ into $M_L = b_2 P + \gamma m - \alpha_1 m^2 - \alpha_2 n_2$ and doing derivation of $b_2$, $m$ respectively, we have: $b_2^* = \frac{1-b_1}{2}$; $m^* = \frac{\gamma}{2\alpha_1}$.

③ When Central government, banking institutions and evaluation institutions build alliances, central government's objective function is same as above, namely: *max* $U_C = b_1 p + (1-\gamma)m - \alpha_6 n_1$. Through calculating, we get: $b_1^* = \frac{1}{2}$, $\gamma^* = \frac{1}{2}$, $b_2^* = \frac{1}{4}$. Putting them into $p^* = \frac{(1-b_1-b_2)(1-r)}{2\alpha_3}$, $m^* = \frac{\gamma}{2\alpha_1}$, then we get the equilibrium solution as: $p^* = \frac{1-r}{8\alpha_3}$; $m^* = \frac{1}{4\alpha_1}$.

## 30.3 The Analysis of Game Model

Through the analyses above, we calculated the different equilibrium under different alliances, from which we can draw the following conclusions:

First, the derivative functions of the objective function of the real estate developers in the game model: $p^* = \frac{(1-b_1)(1-r)}{2\alpha_3}$, $p^* = \frac{(1-b)(1-r)}{2\alpha_3}$ and $p^* = \frac{(1-b_1-b_2)(1-r)}{2\alpha_3}$ indicate that housing price ($P$) in China is related to factors, including $b_1$, $b_2$, $r$, $\alpha_3$, ***et al.***, however, these factors represent central government, local government, banking institutions, evaluating institutions, as well as real estate developers, indicating that housing price ($P$) in China is the outcome of joint action of central government, local governments, banking institutions, evaluating institutions and real estate's developers, and is the result of the five-party game. Therefore, we need to take into account the interests of all participants and comprehensively consider in the real estate market's regulation. Otherwise, the regulation will encounter a constrained situation.

Secondly, many factors affect the price, but the proportions of the contributions to the price are varying between different factors. From the first derivative function: $p^* = \frac{(1-b_1)(1-r)}{2\alpha_3}$, $p^* = \frac{(1-b)(1-r)}{2\alpha_3}$, $p^* = \frac{(1-b_1-b_2)(1-r)}{2\alpha_3}$ to the model equilibrium solution: $p^* = \frac{1-r}{4\alpha_3}$, $p^* = \frac{1-r}{8\alpha_3}$, it can be found evidently that, with the process of this game, a number of factors gradually withdraw from the game, and ultimately, only the interest rates $r$ and the costs coefficient of real estate developers $\alpha_3$ are remained in the game model.

Furthermore, changes in interest rates $r$ not only cause price fluctuations but also affect the repayment rate $k$ of the real estate developers. From model equilibrium solution $p^* = \frac{1-r}{4\alpha_3}$, $p^* = \frac{1-r}{8\alpha_3}$, we can find out that no matter what type of alliance is formed, housing prices in China are inversely proportional to the interest rate $r$. Meanwhile, it can be deduced from $r^* = \frac{\alpha_5 l}{2k\alpha_4}$, $r^* = \frac{\alpha_5 lf}{2k\alpha_4}$, that no matter which alliance condition is formed, the real estate developers repayment rate $k$ and banking institutions lending rate $r$ is inversely proportional. So, central government will face the dilemmas in the regulation, ***i.e.*** in order to increase repayment rates, it is necessary to lower the lending rates; on the other hand, in order to reduce the price, central government will have to increase the lending rate.

Finally, from the comparison of $p^* = \frac{(1-b_1)(1-r)}{2\alpha_3}$, $p^* = \frac{(1-b)(1-r)}{2\alpha_3}$, $p^* = \frac{(1-b_1-b_2)(1-r)}{2\alpha_3}$, it can be concluded that, when local government, real estate evaluating institutions build alliances, the price $p^* = \frac{(1-b_1)(1-r)}{2\alpha_3}$ reach the highest level, resulting in the fact that, although Chinese government made a series of policies, the effect is relatively less significant. Because, when central government launch a new policy, local governments will execute from their own interests, and build alliances with real estate developers to protect their interest, ignoring the policy from central government, which results in reduction in the effects of policies greatly.

## 30.4 Conclusions from the Model and Contributions to the Regulations by Central Government

In this article, based on the chain of interests in the real estate market, we established a five-party, five-stage dynamic game model to discuss the different equilibrium solutions under different alliances. By further analyzing the results of the model, we provide Chinese central government with following recommendations on regulating real estate market in China:

First, although housing prices in China are subject to central government, local government and other stakeholders, they are closely related to the interest rates and real estate development costs. Therefore, central government should pay more attention to the utilization of the interest rate, strengthening the regulation in interest rates to control the housing prices; On the other hand, efforts should be made to reduce the development costs of the real estate developers. Development costs of the real estate developers can be divided into initial land acquisition costs and cost of raw materials in the construction process. Price of the raw materials in the construction process is determined by market supply and demand, which cannot be easily controlled by central government. However, land is a special kind of commodity, its price can be determined by central government, so central government should not only develop specific laws to strictly limit the land price range, but also choose appropriate premium based on the development of the real estate market, eventually, to gradually change the situation that bidding determines the land price and to avoid a one-size-fits-all financial policy.

Second, regulation in interest rates plays a two-way role. It affects not only housing price, but also the repayment rate. So central government must weigh the profits of both sides when utilizing the instruments of interest rate, and prevent bias. To solve this problem, central government should develop a flexible interest rate policy, namely, limiting rate within a certain range, within which different interest rates are applied for different economic actions, to ensure the maximal effect of the interest rates in the regulation and to stabilize real estate development.

Third, when an alliance is established by local governments, real estate evaluating institutions, the price is at the highest level, so central government should fully consider the interests of local governments into the policies. Gradually empowering local government and distributing certain tax revenue to local governments will reduce the difference between central government and local government, so as to ensure the initiative of local government and loosen the coalition between local government, developer and evaluating institutions. What's more, central government should increase punishment on the passive implementation of the policy by local governments and urge them to move closer to the central government.

Finally, it should be noted that the five-party five-stage mixed game model can be carried out in the following two aspects based on the current real estate market development characteristics. First, as mentioned above, in the real estate market, consumers are a vulnerable group, but as the market continues developing, the role of consumers will become more important, so they can be introduced into the model to build a six-party six-staged game model; Second, the interest rate ($r$) in this article is a fixed rate, but with the continuous progress of China's interest rate reform, it can be converted into a floating interest rate, and can be related to the costs of banking institutions, repayment rate of the developers.

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# Chapter 31
# The Empirical Research of the Growth of the Listing Real Estate Company Based on the "Sustainable Growth Rate" Theory

**Shuai Gao and Hong Zhang**

**Abstract** This paper is based on the classical Robert C. Higgins sustainable growth model as the theoretical foundation, for the empirical research of the sustainable growth of the listing Real estate company. Through research: In some of years The real growth rate (RGR) surpassed the sustainable growth rate (SGR), The company is realized to the SGR and meet with the requirement of corporation financial through adjusting financial structure accordingly. Further analysis the affecting factors of SGR with RGR of the listing Real estate company with the reasons for deviation of SGR with RGR and give the corresponding scheme. Meanwhile, Analysis the listing Real estate company adjust affected factors of SGR with RGR made the coordination SGR with RGR measures timely. To provide a reference for the development of other industries.

**Keywords** Real growth rate • Sustainable growth rate • Listing real estate company • Affecting factors • Equity capital

## 31.1 Introduction

The bubble of the real estate market of the Japanese with The financial crisis triggered by the Sub-loan crisis of the United states that caused a serious impact on the word economy, including China's economy. Investigate it's reason the unprecedented prosperity with the misconduct growth rate of the real estate, especially the long-term growth rate higher than the enterprises can take would

S. Gao (✉)
Department of Construction Management, Tsinghua University,
Room 426, Building No. 10, Beijing 100084, China
e-mail: sparkle1979@163.com

H. Zhang
Associate Professor, School of Economics and Management Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China
e-mail: highsky_zh@yahoo.com.cn

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destroy one enterprise. If the growth of one industry is improper, will threat to the sustainable growth of the entire industry. The real estate which has become a pillar industry of China through years of development is important part of the national economy, Taking preventive action for the possible risk of real estate is important sense to ensure sound and fast economic growth in China. This article attempts to analysis existed in-appropriate growth risk from the listing Real estate Company based on the "Sustainable growth rate" theory.

The sustainable growth concept begin to the enlightenment of the "sustainable development". The sustainable development is focused on the explanation that "the maximizing net benefit of economic development in the premise of keeping the quality of natural resources and services". Accordingly to define the sustainable growth rate (SGR) is "The enterprise can support the maximum revenue growth rate under selling no new equity and wishing to maintain its capital structure with operating efficiency".

## 31.2 Research on Enterprise Sustainable Growth

Enterprise achieved growth in mainly three ways: one is the biggest growth relying on internal funds as a source of financing to support the business income growth, named the internal growth rate as the limitation of the accumulation of financial resources funds, hamper the development of enterprise. The two is the pursuit of balanced growth under the premise which requires to maintain the current financial structure with its related financial risk and sells no new equity, Borrowing money in accordance with the retained earnings growth that promotes the revenue growth because of this growth generally won't run out of the enterprise's financial resources, named as the "sustainable growth". The three is to relay on external capital growth as a source of financing including equity financing and debt financing, in which debt financing is the main resource of external financing. Increased significant enterprise's financial risk through debt financing decreases the financing capacity significantly.

The enterprise sustainable growth is based on the Robert C. Higgins's [1] Sustainable growth theory. Higgins thinks that the SGR is which under the premises is not exhausted in financial resources limited the upper of revenue growth. Higgins pointed out that the revenue growth is not the pursuit of maximization, The enterprise managers should arrange reasonable operating income growth rate making it match to corporate financial policy. The rapid growth rate of corporate make a company's resources to become very nervous, the working capital is shortage accordingly which caused the financial crisis or even bankruptcy. On the other hand, The slow speed growth of the part enterprise is unable to meet the needs of the market, ultimately be eliminated by the market or become a takeover target.

James C. Van Home, [2] has established the model under hypothesis of Steady-state and changeable from the angle of the increases in assets equals [3, 4] to the increase in equity add debt according to the strict assumptions and relaxed assumptions hypothesis. However, the model is more complex to difficult analysis the process of all financial activities from the linkage factors.

In China the financial circles sustainable growth of enterprises has also made fruitful research. YouXiaofeng and Wangzhifang [5] introduced and evaluated the development of SGR model, discussed the use of prediction model couldn't be limited to finance growth rather to expand its scope of application. CaoYushan [6] in an article of the evaluation of enterprise growth and China listing corporation evidence, Making "Sustainable growth rate" as the dynamic evaluation standard classified as "high growth" or "low growth" of two growth rate would cause significantly changeable of ROE, but "high growth" or "low growth" is not necessarily "effective" or "invalid". China financial circles focus on the introduction with evaluation of foreign classical theory [7] and model of finance attempting to use the "dynamic" SGR theory to evaluate the development mode of enterprises. The lack of further study and analysis [8] of the SGR mode of a certain industry and its impact on the present situation.

In this paper based on the "sustainable growth" theory of the listing real estate corporation growth, making a systematic research about the status of SGR with its influence factors of the listing real estate corporation, The chapters are as follows: (1) The third section introduces the theory model of SGR. firstly established the theoretical framework of sustainable growth rate, on the basis of analyzing the influence of correlation factors of the sustainable growth rate. (2) The Fourth section based on the related financial indicators of listing real estate corporation, Using "Nonparametric test method" to examine whether the Listing Real estate Company realized the sustainable growth rate or not. (3) The Fifth section analysing the influence factors of SGR about the listing Real estate Company of China. (4) The sixth section, Conclusion, discussing factors on China's Real estate company to achieve sustainable growth, meanwhile, giving some suggestion when SGR deviated from the real growth part of years.

## 31.3 Study on Theory Framework

Based on the research achievements of Higgins, The calculation of SGR is relied on two basic assumptions: The first hypothesis is the operational capability of enterprise assets, asset turnover ratio unchanged, it means that the growth of the enterprises sales revenue is subject to the growth of its asset. The second hypothesis assumes that the enterprise capital structure remains unchanged it means that the growth of equity will lead to the percentage of debt accordingly. Through established the capital structure Higgins connect between the equity of shareholder and the liabilities. On the basis of these two basic assumptions, The sustainable growth rate SGR can be expressed as:

$$\begin{aligned}\mathrm{SGR} &= \text{equity capital growth rate} = \text{Retained earnings/The initial fixed interest}\\ &= \frac{\text{retained earnings}}{\text{Net profit}} \times \frac{\text{Net profit}}{\text{The initial fixed interest}}\\ &= \text{Retained earning rate}(\mathrm{B}) \times \text{Return on equity}(\mathrm{R})\end{aligned} \tag{31.1}$$

The calculation equation is simple that can be compared with company goals directly if The SGR indicator has large differences with the real growth, The managers need improve the management ability of enterprise, adjust the capital structure, to warn the enterprise's financial risk but making the return on equity (R) as the profitable scale that is difficult to probe the affected factors of SGR, and to what extent influence the numerical value of SGR.

On the further decomposition equation:

$$\begin{aligned}
\mathrm{SGR} &= \text{equity capital growth rate} = \text{Retained earnings/The initial fixed interest} \\
&= \frac{\textit{retained earnings}}{\textit{Net profit}} \times \frac{\textit{Net profit}}{\textit{The initial fixed interest}} \\
&= \textit{Retained earning rate}(B) \times \frac{\textit{Net profit}}{\textit{The initial fixed interest}} \\
&= \textit{Retained earning rate}(B) \times \frac{\textit{Net profit}}{\textit{The initial fixed interest}} \\
&= \textit{Retained earning rate}(B) \times \frac{\textit{Net margin}}{\textit{Sales Income}} \times \frac{\textit{Sales Income}}{\textit{Total assets}} \\
&\qquad \times \frac{\textit{Total assets}}{\textit{The initial fixed interest}} \\
&= \textit{Retained earning rate}(B) \times \text{Sales net profit rate}(P) \\
&\qquad \times \textit{Asset turnover}(A) \times \textit{Equity multiplier}(M)
\end{aligned} \tag{31.2}$$

Retained earnings rate and equity multiplier are belong to the enterprise's decision-making factors which reflects the management's attitude towards to risk and opportunity, meanwhile, it is the enterprise financial policy formulation. The sales net profit rate and the asset turnover ratio which reflect the performance of enterprises are the management decision-making results. Above four indicators determine the value of SGR. Further decomposition of the four indicators mentioned above we can find the driving factors of enterprise sustainable growth, so that managers can clear from which aspects to improve the sustainable growth rate, effectively improve the growth ability of the enterprise financial management efficiency. (As shown in Fig. 31.1).

## 31.4 The Empirical Analysis

### 31.4.1 Data Sources and Sample Selection

The main financial data from Wind and RuiSi database. In order to test listing the real estate cooperation whether keep the sustainable growth rate or not and

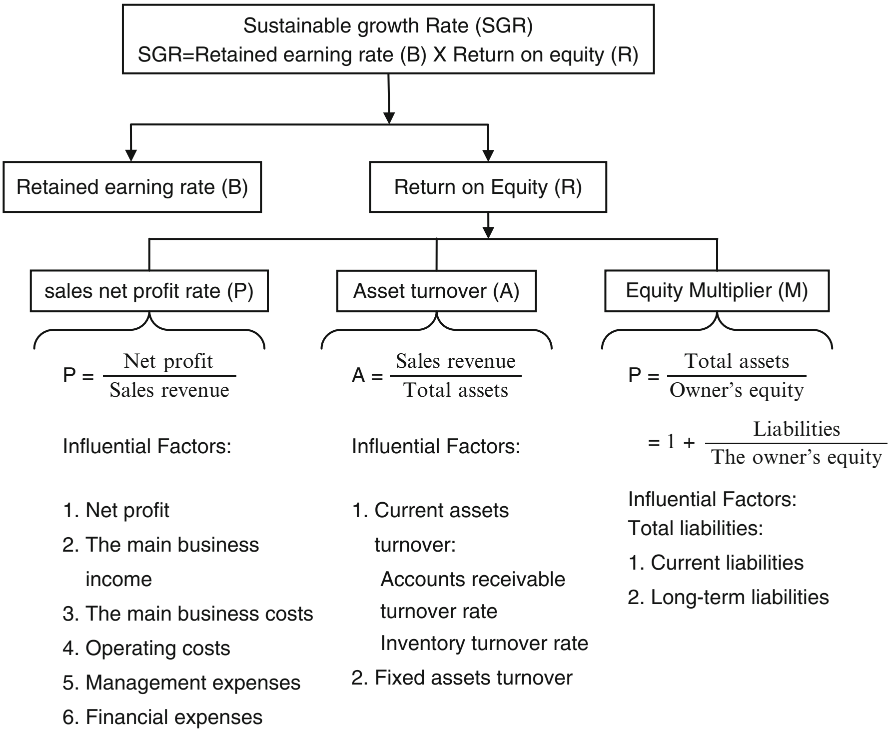


**Fig. 31.1** The influential factors of a sustainable growth rate

analyze its causes. Avoiding the disturbance of random factors as far as possible. This paper selects 1998–2011 a total of 13 years as the analysis period. Until to 2011, The number of listing corporation of China's real estate is 153. Remove abnormal the main business and lose data of 72 companies. We finally chose 81 companies of listing corporation in the real estate industry of Shanghai, ShenZheng as research samples, Obtained the total of 1,134 valid observations.

### *31.4.2 The Index Selection and Statistical Description*

According to the sustainable growth model of Robert C. Higgins. Taking into account the actual statistical data availability, This paper selects six financial indicators. All the variables and the definition seeing Table 31.1.

**Table 31.1** Main research variables and the definition

| Variables | Symbol | Definition |
|---|---|---|
| Sales net profit rate | P | Sales net profit rate = Net profit for the current year/The main business for the current year |
| Total assets turnover | A | Total assets turnover = The main business for the current year/The final total assets[a] |
| Equity multiplier | $T^t$ | Equity multiplier = The final total assets/The interests of shareholders at the beginning |
| Retained earnings rate | R | Retained earnings rate = 1 − Cash dividend for the current year[b]/Net profit for the current year |
| The real growth rate | g | The real growth rate = The final main business income/The beginning main business income − 1 |
| The sustainable growth rate | SGR | The sustainable growth rate = Sales net profit rate × Total assets turnover × Equity multiplier × Retained earnings rate |

Note: [a]The denominator of the total assets turnover select the final total assets, but not the annual average total assets; The denominator of the equity multiplier select the beginning of the interests of shareholders, but not the final of the interests of shareholders based on Higgins's model of sustainable growth

[b]The sustainable growth rate is considering the development of the financial money or resources can be supported. So Retained earnings of the sustainable growth rate need deduct cash dividend, Although the dividend dilute net assets of per share and earnings per share, but not consume the financial resources of the enterprise, so don't deduct from retained earnings

### *31.4.3 An Empirical Study on the Sustainable Growth of China Real Estate Company*

The average rate of sustainable growth of sample firms and the actual growth rate, geometric means and standard deviations in 1998–2011 years are shown in Table 31.2. It is seen from Table 31.2, the actual growth of 81 listing corporation were higher than the sustainable growth rate, in addition, the fluctuation of the actual growth rate is far greater than the sustainable growth rate but most of years the actual growth rate is not more than 4–6 times the sustainable growth rate, The range of growth can be accepted by the enterprises [2].

After Kolmogorov-Smirnov (Table 31.3) test can be seen, The significance level sig of the sustainable growth, the real growth rate and the mixed sample are less than 0.05, which refused the sustainable growth rate and the real growth rate obeys the normal distribution assumption, namely that the distribution is non-normal.

#### 31.4.3.1 The Hypothesis Testing of Achieve Sustainable Growth

Because the two groups of data distribution is non-normal, The distribution type is unknown. Further testing the correlation between groups of data, the correlation coefficient was 0.262. Therefore, in order to test whether there is a significant difference between the sustainable growth rate with the real growth rate or not,

**Table 31.2** Summary about the average sustainable growth rate and the real growth rate of Sample Firms

| Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Means | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SGR | 9.0 | 4.2 | 8.4 | 2.6 | 8.1 | 7.0 | 10.9 | −3.2 | −2.7 | 10.2 | 7.0 | 11.7 | 10.8 | 12.2 | 6.9 | 5.0 |
| RGR | 5.1 | 10.3 | 34.7 | 25.3 | 34.9 | 31.8 | 27.6 | 2.9 | 31.4 | 48.6 | 14.3 | 43.8 | 31.9 | 28.9 | 26.5 | 13.7 |

**Table 31.3** Kolmogorov-Smirnov test

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SGR | Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| | Statistic | 1.648 | 2.693 | 2.907 | 2.731 | 3.042 | 2.309 | 2.774 | 3.097 |
| | Asymptotic significant (Bilateral) | .006 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| | df | 81 | 81 | 81 | 81 | 81 | 81 | 81 | |
| | Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Mixed | |
| | Statistic | 3.418 | 1.487 | 1.889 | 1.433 | 1.667 | 1.806 | 10.616 | |
| | Asymptotic significant (Bilateral) | .000 | .024 | .002 | .033 | .008 | .003 | .000 | |
| | Df | 81 | 81 | 81 | 81 | 81 | 81 | 1134 | |
| RGR | Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| | Statistic | 1.640 | 1.732 | 1.764 | 2.047 | 2.034 | 2.117 | 1.482 | 1.875 |
| | Asymptotic significant (Bilateral) | .006 | .005 | .004 | .000 | .001 | .000 | .041 | .003 |
| | df | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 |
| | Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Mixed | |
| | Statistic | 2.397 | 2.494 | 1.973 | 1.827 | 1.619 | 2.632 | 6.786 | |
| | Asymptotic significant (Bilateral) | .000 | .000 | .001 | .003 | .032 | .000 | .000 | |
| | Df | 81 | 81 | 81 | 81 | 81 | 81 | 1134 | |

**Table 31.4** Summary of Wilconxon pairing rank test (SGR-RGR)

| Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|
| Z | −2.159[a] | −.789[b] | −3.821[b] | −1.839[b] | −3.223[b] | −2.366[b] | −2.564[b] | −.899[a] |
| Asymptotic significant (Bilateral)[c] | .031 | .430 | .000 | .066 | .001 | .018 | .010 | .369 |

| Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Mixed |
|---|---|---|---|---|---|---|---|
| Z | −1.478[b] | −2.547[b] | −.643[b] | −2.380[b] | −1.968[b] | −.028[a] | −5.559[a] |
| Asymptotic significant (Bilateral)[c] | .139 | .011 | .520 | .017 | .049 | .977 | 0.000 |

[a]Based on the positive rank
[b]Based on the negative rank
[c]Wilcoxon signed rank test

namely The listing real estate corporation is whether achieve the sustainable growth rate or not, use Wilcoxon pairing test of two related samples tests procedure of Non-parametric test as shown in Table 31.4. Most of years given in the Table 1998–2011 the significance of Z value of the SGR with RGR of listing corporation between the probability of the gradual two-tailed (<0.05) accept no significant difference of the null hypothesis Among 2005–2011 years there is realizing of the sustainable growth and the real growth uniformity. Part of the year between 2000 and 2004 There is not consistent between the real estate sustainable growth and the real growth rate, not to achieve the sustainable growth. Further examine the

**Table 31.5** The results of Rank

| | | N | The mean rank | Sum of ranks |
|---|---|---|---|---|
| RGR-SGR | Negative ranks | 499[a] | 520.98 | 259,969.00 |
| | Positive ranks | 634[b] | 603.22 | 382,442.00 |
| | Ties | 0[c] | | |
| | Gross | 1,133 | | |

[a]SGR < RGR
[b]RGR > SGR
[c]RGR = SGR

relationship of the mixed samples of the listing real estate between the sustainable growth rate and the real growth rate, refuse no significant difference of the null hypothesis, Overall, The Real estate company didn't fully achieve sustainable growth.

#### 31.4.3.2 The Hypothesis Testing of the Fast Growth and the Deficiency Growth

Through Wilconxon pairing rank test results, Most of years The sustainable growth rate and the real growth rate of sample firms is consistent but part of years (2000–2004) has the remarkable difference, Further testing mixed sample, The listing real estate corporation don't achieve sustainable growth rate target, The results of Wilconxon pairing symbol rank as shown in Table 31.5.

From the above results can be seen, the negative ranks of the minus between SGR and RGR equals to 499 of the Sample Firms from 1998 to 2011 accounting for 44 % of the total; the Positive ranks equals to 634, accounting for 56 % of the total, i.e. Overall, the sustainable growth rate is slightly higher than the real growth rate. The ties is zero, namely is not equals between SGR with RGR in the samples. Through the signed rank test to verify the actual growth rate and the sustainable growth rate of listing real estate corporation does not match exactly in the 1998–2012, but we can find there is undergo not-match each other in 2000–2004. The listing real estate corporation improve company financial situation, The sustainable growth rate has been significantly improved in 2005–2011 years.

## 31.5 The Factor Analysis of the China's Listing Corporation Sustainable Growth

Through the empirical analysis above, There is not fully unanimous between SGR with RGR of China' listing real estate, but The real estate company adjust their financial goal immediately when The two of SGR with RGR deviates significantly. Making of the two indicator coordinate well development. How to adjust financial goals, it needs further study the Variation of SGR of the listing real estate company

**Table 31.6** The summary of the SGR factors

| Year | Total assets turnover | Sales net profit | Equity multiplier | Retained interests rate |
|---|---|---|---|---|
| 1998 | 0.50 | 16.00 | 2.02 | 0.59 |
| 1999 | 0.44 | 12.99 | 2.42 | 0.30 |
| 2000 | 0.44 | 12.92 | 2.44 | 0.65 |
| 2001 | 0.41 | 7.05 | 2.25 | 0.40 |
| 2002 | 0.43 | 2.19 | 3.39 | 0.93 |
| 2003 | 0.45 | 5.56 | 3.27 | 0.95 |
| 2004 | 0.48 | 6.65 | 3.61 | 0.95 |
| 2005 | 0.45 | 4.69 | 4.42 | 0.90 |
| 2006 | 0.47 | 5.11 | 3.68 | 0.93 |
| 2007 | 0.48 | 12.59 | 3.04 | 0.97 |
| 2008 | 0.39 | 10.32 | 3.01 | 0.94 |
| 2009 | 0.33 | 15.57 | 2.89 | 0.95 |
| 2010 | 0.32 | 15.97 | 2.92 | 0.97 |
| 2011 | 0.28 | 15.17 | 3.13 | 0.96 |

and its influential factors summed up disciplinarian, for the reference to other industries.

According to Higgins sustainable growth model, we performed the SGR's four factors, including sales net profit rate, total assets turnover, equity multiplier and retained interests rate, further decomposite to explore which factors effect the sustainable growth of the listing real estate corporation.

It is seen from Table 31.6, The total assets turnover rate of China's listing real estate corporation decreased year by year, The sales net interest rate presents two high among low situation, that the sample firms experience have a stabilize profitability going through poor profitability situation during 2000–2005 years, The equity multiplier is slightly rising, less change, explain the debt financing is rising in the firm situation. Retained earnings rate is less volatile, The trend has increased year by year, explain the fewer dividends of the real estate enterprises.

### *31.5.1 Analysis of the Causes the Asset Turnover Rate Declining*

The asset turnover ratio reflects the enterprise's assets operation ability and management efficiency. The asset turnover rate can be further decomposed into accounts receivable turnover, inventory turnover and turnover rate of fixed assets.

It is seen from Table 31.7, The inventory turnover of the listing real estate company is first increased and then decreased, especially the decline in the period of 2005–2011 is particularly significant. From composing of the real estate inventory perspective, The proportion of raw materials is much higher than the finished goods inventory, that means the growth of inventory is mainly due to "stock up",

**Table 31.7** The summary of accounts receivable turnover, inventory turnover and turnover rate of fixed assets of sample company

| Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inventory turnover | 2.82 | 2.93 | 3.00 | 2.63 | 5.40 | 3.76 | 2.92 | 2.72 | 2.21 | 2.28 | 1.32 | 0.96 | 0.81 | 0.63 |
| Account receivable turnover | 6.03 | 3.47 | 3.01 | 8.06 | 8.26 | 9.91 | 8.53 | 10.10 | 17.02 | 22.55 | 20.35 | 23.68 | 23.79 | 26.15 |
| Fixed asset turnover | – | – | 36.01 | 39.17 | 35.88 | 34.94 | 34.78 | 33.79 | 34.04 | 33.13 | 32.71 | 32.59 | 32.42 | 32.73 |

**Table 31.8** The main influence factors of net sales profit changes

| Year | The main business income | Net profit | Cost of main business | Management expenses | Financial expenses |
|---|---|---|---|---|---|
| 1998 | −0.02 | 0.14 | 0.03 | −0.16 | 0.34 |
| 1999 | 0.11 | −0.14 | 0.12 | 0.02 | −0.16 |
| 2000 | 0.26 | 0.29 | 0.14 | 0.11 | 0.05 |
| 2001 | 0.00 | −0.24 | 0.13 | 0.64 | 0.29 |
| 2002 | 0.17 | 0.10 | 0.06 | 0.03 | 0.01 |
| 2003 | 0.19 | 0.25 | 0.20 | −0.07 | −0.04 |
| 2004 | 0.15 | 0.15 | 0.18 | 0.18 | 0.07 |
| 2005 | 0.00 | 0.10 | 0.14 | −0.03 | 0.04 |
| 2006 | 0.29 | 0.54 | 0.30 | 0.06 | 0.20 |
| 2007 | 0.47 | 1.09 | 0.39 | 0.41 | 0.38 |
| 2008 | 0.09 | −0.02 | 0.14 | 0.04 | 0.27 |
| 2009 | 0.28 | 0.60 | 0.39 | 0.03 | −0.12 |
| 2010 | 0.18 | 0.25 | 0.12 | 0.23 | 0.25 |
| 2011 | 0.18 | 0.15 | 0.26 | 0.28 | 0.39 |

not to “unmarketable house” further shows that the inventories of the listing real estate corporation are mostly due to its “initiative” factor, meanwhile, can not deny the fact that the level of the real estate’s inventory management has declined, accelerate inventory turnover management level still has certain promotion space; The accounts receivable turnover rate increased year by year, especially increase rapidly in the initial phase reflects that the listing corporation assets ability is improved obviously. From 2005 to 2011 years the accounts receivable turnover ratio tends to be stable that reflects the company management capacity increase finity. However, The turnover of current assets and the fixed assets turnover ratio has less changed. Overall, from 2005 to 2011 years the total assets turnover rate fell significantly close to the variation trend of inventory turnover. Visibly need to work hard to improve the inventory management level of the listing real estate corporation accelerate inventory turnover rate, so as to promote the total asset turnover improvement effectively.

### *31.5.2 Analyzing Sales Net Interest Rate Change*

Analysis the profit composition of the real estate industry over the years, The operating profit accounted for more than 90 % of the total profit. The listing Real estate corporation prominent main business, The source of profits is stable but the profit margin fluctuate largely and is closely related to the national policy and economic cycle.

Further analysis, Sales net interest rate is determined by the sales revenue (main business revenue) with net profit. Through the Analysis of Table 31.8, the main business income fluctuate largely, including of 2001, 2005, 2008 main business income rose to 0 %. This period is the most stringent period of China. Obviously the development of the real estate industry is closely related to the Chinese policy. At the same time the main business costs rise accompanied with the main business change. The main causes of operating costs rising is direct relationship to the costs of material, labor, machine prices rising which directly led to rise the cost of real estate company. In addition, Management costs and financial costs also rose at different degrees. Net profit is relatively for the middle years figure small, two edge years figure large of which 1999–2005 years net profit is relatively small, 2006–2011 annual net profit is relatively large, which 2008 year is only negative figure. This year Implement strict control policy of real estate of China.

### 31.5.3 Analysis of Equity Multiplier Change

It is seen from Table 31.6, 1998–2011 years the trend of equity multiplier is stable in have rising, can be divided into two stages, 1998–2011 years for the rising phase, 2006–2011 as stationary phase, analysis the factors of equity multiplier effects as shown in Table 31.9.

In 1998–2005 years, The sales net profit ratio drops year by year, in order to enhance the profitability of enterprises, enterprises chose to enhance the asset liability ratio level, use effectively of financial leverage to enhance the profitability so that the equity multiplier has increased greatly, from 2006 to 2011, the level of asset-liability ratio remained at a relatively stable state but the sales net profit ratio increased by a big margin that reflects the overall management level of enterprises have greatly improved. To view the current liabilities and long-term liabilities ratio, Current liabilities is relatively large accounting for 85 % of total liabilities, explain that the enterprise has a big temporary repayment pressure. The financial risk is still serious that should be highly attention by the managers.

### 31.5.4 Analysis on the Change Rate of Retained Earnings

In 1998–2000 years the retained earnings rate of the listing real estate corporation is less. In 2001–2011 years the retained earnings rate is relatively high level, reached 90 %. Obviously most of the listing real estate companies is not dividends, nicked name “Real tight wad”, from another perspective that the real estate industry has better income level, The shareholders give up bonuses at present rather to provide “endogenous” financing channels for enterprises’s expand rapidly, but The enterprises need to improve the cash dividend payment rate to safeguard the interests of medium and small investors.

**Table 31.9** The debt duration structure of the sample company

| Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset-liability ratio | 44.12 | 44.26 | 45.05 | 47.35 | 49.17 | 51.20 | 53.38 | 54.78 | 54.82 | 55.31 | 55.82 | 55.72 | 58.59 | 60.43 |
| The proportion of current liabilities ration | 86.47 | 89.46 | 88.77 | 86.58 | 86.25 | 85.27 | 84.63 | 86.74 | 85.67 | 80.21 | 79.90 | 75.81 | 75.22 | 78.10 |
| The proportion of long term liabilities ration | 13.53 | 10.54 | 11.23 | 13.42 | 13.75 | 14.73 | 15.37 | 13.26 | 14.33 | 19.79 | 20.10 | 24.19 | 24.78 | 21.90 |

## 31.6 Conclusions and Suggestions

### *31.6.1 The Main Conclusion*

Through the empirical analysis, The real growth rate and the sustainable growth rate of the real estate listing corporation is not perfectly matching such as the 2000–2004 years the differential of two index is big. The listing real estate corporation by adjusting the asset turnover ratio, sales net profit rate, equity multiplier, The retained earnings ratio of the sustainable growth financial factors. The 2005–2011 years the two index return to the synchronous growth channel, so as to realizing the sustainable growth rate of the listing real estate corporation increased year by year, The listing real estate apparently make full use of "endogenous" financing channels, at the same time actively expand the "exogenous" financing channels. This measures avoid the bias between the sustainable growth rate and the real growth rate excessively avoid exhaust the company's financial resources that eventually lead to real growth rate fell sharply.

### *31.6.2 Suggestions*

The sustainable growth rate of the listing real estate corporation in China's increased year by year, Timely adjust to consistent with the trend variation of real growth rate, but in some of years the bias of the sustainable growth rate with the actual growth rate is larger, besides the industry's sustainable growth rate is not consistent with the actual growth rate. Further analysis the affecting factors of the sustainable growth rate, finds that the debt structure, asset turnover is still larger optimization space. From the angle of financial management giving the following suggestions:

The optimization of capital structure, improve the debt maturity structure. Different financial leverage and debt maturity structure have different financial govern pattern, with different financial risk and the cost of capital. High current liabilities can reduce capital cost, but the financial risk increased significantly, There is existing debt capacity and debt structure under the conditions of an optimal capital for all enterprises. Suggest that the enterprises improve the matching of short term debt combing with the using of debt capital to alleviate and reduce financial risks.

1. Enhance the management level, improve asset operation ability. In particular, improve inventory management level, reducing in the transit time for some purchased inventory reducing production cycle for self-made inventory improve inventory turnover rate to further revitalizing the existing stock of assets optimize capital structure, excavating the potential of the assets improve asset turnover rate.

2. Reasonable balance of retained earnings and dividend payments. The company cut the dividend payout ratio, even not distribute that can improve the ability of sustainable growth rate. To a certain extent alleviate shortage of resources as the enterprise grow rapidly. If the company can not guarantee satisfactory earnings for many investors. The disappointment and negative emotions of the investor will be reflected in the share price, it would deviate from the objective of financial management. The company should be a reasonable trade-off between retained earnings and payment. Finally rely on increase the profit to handle the relationship between distribution and development.

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# Chapter 32
# Too Many and Too Few: Inefficiencies in China's Affordable and Social Housing Sector

**J. Albert Cao**

**Abstract** China has been building a massive number of affordable and social housing units in the last several years to compensate for an earlier lack of attention on housing affordability and housing needs. However, there are many forms of inefficiency in planning, building and using affordable and social housing. This paper attempts to analyze the causes to those inefficiencies from analysis of institutional arrangements inside and outside the affordable and social housing sector by using evidence from fieldwork conducted in August 2013 in Guangzhou. It argues that the solution to these inefficiencies lies on tackling the inadequacies in institutional arrangements in affordable and social housing.

**Keywords** Affordable • Social • Housing • China • Institutional • Efficiency

## 32.1 Introduction

Over the last 30 years China has made significant changes to its urban housing system, with market replacing state as the dominant housing provider [6, 10, 23]. Housing reform, introduced by the government from 1980, had sought to change urban housing as a welfare good provided by the state to a market good provided by market. The first blueprint for a housing system operational under a market economy emerged in the national housing policy in 1994, which sought to establish a housing system consisting of Economic and Comfortable Housing (ECH) with social security considerations for low and middle income households to purchase, and market housing for high-income households to purchase [16]. In particular, the final phase of housing reforms, introduced in 1998 to promote economic growth to combat the negative impact of the Asian Financial Crisis started in mid-1997,

J.A. Cao (✉)
Department of Real Estate and Construction, Oxford Brookes University,
Gipsy Lane, Oxford OX3 0BP, UK
e-mail: jcao@brookes.ac.uk

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signaled the end of public housing provision for state employees by housing construction by their employers (work units) and whole-scale privatization of the public housing stock [17], in which public housing was sold at large discounts to sitting tenants. On the other hand, a new housing regime of a three tier housing supply system was planned to consist of market housing for high income households to purchase, ECH for low-to-middle income households to purchase, and Low Rent Housing (LRH) for very low income households to rent, with ECH being the core of housing provision. Yet the prosperity of the housing market led to further change of housing policy towards market provision. Market enhancing policies introduced in 2003 established market housing as the dominant form of housing provision in the country [18]. The key change of the 2003 housing policy, however, effectively marginalised ECH, minimized LRH and made ordinary market housing the dominant mode of housing provision. Some national and local housing policy makers considered market housing alone could solve the housing problem of the country's cities [20].

However, there has been rapid house prices inflation in major cities, in particular in the last 10 years, rendering housing unaffordable for more and more middle-income households [4, 8]. In response, new policies to housing provision to combat housing price inflation and provide affordable housing have been attempted from 2006, which include a return to state provision of social housing for the poor and less well-off [3]. The non-market housing provision system was set up in Decree 24 of the government in 2007, which establishes an urban LRH regime and re-defines the role of ECH and LRH with a maximum size standard of 60 $m^2$ per unit for ECH and a maximum size standard of 50 $m^2$ per unit for LRH [19]. Decree 24 represents a major shift of housing policy in China from the over-reliance on marketization in low and middle income housing provision. Afterwards various new vehicles for social and affordable housing have been created and delivered, including Limited Price Housing (LPH) and Public Rental Housing. New construction of LRH and expansion of rent subsidies followed the 2007 housing policy change. To alleviate worsening affordability problem the government initiated an ambitious building program in 2011 to build 36 million Baozhang Housing, or affordable and social housing, units in the 12th Five-year Plan (2011–2015) and to raise the ratio of urban households covered by affordable and social housing to about 20 % by 2015 [12]. Here affordable and social housing include five categories, i.e. LRH, ECH, PRH, LHP and Dangerous and Dilapidated Replacement Housing (DDRH). 11.44 million units of affordable and social housing were completed from January 2011 to October 2012 [13, 21]. In 2013 6.3 million units are going to be started and 4.7 million units completed [22].

Many problems have emerged in the planning, construction, distribution and management of affordable and social housing that cause major concerns as to the efficiency of the program. The most notable of these include poor location and lack of amenities, improper sizes and failure to follow the size standard, construction quality, capture by ineligible households in distribution, vacant units and slow occupation, lack of effective exit mechanism for ineligible tenants and difficulty in enforcing such mechanism. There are claims from practitioners that the policies on affordable and social housing are not prudently formulated to define appropriate target areas and a quality monitoring regime is not in place [9]. Recently audits by provincial governments found that in Shandong, Guangdong, Hainan and Yunnan Provinces there were 56,400 units of affordable and social housing vacant by the end of 2012 [15]. It is imperative for the government to introduce measures to increase the attractiveness of social housing in terms of location, size and tenure to make social housing real alternatives to market housing for low-income groups.

From an international comparison perspective, the Chinese 'great leap forward' in affordable housing construction is reminiscent of the British experience from 1950s to 1970s when public housing construction was highly politicized and increasingly losing sight on effectiveness and efficiency. The resulting high-rise blocks and large public housing estates demonstrate the waste and inefficiency from inappropriate policy, planning, design and construction [11].

In standard economic texts, efficiency refers to the use of resources to maximize the production of goods and services. In absolute terms, a situation can be called economically efficient if no one can be made better off without making someone else worse off (Pareto efficiency), or if no additional output can be obtained without increasing the amount of inputs. A system is efficient if nothing more can be achieved given the resources available. In a similar vein, an economic system is said to be *more efficient* than another (in relative terms) if it can provide more goods and services for the society without using more resources. On the other hand, if there are misplaced resources that can be used more productively elsewhere, if there are poor quality goods wasting valuable resources to produce them, and if there are idle resources unable to be used, then inefficiency occurs. It is conspicuous that China's affordable and social housing sector fails the simple efficiency test.

This paper intends to investigate the inefficiencies in China's affordable and social housing sector after the return to state provision of social housing for the poor and less well-off in 2006, especially after the massive construction program to building tens of millions of units in a few years. It will first explain the analytical framework and the methodology in collecting data in China. Then it examines a case study, affordable and social housing in Guangzhou, for evidence of inefficiencies in affordable and social housing provision and investigates the reasons for such inefficiencies to persist after several years of learning by doing, improved policy guidance and enforcement. Finally the paper explores policy improvements and innovations to raise the efficiency of China's affordable and social housing sector.

## 32.2 Analytical Framework and a Brief Note on Methodology

Urban housing supply in China has been affected by the specific institutional arrangements, or structure of housing provision [2] formed by national and local rules and influenced by the dominance of property-led urban development.

To address the myriad of rules at different levels, a three-level institutional analytical framework will be used in the proposed study. It is based on the theory of new institutional economics [14] and the meta-theoretical synthesis of institutional approach [7], conducting institutional analysis at operational, collective-choice and constitutional levels. The operational level (market) is the bottom level where individuals, firms and operational arms of government agencies make business and allocation decisions. The collective-choice level is the intermediate level where officials regulating both the housing market and affordable and social housing provision make decisions, which are rules bounding decisions at the operation level. Decisions at the collective choice level are enforceable against non-conforming individuals, firms and operation arms at the operation level. The constitutional level is the top level, where decisions made by politicians in turn set the institutional arrangements for the collective choice level. Thus these decisions form the rules that officials at the collective choice level must obey when they formulate rules for the operational level, i.e. the housing market or the public housing allocation system. Decision-making at any level is affected by the existence of contextual factors that are independent of the institutional arrangements surrounding the particular market or local housing system. Institutional arrangements and their impact on transaction costs, property rights and incentives are analyzed at each level and crossing levels.

In the context of this paper, the efficiency of the affordable and social housing regime in China are analyzed in the following areas. First, the institutional framework for the affordable and social housing regime delineates the property rights of the providers and consumers of affordable and social housing. Second, institutional design affects the opportunities for and thus sources of funding. Third, the management regime is profoundly affected by the rules set at operational and collective levels. Finally, related institutional settings affect the effectiveness of rules in the affordable and social housing regime.

This paper is based on fieldwork conducted in August 2013 in Guangzhou, which involved 12 interviews and a focus group meeting. Interviewees and focus group meeting participants are housing professionals, academics, planners and officials. Both secondary and primary data feed into institutional analysis.

## 32.3 Guangzhou Case Study

Guangzhou started to provide *de facto* affordable and social housing provision from 1986 and has completed 214,000 units of affordable and social housing by the end of 2012 [5]. From 1986 to 2005, the city built approximately 30,000 units of affordable and social housing and provided housing subsidies to satisfy the housing needs of more than 40,000 families. Following Decree 24 the Guangzhou Municipal Government enacted local regulations on LRH, ECH, LPH and PRH and on land banking for affordable and social housing. From 2006 to 2010, the city started building approximately 80,600 units of affordable and social housing.

New completions plus housing subsidies met the housing needs of about 80,000 families. In 2011 the city built and acquired a total of 85,000 units as affordable and social housing. The city has been actively exploring ways to complete and refine the system to develop an affordable and social housing regime with the focus on public rental housing provision, merging LRH and PRH, supplemented by rent subsidy, and with gradual phasing out of ECH (*ibid*).

Nevertheless, a number of issues that have implications on efficiency remain in Guangzhou's affordable and social housing sector. First, there has been a large scale building of affordable and social housing in recent years to cope with new government directive, causing concern on whether the quality of siting, planning, construction, distribution and management would be compromised to fulfill very tight government targets. An interviewee questioned this government target as not realistic, leading to *ad hoc* approach to be taken to meet the target. For example, sites not ripe for large housing estate development have been selected for building, leaving problems of poor access and amenity that relies on future development of the surrounding area to improve.

However, interviewees familiar with supply of land from land administration agencies argued that sufficient land parcels at good locations were supplied to local governments to develop. So the decision to use sites of less suitable location is not because there is a shortage of good location sites, but a preference for those sites to be put on more profitable use, leaving sites with less suitable location being used for affordable and social housing.

A more acute problem could be that the target declared by the government to have been met is only met on paper. For example, completions figures are far from the figures of 'built and acquired', with completions for 2011 15,078 but 'built and acquired' being 85,000. An interviewee hinted that the figure for 'built and acquired' included those already built and distributed. Another interviewee indicated that a significant number of the 'built and acquired' is by large companies which basically distributed those units to their employees. Such housing units, counted as PRH, are actually not available to the public, but as a means for those companies to recruit and retain staff.

Second, many sites faraway from city centre, employment and mass transport were chosen for very large scale affordable and social housing development. For example, Luogang Central District, a project with 20,820 housing units (6,112 LPH, 13,940 PRH and 768 relocation housing for households affected by demolition), will become a huge self-contained community of low-income families on the verge of the built-up area. Another example is the Nanyue Garden with 17,005 units (2,040 ECH, 10,993 PRH, 3,012 LRH, 640 relocation housing for households affected by demolition elsewhere, and 320 relocation housing for households affected by demolition in this project), which is near the verge of the built-up area and 2 km to the nearest metro station. Several interviewees agreed that many of those projects are very far away and poorly accessible, but indicated that those sites enjoy lower cost in development.

Third, there are many issues in screening applicants and managing the residential units. An interviewee with very good knowledge on screening indicated that there is under-staffing in the screening process, with much of the work to be done by temporary staff on contract. Another problem is the lack of income data, because such data are from other government agencies rather than the Guangzhou Housing Security Office, which is connected to the Guangzhou Land and Buildings Administration Bureau with the best property information. The problem is widespread throughout the country, with 106 cities and towns being found to have significant problem in screening applicants [1]. For Guangzhou, it was found that 3 unqualified applicants were successful in LRH application, 25 unqualified applicants successfully bought ECH, and 189 LRH residents no longer met the conditions for LRH but still occupied LRH.

Fourth, there are management problems on affordable and social housing, normally within an estate. For purpose-built affordable and social housing estates, estate management is normally struggling as the management fees are set at very low level and some residents refuse to pay mainly on claims of low income, even though they receive income support and rent subsidy. For affordable and social housing built by developers in market housing estates as a planning condition, which are at a very small scale, there are complaints from estate management firms and occupiers of market housing on unfairness as they pay more in property management but enjoy the same level of services.

Fifth, there are problems in removing occupiers who are no longer qualified to stay in the affordable and social housing. For example, some occupiers no longer qualified for LRH found the affordable and social housing to be of higher standard in density and gardening than the market housing they could afford and refused to move. However, both officials and management company staff have no way to evict those occupiers.

## 32.4 What Cause the Inefficiencies

Inefficiencies in China's affordable and social housing sector are multi-faceted and widespread in China. Problems in the housing market, i.e. rapid price inflation, improper size standard and institutional design for housing market administration contribute to high demand for affordable and social housing [3]. However, the main causes are deeply rooted in the institutional arrangements for affordable and social housing affordable and social housing and beyond.

First, there are a number of issues in institutional framework for the affordable and social housing regime in China. For example, there is no legislation at the national level to set the rules for affordable and social housing and to empower the executive units of affordable and social housing. The constitutional level could give higher status to the affordable and social housing sector by setting and changing rules at the collective choice level. There has been a long preparation for a Housing Law but not fruitful yet. Many interviewees argue that there should be a law on affordable and social housing, and were disappointed that an ordinance, being prepared, is delayed. A couple of interviewees attributed the low priority in site selection for affordable and social housing to the low status the sector has compared to other sectors with national legislation. Some estates at inconvenient locations suffer the problem of too many units and too few applicants.

The lack of property rights for occupiers and their managers, delineated by legislation and regulations, causes inefficiency. One interviewee pointed out the poor care the occupiers had on the housing units they lived in because there was no clear rights and thus obligations made explicit to them. Several others claimed the lack of power the management units have led to resistance from occupiers when they collect the necessary fees and ask for compliance. The poor clarity of targeted population, i.e. local citizens or migrant workers, also produces unnecessary confusion in the planning, construction and distribution of affordable housing. To make things worse, local authorities have no rules to follow on whether to include migrant workers as target population for affordable housing. In Guangzhou, migrant workers are not covered and their housing standards are rather poorer than the lowest housing standard to qualify for local affordable and social housing, which has been raised several times when there was a glut of affordable housing and shortage of applicants qualifying the lower standards. In this case, there are too many housing units and too few applicants to qualify.

Second, there is no set funding formula for building affordable and social housing between local authorities and upper levels of governments and no secure sources of funding for future maintenance. Several interviewees said in Guangzhou there is basically no central government funding for building affordable and social housing although other localities with lower level of economic development have funding from central government. The lack of funding often result in local governments build ECH and LPH to sell to buyers rather than LRH and PRH that could be reused as affordable and social housing for many years. What is more important is the lack of certainty on future funding arrangements. This is particularly true for older stock that is acquired from existing housing rather than new build. The lack of central government funding and uncertainty of local funding give rise to inefficiencies, e.g. lack of subsidy to allow occupiers of LRH to pay sustainable level of property management fees. It is obvious that too few resources are put into the provision and maintenance of affordable and social housing in China.

Third, management is often negatively affected by the rules set at operational and collective levels. There is no rule set by the constitutional level to allow local governments to enact tough penalty rules at the operational level to punish cheating behaviour to qualify, unauthorized sale or letting, and unauthorized change of use, which are found to be abundant by the authorities [1]. An interviewee managing a large affordable and social housing estate spoke in earnest for rules to empower the management staff to punish behaviour like refusal to pay rent or property management fees. Another problem is the lack of power to remove non-compliant tenants of LRH from the units or estates they occupy to punish their disruptive behaviour. Several interviewees were deeply concerned on the waste of LRH resources because 'rich' occupiers could not be removed from the units they occupy because LRH management staff having no such power to do so. What the management staff could do is to increase the rents gradually to market level. Even when market rent is paid, the LRH unit is still wasted because it could have been let to someone in need.

Fourth, there is a lack of supporting institutional arrangements to enable more effective screening of applicants and better enforcement of management rules on occupiers. One major problem is the inadequacy of credit search tools to better check the income of and capital assets owned by applicants. The repeating phenomena of some LRH occupiers using new or even luxury cars are the outcome of the lack of supporting financial status check tools. Another problem is the lack of integration of other social services into the provision and management of affordable and social housing. As one interviewee with good knowledge in managing LRH points out, the occupiers of LRH have many problems, like past jail experiences and many illnesses. However, there is not established mechanism for the management staff to have the support of other government agencies specializing on those issues.

A couple of interviewees argued that the commitment made in 2011 by the central government to deliver 36 million units in 5 years and to have 10 million new starts is a waste of resources because many new affordable and social housing projects were ill-perceived and poorly implemented. The provision and management of affordable and social housing is a long-term commitment and should be institutionalized rather than treated as an *ad hoc* project for political expediency. The slowdown of new starts in affordable and social housing from 2012 is a right thing to do. What needs to be explored and delivered is the long-term mechanism to safeguard the funding and institutional support for more effective and efficient provision of affordable and social housing.

## 32.5 Conclusions

China's urban housing provision has been transformed from mostly state provision to mostly market provision. During the process of transformation, a blueprint for a mixed provision of market, quasi-market and state provision was first formulated in 1994 and further improved in 1998. However, such a blueprint was not implemented in practice, and was abandoned in 2003 to favour a dominant market provision, which has failed to deliver housing to low and in many cases medium income households. With hindsight the 1998 blueprint, if implemented, would have generated a better housing outcome.

This study focuses in Guangzhou, where the affordable and social housing sector has been much better developed and managed than most other cities in the country. However, a number of issues can be raised from the evidence in Guangzhou. First, the establishment of a new housing provision regime in 2007 with significant emphasis on affordable and social housing marked a major correction to the 2003 housing policy that is biased to market provision. However, the affordable and social housing system has not been given sufficient status by either a law enacted by the National People's Congress or sufficient authority by rules set by the constitutional level to give priority in the local government administration. Second, the fundamental defect is the lack of institutionalized funding arrangement, rendering a half-hearted effort and economizing behaviour by local governments in building and managing affordable and social housing. Third, the inadequate power owned by the management of affordable and social housing causes ineffective management and further reduce the efficiency of the affordable and social housing system. Fourth, incomplete supporting institutions like income check mechanisms reduce the effectiveness of screening of applicants, leading to wealth capture by unqualified applicants and wasteful use of scarce resources.

The lessons drawn from this study are that the inefficiencies like vacant units, cheating, wasteful use are deeply rooted in the institutional arrangements of the affordable and social housing sector. A step change in efficiency can only be possible if these institutional inadequacies are dealt with.

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# Chapter 33
# Study on the Performance Evaluation of Economical Housing Policy in Xi'an, China

**Donglang Yang, Baohua Huang, and Zhiyong Hou**

**Abstract** Economical housing policy is an important part of the public housing system in China. But there are many problems in the operation of the policy, making good thing that benefits the people have caused more controversy. In this case, it is very necessary to evaluate the performance of the economical housing policy. This paper takes Xi'an as an example, states the implementation status of economical housing policy and the economical housing residents satisfaction status of the city, builds a comprehensive index system for performance evaluation of affordable housing policy according to the goal of economical housing policy and relevant research results, and uses the Delphi and analytic hierarchy process (ahp) to determine the index weight, further more, performance evaluation model was constructed, then respectively calculates overall performance evaluation of Xi'an economical housing policy, individual performance evaluation, performance evaluation in different years and performance evaluation in different regions. In this paper, the research results show that the economical housing policy in Xi'an, to a certain extent, have eased the contradiction between housing and the demand of middle-low-income families, maintained the social stability, the price is reasonable, but the investment and construction of economical housing are insufficient, guarantee surface is not wide enough, the medical and education facilities are imperfection, the environment quality is low and poor result fairness. So the author put forward the necessity of transformation strategies for the government and Suggestions on perfecting the system of economical housing, provide ideas for promoting economical housing policy performance, innovating economical housing construction and supervision mode in Xi'an.

**Keywords** Economical housing • Policy • Xi'an city • Performance evaluation

D. Yang • B. Huang (✉) • Z. Hou
School of Public Policy and Administration & Institute of Real Estate Research, Xi'an Jiaotong University, Xi'an, China
e-mail: yangdl@mail.xjtu.edu.cn; bobo.sunshower@stu.xjtu.edu.cn

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## 33.1 Introduction

In 1994, the State Council of China promulgated the *On Deepening the Reform of the Urban Housing System Decision*, which is the preliminary outline framework [1] to affordable housing as the main form of the affordable housing system reform. Over the years, affordable housing policy has played a very significant role in improving the housing security system in China. However, there are also many problems exposed in the process of making and executing affordable housing policy. These problems not only affect the operation of the system itself, but also affect the fairness of the whole society. Therefore, analysis of the current situation of affordable housing market, and a scientific evaluation on the affordable housing policy performance is necessary [2]. By studying in which way the government can improve and implement the system, we may find the answer for how to improve the efficiency of affordable housing security [3].

In this paper, we take Xi'an city as an example, and construct a performance evaluation index system on the basis of affordable housing policy objectives and related research achievements of affordable housing policy. By using Delphi and hierarchy analysis method to determine the weight of indexes, we set up a performance evaluation model to evaluate the overall performance, individual value of different years, as well as the regional performance differences of Xi'an affordable housing policy. Finally, we put forward relevant policy suggestions accordingly.

## 33.2 Data and Methodology

### *33.2.1 Data Resource*

Xi'an city is the capital of Shaanxi Province. It has a total area of 10,108 km$^2$ which contain nine districts and four counties. In 2011, the GDP of Xi'an is 386.42 billion Yuan, and the resident population is 3,913,100. Xi'an affordable housing policy system has begun since 2000, and has experienced two big adjustments [4]. Now we need to find out the current situation of the system by doing a survey. The survey is divided into two stages. In the first stage, we selected 15 affordable housing projects and conducted in-depth interviews to the owners to know more about the project construction, prices, quality and other information. Stratified sampling method to the second stage, as the performance differences reflect the different location, different stages of affordable housing, the project according to the address and the distance from the city center to the Xi'an city affordable housing is divided into central, suburban and rural areas of 3 circles [5], and select 15 affordable housing district conducted a questionnaire survey, a total of 600 questionnaires, 590 copies of questionnaires recovered, recovery rate of 98.3 %, which collected 510 valid questionnaires, the questionnaire has 86.44 % efficiency. The questionnaire and survey project circle division are shown in Table 33.1.

**Table 33.1** The investigation data in different spheres

| Circle | Classification criterion | Covering projects number | Effective questionnaire number |
|---|---|---|---|
| Center circle | Within the second ring road | 7 | 242 |
| Suburban circle | Between 2nd ring and 3rd ring road | 4 | 129 |
| Outer circle | Out of the 3rd ring road | 4 | 139 |

### *33.2.2 Index System*

In order to fully reflect the affordable housing policy performance, the construction of index system evaluate different aspects, such as how does the affordable housing policy objectives promote the city's economic growth; how well did it solve the housing problems of low-income families; how effective it is to adjust the estate investment structure and market, etc [6]. Based on these goals, this paper is to determine to take the economic effect, the implementation efficiency, effectiveness and fairness as four indicators [7] in criteria layer, and pick out 9 primary indicators and 25 secondary indicators of Xi'an city affordable housing policy performance, which are shown in Table 33.2.

### *33.2.3 Model*

According to the index system, we construct the performance evaluation model of Xi'an city affordable housing policy as below:

$$\begin{aligned} V &= f(X1, X2, X3, X4) \\ &= \alpha_1 f(X11, X12) + \alpha_2 f(X21, X22) + \alpha_3 f(X31, X32) \\ &\quad + \alpha_4 f(X41, X42, X43) \end{aligned} \tag{33.1}$$

In this formula,

V—The overall performance evaluation of affordable housing policy;
f(X11, X12)—The economic effects of affordable housing policy;
f(X21, X22)—The implementation efficiency of affordable housing policy;
f(X31, X32)—The implementation effects of affordable housing policy;
f(X41, X42, X43)—The fairness of affordable housing policy;
$\alpha_1$, $\alpha_2$, $\alpha_3$, $\alpha_4$ means the weight of corresponding layer.

And,

$$f(X11, X12) = a_1 f(X111, X112) + a_2 f(X121, X122) \tag{33.2}$$

$$f(X21, X22) = b_1 f(X211) + b_2 f(X221, X222) \tag{33.3}$$

**Table 33.2** Performance evaluation index system of economical housing policy in Xi'an

| Target layer | Criteria layer | Primary indicators | Secondary indicators | Evaluation criteria |
|---|---|---|---|---|
| The performance of Xi'an city affordable housing policy | The Economic Effect (X1) | Personal Economic Effect (X11) | Price (X111) | Price margin between market price and affordable housing price |
| | | | Consumption (X112) | Rising of non housing consumption |
| | | Social Economic Effect (X12) | Investment (X121) | Affordable housing investment accounted for the proportion of housing investment |
| | | | Income (X122) | Affordable housing sales accounted for the proportion of residential sales |
| | The Implementation efficiency (X2) | Production Efficiency (X21) | Input-output ratio (X211) | The input-output ratio of affordable housing |
| | | Security Efficiency (X22) | Secured number (X221) | The ratio of secured people to security needed people |
| | | | Vacancy rate (X222) | Vacancy rate reasonable or not |
| | The implementation effect (X3) | Longitudinal Effect (X31) | Design quality (X311) | Satisfaction of occupants |
| | | | Construction quality (X312) | Satisfaction of occupants |
| | | | After-sale service quality (X313) | Satisfaction of occupants |

| | | | |
|---|---|---|---|
| | | Road accessibility (X314) | Commuting cost affordable or not |
| | | Infrastructure (X315) | Satisfaction of occupants |
| | | Education and medical facilities (X316) | Satisfaction of occupants |
| | | Environmental pollution (X317) | noise, water pollution problem exist or not |
| | Horizontal Effect (X32) | Housing prices control (X321) | If it helps to control housing prices |
| | | Investment structure (X322) | If it benefits regulation of the real estate investment structure |
| | | Social stability (X323) | If it benefits social stability |
| Fairness (X4) | Fairness of Opportunity (X41) | Object definition (X411) | Strict or not |
| | | Purchase program (X412) | Scientific or not |
| | | Supply standard (X413) | The matching of supply and demand |
| | Fairness of Process (X42) | Purchase program (X421) | Open and transparent or not |
| | | Transaction mode (X422) | Standard or not |
| | Fairness of Result (X43) | Settler group (X431) | If there is a high income earners living |
| | | Supply standard (X432) | The matching of supply and demand |
| | | Usage mode (X433) | Legal or not |

$$f(X31, X32) = c_1 f(X311, X312, X313, X314, X315, X316, X31) + c_2 f(X321, X322, X323) \tag{33.4}$$

$$f(X41, X42, X43) = d_1 f(X411, X412, X413) + d_2 f(X421, X422, X423) + d_3 f(X431, X432, X433) \tag{33.5}$$

In this formula,

$a_i$, $b_i$, $c_i$, $d_i$—the weight of corresponding indicator;
f(X111, X112)—Personal Economic Effect;
f(X121, X122)—Social Economic Effect;
f(X211)—Production Efficiency;
f(X221, X222)—Security Efficiency;
f(X311, X312, X313, X314, X315, X316, X317)—Longitudinal Effect;
f(X321, X322, X323)—Horizontal Effect;
f(X411, X412, X413)—Fairness of Opportunity;
f(X421, X422, X423)—Fairness of Process;
f(X431, X432, X433)—Fairness of Result.

## *33.2.4 Steps of Evaluation*

### 33.2.4.1 The Overall Performance Evaluation

This paper selects the indicators of the average value as the factor values of each index.

The quantitative calculation result and survey data reflect the affordable housing construction performance in different ways. The quantitative calculation result is the data of the year, ultimately reflect the annual overall performance, and the survey data reflect the implementation effect we get from the questionnaire. Thus we should calculate the value of each index in different ways [8]. The details are as follows:

$$\mathrm{Xiii} = \frac{1}{10}\sum_{n=2002}^{2011} xiii_{\mathrm{n}}$$

In this formula, Xiii is Factor Score, and $xiii_{\mathrm{n}}$ is the standardized data of different years' Indicator.

For the data we got from the questionnaires: $\mathrm{Xiii} = \frac{1}{510}\sum_{n=1}^{510} xiii_{\mathrm{n}}$.

**Table 33.3** The calculation results of affordable housing policy performance evaluation in Xi'an

| Indicators | Weight (Wi) | Factors scores | Value (Vi) |
|---|---|---|---|
| X111 | 0.004161 | 2.200 | 0.0092 |
| X112 | 0.002807 | 3.540 | 0.0099 |
| X121 | 0.023608 | 1.700 | 0.0401 |
| X122 | 0.015024 | 2.000 | 0.0300 |
| X211 | 0.057628 | 3.100 | 0.1786 |
| X221 | 0.080989 | 2.200 | 0.1782 |
| X222 | 0.024083 | 3.500 | 0.0843 |
| X311 | 0.019414 | 3.523 | 0.0684 |
| X312 | 0.035052 | 3.290 | 0.1153 |
| X313 | 0.055788 | 3.080 | 0.1718 |
| X314 | 0.045405 | 3.143 | 0.1427 |
| X315 | 0.050722 | 3.130 | 0.1588 |
| X316 | 0.055694 | 2.955 | 0.1646 |
| X317 | 0.052579 | 2.750 | 0.1446 |
| X321 | 0.013749 | 3.500 | 0.0481 |
| X322 | 0.039409 | 3.000 | 0.1182 |
| X323 | 0.042588 | 4.070 | 0.1733 |
| X411 | 0.02336 | 2.600 | 0.0607 |
| X412 | 0.024816 | 4.200 | 0.1042 |
| X413 | 0.028465 | 3.600 | 0.1025 |
| X421 | 0.057004 | 3.300 | 0.1881 |
| X422 | 0.040723 | 3.300 | 0.1344 |
| X431 | 0.069467 | 2.440 | 0.1695 |
| X432 | 0.056803 | 2.560 | 0.1454 |
| X433 | 0.080662 | 2.790 | 0.2250 |

#### 33.2.4.2 The Individual Performance Evaluation

Calculate the synthetic weight of secondary indicators to the criteria layer identified above, and then get the factor score of every indicator. Finally we can figure out the individual performance evaluation by these scores.

#### 33.2.4.3 The Performance Evaluation of Different Years

In different years, the investment, construction and distribution of affordable housing are not the same, so performance evaluation of different years is necessary.

By using the standardized data, we can calculate the weight of the secondary indicators to the primary indicators, and then we got the evaluation of social and economic effects, the production efficiency and security of Xi'an city affordable housing policy in different years, which can be shown in Table 33.3.

#### 33.2.4.4 The Performance Evaluation of Regional Differences

During the investigation, we found out the regional differences exist in longitudinal effect, fairness of process and fairness of results. In order to assure the accuracy of the evaluation results, a comparison of different circles is needed.

Calculate the weight of secondary indicators to the primary indicators, and then get the evaluation results of different circles.

## 33.3 Results

### *33.3.1 Statistical Analysis*

According to the performance evaluation model, Xi'an city affordable housing policy performance of V can be calculated as follows:

$$V = \sum_{i=1}^{25} vi$$

In this formula, vi means the evaluation of secondary indicators for the target layer.

Then we can figure out the overall performance evaluation of Xi'an city afford-able housing policy is 2.9661. More details can be seen in Fig. 33.1.

The comparison of different circles' social and economic effect, production efficiency, and security efficiency is shown in Fig. 33.2.

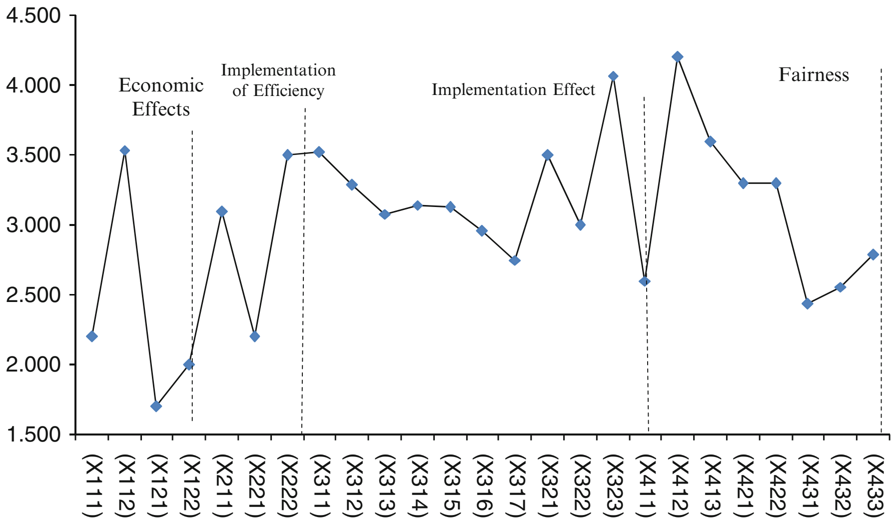


**Fig. 33.1** The individual performance evaluation


**Fig. 33.2** The performance evaluation of different years

## *33.3.2 Results Analysis*

The total score of overall performance evaluation is only 2.9661[2], which means that the effect of Xi'an city affordable housing policy implementation is significant but meanwhile many problems in it cannot be ignored.

From the individual performance evaluation results, we can see the efficiency, effectiveness, fairness are at average level, and the social economic effect is insufficient. From the comparison of the performance of different years, we can see the social economic effect of Xi'an city affordable housing policy declined gradually during 2002~2011. That is because the real estate industry developed rapidly during these years, and the investment of affordable housing has declined. In addition, during the period of 2002~2007, the security efficiency gradually decreased. The main reason is the rapid urbanization has brought large new urban population so that the demand for house expanded quickly. Although in 2008~2011, security efficiency has improved, but the highest security efficiency can be found in 2002~2003, because many resettlement programs were carried out at that time. From the comparison of the performance of different circles, we may find the satisfaction of fairness of center circle is much lower than the suburb and outer circles. The possible explanation is that the purchase and transaction processes are not standardized, and the center circle has more affordable housing projects so unfairness may happen more frequently.

Figure 33.3 shows the comparison of performance evaluation of different circle.

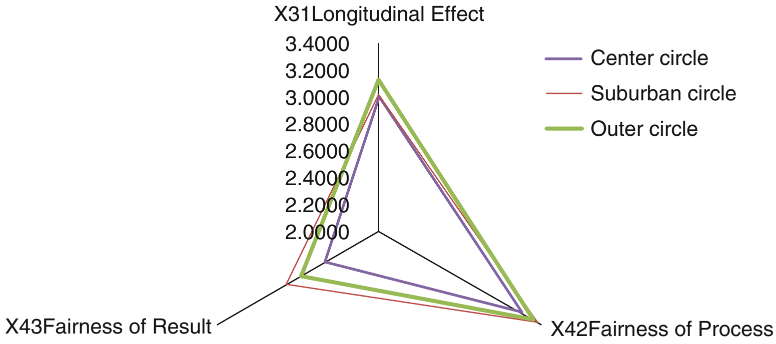


**Fig. 33.3** The performance evaluation of different circle

## 33.4 Conclusions and Policy Recommendations

### *33.4.1 Main Conclusions*

Based on the analysis of the Xi'an city affordable housing policy performance, we can tell it is not satisfactory. Specifically, the main conclusions of this study are as follows:

1. Xi'an city affordable housing policy to some extent alleviated the housing stress of low-income families, which is helpful for maintaining social stability. 83.3 % of the respondents said that the purchasing of affordable housing has increased their sense of happiness.
2. The price of affordable housing is reasonable. Data shows that, more than 55 % of the respondents think that their affordable housing prices are reasonable. In this case, the price positioning of affordable housing Xi'an city is mainly worth the name "affordable", but some projects still need to reconsider about their price positioning.
3. Affordable housing construction investment is insufficient; the security surface is not wide enough. Statistical data shows, 2011, Xi'an City has a non-agricultural population of 3,913,100, and a low-income population of 782,620. However, the affordable housing coverage is only 2.3 %, which is very low and cannot meet the requirement of the rapid urbanization.
4. The medical and educational facilities surrounding affordable housing projects are not good, and the environment quality is low, especially the center circle, according to the research results.
5. Fairness affordable housing policy of is too poor, and regional differences are obvious.

### 33.4.2 Policy Recommendations

According to the analysis above, we have some policy recommendations which can be divided to following aspects:

1. Affirmed the validity of affordable housing policy, and increase affordable housing consumption financial subsidies.
2. Moderately expand affordable housing construction scale according to the pace of urbanization of Xi'an City.
3. Improve the environment quality surrounding the affordable housing projects, the quantity and quality of educational and medical facilities are included.
4. Improve the audit and supervision mechanism of affordable housing, in order to assure the fairness of it.

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# Chapter 34
# Sustainability Reporting in Construction Contractors: A Case Study

**Jian Zuo, Zhenyu Zhao, Bo Xia, George Zillante, and Zhi-Yang Pan**

**Abstract** Construction activities have significant impacts on the environment, economy and society. As a result, sustainability has become an agenda in construction related business. This is evidenced by an increasingly number of construction related companies adopting sustainability reporting practice. Construction contractors are no exception. This study aims to investigate the sustainability reporting practices adopted by top Chinese contractors active in the international arena. The focus is placed on those Chinese contractors ranked top 50 by the Engineering News Record (ENR) top 225 international contractors. The results showed that the sustainability reporting practices of these top Chinese contractors, in terms of both approaches and the depth, varied significantly however there is a clear trend of growing level of disclosure of sustainability related information. Similarly, environmental sustainability seems the predominate focus of sustainability

J. Zuo (✉)
School of Natural and Built Environments, University of South Australia,
Adelaide, SA, Australia
e-mail: Jian.Zuo@unisa.edu.au

Z. Zhao
Department of Engineering Management, School of Economics and Management,
North China Electric Power University, Beijing, China
e-mail: zhaozhenyuxm@263.net

B. Xia
School of Urban Development, Queensland University of Technology,
Brisbane, QLD, Australia
e-mail: paul.xia@qut.edu.au

G. Zillante
School of Architecture and Built Environment, The University of Adelaide,
Adelaide, SA, Australia
e-mail: george.zillante@adelaide.edu.au

Z.-Y. Pan
School of Energy and Electrical Engineering, Hohai University, Nanjing 211100, China

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reporting exercises of top international contractors from China. These findings help to assist senior management of construction contractors to form business strategies to facilitate disclosure and other sustainability related practices.

**Keywords** Sustainability reporting • China • Contractors

## 34.1 Introduction

It is well recognized that the construction activities have significant environmental, social and economic impacts. These impacts are two-folded. The positive impacts include the contributions toward the national and local economy; employment opportunities; and providing various types of facilities to fulfil human beings' requirements [6, 13]. On the other hand, the negative impacts of construction activities have attracted growing public concerns. These impacts include: construction and demolition waste, carbon emissions, and disturbance to the local community (e.g. noise, dust, traffic congestion) [16, 20]. From a life cycle perspective, buildings, as end product of construction activities, continue to consume energy and emit greenhouse gas [8]. As a result, there is a growing number of construction related companies pay attention to sustainability and incorporate its principles into their activities. Of these practices, the disclosure of sustainability commitments and performance emerges. This is a response of construction companies to pressing demands on sustainability following leading practices of large companies worldwide. A KPMG survey found that 80 % of the largest 250 companies released sustainability reports in 2008 which is a significant grow compared to the level in 2005 [10]. An analysis of sustainability practice of the Global Fortune 250 companies showed that other issues than financial have been paid more attention such as environment, employee welfare, health and safety, engagement of community, and workplace diversity [9]. Indeed, the integrated reporting practice has been called upon following the extensive debate of what a sustainability report should cover [4].

Sustainability reporting is defined by the World Business Council for Sustainable Development (WBCSD) as: "...public reports by companies to provide internal and external stakeholders with a picture of corporate position and activities on economic, environmental and social dimensions" ([18], p. 7). Leading sustainability disclosure initiatives include: Global Reporting Initiatives, Dow Jones Sustainability Index, and the UN Global Impact.

The sustainability reporting practice is mainly driven by perceived benefits such as the long term success of the business due to improved communication between stakeholders [1]. Other drivers include a variety issues related to the regulatory, political, social and ethical [17]. The quality of sustainability disclosure is heavily influenced by the senior management [14].

However, construction industry falls behind to other sectors in terms of sustainability reporting practice [7]. The aim of this research is to examine the sustainability reporting practice adopted by Chinese contractors that are active in the international arena. A qualitative approach is adopted to satisfy this research aim.

## 34.2 Research Methodology

This research adopted a similar approach of Zuo et al.'s. [22] study. The Top 225 International Contractors list is published by the Engineering News Record (ENR) every year. This data set has been used in a number of studies (e.g. [11, 12, 19, 21]).

Fifty-two Chinese contractors were listed in the ENR Top 225 International Contractors 2012. This study placed focus on those ranked into top 50. As shown in Table 34.1, there are nine Chinese contractors falling into this category with total revenue of more than US 36.6 billion in 2011. This is, nevertheless, just over the revenue of top ranked international contractors, i.e. HOCHTIEF AG (Germany). A content analysis approach was utilized in a bid to highlight the common practices adopted by these companies in terms of disclosure of their sustainability commitments.

Similar to Zuo et al. [22], the research questions of this study are:

1. The approaches adopted by these companies to disclose their commitments toward sustainable development;
2. The depth and coverage of these practices; and
3. The compliance of these practices to leading sustainability initiatives such as the Global Reporting Initiatives, Dow Jones Sustainability Index, and the UN Global Impact.

It should be noted that the data related to sustainability reporting practices of these companies were collected between April and May 2013. Any data available beyond this time frame were not considered in this study. Similarly, these firms provide both English and Chinese versions of their website. A preliminary analysis found that the Chinese version website contains much more comprehensive information than the English version. Therefore, the Chinese version websites were sought for sustainability reporting related information.

**Table 34.1** Chinese contractors listed by ENR [5]

| Rank | | | 2011 Revenue |
|---|---|---|---|
| 2012 | 2011 | Company | (US$ million) |
| 10 | 11 | China Communications Construction Group | 9,546.9 |
| 22 | 20 | China State Construction Eng'g Corp. | 4,509.6 |
| 23 | 24 | Sinohydro Group | 4,399.6 |
| 24 | 26 | China National Machinery Industry Corp. | 4,307.4 |
| 30 | 29 | China Railway Construction Corp. | 3,782.0 |
| 39 | 33 | China Railway Group | 2,826.9 |
| 42 | 61 | China Metallurgical Group Corp. | 2,623.3 |
| 46 | 32 | CITIC Construction Co. | 2,417.2 |
| 48 | 27 | China Petroleum Engineering & Construction Corp. | 2,230.8 |

## 34.3 Findings

### 34.3.1 Online Disclosure

Vast majority of these top Chinese international contractors have dedicated website to disclose their sustainability practice. These websites were given different titles such as: sustainability, sustainable development, corporate sustainability, CSR, and social responsibility. The common topics of these online disclosures include: governance, philanthropy, environment, employee welfare, and local community. However, the coverage and depth of information provided varied significantly. For instance, the China State Construction Corporation has a wide coverage of sustainability topics on its website such as green building, society, staff development, quality, health and safety where case studies were provided as exemplars. By contrast, the China National Machinery Industry Corporation and China Railway Group have a specific focus on CSR in terms of online disclosure. The China Communications Construction Group, the top ranked Chinese international contractor, regards the Corporate Social Responsibility as critical component of its corporate culture. China Petroleum Engineering & Construction Corporation placed social responsibility into safety and environmental protection field of interest.

The sustainability related principles were embedded into the business vision. For instance, the China National Machinery Industry Corporation's CSR vision is [2]:

> ...Put the people first, safeguard the rights and interests of the employees and build up the channel of the growth so that the employees can work and live in a harmonious and safe and productive environment and enjoy the development results of the enterprise.
>
> ...Adhering to the strong sense of the environmental protection, efforts should be made to bring the environmental responsibility into merge with our own operational activities and fully utilize the R&D strength so that contributions can be made to the sustainable development of the nature and the human society with green technologies, green products, green designs and green engineering projects.
>
> ...With benevolent loving cares, warm helping hands should be extended for the public charity affairs so as to serve the construction of a harmonious society.

As shown in Fig. 34.1, China State Construction Corporation has set up a committee dedicated for social responsibility which is in charge of developing, implementing and auditing of related company policies and management regulations. The members of this committee are the Board Chairman, General managers, and Head of divisions and functional departments.

### 34.3.2 Sustainability Reporting

All these top Chinese international contractors publish standalone sustainability reports on a regular basis, normally every year. The only exception is the China Petroleum Engineering & Construction Corporation, which has its sustainability information as part of CSR report of its parent company, China National Petroleum Corporation.

**Fig. 34.1** Corporate sustainability governance in China State Construction Corporation

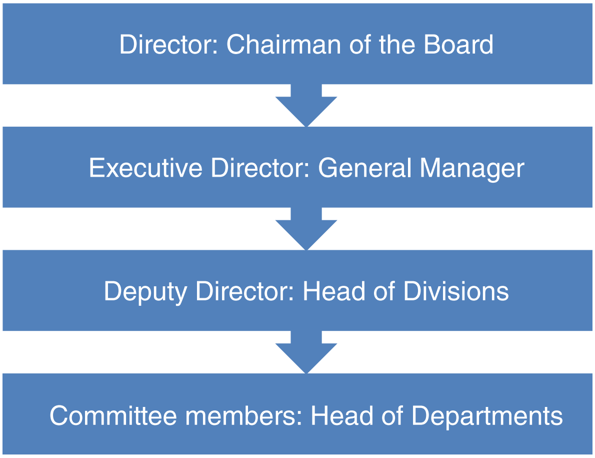


**Fig. 34.2** Sustainability principles adopted by China State Construction Corporation


One of key components of these sustainability reports is the identification of related stakeholders. For instance, the 2011 CSR Report of China State Construction Corporation listed the following stakeholders: employees, government, strategic partners, supply chain, shareholders, customers, financial institutions, community and public. These stakeholders sit in the centre of all responsibilities of the corporation (see Fig. 34.2). Effective communication with all stakeholders is required.

Another key component is the sustainability performance of the firm. In its 2011 CSR Report, China National Machinery Industry Corporation provided the

**Table 34.2** GRI endorsement of sustainability reports

| ENR ranking | Number of Chinese international contractors with GRI endorsement |
|---|---|
| 1st–30th | 4 (5)* |
| 31th–50th | 1 (4) |

Note: 4 (5) indicates 4 out of 5 companies have their sustainability reports listed by GRI

following performance data: revenue and profit, taxation, energy consumption per unit of output, COD emission, $SO_2$ emission, number of employees, number of safety accidents, investment on safety, and donation. These performance criteria are shared with other top Chinese international contractors.

The strategic goal of the corporation is also a common item of sustainability report. For example, China State Construction Corporation defines its strategic goal as ([3], p. 5):

> One Most: most international competitive building real estate enterprise integration group
>
> Two Entries: by 2015, aiming to enter the top fifth of the Top 500 Global Enterprises, and one of the world's three strongest construction and real estate groups

It is interesting to note that majority of these top Chinese international contractors specifically listed the evaluation outcomes released by third party as part of their sustainability report. Very detailed case studies were also provided to show the sustainability commitments and performance of the corporation.

### *34.3.3 Global Reporting Initiatives (GRI) Compliance*

The examination of Sustainability Disclosure Database of the Global Reporting Initiatives showed that, by the time of this study, 55.6 % of top Chinese international contractors have their sustainability reports endorsed by the GRI. It is worth noting this percentage is much higher than that of ENR top 50 international contractors 2009 (see [22]). Table 34.2 shows that a trend that Chinese international contractors with higher ENR ranking pursuit external certification of their sustainability reports. For instance, China State Construction Engineering Corporation's sustainability report has been included in the GRI list by 2011. Dongfang Electric Corporation has its Social Responsibility Report endorsed by GRI since 2009.

### *34.3.4 Dow Jones Sustainability Index*

According to the Sustainability Yearbook recently released by RobecoSAM AG, none of top Chinese international contractors were listed in the Dow Jones Sustainability Index in 2012 [15]. By contrast, the top two ranked ENR international contractors, HOCHTIEF AG and Grupo ACS were identified as sustainability leaders in the heavy construction industry which covers the delivery of infrastructure, commercial and residential buildings.

### *34.3.5 UN Global Impact*

There are only two top Chinese international contractors that participated into the UN Global Impact initiative. China National Machinery Industry Corporation and China Railway Construction Corporation commenced their participation since 2011 and 2010 respectively. This percentage is much lower than that of top 50 ENR international contractors in 2009. None of Chinese international contractors ranked below 30th have participated into the UN Global Impact initiative.

## 34.4 Conclusions

This study examined the sustainability disclosure practices adopted by top Chinese international contractors that are listed in the ENR top 225 International Contractors. The results showed that these Chinese international contractors are very active on sustainability policy in terms of both online disclosure and releasing sustainability reports regularly. However, only half of these companies' sustainability reports were listed by GRI. None of top Chinese international contractors were listed by Dow Jones Sustainability Index and only 9 % of them participated into UN Global Impact. It appears that Chinese international contractors lag behind of their fellow ENR Top International Contractors in terms of having their sustainability disclosure practice scrutinized by the third party with international standings such as GRI and Dow Jones Sustainability Index.

The results also showed that the sustainability reporting practices adopted by top Chinese international contractors varied significantly from one to the other. However, a clear trend emerges which is a growing level of disclosure of sustainability related information. In addition, environmental aspects of sustainability such as energy efficiency and pollution control were placed as the predominate focus in sustainability reports of top international contractors from China. However, social and financial aspects of sustainability have received growing attention, particularly from those with top ranking.

It is worth noting that the disaster relief/aid also featured in sustainability disclosure of top Chinese international contractors. This is arguably due to massive-scale natural disasters occurred in last a few years. Many top Chinese international contractors list it as a key component of corporate sustainability/social responsibility and provide case studies to show how the corporation involved in the disaster recovery process.

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# Chapter 35
# A Comparative Study of the Direct Costs Between Prefabricated Housing System and the Traditional Construction Technology—A Case Study of Precast Concrete Wall Panel

**Shan Zhang, Yuhong Pan, Ning Li, and Qi Sun**

**Abstract** Prefabricated house as a form of housing industrialization mode not only can improve the efficiency, but also has the advantage of the comprehensive cost reduction, energy saving, environmental protection, promote the development of the construction industry. Firstly, the article introduces status of housing industrialization development at home and abroad and a comparison of the prefabricated housing system and the traditional construction technology is made in terms of cost construction and construction process. Then, the comparison of direct cost is made for 100 m$^2$ of walls between precast concrete wall panel and the cast-in-site wall by using the method of fixed set of price. Moreover, sensitivity analysis is done. As a result, the use of prefabricated housing system on a large scale is recommended for prefabricated house developments in Chinese Mainland.

**Keywords** Prefabricated housing system • Precast concrete wall panel • Direct cost

## 35.1 Introduction

Housing construction is still dependent on traditional construction methods. Cast-in-situ construction is the main way of traditional construction and the cost of this construction method is relatively low. But there are a lot of shortcomings in this method, such as more wet work, a mass of manual labors, affected by environment, low efficiency, big noise and serious dust pollution. These don't agree with green, low carbon and sustainable development requirements. Prefabricated housing system is one of the residential industrialization modes, as a new green environmental protection energy-saving building, according to the architectural design requirements of industrialization, extensively used in residential construction projects with the main

S. Zhang (✉) • Y. Pan • N. Li • Q. Sun
School of Management, Chongqing Jiao Tong University, Chongqing, China
e-mail: zhangshan1211@163.com

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structure size precision, fine workmanship and in conformity with the modularization and standardization of prefabricated construction. This construction method solves the deficiencies of the traditional construction mode, not only stable quality, decreasing the wet work, shortening the construction period and saving material, but also protecting the environment [1]. Prefabricated building products are independent units in the residential construction. They have the function of rules [2]. Precast concrete wall panel (hereinafter referred to as PC) is one of the frequently used prefabricated. Prefabricated factory production promoted the development of housing industrialization, making the prefabricated housing as a model into the construction market. But, up to now China prefabricated housing system is still in its infancy and not always accepted by the public. It is because the system of the building is not perfect enough; some prices are still on the high side. Therefore, this article finds out the key factors that influence the cost, thus put forward Suggestions to promote the use of prefabricated housing system through the comparative analysis of the traditional brick wall with precast concrete panel of the direct cost.

## 35.2 The Development Status of Both at Home and Abroad

Prefabricated housing as a form of housing industrialization mode became a basic trend of evolution in the world's residential construction mode. It became the best choice of many western countries to solve the problem of shortage of living after World War II, because of the speed, quality and reliable of construction. Sweden is the most developed country in the residential industrialization in the world, with 80 % of its residential using residential general system, based on the general components; There are 34 companies specializing in the production of unit construction in the United States. Its residential building and the commercialization of components has a high degree of integration, almost 100 % and concrete commercialization with degree of 84 % [3]; From the residential structure system, abroad have developed timberwork, steel structure, reinforced concrete structure system, and constantly make residential product performance index improved.

At present, the prefabricated housing is still in its infancy, in the extensive state, no matter comparing with foreign counterparts, or comparing with other domestic industries. The industrialization level is still in a relatively backward state. Chongqing Wan Ke real estate co., LTD has researched in precast concrete wall panel (all of the following are referred to as PC), but also in the attempt stage, no large-scale promotion. Many domestic experts and scholars have conducted research in this field. GUO Le-gong, GUO Le-ning [4] and others revealed the superiority of precast monolithic assembly floor through comparing the calculation of structural internal force and project cost of precast panel assembled monolithic floor and cast-in-site floor in three technical solutions; LIANG Gui-bao [5], taking a prefabricated villa in Shanghai as an example, introduced the feasibility of prefabricated steel structure residence system from the aspects of structure system, construction performance and project cost; WANG Zhi-hong [6] thought housing components are lack of unified management and coordination and should set up housing standard system and certification system; KAI Yan [7] thought priority direction of the housing industrialization was the introduction and perfect of complete sets of technology, at the same time emphasized the importance of modular coordination in housing industrialization; LI Zhong-fu [8] thought that development of housing industrialization must promote residential building standardization and realize industrialization of residential construction technology integration; SONG Fei-fei [9] thought using the modern industrialization means to build housing can make residential construction high quality and whole life through the introduction of the advantages and development of prefabricated concrete structure; Zhang Cong-Xiao, Li Jian-tao [10] and other scholars believed that the quality of the principal part of the project can be guarantee through ensuring the small concrete prefabricated parts quality; Ye Ming [11] thought building housing component system is an important guarantee to improve housing industrialization. All researches above illustrate the prefabricated housing system in China has very good prospect for development, and will promote the development of China's construction industry.

## 35.3 Comparisons of Cost Construction and Construction Process Between the Traditional Construction Technology and the Prefabricated Housing System

### *35.3.1 A Comparison of Cost Construction Between the Traditional Construction Technology and the Prefabricated Housing System, the Following Table 35.1*

**Table 35.1** Comparison of cost construction between the traditional construction technology and the prefabricated housing system

| The construction method | Project construction cost | The difference |
|---|---|---|
| The traditional cast-in-site construction | Mainly by the direct cost, indirect cost, profits and taxes, the indirect costs including management fees and charges | Direct costs include the materials cost and labor cost, mechanical cost, measures (including the scaffold and the template) |
| Prefabricated housing construction | Mainly by the direct costs, indirect costs, profits, taxes, and the traditional way, the indirect costs including management fees and charges | Direct costs include prefabricated production costs, freight, installation expenses, measures (including the scaffold and the template) [12] |

Note: Direct cost of two construction ways is primary costs of construction enterprise, and it is the major part of the cost, and basis of budget fare calculation. Indirect costs including management fees and charges according to their own circumstances elasticity changes. Charges and taxes are uncompetitive fees. The rate of charges and taxes are fixed [13]

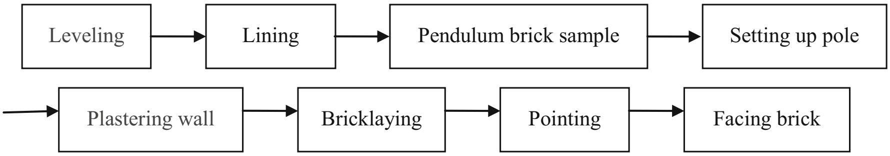


**Fig. 35.1** Construction process of Traditional brick wall (Data comes from the author)

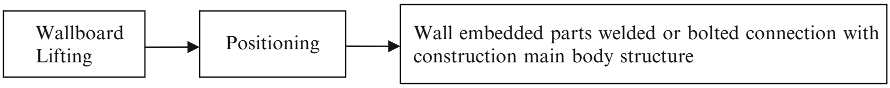


**Fig. 35.2** Construction process of PC wall panel (Data comes from the author)

## *35.3.2 A Comparison of Construction Process Between the Traditional Construction Technology and the Prefabricated Housing System*

### 35.3.2.1 Construction Process of Traditional Brick Wall

Traditional brick wall is basically manual operation way, its construction technology (see Fig. 35.1).

### 35.3.2.2 Construction Process of PC Wall Panel

From Fig. 35.1, we can see traditional brick wall construction process is trivial, manual labor is big, degree of mechanization is low, and construction speed is slow. And it will cause certain influence on the surroundings. But PC panel has some application advantages, such as reducing the load bearing wall, increasing indoor space. The factory production of PC wall panels decrease the pollution of environment, conducive to all kinds of waste materials recycling and reduce the waste of materials, etc. PC wall panel is completed in production workshop, installed in construction field, so it is easy to guarantee quality and less construction site operation process (see Fig. 35.2). PC wall panels' high mechanization degree will help to shorten the construction period, improve the quality of residential products.

## 35.4 Comparison of Direct Cost Between the Prefabricated Housing System and the Traditional Construction Technology

Based on 100's outer wall, this paper uses Guang Lian-da software and the method of fixed set of price to compare the direct costs between the prefabricated housing system and the traditional construction technology based on the direct cost calculation of the brick wall and PC wall panel.

### *35.4.1 Calculation of Direct Cost on Traditional Construction Technology*

An area of 100 $m^2$ of traditional brick wall process includes building construction and decoration parts. Building construction includes shale hollow brick wall brick walls and masonry strong gluten content of two parts. Decorative parts include general plaster wall, double plaster, exterior wall tile, interior wall latex paint wall and polymer cement waterproof mortar. This paper use Guang Lian-da software to get the following summary about labor, materials, and machinery costs, as shown in Table 35.2.

By Table 35.2 showing, 100 $m^2$ of traditional brick wall required the composition of the material entity for 32.5 cement, steel, sand, shale hollow brick, standard brick, lime putty, sawn timber, exterior wall tile, latex paint, glue, adhesive, polystyrene insulation board, fiberglass gridding cloth, special jointing agent, water and electricity (machinery) in construction process. The cost of materials price is:

$$\begin{aligned}&1,511.34 + 353.29 + 1,086.38 + 2,643.84 + 3,421.44 + 161.15 + 17.00\\&+2,838.30 + 793.80 + 54.31 + 359.75 + 2,100 + 255.20\\&+347.60 + 58.18 + 39.78 = 16,041.35\,Yuan.\end{aligned}$$

Material cost of per square meter of the traditional brick wall is: $16,041.35 \div 100 = 140.41$ *Yuan*.

The cost of machinery is: $56.86 + 105.30 = 162.16$ *Yuan*.

Mechanical cost per square meter of the traditional brick wall is:

$$162.16 \div 100 = 1.62\,Yuan.$$

The cost of labor is: $2,302.68 + 34.23 + 13,074.36 + 72.16 + 532.00 = 16,015.07$ *Yuan*.

Labor cost of per square meter of the traditional brick wall is:

$$16,015.07 \div 100 = 160.15\,Yuan.$$

The direct cost of the traditional brick wall = material cost + mechanical cost + labor cost = $160.41 + 1.62 + 160.15 = 322.18$ *Yuan*.

**Table 35.2** Quantity and price of traditional brick wall in terms of labor, materials and mechanical

| Labor, materials, mechanical quantity and price | | | | | |
|---|---|---|---|---|---|
| Project name: 100 $m^2$ traditional brick wall | | – | – | – | Unit: RMB |
| Number | Name, specification and model number | Unit of measurement | Quantity | Unit price | Us price |
| 一 | Labor | – | – | – | – |
| 1 | Comprehensive man-days | Man-days | 226.133 | 68.000 | 15,377.04 |
| 2 | Mechanical | Man-days | 2.800 | 38.000 | 106.40 |
| 3 | Decoration integrated man-days | Man-days | 4.750 | 112.000 | 532.00 |
| 二 | Materials | – | – | – | – |
| 1 | 32.5 cement | kg | 4,380.700 | 0.345 | 1,511.34 |
| 2 | Steel | t | 0.072 | 4,900.000 | 353.29 |
| 3 | Sand | t | 13.928 | 78.000 | 1,086.38 |
| 4 | Standard brick 200 × 95 × 53 | Thousand brick | 5.184 | 510.000 | 2,643.84 |
| 5 | Shale hollow brick | $m^3$ | 15.552 | 220.000 | 3,421.44 |
| 6 | Lime putty | $m^3$ | 0.645 | 250.000 | 161.15 |
| 7 | Sawn timber | $m^3$ | 0.010 | 1,700.000 | 17.00 |
| 8 | Exterior wall tile | $m^2$ | 94.610 | 30.000 | 2,838.30 |
| 9 | Latex paint | kg | 28.350 | 28.000 | 793.80 |
| 10 | Glue | kg | 25.860 | 2.100 | 54.31 |
| 11 | Adhesive | kg | 14.390 | 25.000 | 359.75 |
| 12 | Polystyrene insulation board | $m^2$ | 105.000 | 20.000 | 2,100.00 |
| 13 | Fiberglass gridding cloth | $m^2$ | 116.000 | 2.200 | 255.20 |
| 14 | Special jointing agent | kg | 158.000 | 2.200 | 347.60 |
| 15 | Water | $m^3$ | 14.546 | 4.000 | 58.18 |
| 16 | Electricity | kW/h | 15.911 | 2.500 | 39.78 |
| 三 | Construction machinery | – | – | – | – |
| 1 | Mortar mixer 200 L | Machine-team | 1.848 | 87.750 | 162.16 |

Note
(1) The wall is shale hollow brick masonry wall, plastering with 1:3 cement mortar
(2) Interior wall uses twice of latex paint
(3) Exterior wall is for: on the surface of paste sticking polystyrene insulation board; on the surface of fiberglass mesh sticking exterior wall tile with polymer cement waterproof mortar; ticking off seam of brick
(4) The price is executing the information of Chongqing construction cost of 2012, 6 (247)

## 35.4.2 Calculation of Direct Cost on PC Wall Panel

Owing to traditional masonry construction is a common way of construction, so the traditional brick wall can be directly applied quota and combined with the market price to calculate. And PC wall panels are kinds of prefabricated and factory production, then transported to the site for installation. But now application is less, so the data reference is less, there is no quota to paraphrase. Therefore this article calculates material cost, mechanical cost and labor cost of PC wall panels through empirical data and applying the quotas of non-prestressed precast concrete hollow panel, a build motor transport (both in terms of a km) and interior wall tile, and conversion.

**Table 35.3** The material cost of PC wall panel

| Mode of production | The cost of materials | Material cost (RMB) |
|---|---|---|
| Precast concrete wall panel | Material cost of precast concrete wall panel | 35.87 |
| | Steel bar | 73.5 |
| | Exterior wall tile | 30 |
| | Plastic film and net type splitter | 60 |
| | In total | 199.37 |

#### 35.4.2.1 The Cost of Materials

The material costs of PC wall panels are mainly in production stage. For 1 $m^2$, this paper calculated the material cost difference between precast concrete panels and traditional brick wall. From the production process of PC wall panel, it requires reinforcing steel and plastic film and net type splitter. Though Guang Lian-da software we can get these figures: material cost of 1 $m^3$ of precast concrete wall is 224.29 *Yuan*. Taking 160 PC wall panel for example, material cost is 35.87 *Yuan* by conversion to 1 $m^2$. According to the empirical data, 1 $m^2$ PC wall panel needs 15 kg steel bar. One ton steel bar price is 4,900 *Yuan*, so the steel bar's cost of 1 $m^2$ PC wall panel is 73.5 *Yuan*. One square meter of the exterior wall title is 30 *Yuan*. One square meter of plastic film and net type splitter cost is two times the cost of materials for exterior wall tile [14], which is 60 *Yuan*. To sum up, the material cost of 1 $m^2$ of PC wall panel is 199.37 *Yuan*. The material cost list of 1 $m^2$ of PC wall panel as shown in Table 35.3.

#### 35.4.2.2 The Cost of Machinery Equipment

Through Guang Lian-da software analysis, the mechanical cost of PC wall panel is calculated by taking the non-prestressed precast concrete hollow panel norm, the type of build motor transport (both in terms of a km) quotas and interior wall face brick quotas. Above the corresponding quantity is 1 $m^3$ (6.25 $m^2$), respectively, 1 $m^3$ (6.25 $m^2$), and 1 $m^3$, software calculation corresponds to 3.43 *Yuan*, 8.67 *Yuan* and 0.24 *Yuan*. Taking 160 PC wall panel for example, 1 $m^2$ of Mechanical cost is 2.18 *Yuan*. The mechanical cost list of 1 $m^2$ of PC wall panel as shown in Table 35.4.

#### 35.4.2.3 The Cost of Labor

Through Guang Lian-da software analysis, the mechanical cost of PC wall panel is calculated by taking the quotas of non-prestressed precast concrete hollow panel, the type of build motor transport (both in terms of a km) and interior wall face brick.

**Table 35.4** The mechanical cost of PC wall panel

| Mode of production | The cost of mechanical | Mechanical cost (RMB) |
|---|---|---|
| Precast concrete wall panel | The mechanical cost of making precast concrete wall panel | 0.55 |
| | The mechanical cost of making precast concrete wall panel | 1.39 |
| | The mechanical cost of interior wall face brick | 0.24 |
| | In total | 2.18 |

**Table 35.5** The labor cost of PC wall panel

| Mode of production | The cost of labor | Labor cost (RMB) |
|---|---|---|
| Precast concrete wall panel | The labor cost of making precast concrete wall panel | 54.66 |
| | The labor cost of making precast concrete wall panel | 5.23 |
| | The labor cost of interior wall face brick | 74.58 |
| | The labor cost of industrial workers | 4 |
| | In total | 138.47 |

Above the corresponding quantity is 1 $m^3$, 1 $m^3$, 1 $m^2$. Software calculation corresponds to 341.63 *Yuan*, 32.66 *Yuan* and 74.58 *Yuan*. One square meter of labor cost is 54.66 *Yuan*, 5.23 *Yuan* and 74.58 *Yuan*. Since PC wall panel is the result of the industrialization of production, so the labor cost should also join in the industrialization of the workers' wages. According to statistics, the industrialization of workers can product 30 $m^2$ of PC wall panels in one man-day, and the daily wages of industrial worker's is 120 *Yuan*. So every square meter of PC wall panel including industrial workers labor costs is 4 *Yuan*. So 1 $m^2$ of PC wall panels labor cost is 138.47 *Yuan*. The labor cost list of 1 $m^2$ of PC wall panel as shown in Table 35.5.

Through the above calculation, we can conclude that the direct cost of 1 $m^2$ PC wall panel = material cost + mechanical cost + labor cost = 199.37 + 2.18 + 139.47 = 340.02 *Yuan*.

### *35.4.3 Comparison of Direct Cost of the Two Products in the Production Stage*

Direct cost of two kinds of products is in the production stage, as shown in Table 35.6.

To sum up, in the unit direct cost, PC wall panel is 105.5 % of the traditional brick wall, namely the direct cost of the PC wall panel was 5.5 % higher than traditional brick wall; In terms of unit cost of materials, PC wall panel is 124.3 % of

**Table 35.6** Comparison of direct cost between the PC wall panel and the traditional brick

| Mode of production | Mechanical cost | Material cost | Labor cost | Direct cost |
|---|---|---|---|---|
| Precast concrete wall panel (1) | 199.37 | 2.18 | 138.47 | 340.02 |
| Traditional brick wall (2) | 160.41 | 1.62 | 160.15 | 322.18 |
| (1)/(2) | 124.3 % | 134.6 % | 86.5 % | 105.5 % |

the traditional brick wall, namely the material cost of PC unit wall panel was 24.3 % higher than that of the traditional brick wall; In terms of unit cost of machinery, PC wall panel is 134.6 % of the traditional brick partition, namely the mechanical cost of PC unit wall panel was 24.3 % higher than that of the traditional brick wall; In terms of unit cost of Labor, PC wall panel is 86.5 % of the traditional brick partition, namely the mechanical cost of PC unit wall panel was 13.5 % less than that of the traditional brick wall. Through the analysis, in terms of total production cost the PC wall panel is not much higher than the traditional brick wall; in the cost of materials and machinery, the PC wall panel is higher than traditional brick wall; in terms of labor cost, the PC wall panel is less than traditional brick wall. So we can reduce the material cost and mechanical cost of prefabricated to reduce the cost of prefabricated house. At the same time, we can use the methods of integration technology, saving material and reducing consumption, improving efficiency to reduce the comprehensive construction cost.

## 35.5 The Suggestions to the Use of PC Wall Panel

1. Factories should increase the quantities of PC wall panel and realize the scale production mode.

   Calculated by above, unit direct cost of PC wall panel is slightly higher than that of traditional brick walls. The reason is that the cost of materials and machinery is high in the production of PC wall panel. So it should realize the factory production of PC wall panel, improve productivity; increase the scale of production to reduce the unit cost of PC wall panel.
2. Factories can use the methods of introducing foreign advanced technology, strengthening technology development, producing alternative new materials to reduce the costs of PC wall panel.

   The materials of PC wall panel consist mainly of precast concrete material, steel bar, exterior wall tile, plastic film and net type splitter. One of the biggest impacts is the cost of steel bar; the second one is the plastic film and net type splitter. And the market price of these two kinds of material is higher Resulting in Relatively high cost of PC wall panel. Therefore, vigorously developing new technology, new material can reduced construction cost of PC wall panel, thus it can be widely accepted and recognized.
3. It is necessary to optimize the production process of PC wall panel, strengthen outside mechanized production and installation of PC wall panel, and reduce the use of Labors.

The mechanical efficiency of PC wall panel is higher than traditional brick wall, but mechanical cost accounted for relatively small of the proportion, so it is less impact on direct cost. Therefore, strengthening the mechanized production, reducing the use of labor can greatly reduce cost directly with little increase of mechanical cost, so as to reduce the cost of PC wall panel.

4. The methods of strengthening the recycling of materials and reducing the wastage of the material, can save the cost.

   PC wall panel is prefabricated factory production, so it can reduce the waste of materials, and can recycle waste materials, reduce the cost of materials. In this way does it not only reduce the cost, but decrease the pollution of environment.

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# Chapter 36
# Consideration to the Positioning and the Role of Building in Business Continuity Plan

**Takuro Yoshida, Masahiro Murakami, Masamitsu Miyamura, and Tomohiro Kubo**

**Abstract** In Japan, interest in BCP (Business Continuity Plan) rises after the East Japan Great Earthquake Disaster. This shows a new viewpoint for the way of the building. This study considered the relation between the building and BCP and understood the next matters. At first, as for the disaster prevention and the security of the building, there is the problem which should supplement the disaster prevention and the security of the building from the viewpoint of business continuity even if it is at the important position in BCP. In addition, the building supports business continuation but it is targeted for restoration if it gets damage. Furthermore, seeing from BCP, there is room that a new element is introduced for the today's method of the building planning. These matters remain in the level of the hypothesis at present. However, based on recent suffering experience, there is such significance that is able to capture the orientation of the problem that the building field should work on. In addition, it raises recognition for the importance of disaster prevention and the security still more.

**Keywords** Business Continuity Plan • Disaster • Resource • Restoration • Risk • Recovery • Building planning

## 36.1 Introduction

Small and Medium Enterprise Agency has issued a "small business BCP formulation operational guideline". Business continuity plan (BCP) is described as follows on it.

T. Yoshida (✉)
Department of Architecture, Kogakuin University, Shinjuku, Tokyo, Japan
e-mail: yoshida@cc.kogakuin.ac.jp

M. Murakami • M. Miyamura • T. Kubo
Urban Design and Planning, Kogakuin University, Shinjuku, Tokyo, Japan
e-mail: murakami@cc.kogakuin.ac.jp; miyamura@cc.kogakuin.ac.jp; tkubo@cc.kogakuin.ac.jp

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When a company encounters such emergency as natural disaster, major fire, terrorist attacks, it does the following. The company minimizes the damage of the business assets. In order to allow early recovery or continuity of the core business, the company keeps arrangements method and means for business continuity during emergencies and activities to be performed in normal times.

In Japan, in recent years, interest in BCP has increased. Previously, the main theme of measures in emergencies and disaster was recovery and ensuring the safety. On the other hand, in the BCP, business continuity is the theme. In BCP, the business itself is reviewed in terms of continuity. Then, the effect of investment for proper business continuity is the important metric.

At newly building, maintenance operation, refurbishment, the significant investment for facilities is required. The evaluation of quality of facilities occupies a large position in the BCP,. And the evaluation of business continuity provided by additional investment required for BCP is the key.

That said, building officials tend to fascinated by disaster. However, the risk covered by the BCP has a wide range of content.

To what building to be, BCP will become a new point of view. The purpose of this paper is as follows. The basic purpose is to capture systematically what the building to be seen from the BCP. Thus, we discuss on the overall framework of BCP and on issues of building for BCP,. In the case of the discussion, we use the Engineering University as example.

## 36.2 Various Risks Involved in Doing Business

Measures for risk leading to damage of building require a lot of money. Then, the position of them in BCP is also large. The risk measures that have been taken in the building of general are the following. First, they are such disasters as earthquakes, typhoons, and fire. Next is breakdown or accident on equipments, doorways and windows. Case is small in Japan; interest in terrorism is high in Europe and the United States. On the other hand, measures for tsunami, storm surges, floods, landslides have been to be difficult in building level. However, in the BCP, it is inevitable also consider these.

Risks which do not lead directly to the damage of the building are many. The risk which is concerned with financial, legal, and labor here is a basic engaged in business. There is also the risk involved in business strategy and business environment to support business development. There is the-risk related to information systems that support the various performance of job. And there is such as crime and pandemic.

An overview of them is shown in Table 36.1.

By the way, many of the various risks that do not lead directly to the damage of building, in fact, are involved with building. The size and function of

**Table 36.1** Risk seen in relation to building damage

| | | | |
|---|---|---|---|
| Risk that will lead directly to the damage of the building | Disaster | Corresponding building level is difficult. | Tsunami, storm surges, floods, landslides |
| | | Measures building level is in progress. | Earthquake, typhoon, fire |
| | Accident, failure | | Power failure, damage, life |
| | Negligence | | Operational errors, misuse |
| Risk does not lead to direct damage to the building. | Risks associated with life basic business | Financial risk | |
| | | Legal risk | Compliance |
| | | Labor risk | Sabotage |
| | Risks associated with business development. | Risk business strategy | |
| | | Business environment risk | |
| | Risks associated with information systems | | Power failure, failure, cyber terrorism |
| | Social risks | | Pandemic, crime, terrorism, coup, war |

building heavily involved with such as responding to business strategy, business environment, adaptation to problems of labor and appropriate prevention of crime. These are issues that lead deeply building planning, building construction method, and building equipment. The involvement of the BCP and building is wide and deep.

## 36.3 Business Damage and Risk

Damage of various businesses will depend on strength and type of the risk. Risk measures of higher level can reduce damage of the risk occurs. Evaluation of the damage that would be reduced by risk measures and the cost of it are required. The problem is that the occurrence of risk is the probability event.

For example, the probability of occurrence of earthquake has been publicly known. Also we can predict damage of building in accordance with the extent of the earthquake to some extent. And the problem is that there are damage of building and various other kind of damage. And there are various secondary damages caused by damage of building. In the process of BCP formulation, consideration enough about these is necessary.

## 36.4 BCP of Resources Corresponding and BCP of Business Correspondence

Business such as industry is constituted by a variety of business. Provided so as to correspond to the location and content of business, each business is practiced in the offices and departments. These activities are practiced on the basis of the fund, personnel, and facilities. And they offer and create value-added products and services. As a whole, throughout the various works of their businesses, such companies can promote the survival development. In BCP, from the point of view of BCP formulation, the unity of appropriate business is captured. In reality, such as offices or departments of existing corresponds to this.

In the BCP of offices and departments, there are two types. One is of the content related to the entire enterprise. Another is that of content specific to the office or department. That the BCP of two types should be developed with good balance is essential. For office, the contents of the BCP are due to the uniqueness of the location. As the department, based on the contents of the BCP, there are two types. One is the department that is included like in BCP overall. The other is such department that the uniqueness of the business is reflected properly.

The resource in issue in BCP is such as the relevant public infrastructure, personnel, funds, facilities, materials, and information systems which are necessary for conducting business. There is a case that each office or department develops a BCP own. Further, the BCP of each office or department may be included in the overall BCP. In either case, it is essential to verify if they are treated properly in BCP overall. Each resource should be treated efficiently centrally as a whole basically. The BCP corresponding to the business and the BCP corresponding to the resource are in the relationship of the warp and weft. Investment in resources is an important challenge in the balance of the improvement of investment efficiency and enhancement of risk measures, and optimal solution should be sought.

## 36.5 Normal Business and Business at Disaster Time

In general, normal business of such as industry, is roughly classified as follows. First, it is the business of providing and creation of value-added products and services that are specific to such companies. Next, it is the business such as accounting affairs and general affairs to support them. Even in the company of the same industry, culture, location, scale and the like, form of organization and business content are different. At development of the BCP, there is such mean as to review and confirm these normal businesses.

At the organization of Kogakuin University, on the basis of the Board of Directors, there are corporate office, the University, middle and high school, the like open college, and others. It can be expressed as shown in Fig. 36.1. At this level, features of private university are not represented in general.

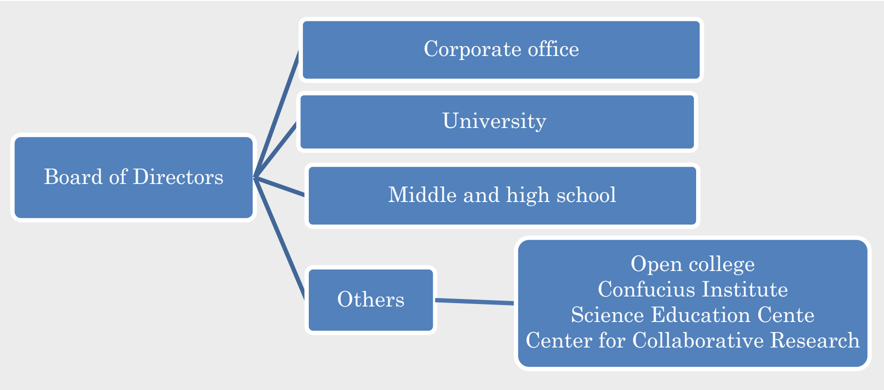


**Fig. 36.1** Organization of Kogakuin University

Organization of Kogakuin University is composed of faculties, graduate school, research institute and office. The feature of university appears on contents of faculties, graduate school, research institute.

The office sector, there is a clerical organization such as corporate office, university office; middle and high school office, and others. Duties regulations of office division have been enacted. These include overview of the work of each department explicitly.

For education and research, there is no equivalent regulation to the division of duties prescribed in administrative division. So, if we can look for something similar, there is the following. In the university, the policy of degree awarded is established. Each faculty and department provides the philosophy of education and research objectives.

Syllabus is shown in each subject. However, there is nothing to indicate business of education and research directly. The regulation of the University describes that indicating duty of professor is education and research. However, it does not touch the concrete content more. In the regulation of the University, the function of Faculty Council is described such as to determine personnel affairs and academic affairs. Now, we can infer one side of concrete business of education and research. As for business of education and research of the University, at provisions of division duties of the department in charge of this in the office sector, there is a description of certain.

In any case, for the work of professors who are responsible for education and research, there is nothing that has been documented. From the point of view of BCP formulation, this is the situation should be improved.

On the other hand, the normal business of the administrative division, said to have been documented, but about the appropriate representation of the business of reality, verification is always required. And, responding to changing conditions is required.

The business at disaster time is the work to be continued out of the normal business and the disaster response operations. Doing all the normal operations in large disaster is difficult. It is necessary to select the business involved in the survival of the organization and to turn on the limited resources to the continuity of its business. Among the various types of business, the bottleneck is what makes it difficult to continue main business. Anyway whether or not to develop a BCP, already awareness of its existence may be known. In BCP, on conducting the necessary analysis and the confirmation of the bottleneck, appropriate measure should be taken in advance.

On the disaster response operations, to secure safety of human life and to prevent secondary damage could not wait. Resources of all possible should be turned on these. In parallel, there are urgent tasks to recovery-related operations. When recovering damage of hardware and software caused by the disaster by introducing limited resources, accurate identify as bottlenecks is important.

In relation to recovery, first, grasping the damage and making the prospect of recovery should be done. Those who can be recovered in the range of individual departments or small group can be achieved immediately by making clear what is the outlook. The problem is the response to the bottleneck which cannot be treated in the range of individual departments, or small groups, The BCP makes clear it in advance to be widely recognized, and commits resources to accurately time at the disaster to achieve business continuity.

Addition to the business as a disaster response operations, endurance safety of human life, prevention of secondary damage, and restoration, such as a company, there is a social business. In Kogakuin University, contributing to the disaster countermeasure activities and community acceptance of stranded commuters are determined in advance. These operations may have effectiveness by predetermination and adequate training.

## 36.6 Preparation of Resources and Input of Resources at Disaster Time

Most of the resources to be utilized to the affected time are resource in the performance of normal operations. The resources that are not utilized usually are some facilities for backup in the affected time and stockpiles for disaster time. Each member performs normal operations usually and plays a role-based BCP at disaster time. Usually facilities such as building are places for normal business and places for the activity corresponding to the BCP at the disaster time. At the disaster time when the problem is decision on each resource which can take advantage of the business such as restoration, or become the subject of restoration with suffering of damage.

Resources can be divided into resources of the company itself and external resources. At the level of personnel, funds, and facilities, resources of companies are common regardless of the type of company. Specific content of each is different depending on the kind of industries.

Resources for Engineering University approximately are shown in Table 36.2. Most of these are involved in normal business. In BCP, the contribution of them to

**Table 36.2** Type of resource (in the case of Engineering University)

| Resources | | | Supplement, case |
|---|---|---|---|
| Internal resources | Personnel | Disaster countermeasures | Personnel dealing with disaster response as the normal business, personnel applied to disaster preparedness in the disaster. |
| | | General faculty | Personnel to play a role as firefighters of self-defense |
| | | Students | Personnel for disaster control due to training |
| | Funds | | Amount, possibility to use |
| | Facilities | Building | Place for variety of business, mobile vehicle route |
| | | Building equipment | Air conditioning, plumbing, electrical, lift |
| | | Furniture, fixtures | Desks, chairs, storage furniture, simple partition |
| | | Educational facilities | Classroom, exercise room, lab |
| | | Research facilities | Laboratory, research equipment |
| | | Information equipment | Servers, computers, network |
| | | Disaster prevention equipment | Disaster prevention center, fire prevention equipment |
| | | Outdoor | Outdoor facilities, passage, square, planting, well |
| | Information | | Documents, electronic information |
| | Material | | Stockpiles |
| | Complementary facilities | | Another campus, others |
| External resources | Partner organizations suppliers | | Governments, partner universities, main banks, traders |
| | Public infrastructure | Roads | Level of the disaster, congestion |
| | | Transportation | Level of the disaster, service status |
| | | Energy | Supply of electricity, gas |
| | | Water | Extent of the damage on waterworks and drainage |
| | | Communication | Telephone, Internet, wireless |

disaster is formulated and corresponding of personnel to the affected disaster is equipped by training.

Building is the place for normal business operations of various on every day. It is also the place in which various resources are operated to be subjected to normal operations. At the disaster time, the building takes an active role as the place for disaster response activities. On the other hand, if the building has suffered damage, it becomes important restoration target. There is ambivalence in building.

The external resources are some outside organizations, outside companies, and public infrastructure. The usual trading and cooperative relationship of organizations and companies of various types are re-considered in the formulation of BCP. Evaluation as a recovery target and evaluation of as resource for recovery are required. In addition, some active cooperation may also be build at disaster time.

Public infrastructure plays such important role as to conduct of business, as well as to support the general and social life and activity, at disaster; the awareness of situation is needed first. Transmission of information about it is the most important role of public.

## 36.7 Outline of BCP Formulation

On the BCP formulation, two of the following is the essence. The first is to understand the business impact of the damage caused by various risks. And, thereby the second is responding to their effects.

For various risks whose occurrence is assumed, various analyzes are performed with an assumption of the risk scenario. The risk scenario is assumed on understanding how the damage caused by each risk occurs, and how it affects the various work. The magnitude of the damage is different by strength of the risk of various types, as well as, peripheral status and time of occurrence. For a variety of damage, the appropriate evaluation from the point of view of business continuity is made to be lead to the study of the measures. In parallel with the point of view of business continuity, evaluation for the various stakeholders (customers, investors, business partners, employees,) is also important. The analysis of these series is Business Impact Analysis (BIA).

Among the various types of damage, what will lead to suspension of business is a bottleneck. In BCP, to take the appropriate measures for bottleneck will be focuses. In addition, the various risks and the damage caused by it are considered comprehensively to take appropriate measures in light of the management strategy.

The occurrence of damage to be fatal to business execution should be avoided as much as possible. At the pinch when bottleneck occurs, it should be recovered in the period needed for it. These should be done accurately based on the realistic status of the resource. There, advanced technical judgment and superior strategic decision of management is essential.

For the occurrence of risk, risk damage, influence of damage on the business, the development of related data and technologies to estimate and predict, are progressing by leaps and bounds in recent years. On the other hand, when each company develops BCP for it, unique conditions must be appropriately reflected. There, the basis of the data and technique which can be used in general, the BIA is performed properly reflecting the unique conditions. And, at the time of risk, the evaluation and selection of a strategy for business minimal to be continued is done. Performing the evaluation and selection of strategy for resumption of operations recovers early damage. And, management strategy decisions that take into account the resources realistic conditions are required. Development of these BCP is also a review and improvement of business of such company itself.

## 36.8 Building and BCP

Among mentioned so far, building appears in various aspects of BCP. Among the risk of direct damage to the building, about earthquake, fire, strong wind, the development of systems and techniques for addressing these have been promoted. For new building, to reflect them appropriately is an issue. And, evaluation of the building required for such judgment of cost-effectiveness is not too difficult.

On the other hand, in the case of existing buildings, we study such as renovation for business continuity in light of the evaluation of the existing condition. It is necessary to consider a various research including the existing condition.

Research related to the earthquake is an important issue in investigation of the existing condition. In Japan, the development of technology and systems on seismic diagnosis and seismic retrofitting is in progress. However, from the viewpoint of business continuity, review of certain is desired. In addition to ensuring the safety and security of lives and property, the effects of damage done to business, evaluation are needed including evaluation of restoration measures. The context of the bottleneck is particularly important. There, evaluation relating to the equipment and structural secondary member is also important.

In the survey of real condition of existing building, evaluation leading to measure not only for the reinforcement of the building and equipment but for change of layout planning, facility improvements, and renovation is essential. Change of the deployment plan, improvements of equipment, and renovation for business continuity spend cost according to its contents with. The problem is cost-effectiveness.

In the deployment plan in the building, optimal placement as a place for normal business is realized. The problem is the adequacy of the arrangement plan seen from BCP. At present, there is nothing which was established in a systematic manner to determine the appropriateness of the deployment plan as seen from the BCP. As safe evacuation of the disaster, said to have been achieved at a high level, this alone is insufficient. There, there is a problem that required for the building sector.

For new building, it is possible to formulate a new deployment plan that reflects the BCP. For existing building, if the deployment plan and improvements of facilities may change, renovation is to be carried out many costs required for them. A rough estimate is the role of the building sector. At the evaluation of the effect, relevant stakeholders are involved. And, it is something that should be made by management with strategic judgment in the end. At development of materials that can be utilized in the judgment by management, evaluation of stakeholders and estimation of the cost, the role of the building sector is large.

On the BCP, in addition to the existing building, such case may occur as the complementary property is desired. In this case, in terms of the key conditions for setting complementary facilities, the evaluation of existing building is important. Further, instead of the building itself, depending on factors related to the location of such transportation and energy supply, sometimes building may not be able to exhibit its function. For these things, it is necessary to keep in mind at the building sector.

## 36.9 Building Costs and BCP

About taking a lot of money to disaster prevention of existing building and restoration of the affected building, the building sector has discussed in various ways, and measures have been taken. In BCP, in which, to capture the risk comprehensively and systematically in business continuity, various damages by disaster directly to the building can also be positioned relative to each other. This does not reduce the positioning of building disaster. This rather deepens broader interest to building disaster prevention, and lead to the promotion of investment for that.

Central theme of the BCP is business continuity but, BCP is also a new perspective to the business itself. From the point of view of continuity, what the business itself should be is reviewed. A building is the place for business and also the facility required for the activity. For such building, BCP leads to new requirements. For operation and planning the building sector is required to effort in a different perspective from that of the past. And many costs may be accompanied.

About these matters, in the current building sector the development of materials and systematic approach practical is incomplete. However, risks do not wait. Each continual squeezing the wisdom and repetition of performance in the individual project may connect to systematic response of building field to the BCP. There, more sophisticated economic evaluation is required.

## 36.10 The New Point of View of Building Seen from the BCP

In BCP, building is expected to be a place for business in disaster situations, but it becomes object for recovery operations if it suffered damage.

So far, such disaster as earthquake, fire, typhoons, we have experienced those disasters to repeat coming and results in damage to the building. In the basis of this, the development of technology and systems whose target is securing safety of human life has been carried. In BCP, from the viewpoint of business continuity, building measure for disaster recovery is enhanced. In general, the securing safety of human life is the mission of building much heavier than business continuity. However, also, by industries, in the circumstances of the individual, about the weight of realistic business continuity, appropriate evaluation is to be asked. Upon restoration of the building, where the limited resources should be concentrated is a realistic challenge. Including this matter, in the building sector, there are many challenges to delve enough.

Among such disaster to bring damage to the building as tsunami, storm surges, floods, landslides, etc., there is a limit to the measures of building. For these, it is necessary to consider in the building sector the possibility of countermeasures contemporary and to obtain its proper social understanding.

If there is not physically damage of the building itself, depending on the damage of public infrastructure building may not be able to exhibit the function. Securing temporary energy at emergency is a challenge that forms a part of the BCP, and the response to the damage of public infrastructure is an important issue related to business continuity directly. Even if there is no physical damage caused by the disaster, if such state continues the function cannot exert, it will bring damage to the building. Delays of restoration of public infrastructure, and the continuation of the state off limits is the serious problem.

It is a critical challenge in BCP formulation with greater consideration to make function of as a place for business in the affected time. In order to ensure the minimal function of building, for moving means, energy supply, plumbing, and information systems, prevention of damage and speedy recovery are important. Already, from the point of view of safety and disaster prevention, development of system and technology is certain to be. From the viewpoint of the BCP, it may be necessary to review generally such importance for individual factors.

In commerce and manufacturing the relationship between building and core businesses which should be continued is a relatively clear. Also good example can be found. But now, for the University as higher education institutions, the arrangement of relationship between the building and the core businesses is not clear. Up image of this area is desired.

At the disaster time, the original building features become difficult to be in use by damage, and the problem inherent in the original function itself may be exposed. The problem about size and layout of emergency facilities and stockpile warehouse may be exposed. Also the problem about normal layout of such personnel and departments as should make up the task force in the disaster may be exposed. Those problems are challenges on how to building planning. Including these matters, the method of building planning corresponding to the BCP still has not been established as the common understanding for the overall picture. The creation of method how to appropriately reflect in the future building planning of BCP, and the development of how to reflect the renovation of an existing building are challenges to be expected.

## 36.11 Closing

The interest to BCP has been increasing in recent years in Japan, and BCP has brought a new perspective to the way of building. In light of this, we considered the relationship of building and BCP. Among them, though safety and disaster prevention of building are in important position in the BCP, from the point of view of business continuity, it has been found that there are issues that need to be complemented with building. First, building supports business continuity, but, if it takes the damage it becomes a recovery target. Further, there may be room for a new element which should be introduced into the method of building planning from the view point of BCP. These have remained in the level of hypothesis at present, but such significance as to capture the orientation of the object of building field is able to be admitted based on the experience of disaster in recent years.

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# Chapter 37
# Cultural Diversity and Workplace Safety on Australian Construction Sites

**Yingbin Feng**

**Abstract** Cultural diversity has inevitably become a distinctive feature of Australia's construction workforce. However, the cultural divergences of the construction workers in different ethnic groups and their implications for occupational health and safety management remain unclear. It is not known how the occupational health and safety performance and the workers' safety behaviours in a culturally diverse workforce would be influenced by the cultural divergences. Therefore, there is a need for a systematic investigation into the cultural divergences among workers in difference ethnic groups and their impacts on the workplace health and safety management in the construction industry. This research study aims to investigate the OHS implications of cultural divergences in the Australian construction workforce. Data were collected through semi-structured interviews. The findings include the organisational challenges presented by the cultural divergences to the employers and the impact of cultural divergences upon workers' safety behaviours.

**Keywords** Construction • Safety • Culture diversity • Australia

## 37.1 Introduction

Ethnic and cultural diversity is one of the defining features of Australian social and economic life. Historically, Australia has relied heavily on immigration for its population growth. According to the 2006 Census 22.2 % of the Australian

Y. Feng (✉)
School of Computing, Engineering and Mathematics, University of Western Sydney,
Locked Bag 1797, Penrith, NSW 2751, Australia
e-mail: y.feng@uws.edu.au

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population was born over-seas, and 62 % of this overseas born population, originate from non-English speaking countries [2, 5]. A high level of ethnic and cultural diversity also characterizes the Australian workforce. Sixteen per cent of the Australian labor force is from non-English speaking background [5] and the Australian construction industry is one of Australia's largest and most culturally diverse, directly employing about 9.2 % of the working population [2]. Diversity may be defined as the presence of differences among members of a social unit [10]. Diversity is an increasingly important factor in organizational life as organizations worldwide become more diverse in terms of gender, race, ethnicity, age, national origin and other personal characteristics of member [19].

The construction industry is notorious for its poor safety record when compared with other industries. It was estimated that 640,700 persons suffer a work related injury each year in Australia [2]. There were 40 fatalities recorded in the preliminary data for 2008–2009, which was the highest number of fatalities of all industries. This corresponds to a fatality rate of 5.9 fatalities per 100,000 in 2008–2009, which is more than twice the rate of 2.3 for all industries [3, 18].

Numerous studies undertaken regarding cultural diversity within the construction industry have already identified that if workplace safety is not effectively managed, the consequences result in increased safety risks on construction sites. Studies have also identified that workers of non-English speaking backgrounds (NESB) are more exposed to safety risks compared to other workers. Geraghty [9] identified that migrant workers contribute an alarming rate of accidents and an injury rate at twice of the local workers. It has been revealed that injuries to foreign-born workers accounted for 29 % of all documented occupational grievances [1] and this data has been linked to 44,300 work related injuries to NESB workers. Consequently, if management is ineffective, NESB workers can place significant risk on employers who must comply with the strict safety regulations [15].

Previous research has identified various factors that may contribute to the high level of workplace injuries of workers within the Australian construction industry. However, there are few studies which systematically investigate the workplace safety issues in a multicultural workforce in the construction industry. Additionally there is little evidence that Construction Company's provide sufficient training to supervisors and managers on how to work with the cultural diverse workforce. Against this background, this research was proposed to examine the workplace safety implications of cultural diversity issues on construction sites. This paper presents the preliminary results of the pilot study, which focused on the identification of safety issues in a multicultural workforce and the development of a data collection instrument for the next stage of this research project.

## 37.2 Literature Review

### *37.2.1 Cultural Diversity in Australia*

The American Heritage Dictionary defines culture as ‘the totality of socially transmitted behaviour patterns, arts, beliefs, institutions, and all other products of human work and thought considered as the expression of a particular period, class, community, or population’. Culture determines how we communicate, how we relate to people, how we regard property, our interaction with the environment, and our perspectives of time.

From 1973, Australian policy was implemented to accept multiculturalism. The current Australian policy is characterised by an emphasis on the productive or economic benefits of cultural diversity. The Diversity Works Policy (previously entitled Productive Diversity) seeks to promote the positive economic outcomes of managing cultural diversity. The policy commits the Australian Government to three core strategic priorities: community harmony, access and equity, and diversity management [4]. Even in best practice organisations, diversity management has a narrow focus, e.g. prioritising women, harassment, caring responsibilities and disability ahead of religion, nationality and race. Of note is the fact that there was a relative absence of initiatives addressing issues associated with race and ethnicity.

### *37.2.2 Cultural Diversity in Construction*

Cultural diversity has resulted in Australian Construction sites being characterized by clearly distinguishable cultural and linguistic territories, typically demarked by occupational boundaries [15]. For example, Italians tend to concentrate in concrete trades, Croatians in carpentry trades, Koreans in tiling trades, Maoris in steelwork and scaffolding, Irish in labouring, etc. [15]. There is evidence that this cultural trade demarcation presents a significant organizational challenge for project managers. For example, Loosemore and Lee [14] found significant communication problems with migrant workers on Australian construction sites. Loosemore and Chau [13] found worrying evidence of racism and discrimination towards them. There is also evidence that migrant workers are exposed to higher safety risks than those born locally. For example, Geraghty [9] identified an alarming number of accidents among migrant workers and an injury rate twice that of local workers.

Cultural diversity within a workforce manifests itself in many tacit and explicit ways and can be evident in the different physical traits, customs, beliefs, attitudes, values, codes of dress, artefacts, habits and behaviours that characterize a workforce [17, 21]. Cultural factors also determine the ways in which employees encode and decode messages, the meanings they attribute to messages and the conditions under which certain messages may or may not be sent, noticed or interpreted [11]. However, arguably the most distinctive and overt expression of culture is linguistic.

Language problems are the greatest barrier to the smooth integration of migrants into a workforce, at least in the short term [6, 21]. Indeed, almost 40 years ago, Mills [16] warned of this problem amongst ethnic groups in the USA construction industry and more recently. Lim and Alum [12] identified communication problems with foreign workers as the fifth most important problem to be addressed in improving the productivity of the Singaporean construction industry.

The phenomenon of cultural conflict and racism often causes problems when two cultural groups that are in conflict in a global context, are dependent upon each other within the project program. The consequence of this phenomenon was that interactions with and between different ethnic groups on site were often difficult, repetitive, protracted and frustrating. There is evidence that over the last few years, the number of racist incidents in Australia has grown. Similarly, Loosemore and Chau [13] found very high rates of racist experiences by Asian-Australians in construction workplaces, principally including 'racist name-calling' (66 %), 'racist jokes' (67 %), ' racist material' (64 %), 'segregation' (56 %), 'offensive gestures' (49 %) and 'physical abuse' (56 %). They concluded that "racism is seen as an inevitable consequence of working in the construction industry, one that is largely ignored by managers and accepted and tolerated by workers".

## 37.3 Methods

As the first stage of a 3-year research program, this paper aims to identify potential workplace safety issues caused by the cultural diversity on construction sites. The deliverable of this stage was the development of a data collection instrument for the next stage of this research, which aims to develop a framework for managing construction safety in a multicultural workforce.

The interviews were semi-structured so that the research can ask in different ways for different participants. A semi-structured interview is flexible, as it allows new questions to be brought up during the interviews as a result of what the interviewee says [20]. The interview questions aims to explore the interviewees' perceptions towards cultural diversity issues and their impact on the safety practices on sites. This study's interview is shown in Table 37.1. The table indicates the subjects and areas of focus for the semi-structured interviews.

The interviewees consist of ten safety officers/safety coordinators/safety managers from ten different construction firms. All of the ten interviewees have more than 8 years of experience in the construction industry. The initial contact with the interviewees was through the researcher's personal connections. All the ten interviewees are currently working on the construction sites in Sydney which involve a multicultural workforce. The interviews were conducted in the interviewees' site offices or the cafe to enable a friendly conversation. The average duration of the 10 interviews was 2 h and 10 min. Sometime the interviewees had to get back to work and then the interviews had to be interrupted. In such cases, a follow-up interview was scheduled at another day. The interviews were recorded for the subsequent coding and analysis.

**Table 37.1** Semi-structured interview schedule

| Section | Subject | Area of focus |
|---|---|---|
| A | Cultural diversity | Cultural diversity situation;<br>Issues caused by this situation. |
| B | Impact on safety practices | Management commitment;<br>Communication;<br>Workers' involvement;<br>Supportive environment;<br>Supervisory environment;<br>Personal risk appreciation;<br>Work pressure;<br>Training and education;<br>Rules and procedure;<br>Appraisal of work hazards. |
| C | Recommended actions | Action by managers;<br>Actions by supervisory staff;<br>Actions by frontline workers. |

## 37.4 Results and Discussions

Through the analysis of the contents of interviews, the workplace safety related issues which were caused by the cultural diversity on the ten construction sites were identified. These issues are now discussed in the following ten categories of safety practices [8]: (1) Management commitment; (2) Communication; (3) Workers' involvement; (4) Supportive environment; (5) Supervisory environment; (6) Personal risk appreciation; (7) Work pressure; (8) Training and education; (9) Rules and procedure; (10) Appraisal of work hazards.

### *37.4.1 Management Commitment*

The interview result shows that the management's commitment to workplace safety was impacted by the cultural diversity on site. A safety manager of Firm C noted:

> *Cultural diversity is obviously a factor which has an impact on the demonstration of the management's support or priority towards workers' safety. The fact is that managers, supervisors and workers in my project belong to different ethnic groups. We did not perceive the efforts of managements to address the cultural conflicts between workers and construct a harmonious working environment. The managers did not provide enough language assistance for the workers with limited English. Moreover, management seldom recognizes the custom of different ethnic groups.*

Moreover, it was also noted that different ethnic groups may have different views on the company's incentives and penalties schemes, as a safety manager of Firm A shared:

> *The workers with Asian background are afraid of penalized due to safety reasons; while the workers with Australian cultural background do not seem to care about the penalties as they feel that the chance of being punished would be very small.*

### 37.4.2 Communication

Communication is a major issue which is caused by the cultural diversity in a project team. This is consistent with the findings of previous studies regarding cultural diversity issues in construction industry (e.g. [13, 14]). The interviews of this study indicate the following communication problems caused by the cultural diversity on site:

- *Workers with limited English are more likely to breach safe work procedures;*
- *Not being able to communicate to co-workers on site increases safety risks;*
- *Workers with limited English have difficulties in understanding the safety instructions;*
- *Non–English-Speaking-Background (NESB) Workers did not report the incidents due to the limited English ability;*
- *NESB Workers are reluctant be involved in safety activities (e.g., safety audit, safety committee, and safety inspections) due to their communication problems;*
- *On site signage should be in different languages to address all cultural groups;*
- *NESB workers did not fully understand the safety risks associated with the work they undertake;*

### 37.4.3 Workers' Involvement

Workers' involvement addresses the extent to which the workers are involved in safety activities, such as safety inspections, accident investigations, developing safety interventions and policies, reporting injuries and potentially hazardous situations, etc. [7]. Almost all of the interviewees have noted the impact of cultural diversity on workers' involvement in the safety related activities. For example:

- *The workers who are ethnic minorities seem reluctant to report any incidences or near misses because they do not want 'make trouble';*
- *NESB workers do not like to be involved in the safety committees because they sometimes cannot fully understand the discussions during the meetings;*
- *People do not report others for not working safely because they do not have good relationships.*

### 37.4.4 Supportive Environment

Supportive environment refers to the degree of trust and support within a group of workers, confidence that people have in working relationships with co-workers, and general morale [7]. The interview result shows that supportive environment was impacted by the cultural diversity through the following ways:

- *Workers are not likely to report unsafe behaviors of their co-workers for fear of being retaliated against;*

- *workers prefer to work with people with the same or similar cultural background;*
- *onsite racism leads to workers not working together safely;*
- *Racism lowers morale between workers;*
- *Racist name-calling and hate talk distract workers from doing their work safely.*

### 37.4.5 Supervisory Environment

The success of a safety management system program relies not only upon the management commitment, but also upon the ability of supervisory personnel to ensure that the program is carried out during daily operations [7]. The examples of the issues related to supervisory environment which were identified from the interviews are:

- *Supervisors are lack of cross-cultural leadership abilities;*
- *Supervisors are not concerned about the cultural conflict on sites;*
- *Supervisors do not have good relationships with the workers who have different cultural background with them;*

### 37.4.6 Personal Risk Appreciation

Attitudes toward safety have been found to be associated with personal perception of risks and individuals' willingness to take risks. Some interviewees commented that people's view and attitude on safety risks are always different to those of workers from other cultures. A safety officer from company A shared that the workers with Australian culture are more concerned about the results while the workers with Asian culture seem to be more concerned about the process of doing the job. It is therefore likely that the Australian workers are more willing to take risks to complete a construction task than the Asian workers.

### 37.4.7 Work Pressure

Work pressure refers to the degree to which workers feel under pressure to complete work, and the amount of time to plan and carry out the construction work [7]. The workers with different cultural backgrounds were observed to have different attitudes towards the work pressure. For example, the safety coordinator of company F noted that "*workers with western culture seem to be more efficient when doing a job and they tend to more self-motivated, while the workers with eastern culture seem to be more passive and tend to rely on the supervisors' instructions*". Therefore, it seems that workers with eastern culture are more likely to work under pressure.

### 37.4.8 Training and Education

All the interviewees commented that cultural issues be incorporated in the current safety training systems. They argued that training is a critical source of solving cultural conflict on construction sites. The interviewees also recommended that the safety training programs should cover the contents such as overview of the workers' background on their sites, cross-cultural leadership and supervisory skills, principles of equal employee opportunities and anti-discrimination, etc.

### 37.4.9 Rules and Procedure

Safety rules and procedures are the core component of safety management systems. As noted earlier, safety rules and procedures may have different impacts on the safety behaviors of workers from different ethnic groups. Workers with western culture are more concerned about the results rather than the process, thus they may not be strictly adhere to the safety rules and safe work procedures. Eight out of the ten interviewees also noted that managing cultural issues was not adequately addressed in their companies' safety management systems and rules. Another issue related to this category is that the safety rules and procedures are not fully understood by the NESB workers.

### 37.4.10 Appraisal of Work Hazards

Workplace hazards are defined as tangible factors that may pose risks for possible injuries. The interviewees did not report any cultural issues related to the appraisal of work hazards. They recognized that their companies have implemented the hazard analysis or risk management programme as well as the control measures for identified risks, regardless of the workers' cultural background.

## 37.5 Conclusions

This paper examined the workplace safety issues caused by the cultural diversity on the Australian construction sites. The results of the semi-structured interviews indicate that cultural diversity has an influential impact on most of the safety practices on construction sites, e.g., management commitment; communication; workers' involvement; supportive environment; supervisory environment; personal risk appreciation; work pressure; training and education; and rules and procedures. The issues that were identified from the semi-structured interviews will be used to develop a quantitative data collection instrument which aims to develop a framework for managing construction safety in a multicultural workforce (the second stage of this research). In the future, further analysis of the workplace implications of the cultural diversity on construction sites will be conducted in the context of cultural and organizational theories.

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# Chapter 38
# Research on the Evolution Processes and Modes of Construction Project Safety Accidents

**Xiaoli Yan**

**Abstract** Construction project safety accidents are caused by the complex interaction between a series of inner system factors and outer environment, and will endure a series of processes from the beginning to the end. The causation factors of the construction project accidents, including the human resource, machinery, material, method and environment and the evolution mode of the accidents are analyzed in this paper. The development of construction projects safety accidents is divided into four stages, which are occurrence, preliminary development, evolution and termination. The modes are analyzed and the concept models to describe mechanism of each stage are presented in this paper, which will provide theoretical reference for preventing and dealing with the construction projects safety accidents.

**Keywords** Construction project • Safety accidents • Evolution • Development • Mechanism

## 38.1 Introduction

Large scale city construction is in rapid development meanwhile. At the same time, many construction safety accidents happen every year during the construction in China and all over the world. For example, the two famous accidents happened in Shanghai, China of "11.15 Fire Accident in Jiaozhou Road" in 2011 and "Lianhua Hepan Jingyuan Building Collapse Accident" in 2010 have endangered the city public safety greatly and have exerted very bad influence to the public.

The construction project accidents usually happen during the projects construction stage in the construction site, when the project entities come into being. Large varieties and quantities of production factors including human beings, machinery, material,

X. Yan (✉)
School of Management Studies, Shanghai University of Engineering Science,
Shanghai 201620, China
e-mail: yanxiaoli821@163.com

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method and money are involved and are exposed to all kinds of risks from the nature and social environment, which cause lots of accidents to happen during this stage. Especially for those projects that have large investment scale, long period, complex inner structure, plenty of participants, the accidents will seriously disturb the realization of the project aim, cause serious loss and bad social influence.

This paper will make research on the evolution and development mechanism of construction project safety accidents, divide the stages of the whole process and construct the concept model of the evolution and development mechanism. The mechanism can indicate the inner regular pattern of the accidents, which will be helpful to find out the source the formation pattern, the development power and direction of the accidents.

## 38.2 The Division of the Evolution Stage of Construction Project Safety Accidents

The processes of the accidents from the beginning to the end can be divided into five stages: formation, occurrence, preliminary development, evolution and end, shown in Fig. 38.1.

The formation of the construction project safety accidents mainly is the result of the interaction of different production factors, including the inner factors and external environment and is a gradual and accumulated process. The burst of the accidents is also the termination of the formation phase. After the occurrence of the accidents, there usually exists a development process in the whole process. In this stage, the accidents strengthen in time continuation, space spread and intensity enhance. If new qualitative changes happen, new accidents happen and the evolution stage begins. Finally, the safety accidents terminate automatically or by man intervening.

## 38.3 The Formation of the Construction Safety Accidents

### *38.3.1 Accident-Causing Theory*

The accident-causing theory describes the accident mechanism and model extracted from large volume of typical accidents, which reflects the regular pattern of the accident and can provide scientific and complete reference for the analysis and prevention of the accidents [1]. Based on the theory, the practical safety management


**Fig. 38.1** The stage division of the construction project safety accidents

work will be improved. Many researchers have published their achievements in the finding of the accidents causing factors from different perspectives. The several typical accident-causing theories include accident causal chain theory, as represented by W.H. Heinrich and Bird and Bird, unexpected energy transfer theory, as represented by Gibson and Hadden, track crossing theory, as represented by W. g. Jonson and Skiba.etc [2–5].

### *38.3.2 Analysis of Accident Causing Factors*

Construction projects, especially large scale construction projects have complex structure and are composed of varieties of factors and interactive sub-systems. At the same time, lots of participants and specialties are involved in the system to handle the complex system, which may cause profit conflict. Sometimes the safety accidents arise because of the profit conflict [6, 7].

The construction projects safety accidents depend not only on the technology level and state, but also on the management level and the physical and psychology state of different production process, different participants and different machines' of the management system. The production factors of human resource, machine, material, method and environment jointly compose the system factors that influence the construction safety accidents.

#### 38.3.2.1 Factor of 'Human Resource'—Quantities of Participants from Different Companies

Construction projects usually involve lots of participants from different companies including owners, constructors, designers, counselors and material suppliers. On one side, the abilities of participants are vital to the success of the project. The hidden safety accidents will increase if the participants lack safety control abilities. On the other side, the benefit conflicts exist between them may cause some participants to damage the project in seeking the biggest profits for themselves. For example, the constructors may choose low quality construction materials for building or less educated technical workers to operate on some special procedures, which both decrease their cost but increase the risk of the projects. All these are direct or indirect factors that can cause safety accidents to occur.

In addition, unlike the fixed construction products, the workers in the construction industry have high mobility comparing to other industries. According to statistics, the workers in the construction industry have lower education level and have more serious employment injuries. All these factors increase difficulty of the safety management of the construction projects.

#### 38.3.2.2 Factors of 'Machine, material and method'—Lots of Production Factors

1. Two kinds of machinery are involved in the construction field. Some become the components of the entity after construction like the elevator, ventilation equipment, etc.. The others are the tools and equipments used during the construction process, including conveyers like the tower crane, operating tools like the formwork or the scaffold. The machine can bring serious safety accident because of the quality problem of itself or the human's operation.
2. The materials used in the construction fields are the components of the project entities. They are large in quantities and varieties. Good quality of the material, right choice, strict test and appropriate use of the material will directly affect the safety of the projects.
3. The methods used in the construction projects include the two sides of technology level and the management level. Construction projects have different methods and technology in different process, accidents may happen because of the technology factor, for example, deep foundation excavation, blasting engineering, etc.. Sometimes accidents may happen in process with new technology are firstly used.

On management level, accident may happen because of the lack of safety investment, unhealthy safety management organization, inadequate safety management system, inadequate preparation for new technologies and nonstandard market action.

#### 38.3.2.3 Factor of Complex Environment

The complex environment refers to not only the natural environment but also the market and social environment. All these environment factors may directly or indirectly cause accidents in the construction project site. For example, the construction standard and policies are still not mature, the standards of design we have now are not fully developed.

The construction projects are carried out in the field. On one side, the engineering projects are exposed to the nature and are easily affected by the natural environment and uncontrollable environment factors. On the other side, the working environment is confined by the gathering of large quantities of man force, material and equipment in narrow field and accidents are easily caused because of that.

### *38.3.3 Formation Mode and Way of Construction Projects Accidents*

Track crossing theory thinks that production system is made of three factors of man, machine and entity. They are in the same environment. The accident happen

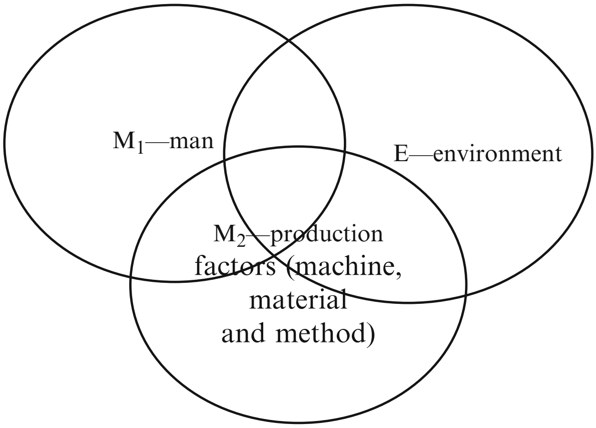


**Fig. 38.2** Track crossing of the three factors of man, production factors and environment

because of the unsafe action of human beings encounter the unsafe state of the entity (machine or environment). This paper divides the construction accidents causing factors into three categories: man, production factors and environment. The three kinds of factors form the "man—production factors—environment" system. The three sub-systems are interrelated and interactive. This paper applies the assemblage to indicate the formation mode of the construction projects accidents, shown in Fig. 38.2.

The existence of the inner factors like man and production factors and the outside factors will not directly or instantly lead the accidents' to happen but need the other factors to ignite it. The construction accidents are interactive results of kinds of factors. The way to prevent the accidents is to prevent the track crossing of the three factors.

## 38.4 Evolvement Mode and Rules of Construction Accidents

The evolvement roadmap of the construction project accidents from occurrence to termination is shown in Fig. 38.3.

### *38.4.1 Occurrence Mode of Construction Projects Accidents*

#### 38.4.1.1 Accidents That Happen Suddenly or Gradually

The construction project accidents can be classified as the accidents happen suddenly and the accidents happen gradually. The former accidents happen in very short time and usually have a definite beginning time or short period. The gradually

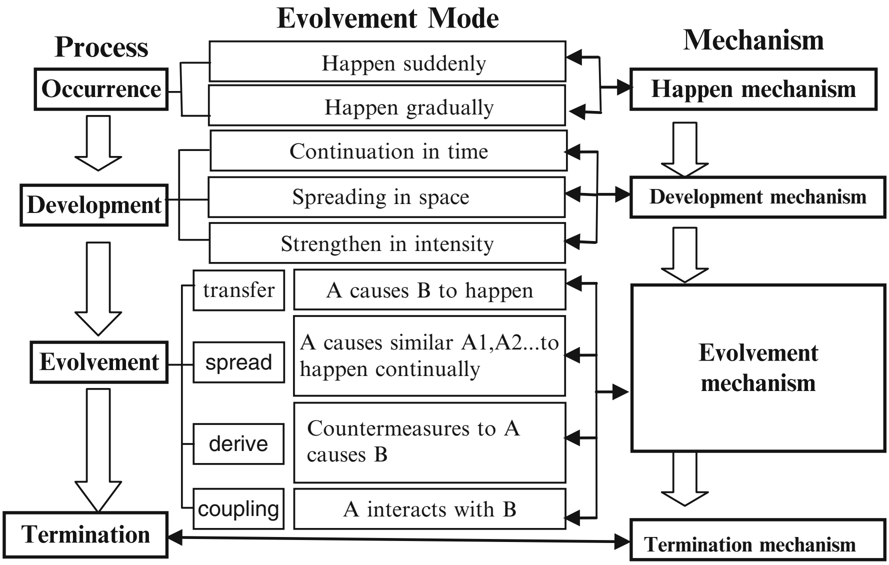


**Fig. 38.3** The roadmap of construction project accidents from occurrence to termination

happening accidents cause damage little by little. For example, the accidents like falling from the high altitude, object attack and electric shock injury belong to the former accident, while the accidents like the foundation pit collapse happen after some time's accumulation. Usually the accidents happen gradually leave long time for the people to cope with it while the accidents happen suddenly leave great difficulties for the coping work. The different indication should be payed attention to in different stages and corresponding countermeasures should be adopted to cope with the gradually happened accidents.

#### 38.4.1.2 Accidents That Can Be Fore-Casted or Cannot

The construction projects accidents can be classified as accidents can and cannot be forecasted. The former kind of accidents refers to the accidents which probability can be forecasted by monitor of the sign and causative factor. The accidents can be forecasted are different from the accidents that happen gradually, they are accidents happen suddenly, but there are some signs before they happen and the probability can be forecasted. While the accidents that happen gradually have long accumulation process and have no definite beginning and end time [8].

The mutation theory can be used here to construct the concept model to describe the happen of accidents. The factors of man, machine, material, method and environment can be used as the control variables, the function sate of the system can be used as state variables and the mutation potential function can be constructed, then the mathematic tools can be used to calculate to describe the mechanism, which can be discussed later in other papers.

$$V = f(U_1, U_2)$$

Here, $U_1$ is the assemble of the system controlling parameter,

$$U_1 = \{M_1(a_1, a_2, \ldots a_n), M_2(b_1, b_2, \ldots b_n), M_3(c_1, c_2, \ldots c_n), M_4(d_1, d_2, \ldots d_n), \\ E(e_1, e_2, \ldots e_n)\};$$

$U_2$ is the assemble of the system state parameter, $U_2 = \{N_1, N_2 \ldots N_n\}$.

$M_1$—Factor of human resource;
$M_2$—Factor of machinery;
$M_3$—Factor of material;
$M_4$—Factor of method;
E—Factor of environment;

### *38.4.2 Development Mode of the Construction Projects Accidents*

The development of the construction projects accidents includes increase in extent and scope. From the perspective of extent, it refers to the intensity strengthening, which increased damage to the supporting body. From the perspective of scope, it refers to the increase of the space. The development mode can be divided into three kinds:

1. Develop during very short time. The formation process of these accidents is very short, and the development process is also very short. This kind of accidents has no big development in the coverage and extent.
2. Develop continually. This kind of accidents has a long last time and has a clear process of development and will increase continually in the damage extent and coverage.
3. Develop dis-continually. This kind of accidents has a clear process of development and evolvement and will increase in the damage extent and coverage, but they don't increase continually, and will enhance after being weak for some time.

### *38.4.3 Evolvement of Construction Projects Accidents*

New qualitative change may occur during the development process of the construction projects accident, which may cause new accidents. The stage with new accidents emerge is called the evolution stage. The difference between development and evolvement is there is no qualitative change in the former stage but in the latter stage. So the evolvement can be seen as the continuation of the original accidents but also can be seen as the occurrence of new accidents, which relate with the original accidents jointly.

The evolvement is the accidents' development result and it can bring new affect that the original accidents cannot produce, which can be deemed as the evaluation standard of the evolvement. The evolvement modes of the construction projects accidents can be listed as follows:

1. Transferring: New qualitative change may happen during the development process of the construction project accidents and new accidents may emerge.
2. Spreading: The construction project accidents will spread in the scope coverage and the quantities of the supporting body increase. Such as the fire spreads.
3. Deriving: New accidents arise by the countermeasures to cope with the construction projects accidents.
4. Coupling: kinds of factors and subsystems in the accidents interact with each other and cooperate with each other during the evolvement of the construction projects accidents.

### *38.4.4 Termination of the Construction Projects Accidents*

The termination stage follows up with the evolvement stage. It includes the whole process from the weakening of the damage force to the complete end of the accidents. When the accidents don't expand and strengthen in scope and intensity, the termination process can be deemed as beginning. For example, the termination of the fire accident begins as the fire fades and the scope doesn't magnify and it ends as the fire is extinct completely.

## 38.5 Conclusion

With the larger of the construction projects scale in modern world, the accidents occurrence probability and the damage loss will increase. The construction project accidents causing factors include human resource, machinery, material, method and environment. The accident process can be divided into four phases, which are occurrence, development, evolvement and termination. There exist inner patterns and rules in the accidents evolution. This paper analyses the evolvement modes of each stage and constructs the concept model of the evolvement mechanism. The accidents evolution mechanism and theory will help to provide reference to decrease practical incidence rate and the damage loss, which is especially important in the background of great attention to the public safety today.

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# Chapter 39
# Study on Design Method of Project Management System Based on Nuclear Power Engineering General Contracting Enterprise

**Jianjun She, Hu Cheng, and Yumeng Chen**

**Abstract** The project management system has a very important role in the control of project in the general contracting enterprise. This paper research project management system based on nuclear power engineering general contracting enterprise, firstly defines the concept of a project management system, and then analyzes the design method of construction project process management subsystem, organizational subsystem, responsibility center subsystem, cost management subsystem, enterprise database subsystem. The objective of the paper is to provide the theoretical base for the design of construction project management system of similar project.

**Keywords** Engineering general contracting enterprise • Construction project management system • Design method • Nuclear power engineering

## 39.1 Introduction

The implementation of large-scale engineering project is a complex system, which has different management model, practice, concept and culture from general engineering project because of the characteristics of capital strength, long construction

J. She (✉)
College of Civil Engineering, Southeast University, Nanjing, China

College of Civil Engineering, Nanjing University of Technology, Nanjing, China
e-mail: shejj1016@126.com

H. Cheng
College of Civil Engineering, Southeast University, Nanjing, China
e-mail: pmri@seu.edu.cn

Y. Chen
Quality Guarantee Department, Nuclear Power Engineering Division, China Nuclear Industry Huaxing Construction Company Limited, Nanjing, China
e-mail: chenym@cnhxcc.com.cn

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cycle and complex technology, and we have to research and analyze the internal management system, external association of projects based on the principle of system engineering to achieve optimized goal and coordinated development with the external environment. This paper carried on deeply design and analysis of project management system based on nuclear power engineering general contracting enterprise. The purpose of related research is to achieve the control requirements of nuclear power engineering projects, such as standardization, intensification, specialization, informatization, and to promote management level of the business division and project department of the nuclear engineering project, and to optimize the organizational structure, management process and management system.

## 39.2 The Concept and Composition of the Construction Project Management System

Nuclear power engineering usually refers to a complete nuclear power plant project, which is consisted of nuclear island, conventional island and plant facilities. The three parts are composed of a number of systems, and each system is a system engineering with highly technical features and many interfaces. They also put forward high requirements to plan, control and coordination in design, procurement, manufacturing, construction, installation and a series of work. Nuclear power project is a complex of technical, organizational, behavior and information systems, and its project system is composed of the target system, object system, behavior system, organization system, management system, environment system [1]. There is a complicated relationship between each system which constitute a complete project system.

Construction project management system is formed by the organization, methods, information and process systems. Meanwhile, it's also an organic whole composed by a set of process and related functions. As a whole, it should contain the following work [2].

1. Plan, demonstrate and control the target system of the project and ensure the implementation of the project objectives through the project and the project management process.
2. Plan and appraise the objective systems of the project.
3. Plan and control the behavior system of the project.
4. Communicate, coordinate and command the organization system of the project.

Firstly, this paper focused on the study of construction project management system in the project system, and then introduced five subsystems, such as process management subsystem, organizational subsystem, responsibility center subsystem, cost management subsystem, enterprise database subsystem. These five subsystems are connected with each other, and together constitute the construction project management system.

## 39.3 The Design Frame Research of Construction Project Management System

The design object of the construction project management system is mainly to the five subsystems. The overall design idea of the construction project management system is illustrated in Fig. 39.1. These five subsystems connect, support and supplement with each other. The design work mainly includes following design steps based on design idea of integration.

1. Firstly, this paper investigates the situation of enterprise, argues the overall plan of project management, analyzes the engineering system and the professional work process of nuclear power project, and then designs the management process on the basis of the above work.
2. Secondly, design the organization system. This organization system includes two levels which are business division and nuclear power project department, and the

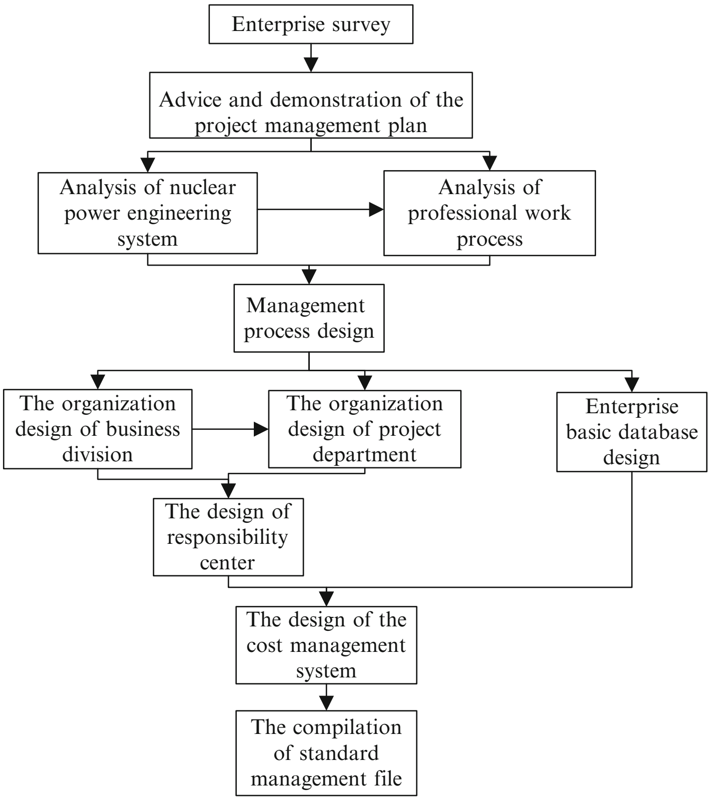


**Fig. 39.1** The overall design framework of nuclear engineering project management system

former is for the organization structure design of company level, the latter is for the organization structure design of the various nuclear power project department.
3. Thirdly, design the responsibility center system of the business division and project department, which help to know classification principles and responsibility assessment index of each responsibility center.
4. Fourthly, design the cost management system on the planning, accounting and analysis to ensure the circle of communication within the cost data and to enhance the cost management of engineering project.
5. Finally, design the enterprise database which is a data supporting platform, and this platform helps enterprise to carry out the bidding decision-making, organization construction, cost control, cost accounting and responsibility cost classification, performance appraisal and other business processes.

## 39.4 The Design Method Research of Construction Project Management Subsystems

### *39.4.1 The Design Method of Project Process Management Subsystem*

The design of process management subsystem is in front of the overall design of the whole project management system. The results of design and optimization will directly affect the organization construction of the business division and project department, the design of responsibility center system and so on. The project process management system mainly includes professional work process design and management process design [3].

#### 39.4.1.1 Professional Work Process Design

Professional work process mainly refers to the specialized construction process in the construction process [4]. Its main design procedure is shown in Fig. 39.2.

1. Division of construction project phase. The project is divided into the bidding stage, the construction preparation stage, construction stage, completion stage and warranty stage.
2. Confirm the job scope of the various stages of construction project. In this research, the analysis methods such as EBS (Engineering Breakdown Structure and WBS (Work Breakdown Structure) are applied.
3. List the main process of professional work process according to each phase of project and draw out the specific professional work process chart.

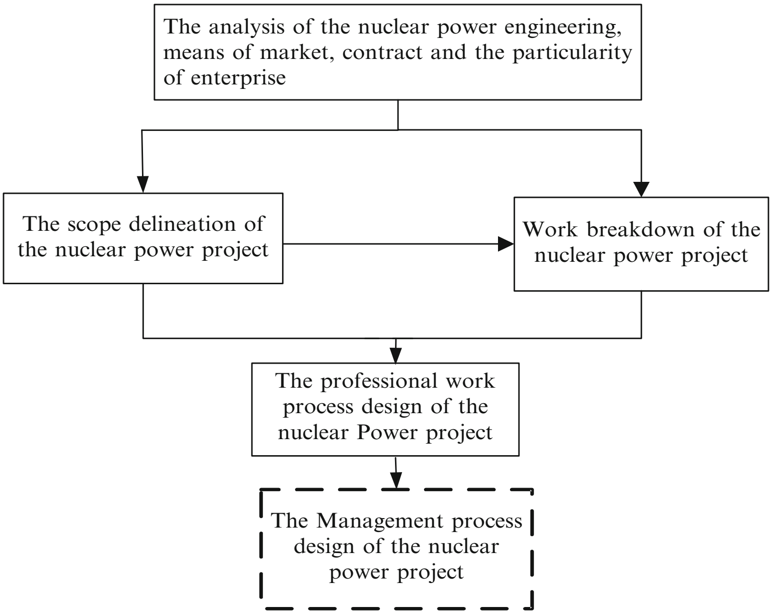


**Fig. 39.2** The professional work process design of the nuclear power project

#### 39.4.1.2 Management Process Design

The design of management process is based on contract analysis and professional work process of the nuclear power construction project. The management process design procedure is shown in Fig. 39.3.

1. Construction project plan and the overall control process design. Firstly, layout the overall process of plan and control of the nuclear power construction project, which helps to guide the drawing of overall and detail process of all management functions.
2. According to the requirements of the construction phase and construction project management, list the work directory of the main management function. The work directory can be subdivided into more detailed secondary directory based on the control precision.
3. Draw the management process of the nuclear power construction project according to the project management work directory.

### *39.4.2 The Design Method of Project Organization Subsystem*

The nuclear power construction project has certain characteristics compared to ordinary ones, such as the scope is wide, the workload of the construction site is

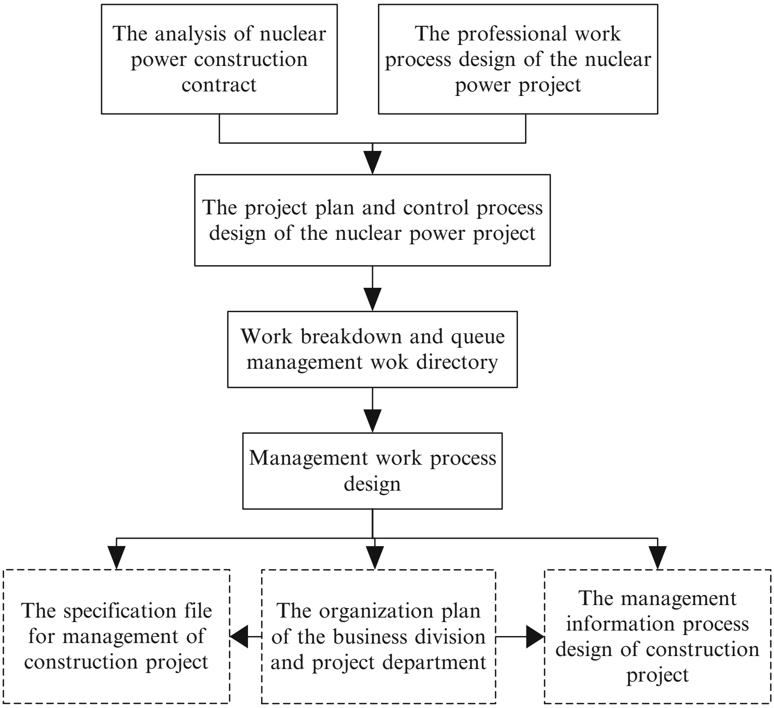


**Fig. 39.3** The management process design of the nuclear power project

huge, and several nuclear island often construct at the same time. In addition, the process control is more rigorous, the construction is difficult, and it has much management interface and large cost. These special characteristics put forward a very high requirement for the construction of the organization system, such as the design must meet the particularity of nuclear power engineering, market and enterprises, and also need to consider the corresponding and difference of the business division and project department. The design procedure is shown in Fig. 39.4.

#### 39.4.2.1 Organization Design Conditions Research

The design of organization system is the core of the construction project management system, and it plays a central role in the nuclear power project management, so we must consider the following key links before the specific design.

1. The analysis of the means and relations of the nuclear power engineering market, and the relationship with various other stakeholders such as owners, design units, contractors, equipment suppliers, supervision units and so on.

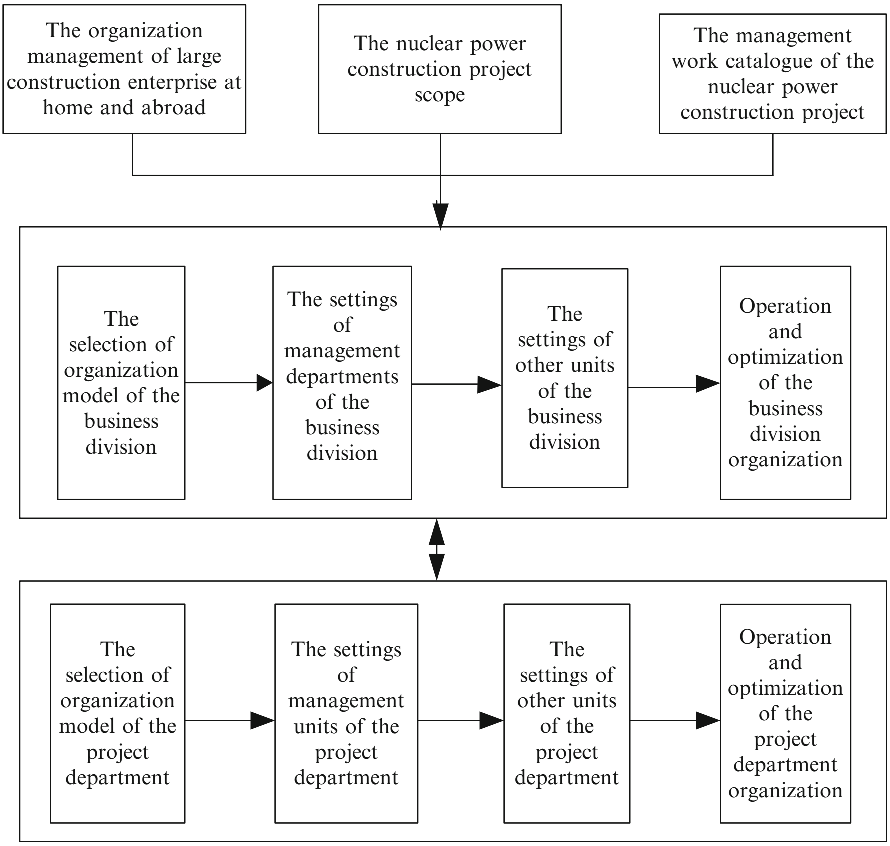


**Fig. 39.4** The organization design process chart of the business division and project department

2. The analysis of the relationship between internal and external of business department, which helps to make clear the relationship between resources supply department and other related departments.
3. The nuclear power engineering system analysis and the construction process analysis.

#### 39.4.2.2 The Organization Scheme of the Business Division

1. The organization design of the business division needs to consider the organization unit dimensions. We can divide the organization of the business division into the department which cater to project management, resource supply or service department and other related departments [5].
2. The organization of the business division should adopt matrix organization. As for the strength of the functions, it can be set according to the level of control to the nuclear power project department by the business division [6].

#### 39.4.2.3 The Organization Scheme of the Project Department

1. Project department design. The setting of the project department can be finer than the business division's, and should be corresponding to the business division's in principle. The project organization structure must be reasonable, simple, efficient and low cost [7].
2. Matrix organization should be adopted. The horizontal setting is various management departments of the project department, such as construction department, quality department, security department, equipment department etc and vertical setting is work areas which are set up according to the division of construction site area. Every work area sets a project group, so as to effectively enhance the control and the utilization efficiency of resources of each work area [8].

### *39.4.3 The Design Method of Construction Project Responsibility Center System*

The main purpose of responsibility center system design is to establish a responsibility center system between the business division and project department, which helps to strengthen the responsibility sense, draw the economic responsibility, and lay the foundation for the implementation of the economic responsibility. The responsibility center system design process is shown in Fig. 39.5.

#### 39.4.3.1 The Concept Definition of Responsibility Center

A responsibility center is an organizational unit which is responsible for a manager. The object of responsibility usually refers to the specific financial results. Responsibility center can be divided into income center, cost center, profit center and investment center.

#### 39.4.3.2 The Design Scheme of Responsibility Center

1. Breakdown the division responsibility center based on the research of basic principle of responsibility center, organization design of business division and project department and nuclear power project management work directory.
2. Set the project responsibility center and classify responsibility center based on the decomposition of division responsibility center.
3. Design all kinds of responsibility center management system, which includes the responsibility center index setting, function and power setting, evaluation method, relation setting and accounting problems between responsibility centers.

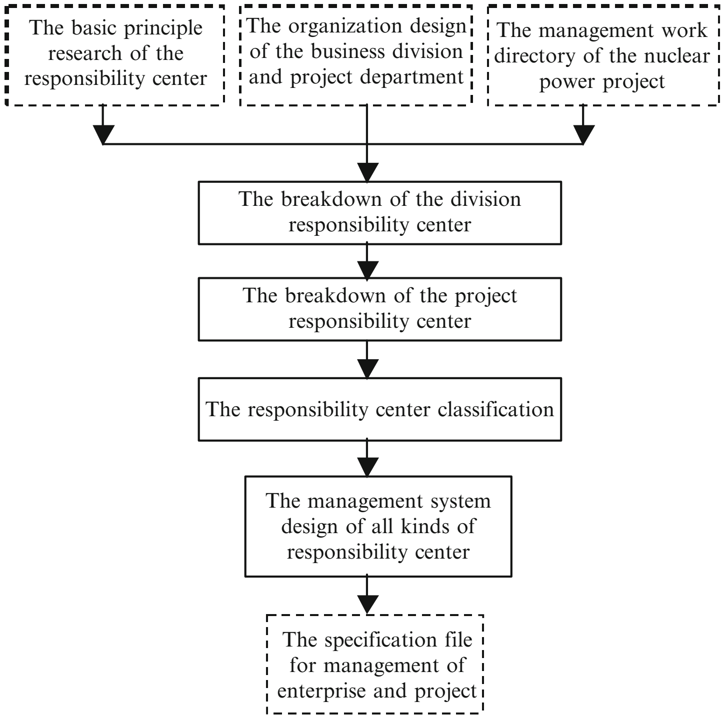


**Fig. 39.5** The design process chart of the responsibility center system

#### 39.4.3.3 Design of Diversity of Responsibility Center Appraisal Index

Currently, nuclear power project responsibility center are given priority to cost evaluation index. With the strengthen of management and control of the project department by the business division, the responsibility center requires multiple appraisal index, and consider cost, quality, safety, schedule, public relations and other dimensions in specific design.

### *39.4.4 The Design Method of Construction Project Cost Management Subsystem*

The design method of construction project cost management subsystem needs construct an integrated procedure including cost prediction (bidding process), plan, responsibility cost determination, expenditure control, accounting, diagnosis, check and settlement from the perspective of the whole construction project process, whose goal is to realize the internal circle communication of cost data (data accumulation and application) by using three systems of the planning,

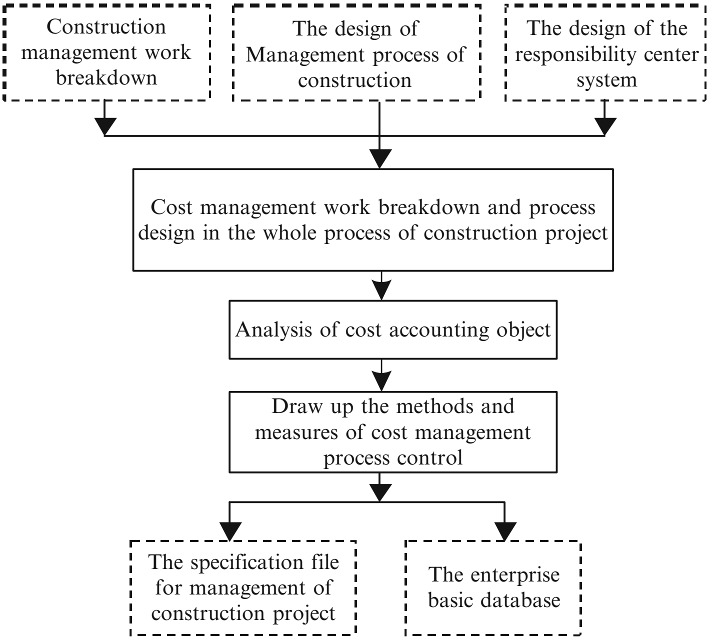


**Fig. 39.6** The cost management system design process chart

accounting, analysis. The specific design process chart of cost management system is shown in Fig. 39.6.

1. Based on construction management work breakdown, construction management process design and responsibility center system, construct an integrated procedure including bidding work, responsibility cost determination, cost accounting, cost analysis, the final cost accounting and information storage etc.
2. Analysis of the cost accounting objects. The objects can be set according to the needs of cost control accuracy, and the common objects are as follow.

   (a) Account according to responsibility center
   (b) Cost accounting for production factors (labor, material and equipment)
   (c) Cost accounting for partial and itemized project
   (d) Accounting for special expenses (such as construction field cost)

3. Cost process control. Draw up the procedures and measures of artificial, material, machinery and cost management.
4. Determine of the cost accounting method
5. Selection and determination of cost report, analysis and diagnosis methods.
6. Selection and determination of performance, responsibility cost assessment, evaluation method and incentive mechanism.
7. Compilation of cost management system documents. The design of cost management system should be integrated with the quotation system, responsibility center system, inventory management, contract management, accounting and so on to solve the communication problem faced by the database system design.

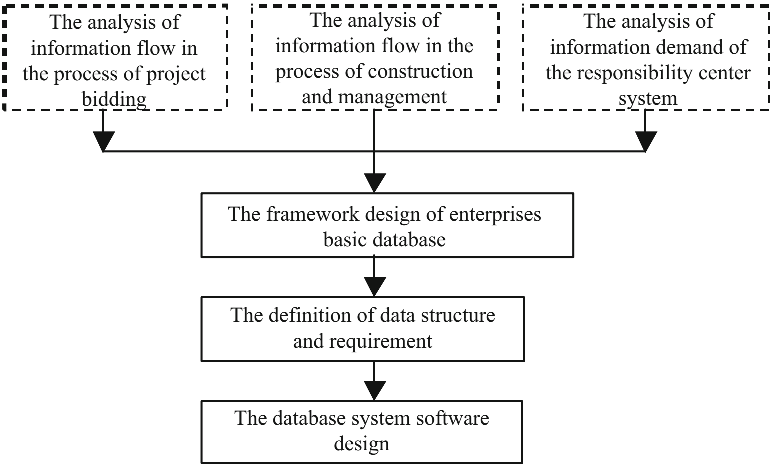


**Fig. 39.7** The enterprise basic database design process chart

### *39.4.5 The Design Method of Enterprise Basic Database Subsystem*

The enterprise basic database system is the basis of design and application of cost management, responsibility center system and other systems, it's also the data supporting platform and the design work of which includes the system design of the enterprises basic database system, the design of the database framework and content, the definition of data structure and requirement based on the information flow analysis of the bidding work, construction and management, responsibility center operation and cost management [9]. These work helps to complete the leading work of the database system software design (information), and the design process is shown in Fig. 39.7.

1. Analyze the output and input information flow in the process of project bidding, construction and management, establishment and operation of responsibility center system, cost management system and so on.
2. The framework design of enterprises basic database. Design the data hierarchy of the basis database system combining with hierarchical setting principle of the business division and project department, and divide the basic data into two hierarchies which are level of business department and level of project department.

   (a) Level of business department data is for the enterprise, such as some information which reflects the engineering contracting market and competitors, enterprise quota which reflects the enterprise productivity, the rules and regulations, information of position and staff, the completed engineering database, price database etc.

(b) Level of project department data is for the project, such as the basic project information, bidding information, price database, database of the construction in process (cost management, schedule management, quality management, HSE management, subcontractor management etc.).
(c) Consider the user's habits, such as the document, tables, graphics, icons, video etc. which are familiar with users to exchange and display data. In addition, the structure and demand of the data should meet the requirement of data accuracy for the nuclear power project management and control of the whole life organization units at all levels.
(d) The enterprises basic database is not only the foundation of the foregoing part of the work, but also the main content of the management information system, which lays the foundation for later engineering project management information system (PMIS).

## 39.5 Conclusions

With the rapid development of economy, the control of project in the general contracting enterprise becomes more and more important. Improving the efficiency of control is the core problem the general contracting enterprise will concern. But currently, there is no research with systemic view to study construction project management system design problems based on the engineering general contracting enterprises. Under such a background, this paper researched project management system with systemic view, introduced the subsystems of the construction project management system, and then described the design method of every subsystem. This research has a positive side in guiding the theoretical and practical application of the control of project in the general contracting enterprise.

**Acknowledgments** The research is supported by Nuclear Power Engineering Construction Project Management Benchmarking Research, China Nuclear Industry Huaxing Construction Company Limited-Southeast University.

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# Chapter 40
# The Risk Assessment of the Public Rental Housing Integrated ABS Project Based on FAHP/FCE

**Yachen Liu and Yong Li**

**Abstract** By the analysis of the ABS mode advantages and applicability in the construction of public rental basis, to consider the benefits and risks of stakeholders involved in the construction of public rental introduction of the ABS mode, and on this basis to build its financing structure model proposed an integrated FAHP/FCE the ABS project risk evaluation, to build integrated FAHP/FCE risk assessment model. This method allows decision-makers (experts) use linguistic variables to assess the ABS project risk factors, with the help of triangular fuzzy numbers, and effectively build the experts preference information to identify indicators Sort vector. Finally, the quantitative analysis of the degree of risk the ABS financing model is used in the construction of public rental instance, and shows the feasibility of ABS project.

**Keywords** ABS • Public rental housing • Integration of fuzzy hierarchy analysis • Fuzzy comprehensive evaluation • Risk assessment

## 40.1 Preface

Public rental housing is an important part of the affordable housing system in China. It played an important role in alleviating the housing pressure of the low-income families to solve housing problems of the city "sandwich". With the increasing demand of the city public rental housing, so the growing investment demand gradually become the focus of attention [1]. Government or state ownes the Public housing, therefore, it reles mainly on the financial allocation as a public rental housing construction funds across the country, but it is far from satisfying the demand for funds of the public rental housing project building. How to issue bonds

Y. Liu (✉) • Y. Li
School of Management, Shenyang Jianzhu University, Shenyang, China
e-mail: 517353460@qq.com

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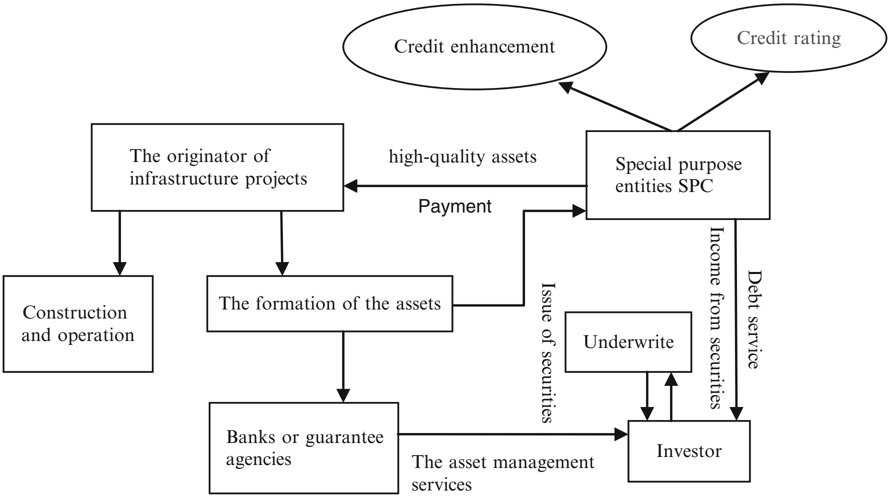
to raise funds through the stock market for solving the problem of lack of funds, so as to explore more diversified, market-oriented and mature capital mode of operation is the key to crack the construction of public rental bottlenecks [2].

The so-called ABS, the abbreviation of the English “Asset BackeSecuritization”, which is based on item belongs asset-backed securities, finance and the assets of the project to ensure the project assets can bring prospective earnings through issue bonds in the capital market to raise money. Simply speaking, in the construction of public rental housing, the government transfer public rental housing which is lack of liquidity, but able to generate stable cash flow income to a specific SPV (Special Purpose Vehicle). SPV issue bonds and obtain Issue revenue with the guarantee of assets, and then buy the usufruct of the government with price stipulated by the contract about the sale of assets (mainly rental income) and use the stable cash income generated by the rent to repay the bonds issued [3].




## 40.2 To Build the Risk Evaluation Index System of ABS Project

### *40.2.1 Building the Risk Pattern System of ABS About Public Housing*

The risk pattern system of ABS about public housing system, mainly involved in four major project participants, such as, the construction of public rental housing government, financial institutions, the project company (SPV), contractors. The size involved Project participants of the risks affect whether they are willing to

**Table 40.1** Public rental ABS Project Risk Evaluation [4]

| Financial risk U1 | Political risks U2 | Construction risk U3 | Business risks U4 | The first level indexes |
|---|---|---|---|---|
| Liquidity-risk U11 | Government-policy changes U21 | Cost to cost overruns U31 | Resource risk U41 | The secondary indicators |
| IRR U12 | Industrial policy changes U22 | The subcontractor/ supplier of the lack of ability U32 | Market risk U42 | |
| Credit risks U13 | Law does not explicitly and regulations change U23 | The owner design changes frequently U33 | Charge for Change U43 | |
| Currency risk U14 | Law failure U24 | Project delay U34 | Operating cost overruns U44 | |

participate in the construction of public housing, according to the parties from participating in their corresponding benefits to consider its risk period, based on the participants to provide resources or services may involve risks to calculate their risk type. In the Project financing, risk allocation is reasonable related to the success or failure of the whole project. This paper fully considers when building project risk evaluation system for all to share the risks of SPV involved and ensures the feasibility of the project, such as, the SPV may involve in the project design, construction, management risk. They can through the construction of the agreement, the fixed price agreement, risk aversion, in the form of turnkey agreement and on the premise of fully considering risk, building risk system as pictured.1.

### *40.2.2 The Determination of Evaluation Index Weight*

Risk evaluation belongs to multiple attribute decision making problems in essence. For multiple attribute decision problems, the influence of the result about the decision is not balanced for each attribute. The weights of attributes can describe the decision-making scheme between the relative importance of various attributes. The difficulty of FCE is how to make scientific and reasonable determine with multiple relative weight of evaluation index [5]. The indicators in Table 40.1 are fuzzy and uncertainty, and difficult to quantify. In addition, the experts' knowledge are often full of fuzzy characteristics, so the description of evaluation index is usually adopts the language variable. Triangular fuzzy Numbers and their comparative judgment matrix [6] will be able to overcome the above difficulties, especially to ascertain the weight of index fuzzy method. It is more scientific and reasonable. First of all, the experts on the evaluation index system of the relative importance of indicators at all levels are compared, and two structure using triangular fuzzy number judgment matrix. This study used 10/10~18/2 to establish the degrees of variable language description of risk indicator [7], and converted them to

**Table 40.2** A description of the linguistic variables and triangular fuzzy number

| Language variable value | Description language variable values | Triangular fuzzy number |
|---|---|---|
| The risk is too high | Compared two risk factors, one is higher than the other extreme | (0.75, 1, 1) |
| The risk is high | Compared two risk factors, one higher than another obvious | (0.5, 0.75, 1) |
| Medium risk | As high as two risk factors | (0.25, 0.5, 0.75) |
| Risk is low | Compared two risk factors, a significantly higher risk than another | (0, 0.25, 0.5) |
| The risk is very low | Compared two risk factors, one is lower than another extreme risk | (0, 0, 0.25) |

corresponding form of triangular fuzzy number (as shown in Table 40.2). Set $A_t = (a_{ij}^t)_{n \times n}$, $i, j = 1, 2, \ldots, n$, $t = 1, 2, \ldots, T$ which means that given the next level of the indicators associated with a decision-making expert t n indicators pairwise comparison fuzzy judgment matrix. Degree of fuzzy evaluation is $a_{ij}^t = (l_{ij}, m_{ij}, u_{ij})$, $i, j = 1, 2, \ldots, n$. Preference information of T given by experts to assemble comprehensive triangle ambiguity:

$$a_{ij} = \frac{1}{\sum_{t=1}^{T} u_t} \leftarrow \left( \sum_{t=1}^{T} u \times a_{ij}^t \right) = \left(l_{ij}, m_{ij}, u_{ij}\right), i, j = 1, 2, \ldots, n \tag{40.1}$$

Where is it experts "t" share weight, moreover, $\sum_{t=1}^{T} u_t = 1$ The triangular fuzzy reflects the ABS project decision-making many experts involved in the feature, and integrated expert preference information, and thus the formation of effective group decision.

Secondly, to determine the weight sort the vector. The next level for a decision index associated with the n indicators triangular fuzzy Sort vector obtained according to equation

$$B_i = \left[ \frac{\sum_{j=1}^{n} l_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} u_{ij}}, \frac{\sum_{j=1}^{n} m_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} m_{ij}}, \frac{\sum_{j=1}^{n} u_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} u_{ij}} \right], \quad i = 1, 2, \ldots, n \tag{40.2}$$

Triangular fuzzy number defuzzification have to go fuzzy values: $w_i = \frac{a+b+c}{3} - \left(\frac{1-\eta}{\eta}\right)\sigma_i, i = 1, 2, \ldots, n,\ a = \frac{\sum_{j=1}^{n} l_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} u_{ij}}, b = \frac{\sum_{j=1}^{n} m_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} m_{ij}}, c = \frac{\sum_{j=1}^{n} u_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} u_{ij}};\ \sigma_i = \left[\frac{a^2+b^2+c^2-ab-ac-bc}{18}\right]^{-\frac{1}{2}}; \lambda = \frac{1-\eta}{\eta}$ And obtained Sort vector, $W' = (w_1, w_2, \ldots, w_n)$ Normalization, then to get indicators associated with a decision-making to the next level n indicators Sort vector $W = \left[\frac{w_1}{\sum_{i=1}^{n} w_i}, \frac{w_2}{\sum_{i=1}^{n} w_i}, \ldots, \frac{w_n}{\sum_{i=1}^{n} w_i}\right]$

### 40.2.3 The Integrated FAHP/FCE the ABS Project Risk Assessment Model

Using triangular fuzzy judgment matrix to determine the risk evaluation weight order vector, On this basis, Risk assessment model can build integrated FAHP/FCE.

Step 1: The construction of the risk assessment hierarchy.

According to Table 40.1, the ABS Project Risk Assessment decomposite level indicators and corresponding secondary indicators and build a hierarchical structure according to the relations of domination between indicators.

Step 2: Using constructor triangular fuzzy judgment matrix to determine the two sort of index weight.

Step 3: Using Fuzzy evaluation matrix to establish two indicators

Here, using language assessment scale to describe the risk level of the indicator. In general, the number of scaling p take an integer between [8, 9] is more appropriate. The above description can be considered a fuzzy set Q:

$\int : \pi^{\rightarrow} \int (Q) : \pi_i{}^{\rightarrow}(c_{l1}^{(i)}, c_{l2}^{(i)}, \ldots, c_{lp}^{(i)})$, so you can have the single factor evaluation matrix.: $C^{(i)} = (C_1^{(i)}, C_2^{(i)}, \ldots, C_n^{(i)})^T, i = 1, 2, \ldots, m$.

Step 4: Single factor comprehensive evaluation.

In the fuzzy comprehensive evaluation process, Model $M(\wedge,\vee)$ often lost Fuzzy Judgment Matrix, so it is often not easily distinguishable from the evaluation results. To make the model integration specialists to consider and take into account the degree of importance of the various risks attribute fuzzy judgment process, With the help LWA2 the improvement. $\mathrm{B} = \mathrm{W}^0\mathrm{C} = \sum_{l=1}^{n} w_l \times c_l\,(l = 1, 2, \ldots, p)$.

It is the weighted average operator of (4).

Step 5: The determine of the level indicators for the evaluation target weight.

Here, just follow the step 2 of the process and methods to calculate an index attribute weight values, and determine the priority vector: $W = (w_1, w_2, \ldots, w_m)$

Step 6: To determine Rank of Fuzzy comprehensive evaluation.

According to step 4 $B_i(i = 1, 2, \ldots, m)$, lead to $\sum_{k=1}^{p} b_k^{(k)} \neq 1$ Normalization processing shall be made. That $s_k^{(i)} = b_k^{(i)} / \sum_{k=1}^{p} b_k^{(k)}$ the proportion of the level of the single-factor comprehensive evaluation vector converse $S_i = (s_1^{(i)}, s_2^{(i)}, \ldots, s_p^{(i)})$.

Consolidated obtained in Step 5 of the weights $W = (w_1, w_2, \ldots, w_m)$,

$B^* = \left[ \frac{\hat{b}_1}{\sum_{K=1}^{P} b_k}, \frac{\hat{b}_2}{\sum_{K=1}^{P} b_k}, \ldots, \frac{\hat{b}_p}{\sum_{K=1}^{P} b_k} \right]$ Taken in accordance with the principle of maximum membership MaxB* = C.

## 40.3 Examples

A public housing project in Shenyang adopt ABS financing mode. The local government as the project owner and A large private enterprise bidding project partners, is responsible for the project construction and operation in accordance with the contractual agreement. Based on experience and preliminary study of the related project risks, the enterprise organization experts identified 16 kinds of risk and divided into four groups: project internal risk, specific risk and external risk projects, and build the risk evaluation of the hierarchy (see Fig. 40.1).

Enterprise organizes five well-known experts in this field, after careful evaluation, are given respectively according to Table 40.2 for criterion layer attribute corresponding to the risk factors, risk index of the two is fuzzy judgment matrix. Considering five experts' background and experience, respectively, given their weight in the order (0.19, 0.21, 0.17, 0.25, 0.18) and using (1) type to transform into triangular fuzzy judgment matrix. As to limited space, only the comprehensive fuzzy judgment matrix (see Table 40.3). Assessed by the experts, if $\eta = 1$, that means experts performance is risk neutral. Then, using (2) and (3) calculation for rule layer element U1, risk factors and the related elements of the sort of vector $W_1 = (w_1^{(1)}, w_2^{(1)}, w_3^{(1)}, w_4^{(1)})$, and the normalized, normalized ranks vector. Other secondary index ordering vector can be obtained with the same techniques and primary index ordering vector (see Table 40.4).

Based on a detailed investigation of partners and project, the enterprise organize the five experts and four experienced engineers, through assessment, then establish evaluation set Q = (very mild, mild, moderate, severe and very severe), to

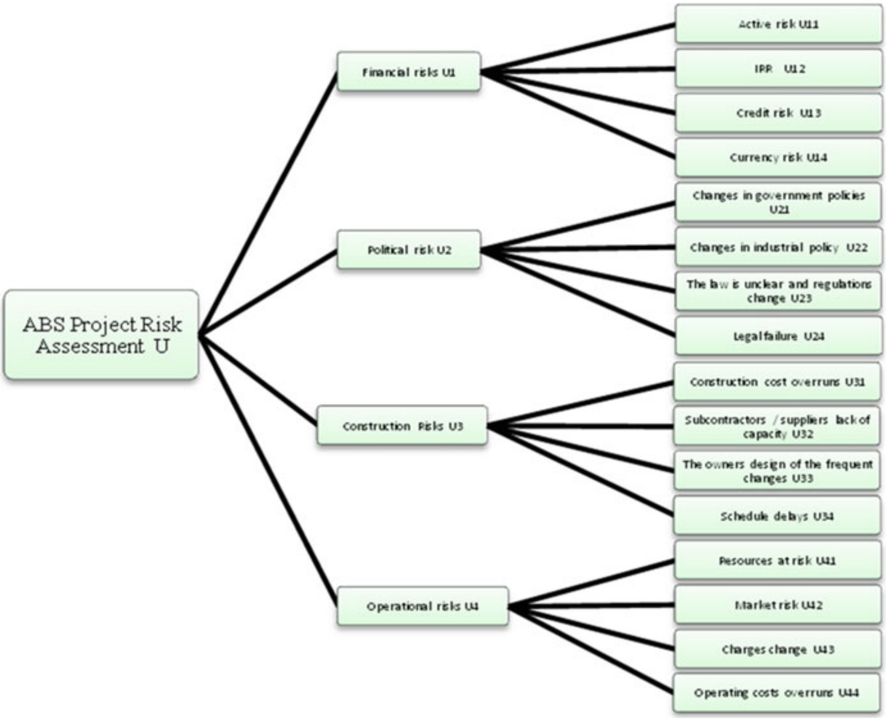



**Fig. 40.1** A public housing ABS project risk hierarchy

**Table 40.3** Public housing project risk factors of two relatively comprehensive triangular fuzzy judgment matrix

| | U11 | U12 | U13 | U14 |
|---|---|---|---|---|
| U11 | (0.25, 0.5, 0.75) | (0.2025, 0.4525, 0.7025) | (0.105, 0.2575, 0.5075) | (0.145, 0.645, 0.395) |
| U12 | (0.355, 0.855, 0.605) | (0.25, 0.5, 0.75) | (0.0475, 0.3975, 0.547) | (0, 0.145, 0.395) |
| U13 | (0.605, 0.855,1) | (0.25, 0.5, 0.75) | (0.605, 0.855, 1) | (0.4925, 0.7425, 0.895) |
| U14 | (0.2975, 0.5475, 0.7975) | (0.25, 0.5, 0.75) | (0, 0.145, 0.395) | (0.4525, 0.6025, 0.9525) |

**Table 40.4** The sort weight vector of risk indicators and risk type

| Risk factors/Risk type | Sort vector of weights |
|---|---|
| Financial risk U1 | W1 = (0.1023, 0.2045, 0.2537, 0.4395) |
| Political risks U2 | W2 = (0.2026, 0.1967, 0.1778, 0.4228) |
| Construction risk U3 | W3 = (0.1946, 0.1123, 0.2871, 0.4060) |
| Operational risk U4 | W4 = (0.1104, 0.1856, 0.2625, 0.4415) |
| Risk type U | W = (0.1104, 0.1856, 0.2625, 0.4415) |

**Table 40.5** The fuzzy evaluation matrix element of public housing project risk

| Risk type U | Risk factors | Weighting factors | Fuzzy evaluation matrix (Very mild, mild, moderate, severe and very severe) |
|---|---|---|---|
| Financial risk U1 | U11 | 0.1023 | C11 = (0.1, 0.1, 0.2, 0.4, 0.1) |
| | U12 | 0.2045 | C12 = (0.1, 0.3, 0.3, 0.2, 0.1) |
| | U13 | 0.2537 | C13 = (0.3, 0.3, 0.2, 0.1, 0.1) |
| | U14 | 0.4395 | C14 = (0.1, 0.2, 0.2, 0.3, 0.2) |
| Political risks U2 | U21 | 0.2026 | C21 = (0.1, 0.1, 0.2, 0.4, 0.2) |
| | U22 | 0.1967 | C22 = (0.3, 0.3, 0.2, 0.1, 0.1) |
| | U23 | 0.1778 | C23 = (0.1, 0.2, 0.5, 0.1, 0.1) |
| | U24 | 0.4228 | C24 = (0.1, 0.1, 0.1, 0.5, 0.2) |
| Construction risk U3 | U31 | 0.1946 | C31 = (0.1, 0.1, 0.3, 0.4, 0.1) |
| | U32 | 0.1123 | C32 = (0.2, 0.4, 0.2, 0.1, 0.1) |
| | U33 | 0.2871 | C33 = (0.1, 0.2, 0.1, 0.5, 0.1) |
| | U34 | 0.406 | C34 = (0.1, 0.3, 0.3, 0.2, 0.1) |
| Operational risk U4 | U41 | 0.1104 | C41 = (0.1, 0.1, 0.2, 0.5, 0.1) |
| | U42 | 0.1856 | C42 = (0.1, 0.1, 0.2, 0.4, 0.2) |
| | U43 | 0.2625 | C43 = (0.2, 0.4, 0.2, 0.1, 0.1) |
| | U44 | 0.4415 | C44 = (0.2, 0.3, 0.1, 0.2, 0.1) |

evaluation the risk factors of each layer, establish fuzzy evaluation matrix (see Table 40.5).

According to the data in Table 40.5, (4) use of a single project risk indicators comprehensive evaluation vector, and gain normalization processing.

S1 = (0.2952, 0.2418, 0.2289, 0.2344)
S2 = (0.2982, 0.1784, 0.2202, 0.3031)
S3 = (0.2888, 0.1784, 0.2024, 0.3895)
S4 = (0.2104, 0.1856, 0.2625, 0.3415)

To get comprehensive evaluation vector B = W0(S1, S2, S3, S4) T = (0.2512, 0.1854, 0.2214, 0.3545). After normalization, get B* = (0.2481, 0.1831, 0.2187, 0.3501), take MaxB* = 0.3501. This ABS project risk comprehensive evaluation level about 0.3501. It means that risk factors appear serious level performance. Besides that, see it from risk types, and mainly external risk of projects facing is consistent with the literature point of view. If the implementation of the project, the enterprise needs to take the appropriate risk management strategies to cope with the potential risks, especially the external risk project. Has been listed in Table 40.4 experts to identify the significant risk, such as design changes owner frequent, charge change, management risk, management of these risks to take reasonable risk allocation strategies. Risk should be managed by the most suited to, and enables the public to use an optimum value which one party, give play to the cooperation in the framework of contract agreement in both sides of the synergy effect.

## 40.4 Conclusion

In the background of all parties seek diversified financing channels to relieve the financial pressure of government's construction about public rental housing, BOT, ABS, etc. to the introduction of private capital and foreign capital financing way, with the increasing of capital demand pressures and the less financing risk get more and more favour. Through the above analysis in the construction of public housing into ABS financing mode, under the construction of public rental housing related contributory risk reasonably, not only increase the charming of public housing construction for private businesses, but also ease the government's fiscal pressure, increasing the ABS this financing mode into the realistic significance of public rental housing construction [10].

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# Chapter 41
# Research on the Forecasting of Construction Accidents with the Cubic Exponential Smoothing Method

**Chao He, Xiaoli Yan, and Yilang Huang**

**Abstract** Construction accidents occur frequently and cause great loss to construction enterprises, the whole industry and the society. Therefore, it is significant to forecast the death tolls of construction engineering accidents to provide decisive reference for development of Chinese construction accident prevention. Being compared with other forecasting method, exponential smoothing method is relatively simple, convenient, and does not need huge volume of historical data. The cubic exponential smoothing model is set up in this paper, and the death tolls of the housing construction and municipal engineering accident from 1988 to 2012 are chosen to predict the construction accidents. The forecasting value result is very close to the original value from 1999 to 2012, which confirms it is reasonable and feasible to use this model to forecast the death tolls of construction engineering accidents. Then, the forecasting values can be predicted in 2013 and 2014, which are 527 and 421. The cubic exponential smoothing method is a reliable predictive model, and it can forecast death tolls in short term. The forecast result can provide reference to apply effective measures and ways to improve the serious construction accidents situation now.

**Keywords** The cubic exponential smoothing model • Construction accidents • Accident forecasting

C. He (✉) • X. Yan • Y. Huang
School of Management Studies, Shanghai University of Engineering Science, Shanghai, China
e-mail: hechao27@163.com; yanxiaoli821@163.com; Cecil1908@163.com

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## 41.1 Introduction

With the increase of national investment to infrastructure, construction has become a pillar industry of national economy. However, construction accidents occur frequently, which has become one of the current hot topics. As shown in Fig. 41.1, the accident death toll is declining as a whole in recent 15 years, but the number of deaths is still so huge that it brings great loss of reputation for construction enterprises and the whole industry. Therefore, forecasting the death toll of construction engineering accidents possesses positive significance. This paper uses the data of the past and current to study the future, predicting the development trend of construction accidents, which have important guiding roles for construction enterprises to make policy, development planning and technical solution [1].

At present, methods like least square method, artificial neural network, grey model, exponential smoothing, and so on are usually used to predict construction engineering accident. The Least square method is mainly used for curve fitting prediction. The premise of artificial neural network believes that the future value has a certain relationship with the previous history values, which restricts its application to some extent [2]. The calculated process of the grey model is complex. Exponential smoothing method is the improvement and development of the moving average method. Compared with other time series methods, exponential smoothing method not only does not need more historical data, but also consider the importance of each phase of the data. The calculation of this method is simple and convenient, playing a significant role in actual forecast. Data about the construction

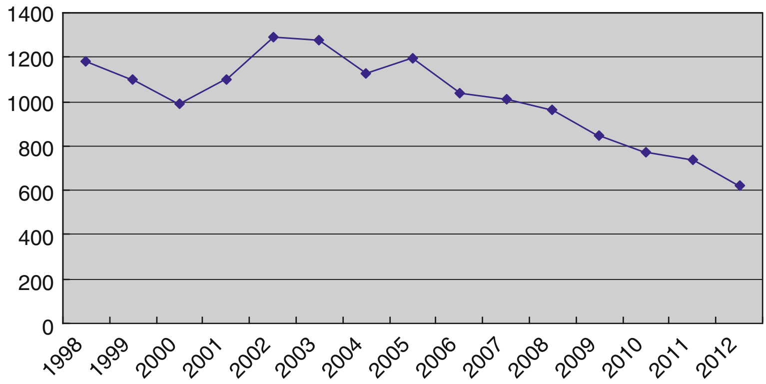


**Fig. 41.1** The trend of death toll in construction accident

accidents forecasting are less and fluctuates largely, and lack of model that could be operated strongly. The exponential smoothing method is suitable for the forecasting of construction accidents.

## 41.2 Forecasting Model

### 41.2.1 The Statistical Indicators of Construction Engineering Accident

Indicators are the key factors in model. Selection of indicators directly influence whether the research result is feasible. The statistical analysis of this paper using the statistical methods to collect related information and data researches the rules of construction engineering accident. The main indicator of Construction accident is the annual accident's actual number. This indicator is adopted throughout the whole process of model calculation.

### 41.2.2 Forecasting Model of Accident

Exponential smoothing method was first put forward by American Robert G. Brown. This method does not need to store a lot of historical data. When making forecasting, it just needs the current actual value $y_t$ and early prediction $s_t^{(1)}$, and then chooses a reasonable smoothing coefficient by forecaster so that a simple forecasting can be conducted. Exponential smoothing includes single exponential smoothing, secondary exponential smoothing, cubic exponential smoothing method, and so on. If it smoothes so many times, the model itself will become more complicated. When the time series changes in unobvious ways, the single exponential smoothing method can be chosen. When the time series presents linear trend, the secondary exponential smoothing method can be chosen. Otherwise, the cubic exponential smoothing method could be chosen. As shown in Fig. 41.1, construction engineering accidents present non-linear relationship, and then the cubic exponential smoothing method should be selected. The cubic exponential smoothing method usually used in non-linear and short-term forecasting. The forecasting model is as follows [3–5]:

$$\widetilde{y}_{t+T} = a_t + b_t \times T + c_t \times T^2 \tag{41.1}$$

The ahead of periods in forecasting is represented by "T". The forecasting value at time "t + T" is represented by $\widetilde{y}_{t+T}$.

"a" represents a constant value. The single exponential smoothing is represented by $s_t^{(1)}$. The secondary exponential smoothing is represented by $s_t^{(2)}$. The cubic exponential smoothing method is represented by $s_t^{(3)}$. The actual value is represented by $y_t$. Exponential smoothing method is as follows:

$$s_t^{(1)} = a \times y_t + (1-a) \times s_{t-1}^{(1)} \tag{41.2}$$

$$s_t^{(2)} = a \times s_t^{(1)} + (1-a) \times s_{t-1}^{(2)} \tag{41.3}$$

$$s_t^{(3)} = a \times s_t^{(2)} + (1-a) s_{t-1}^{3} \tag{41.4}$$

The parameters in (41.1) respectively are represented by the following formula:

$$a_t = 3s_t^{(1)} - 3s_t^{(2)} + s_t^{3} \tag{41.5}$$

$$b_t = \frac{a}{2(1-a)^2} \times \left[(6-5a)s_t^{(1)} - 2(5-4a)s_t^{(2)} + (4-3a)s_t^{(3)}\right] \tag{41.6}$$

$$c_t = \frac{a^2}{2(1-a)^2} \left(s_t^{(1)} - 2s_t^{(2)} + s_t^{(3)}\right) \tag{41.7}$$

### *41.2.3 The Present Situation of Study*

The cubic exponential smoothing method is used widely, Such as commodity sales forecast, disease forecast, coal mine accident forecast, port throughput forecast, railway passenger traffic, and so on. At present, literatures about the application of cubic exponential smoothing method in construction accidents forecasting are rare. This method possesses many characteristics, such as simple in calculation process, good adaptability, less storage data, and so on. It is not like the grey model which needs tedious calculation. As long as the method is operated properly, the higher prediction accuracy can be obtained.

## 41.3 Forecasting the Death Toll of Construction Engineering Accidents

### *41.3.1 The Forecasting Purpose*

Forecasting the death toll of construction engineering accidents aims to prevent accidents. Casualties and property losses can be largely reduced by effective construction engineering accident forecasting, improving the corporate image. The cubic exponential smoothing method is an effective method to forecast

**Table 41.1** The death tolls of building construction accidents in China from 1998 to 2012 [6]

| Year | Death | Year | Death | Year | Death |
|---|---|---|---|---|---|
| 1998 | 1,180 | 2003 | 1,279 | 2008 | 963 |
| 1999 | 1,097 | 2004 | 1,125 | 2009 | 846 |
| 2000 | 987 | 2005 | 1,193 | 2010 | 772 |
| 2001 | 1,097 | 2006 | 1,041 | 2011 | 738 |
| 2002 | 1,292 | 2007 | 1,012 | 2012 | 624 |

Note: The death tolls of building construction are death tolls of the housing construction and municipal engineering accident

casualties in the short term. This method is simple, easy to operate, and not needing to store large amounts of historical data. Reasonable and effective forecasting can be used to indicate the direction for prevention.

### *41.3.2 Case Calculation*

By reasonably collecting data which related to the construction accident, the death tolls of building construction from 1998 to 2012 are selected as the original data sequence, as shown in Table 41.1. Because of the time series data present nonlinear relation in the table, the cubic exponential smoothing method is suit to be adopted to forecast the death tolls of building construction accidents for 2013 and 2014.

First of all, the initial value should be estimated when using the cubic exponential smoothing method. As only 15 years data were collected in this case, estimate the initial value's influence on the forecasting value can't be ignored. Generally, the initial value is determined by the average of the first three numbers or the least square method. The average of the first three numbers was chosen to determine the initial value in this case, namely:

$$s_0^{(1)} = s_0^{(2)} = s_0^{(3)} = \frac{x_1 + x_2 + x_3}{3} = \frac{1{,}180 + 1{,}097 + 987}{3} = 1{,}088$$

The number of "a" varies from 0~1, and it is difficult to determine "a". The smoothing coefficient "a" plays a key role in exponential smoothing method and embodies the contribution of each phase of the data. "a" mostly rely on the researcher's experience to select in practice [7]. According to experience and judgment method, a slightly big value that between 0.3~0.5 can be chosen when the time series has a fluctuation [8]. After calculating so many times, the forecasting error is minimum when a = 0.33.

The forecasting values from 1999 to 2012 are respectively determined by the data of this year the year before and taking T = 1, and which are calculated according to the formula (41.1).

Through the calculation can obtain the following numbers.

$s_{2012}^{(1)} = 778.9925$, $s_{2012}^{(2)} = 901.4183$, $s_{2012}^{(3)} = 992.7029$, $a_{2012} = 625.4255$, $b_{2012} = -94.75293$, $c_{2012} = -3.77731$.

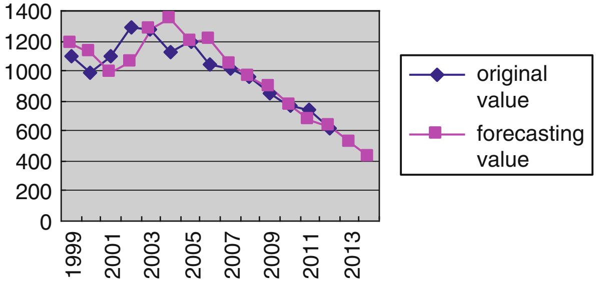


**Fig. 41.2** Original value and forecasting value contrast table

$\widetilde{y}_{2012+T} = 625.4255 + (-94.75293)T + (-3.77731)T^2$ When T = 1, the forecasting value ($\widetilde{y}_{2013} = 527$) can be gotten. When T = 2, the forecasting value ($\widetilde{y}_{2013} = 421$) can be gotten.

### *41.3.3 Analysis of the Forecasting Results*

The error among forecasting value and actual value from 2010 to 2012 are respectively 0, 8.78 %, and 0.76 %. The error is small so that the cubic exponential smoothing method is feasible to forecast the death tolls of construction engineering accidents. As shown in Fig. 41.2, the forecasting value is close to the original value, which illustrate that the accuracy is high. As shown in Table 41.2, the forecasting value is 527 in 2013 and 421 in 2014, and it trend to descend. But the number is still large, which will cause loss to construction enterprise. Situation is still grim. To solve this kind of situation, government and construction enterprises must take effective measures to control accidents in minimum range, achieving the safe production in maximum.

## 41.4 Conclusions

Safety is one of the hottest topics in construction industry. In the time being, the death tolls of construction engineering accident are declining, but the number is still huge. Facing the situation of frequent accidents and serious casualties in construction industry, accident statistics and forecasting should be taken as one of the effective means to guarantee construction safety production and accidents prevention, which provides decisive reference for development of Chinese construction accident prevention. The death tolls of construction engineering accident from 1988 to 2012 are predicted by the cubic exponential smoothing method in this paper. The forecasting value is very close to the original value, illustrating the forecasting is feasible. The cubic exponential smoothing method is a reliable predictive model in construction accidents, and it can forecast death tolls in short term.

**Table 41.2** The forecast calculation table of the cubic exponential smoothing method

| Year | | Single smoothing | Secondary smoothing | Cubic smoothing | | | | Forecasting value |
|---|---|---|---|---|---|---|---|---|
| Initial value | Death | 1088 | 1088 | 1088 | a | b | c | (integer) |
| 1998 | 1,180 | 1,118.36 | 1,098.019 | 1,091.306 | 1,152.33 | 25.09709 | 1.65310 | |
| 1999 | 1,097 | 1,111.311 | 1,102.405 | 1,094.969 | 1,121.687 | 6.01233 | 0.17825 | 1,179 |
| 2000 | 987 | 1,070.289 | 1,091.807 | 1,093.925 | 1,029.371 | −32.06170 | −2.35310 | 1,128 |
| 2001 | 1,097 | 1,079.103 | 1,087.615 | 1,091.843 | 1,066.309 | −8.93083 | −0.51952 | 995 |
| 2002 | 1,292 | 1,149.359 | 1,107.99 | 1,097.172 | 1,221.278 | 54.17542 | 3.70562 | 1,057 |
| 2003 | 1,279 | 1,192.141 | 1,135.76 | 1,109.906 | 1,279.048 | 61.54323 | 3.70276 | 1,279 |
| 2004 | 1,125 | 1,169.984 | 1,147.054 | 1,122.165 | 1,190.955 | 9.12658 | −0.23763 | 1,344 |
| 2005 | 1,193 | 1,177.579 | 1,157.127 | 1,133.702 | 1,195.059 | 6.78420 | −0.36061 | 1,200 |
| 2006 | 1,041 | 1,132.508 | 1,149.003 | 1,138.752 | 1,089.267 | −37.71567 | −3.24423 | 1,201 |
| 2007 | 1,012 | 1,092.741 | 1,130.436 | 1,136.008 | 1,022.92 | −54.10854 | −3.89662 | 1,048 |
| 2008 | 963 | 1,049.926 | 1,103.868 | 1,125.402 | 963.5759 | −62.42410 | −3.93102 | 965 |
| 2009 | 846 | 982.6305 | 1,063.86 | 1,105.093 | 861.4053 | −84.25888 | −4.85138 | 897 |
| 2010 | 772 | 913.1224 | 1,014.116 | 1,075.071 | 772.0887 | −94.04214 | −4.85669 | 772 |
| 2011 | 738 | 855.332 | 961.7175 | 1,037.664 | 718.5075 | −86.07567 | −3.69215 | 673 |
| 2012 | 624 | 778.9925 | 901.4183 | 992.7029 | 625.4255 | −94.75293 | −3.77731 | 629 |
| 2013 | | | | | | | | 527 |
| 2014 | | | | | | | | 421 |

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# Chapter 42
# Analysis of the Interactions Between Risks Affecting Construction Project Cost

**Pengpeng Li, Jiayuan Wang, and Hongping Yuan**

**Abstract** Previous studies regarding construction project risk management mainly hypothesized that risk factors are independent and they do not interact with each other. The applicability of those studies, however, is limited because they cannot effectively reflect the risks happening in real construction projects. Based on the principles of system dynamics approach, this paper thus proposes to analyze the interrelations between major risks influencing construction project cost. To this end, this paper establishes a risk assessment model to analyze the interactions between risk factors involved. The model developed is validated and simulated based on data collected from the Xinzheng airport rehabilitation and expansion project. The findings demonstrate that the existence of interactions between risk factors can significantly influence the entire project cost. That the results of sensitivity analysis tell that the most sensitive factors in affecting project cost include "contractors' poor management capacity", "engineering change", and "rise in material and equipment price". This study contributes to the body of knowledge of construction project risk management by furthering the understanding of risks affecting project cost.

**Keywords** Risks • Interactions • Construction cost • System dynamics

P. Li • J. Wang
College of Civil Engineering, Shenzhen University, Shenzhen, China

H. Yuan (✉)
School of Economics and Management, Southwest Jiaotong University,
Leshan, Sichuan 610031, China
e-mail: hpyuan2005@gmail.com

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## 42.1 Introduction

Due to huge amounts of investments, various project stakeholders involved, long period of construction duration and adoption of various complicated technologies, construction projects have been exposed of high level of risks and uncertainties, which might threat the achievement of project goals. The effect of risks and uncertainties inherent in any stage of a project's development process plays a significant role in influencing the project performance. Thus, it is essential to effectively analyze the risks in construction projects in order to enhance the overall performance.

Generally risk management process consists of three main phases, i.e. risk identification, risk analysis and response planning and control [1]. In risk analysis phase, the impact of different risks on project performance is assessed. Risk analysis helps project managers obtain an overall and comprehensive understanding of the risk level of the project, and determine the most important risks influencing the project performance.

Available risk analysis techniques may be divided into qualitative and quantitative risk assessment approaches, such as checklists, cause-effect diagrams, flowcharts for qualitative risk analysis, and the PERT (Program Evaluation and Review Technique), Monte Carlo simulation and the AHP (Analytic Hierarchy Process) for quantitative risk analysis. None of these techniques, however, can handle the interrelationships between different risks. This is because previous construction risk management related studies are largely carried out with a hypothesis that risks are independent. The applicability of those studies is thus limited because they only assessed one single risk's impact on the project at a time, ignoring the effect caused by a chain of other risks [2]. Moreover, due to these interactions, the occurrence of one risk may trigger, strengthen or weaken other risks or portfolios of risks. Hence, the cumulative chain impact of risks may surpass the sum of their individual impacts [1]. Commonly practiced risk analysis approaches have not provided reliable information regarding the actual impact of risks as they do not consider such interactions. As a result, it may mislead project managers understanding toward risks' influence on project performance.

Recently, a few research institutes begin to realize the importance of risk interactions. Latest Project Risk Analysis and Management Guidelines (PRAM guide) published by British Association of project management (APM) stated that the interactions between risks are essential to risk analysis [3]. The International Organization for Standardization (ISO) also emphasized risks' systematics and dynamics as one of the principle for effective risk management in risk management standard ISO 31000 [4]. Moreover, Yuan et al. [5] used SEM to analyze and examine risks' relationships in PPP project, showing that positive cause-and-effect collections exist between the physical and process-related risks [5]. Wang et al. [6] established a risk management framework to response risks in developing countries' projects; the framework reflected risks' hierarchical structure and relationships [6]. Luu et al. [7] evaluated risks leading to project delay with the Bayesian Belief Network approach, finding that causal relationships between risks has an important role to play in determining the risk effect [7].

It can be summarized from the above discussions that existing studies achieved a common understanding of the importance of risk interactions but there is still a lack of appropriate approach to quantitatively assess the impact of risks' interactions on the project performance. Therefore, based on the principles of system dynamics, this paper aims to analyze the interrelations between major risks influencing construction project cost. First a risk assessment model is developed. Then, the model is validated and applied based on data collected from the Xinzheng airport rehabilitation and expansion project. Finally, through sensitivity analysis the most sensitive risks in affecting the project cost are identified and analyzed.

## 42.2 Interactive Structure of Cost Risks: Modeling and Simulation

### *42.2.1 Selection and Analysis of Risks*

In this paper, major cost risks of a construction project are identified and modeled using a series of cause-and-effect feedback loops. For this purpose, the influential factors affecting construction cost were selected in line with the study by Wang et al. [8]. In their study seven risks affecting construction project cost were selected for modeling and simulation, including engineering change (F1), inaccuracy of survey data (F2), schedule pressure (F3), construction funds shortage (F4), contractors' poor management capacity (F5), lack of skilled workers (F6), and rise in material and equipment price (F7) [8]. Their interactions are analyzed as follows (Fig. 42.1).

- It is acknowledged that inaccurate geological survey may bring foundation design change [9]. So there is a causal relationship between them. Correspondingly, engineering change will cause demolition and rework which results in workload rising and consequently increase the unit cost and the possibility of construction funds shortage [8]. Therefore, the inaccurate survey data has a certain causal relationship with risk of construction funds shortage [10]. The increased workload will cause delay and increase the schedule pressure.
- Construction funds shortage will cause delay and finally result in schedule pressure [10]. On the contrary, schedule pressure may have negative impacts on project objective in terms of cost overrun because project manager would hire more workers for crashing. This will increase the labor unit cost and exacerbate risk of construction funds shortage [11]. Therefore, there exists a positive feedback relationship between construction funds shortage and schedule pressure.

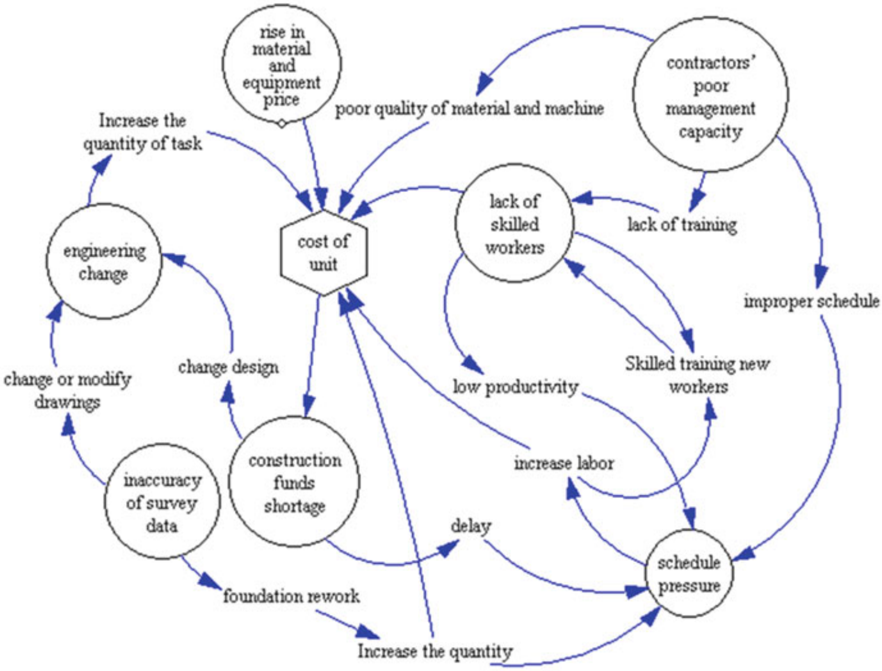


**Fig. 42.1** Interactions between project cost risks

- Contractors' poor management capacity may cause negative impacts on project objectives in terms of unreasonable process plan and materials and equipments supply delay, causing schedule pressure eventually. As analyzed previously, schedule pressure may bring more workers, and as a result project managers will add additional work training and exacerbate risk of the lack of skilled workers. These will lead to an increased labor cost indirectly. In turn, due to the lack of skilled workers, the overall productivity will descend, increasing project delay and schedule pressure. Thus, there is a mutually reinforced relationship between the lack of skilled workers and the schedule pressure.

### *42.2.2 Model Development*

It is acknowledged that direct cost is always the most risky one in construction cost composition, including direct labor cost, material cost and equipment cost. This paper intends to analyze the interrelations between major risks influencing these three direct costs. For clear description and easy calculation, we divide total cost of labor, material and equipment over the unit of per square meter. After that, the risks identified are integrated into the model to investigate their

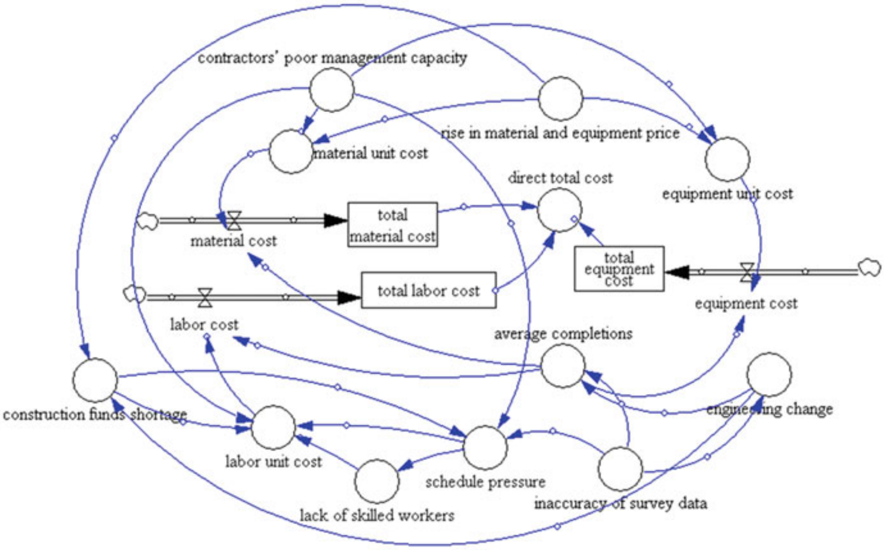


**Fig. 42.2** The project cost risk assessment model

**Table 42.1** Types of variables in the model

| Variable | Type | Variable | Type |
|---|---|---|---|
| Total material cost | Stock | Material cost | Flow |
| Total labor cost | Stock | Labor cost | Flow |
| Total equipment cost | Stock | Equipment cost | Flow |
| Labor unit cost | Auxiliary | Equipment unit cost | Auxiliary |
| Material unit cost | Auxiliary | Engineering change | Auxiliary |
| Direct total cost | Auxiliary | Lack of skilled workers | Auxiliary |
| Average completions | Auxiliary | Schedule pressure | Auxiliary |
| Rise in material and equipment price | Auxiliary | Contractors' poor management capacity | Auxiliary |
| Inaccuracy of survey data | Auxiliary | Construction funds shortage | Auxiliary |

interactive impacts on the project cost in two scenarios: the first is to calculate their individual impact on the cost and sum up all the influence and the second is to evaluate their impact on the project cost by taking their interactions into consideration. At the end, results from the above two scenarios are compared and discussed. The project cost risk assessment model is displayed in Fig. 42.2 and the variables involved showed in Table 42.1.

## 42.3 Model Application, Results and Discussions

### *42.3.1 Introduction of the Case*

The studied project is located in Xinzheng Airport of Henan province, which is a rehabilitation and expansion project of the airport. The construction area is 28,000 $m^2$, including a single warehouse and a building with reinforced concrete structure of five layers. The preliminary duration and cost of the project are approximately 7 months and 61.8 million yuan, respectively. The direct cost was estimated to be 20.44 million yuan and the planned weekly average completion area was 1,000 $m^2$.

### *42.3.2 Estimation of Parameters*

1. Values of various costs and engineering completion are determined by the case.
2. Values of different risks cannot be obtained directly from the project data. Thus we send questionnaires to project stakeholders such as project managers, cost engineers, supervision engineers. Based on data collected, we weighted the average value of each risk, which is shown in Table 42.2.

### *42.3.3 Introduction of Risks Identified*

According to the planned project duration of 7 months, we set the simulation duration as 28 weeks in the model. Different risks are defined by appropriate mathematical function as described below.

1. Engineering change: It may bring additional amount of tasks at particular points in time. So STEP Function is used to describe the risk, which means the amount of tasks will increase to an estimated value at a particular point.
2. Rise in material and equipment price: Its probability of occurrence is relative low, but if market condition or policies change, it will cause rise in cost of material and machine at particular points. So STEP Function is adopted as well.

**Table 42.2** Variables in the model

| Risks | Values | Risks | Values |
|---|---|---|---|
| Labor unit cost (10,000/$m^2$) | 0.015 | Engineering change (Dnml) | 0.35 |
| Material unit cost (10,000/$m^2$) | 0.048 | Inaccuracy of survey data (Dnml) | 0.5 |
| Equipment unit cost (10,000/$m^2$) | 0.01 | Construction funds shortage (Dnml) | 0.6 |
| Average completions weekly ($m^2$) | 1,000 | Schedule pressure (Dnml) | 0.24 |
| Rise in material and equipment price (Dnml) | 0.66 | Contractors' poor management capacity (Dnml) | 0.45 |
| Lack of skilled workers (Dnml) | 0.34 | | |

**Table 42.3** Simulated results (unit: million yuan)

| Risk factor | Total labor cost | Total material cost | Total equipment cost | Direct total cost | Estimated cost | Cost overrun |
|---|---|---|---|---|---|---|
| F1 | 4.62 | 14.784 | 3.08 | 22.484 | 20.44 | 2.044 |
| F2 | 4.275 | 13.68 | 2.85 | 20.805 | 20.44 | 0.365 |
| F3 | 5.208 | 13.44 | 2.80 | 21.448 | 20.44 | 1.008 |
| F4 | 6.72 | 13.44 | 2.80 | 22.96 | 20.44 | 2.52 |
| F5 | 6.09 | 19.488 | 4.06 | 29.638 | 20.44 | 9.198 |
| F6 | 5.628 | 13.44 | 2.80 | 21.868 | 20.44 | 1.428 |
| F7 | 4.20 | 17.8752 | 5.64 | 25.7992 | 20.44 | 5.3592 |
| **Cumulative impact on total cost overrun by individual risk** | | | | | | **21.9222** |
| Scenario one | 12.9877 | 27.6393 | 5.75818 | 46.3852 | 20.44 | 25.9452 |

3. Inaccuracy of survey data: According to its acting on project, we apply PULSE Function to describe it, meaning that the variable will return to its original value after change.
4. Values of other risks are determined by the questionnaire survey.

### *42.3.4 Model Simulations*

In the base case, the total labor, material and equipment cost are 4.2, 13.44, 2.8 million yuan, respectively. Simulation results are showed in Table 42.3. First, when take risk interactions into consideration, the total cost of labor, material and equipment are 12.99, 27.64 and 5.76 million yuan, respectively. The values are all far higher than any individual risk's impact on corresponding costs. Second, as to the total direct cost, in the first scenario, value of the cost overrun is 25.95 million yuan, which is much higher than 21.92 million yuan in the scenario two. Thus, it confirmed that when a chain of risks happened, their cumulative impact on the project cost will be higher than the sum of individual risks.

Based on the results, project manager are advised to pay particular attention to risks which may have interactive relationships. Also, the chain effect of project risks on project objectives (such as project cost) should be investigated to ensure the effectiveness of project risk management.

## 42.4 Sensitivity Analysis

Findings above have verified the theoretical hypothesis that there are interactive relationships between risks, and such interactions may escalate the overall impacts on the project cost. As a result, the actual impact of combined risk effect will be higher than the sum of their individual impacts. On the other hand, each risk's

**Table 42.4** Policy simulations (million yuan)

| Change (10 %) | | F1 | F2 | F3 | F4 | F5 | F6 | F7 |
|---|---|---|---|---|---|---|---|---|
| Total cost | Before | 45.72 | 45.72 | 0.4572 | 0.4572 | 45.72 | 45.72 | 45.72 |
| | After | 46.21 | 45.78 | 0.4587 | 0.4602 | 46.75 | 45.92 | 46.39 |
| | Change | 1.06 % | 0.14 % | 0.33 % | 0.67 % | 2.25 % | 0.43 % | 1.46 % |

sensitivity to this impact is also essential to effective risk management. Thus, the following section analyze risks' sensitivity to the impact on the project cost. The results are shown in Table 42.4.

The results of sensitivity analysis tell that the most sensitive risks in affecting project cost include "contractors' poor management capacity", "engineering change", and "rise in material and equipment price". The last one is determined by external environment, which is not easy to control, so project managers should focus on the improvement of contractors' capacity and reduction of engineering changes in project risk management.

## 42.5 Conclusions

This paper presents a cost risk assessment model which is capable of analyzing risks by considering the interactions inherent in the risks, and quantifying their impact on the project cost. The results from an empirical case study revealed that project risks are not independent, and the impact of their interactions on the project cost is higher than the sum influence of individual factors. In the meanwhile, three risks were identified as sensitive factors because they have the most influence in the project cost when a same scale change happens. The model and results presented can be useful in effective project risk management.

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# Chapter 43
# Applying the DSM to Design Project Scheduling: A Case Study

**Yanjun Qian and Donglang Yang**

**Abstract** Recently, Design Structure Matrix (DSM) has gained increasing attention in scheduling product design projects that consist of many interrelated activities. One common objective of scheduling is to find an activity sequence that minimizes the total feedback length. In this study, we apply the DSM method to the development of pressure reducers in a Chinese company. We first identify 72 activities involved in the projects. Then, we establish the information dependencies among the activities and build a DSM. Finally, the interrelated activities are reorganized with the objective of minimizing total feedback lengths. Application results show that the complex information relations among activities in pressure reducer design can be clearly represented by the DSM. Moreover, the DSM provides a useful tool for investigating iteration, as well as a useful tool for scheduling interrelated activities.

**Keywords** Product development • Project scheduling • Design structure matrix • Interrelated activities

## 43.1 Introduction

Many practitioners and researchers have reported that product design projects often involves a number of decision-making activities, for example, the design of an automobile may involve thousands of engineers making millions of design decisions [6]. Moreover, none of these activities are performed in isolation; instead, each design choice may affect many other design parameters [6, 16]. Therefore, cyclic information flows are common in design projects.

Y. Qian (✉) • D. Yang
School of Public Policy and Administration & Institute of Real Estate Research, Xi'an Jiaotong University, Xi'an, China
e-mail: qian_yanjun@hotmail.com; yangdl@mail.xjtu.edu.cn

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Formal project scheduling techniques, such as critical path method (CPM), program evaluation and review technique (PERT), utilize activity duration estimates and precedence relationships representing the network of activities. Although they are widely used in many industries for project scheduling, they cannot effectively deal with cyclic information flows among activities, limiting their capacity of scheduling for product design projects [10, 13]. Moreover, in PERT/CPM, the underlying precedence relationships among activities are assumed known and unchanged, but in many complex product design projects, clear precedence constraints do not exist and are rarely known in advance [1, 20].

To address the shortfalls of CPM and PERT, one known method is Design Structure Matrix (DSM), which is a matrix representation of a project with elements denoting individual design activities and off-diagonal entries representing the information dependencies among these activities [2, 21]. Recently, DSM has gained increasing attention in scheduling product design projects that consist of many interrelated activities. For example, DSM has been used for scheduling development activities at dozens of companies, such as Boeing, General Motors, and Intel [7, 19]. One common objective of scheduling is to find an activity sequence that minimizes the total feedback length. In this study, we apply the DSM method to the development of pressure reducer in a Chinese company.

The remainder of this study is organized as follows. After introducing the DSM method in Sect. 43.2, we present its application to the design of pressure reducers in our case study company. Section 43.4 gives the conclusions.

## 43.2 The DSM Method

Literature has shown that the information dependencies among product design activities can be clearly modeled by the DSM [2, 7, 14]. As illustrated in Fig. 43.1, the basic DSM is a binary matrix representation of a project with elements denoting individual design activities and off-diagonal entries representing the information dependencies among these activities [2, 6]. Along each row, the off-diagonal entries indicate all of the activities whose output information is required to perform the activity corresponding to that row; reading down each column reveals that which other activities receive its output [2, 21]. When activities are executed in the order listed from top to bottom, sub-diagonal entries represent an input from upstream activities to downstream activities, and super-diagonal entries denote a feedback from downstream activities to upstream activities [3, 9, 17]. As such, DSM provides a compact representation of a complex system by showing information dependencies in a square matrix [4]. To improve product development performance, the DSM approach suggests re-sequencing the design activities so as to minimize iterations [6, 21].

The DSM approach was first introduced by Steward [22]. Eppinger et al. [6] extended Steward's work by explicitly including numerical measures of the degree of activity dependence. In recent years, DSM has gained increasing attention in

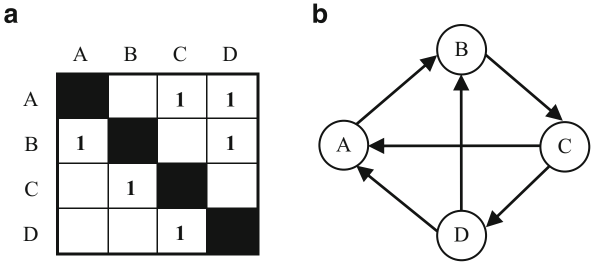


**Fig. 43.1** Representation of design projects: four-activity example. (**a**) DSM representation, (**b**) equivalent graph

scheduling product design projects that consist of many interrelated activities. For example, DSM has been used for scheduling design activities at dozens of companies, such as Boeing, General Motors, Westland Helicopters, and Intel [5, 7, 15].

Quite a few researchers have examined how to sequence design activities in a DSM. Because feedbacks cause rework, some researchers (e.g., [1, 11, 21, 23]) have examined the issue of finding an activity sequence with minimum total feedback value. A common assumption in these works is that the positions of feedbacks will not significantly affect the development time and costs [21]. Therefore, they are not applicable for the projects where the positions of feedbacks will affect the development time and costs. To address this shortfall, Gebala and Eppinger [8] and Eppinger et al. [6], suggest another important objective of sequencing interrelated activities, i.e., to find an activity sequence with minimum total feedback length. Several schemes for identifying an activity sequence with minimum total feedback length are available, including the competent genetic algorithm proposed by Meier et al. [18], the fitness differential adaptive parameter controlled evolutionary algorithm developed by Lancaster and Cheng [12], and the exchange-based heuristic developed by Lin et al. [19].

## 43.3 Case Study

In this section, we apply the DSM method to the development of pressure reducers in a Chinese company. Since 1990s, the company has been facing considerable challenges to develop higher quality, lower cost products in short intervals. The existing lengthy and costly product development is regarded as a major obstacle to meet these challenges.

The pressure reducers manufactured by the company are highly advanced, complex systems. The systems are used in extreme high pressure and high fluidity environments. Moreover, design of the pressure reducers requires integration of technical expertise from several engineering disciplines. To collect the data, we analyzed two pressure reducer development projects which were completed in 2012.

We first read through the available project documents and identified 72 activities involved in the projects. The information dependencies among the activities are divided into two categories: hard dependency and soft dependency. Hard dependency of activity $A$ on activity $B$ means that activity $A$ must be scheduled after activity $B$. Soft dependency of activity $A$ on $B$ represents that activity $A$ depends on the information input from activity $B$, but is allowed to precede activity $B$. For each activity, we conducted extensive interviews with the relevant engineers, and asked questions such as "What are the activities whose outputs affect *Component Design*?" and "Which activities must precede *Component Design*?" Then we established information dependencies among the activities and built a DSM. To ensure accurate data entries, these records were doubled checked by the project managers who are familiar with the projects. After that, we identified the interrelated activities in the projects using the method presented in Kusiak and Wang [11]. Overall, 29 interrelated activities are identified and their information dependency relations are shown in Fig. 43.2, where the entry "1" denotes a soft information dependency, and the entry "H" denotes a hard information dependency. For example, Fig. 43.2 shows that activity 1 must precede activity 2, and activity 3 depends on the information input from activity 2, but is allowed to precede activity 2.

As shown in Fig. 43.2, there are three large feedback loops. The first one consists of activities {1, 2, 3, 4, 5}, the second one consists of activities {10, 11, 12, 13, 14, 15, 16}, and the third one consists of activities {26, 27, 28, 29}. These feedback loops result in design iterations and lengthy product development. Literature has shown that in most cases, finding an activity sequence with minimum total feedback length can lead to considerable savings in both development time and costs [12, 18]. Therefore, we apply the method presented in Lin et al. [19] to reorder the activities in three feedback loops such that the total feedback length is minimized. The reordered activity sequence is shown in Fig. 43.3, where the total feedback length is reduced from original 29 to 10.

## 43.4 Conclusions

In recent years, DSM has gained increasing attention in scheduling product design projects that consist of many interrelated activities. One common objective of scheduling is to find an activity sequence that minimizes the total feedback length. In this study, we apply the DSM method to the development of pressure reducers in a Chinese company. We first identify 72 activities involved in the projects. Then, we establish the information dependencies among the activities and build a DSM. Finally, the interrelated activities are reorganized with the objective of minimizing total feedback lengths. Application results show that the complex information relations among activities in pressure reducer development can be clearly represented by the DSM. Moreover, the DSM provides a useful tool for investigating iteration, as well as a useful tool for scheduling interrelated activities. In the future, it is meaningful to test the broader application of the DSM by applying it to other development projects.

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assembly preliminary design | 1 | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| Component design | 2 | H | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| Outsourced components selection | 3 | H | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| Standard components selection | 4 | H | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| Design evaluation | 5 | H | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Optimizingthe design | 6 | | | | | H | | | | | | | | | | | | | | | | | | | | | | | | |
| Design of experimentation outline | 7 | H | | | | | H | | | | | | | | | | | | | | | | | | | | | | | |
| Design confirmation | 8 | | | | | | H | H | | | | | | | | | | | | | | | | | | | | | | |
| Material preparation | 9 | | | | | | 1 | | H | | | | | | | | | | | | | | | | | | | | | |
| Compiling technical document | 1 | | | | | | 1 | 1 | H | | | 1 | | | | 1 | | | | | | | | | | | | | | |
| Manufacturing tool design | 1 | | | | | | 1 | | H | | | | | | | | | | | | | | | | | | | | | |
| Manufacturing self-made components | 1 | | | | | | | | | 1 | H | | | | 1 | | 1 | | | | | | | | | | | | | |
| Purchasing standard and outsourcing | 1 | | | | | | 1 | | H | | | | | | | | | | | | | | | | | | | | | |
| Manufacturing tool fabrication | 1 | | | | | | | | | 1 | | H | | | | | | | | | | | | | | | | | | |
| Design assembling tools | 1 | | | | | | 1 | 1 | H | | | | | | | | | | | | | | | | | | | | | |
| Assembling tool fabrication | 1 | | | | | | | | | 1 | | | | | | H | | | | | | | | | | | | | | |
| Purchasing experimental equipments | 1 | | | | | | 1 | 1 | H | | | | | | | | | | | | | | | | | | | | | |
| Assembling components | 1 | | | | | | | | | | | | H | H | | | | | | | | | | | | | | | | |
| Assembling product | 1 | | | | | | | | | | 1 | | | | | 1 | H | | H | | | | | | | | | | | |
| Principle test | 2 | | | | | | | | | | 1 | | | | | 1 | H | H | | H | | | | | | | | | | |
| System matching test | 2 | | | | | | | | | | | | | | | | | 1 | | | H | | | | | | | | | |
| Review of detail design | 2 | | | | | | | | | | | | | | | | | | | | 1 | H | | | | | | | | |
| Prototype phase preparation | 2 | | | | | | | | | | | | | | | | | | | | | | H | | | | | | | |
| Summary of detail design problems | 2 | | | | | | | | | | | | | | | | | | | | | | 1 | H | | | | | | |
| Planning prototype phase | 2 | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | H | | | | | |
| Resolving design problems | 2 | | | | | | | | | | | | | | | | | | | | | | | | 1 | H | | 1 | | |
| Design of prototype testing plan | 2 | | | | | | | | | | | | | | | | | | | | | | 1 | | H | | 1 | | | |
| Design calculation | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | H | 1 | | 1 |
| Product prototype design | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | H | H | H | |

Fig. 43.2 Initial DSM for interrelated activities in pressure reducer design

| | | 1 | 5 | 4 | 2 | 3 | 6 | 7 | 8 | 9 | 15 | 16 | 11 | 10 | 14 | 13 | 12 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assembly preliminary design | **1** | | 1 | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| Design evaluation | **5** | H | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Standard components selection | **4** | H | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Component design | **2** | H | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Outsourced components selection | **3** | H | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Optimizing the design | **6** | | H | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Design of experimentation outline | **7** | H | | | | | H | | | | | | | | | | | | | | | | | | | | | | | |
| Design confirmation | **8** | | | | | | H | H | | | | | | | | | | | | | | | | | | | | | | |
| Material preparation | **9** | | | | | | 1 | | H | | | | | | | | | | | | | | | | | | | | | |
| Design assembling tools | **15** | | | | | | 1 | 1 | H | | | | | | | | | | | | | | | | | | | | | |
| Assembling tool fabrication | **16** | | | | | | | | | 1 | H | | | | | | | | | | | | | | | | | | | |
| Manufacturing tool design | **11** | | | | | | 1 | | H | | | | | | | | | | | | | | | | | | | | | |
| Compiling technical document | **10** | | | | | | 1 | 1 | H | | 1 | | 1 | | | | | | | | | | | | | | | | | |
| Manufacturing tool fabrication | **14** | | | | | | | | | 1 | | | H | | | | | | | | | | | | | | | | | |
| Purchasing standard and outsourcing components | **13** | | | | | | 1 | | H | | | | | | | | | | | | | | | | | | | | | |
| Manufacturing self-made components | **12** | | | | | | | | | 1 | | 1 | | H | 1 | | | | | | | | | | | | | | | |
| Purchasing experimental equipments | **17** | | | | | | 1 | 1 | H | | | | | | | | | | | | | | | | | | | | | |
| Assembling components | **18** | | | | | | | | | | | | | | | H | H | | | | | | | | | | | | | |
| Assembling product | **19** | | | | | | | | | | 1 | H | | 1 | | | | | H | | | | | | | | | | | |
| Principle test | **20** | | | | | | | | | | 1 | H | | 1 | | | | H | | H | | | | | | | | | | |
| System matching test | **21** | | | | | | | | | | | | | | | | | 1 | | | H | | | | | | | | | |
| Review of detail design | **22** | | | | | | | | | | | | | | | | | | | | 1 | H | | | | | | | | |
| Prototype phase preparation | **23** | | | | | | | | | | | | | | | | | | | | | | H | | | | | | | |
| Summary of detail design problems | **24** | | | | | | | | | | | | | | | | | | | | | | 1 | H | | | | | | |
| Planning prototype phase | **25** | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | H | | | | | |
| Resolving design problems | **26** | | | | | | | | | | | | | | | | | | | | | | | | 1 | H | | 1 | | |
| Design of prototype testing plan | **27** | | | | | | | | | | | | | | | | | | | | | | 1 | | H | | 1 | | | |
| Design calculation | **28** | | | | | | | | | | | | | | | | | | | | | | | | | | H | 1 | | 1 |
| Product prototype design | **29** | | | | | | | | | | | | | | | | | | | | | | | | | | H | H | H | |

**Fig. 43.3** Reordered interrelated activities in pressure reducer design

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# Chapter 44
# 'Performance' Specifications for Improved Productivity and Better Value

**John Douglas Thomson**

**Abstract** This research examines how the use of 'performance' specifications could achieve higher productivity and better 'value' for owner and contractor. The inductive methodology identified that construction industry advisors were helpful in assisting the (public sector) owner in defining the owner's 'performance' requirements, period and price, and for all subsequent phases through to contract completion. 'Performance' requirements expressed in the owner's capability brief were used for tendering and contracting purposes, within a context of fixed period and price. This necessitated tenderers to focus solely on best 'value'. A 'performance' contract transferred design and construction risk to the marketplace and demanded competitive, innovative tenders. When compared to projects where method and/or material risks are carried by the owner, the 'performance' based project delivered improved productivity and better 'value' for both owner and contractor.

**Keywords** Relationships • Interface • Performance • Innovation • Capability

## 44.1 Current State of the Industry

In Australia as in the UK, USA and many other developed countries, there has been much government initiated research directed to improving the productivity of domestic construction. This research is ongoing with little demonstrable productivity improvement ([1, 5, 9, 11, 12, 16, 17, 42, 44–46]; Queensland Government 2000). 'Productivity refers to the ratio of output produced to inputs used. At the national level, productivity measures capture the ability of an economy to harness its physical and human resources to generate output and income' ([4, 39], p. 1). But do

J.D. Thomson (✉)
Graduate School of Business and Law, RMIT University,
405 Russell St., Melbourne 3000, Australia
e-mail: doug.thomson@rmit.edu.au

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governments know what the productivity levels of their domestic construction projects are? Green [27] reports research by the Centre for Economics and Business Research states that the UK's public sector procurement process is the most expensive in the EU. Despite voluminous regulation, the Council of Australian Governments (COAG) ([22], p. 3) recently agreed to establish an independent review panel to 'conduct a broad ranging investigation into cost, competitiveness and productivity challenges in the commercial, civil and large scale residential construction industry'. Further, the Productivity Commission ([40], p. 1) has been asked 'to undertake a study to benchmark Australia's major project development assessment and approvals processes against international best practice'. Clearly, all is not well.

## 44.2 Research Question

This research examines how the use of 'performance' specifications could achieve higher productivity and better 'value' for owner and contractor.

## 44.3 Different Cultures

While it is sometimes assumed the public sector has construction industry professionals in their facilities procurement and project teams, this is seldom the case as such individuals are attracted more to the private sector [6]. As a result, few senior Australian public sector facilities procurement staff or project managers have private sector construction or project management experience, yet carry the responsibility for the spending of public moneys associated with the planning, development, delivery and maintenance of billions of dollars of government infrastructure. Those few construction industry professionals who do enter the Australian public sector tend to lose touch with the construction industry as they adjust to the public sector's culture, needs and regulations. Such professionals usually have experience in few sectors of the construction industry and soon become interested in pursuing public sector careers rather than staying in touch with the construction industry. To this should be added the considerable public sector staff turnover as individuals seek promotion, status and a higher salary in other public sector policy or higher level management jobs. It cannot be assumed that the Australian public sector has experienced construction industry professionals appropriately located in construction industry related jobs. This causes relationship and other problems at the public sector owner interface with the construction industry such as achieving good design, selecting a procurement method, and achieving the project performance necessary for productivity and 'value' achievement.

## 44.4 The 'Performance' Specification

Lopez and Love [33] found that 'design errors can adversely influence project performance' and 'were found to not significantly vary with the procurement method or project type used'. Design adjustments taken at a later time are 'directly responsible for considerable costs driven by changes that could have been avoided emerging at later stages of a project [31]. Late changes are far more costly and time consuming than when they are made early on in a project' [29]. The 'ability to influence the final characteristics of a project's product is highest at the start of the project and decreases as the project progresses towards completion . . . the cost of changes and correcting errors typically increases substantially as the project approaches completion' ([41], p. 17). Levitt and Mahalingam [32] suggest that an owner's project planning ability to influence project outcomes falls rapidly once the project begins (the inverse of the cost S-curve) – when outcomes become known, all project funds have already been expended and no influence remains.

Many owners do a poor job of adequately defining a project's scope leading to a poor design basis ([19], p. 115). Adequate and timely preconstruction planning is essential for the successful delivery of projects ([29, p. 567], [34]). But how long and at what cost should this be? Such planning commences with the project owner, not with the construction industry. A project owner is defined as the organization responsible for commissioning and financing a project [13]. The effectiveness of an owner's front-end planning will profoundly affect project cost and schedule performance as well as the overall success of a project in achieving better 'value' [26]. While project planning provides a common reference point that serves as a basis for project monitoring, control, and corrective action [43], it is also necessary for construction industry professionals to understand the owner's needs prior to any project commencement ([29], p. 567). But the resources a (public sector) owner allocates to the conceptual planning stage are often well intentioned but inadequate or inappropriate. Well prior to the start of a construction project it is necessary for the owner to develop a vision of and strategy for its future and the 'performance' capabilities it needs to achieve that vision and strategy. These 'performance' capabilities are usually expressed in the form of a 'capability' brief. This is a challenging process for owners because of their limited knowledge, experience and understanding of current trends and developments in the construction industry. This could be a primary reason for owner's poor scope definition, recognized by industry practitioners as one of the leading causes of project failure, adversely affecting projects in the areas of cost, schedule, and operational characteristics ([19], p. 115).

The Australian Government's 'capability' brief is a 'performance' specification which describes the government's vision and strategy through 'capability' requirement statements. If the 'capability' is incorrectly or inadequately defined, a poor result is inevitable. But the Australian public sector's development of its 'capability' brief is usually neither made accessible to industry nor involves industry [7–10, 23]. This exclusion makes it very difficult for the construction industry to be informed of the public sector owner's 'performance' requirements, or stakeholders'/users' interests, to contribute to its development, or assist in the translation of the capability 'performance' requirements into construction industry 'performance' language. Including industry advisors early in the public sector owner's 'capability' brief development process is likely to achieve better 'performance' needs definition so improving 'value' outcomes. This would give the (public sector) owner experienced and current private sector advice in the development of the 'capability' performance brief, improved price and period estimates, and procurement delivery options through to contract completion which are consistent with current industry trends and developments [25, 36]. There are many companies who could offer this service. Such companies should not however be permitted to bid for the contract or subcontracts for reason of conflict of interest and confidentiality, and would need to be the subject of a confidentiality agreement with the (public sector) owner.

*Observation 1: The owner should engage construction (and other) industry advisors from early in the 'capability' development stage through to contract completion to provide experienced, current construction industry advice and to assist the owner to manage the project.*

## 44.5 Fix the Price, Fix the Period for Better 'Performance'

The Chan and Chan [18] review of journals on project success revealed that cost (price), time (period) and quality ('value') ([2] 'iron triangle') are the three most important 'performance' indicators in projects, and so provide a 'focus on key success factors' [20] 'to meet customers needs' [24]. The purpose of the Barnes triangle of objectives was to illustrate that the three primary objectives of cost, time and quality are interrelated – greater emphasis on achieving one or two of these objectives may be made at the expense of the other criteria. Porter [38] defines 'value' as the amount buyers are willing to pay for what a firm provides. This invokes thoughts of competition, innovation, and 'value' comparisons. In keeping with this theme, a Pareto-efficient development is where Pareto optimality refers to which firm can achieve best 'value' for the same price over the same period [14]. For example, suppose the cost and start and finish times were fixed for a new construction proposal, and all tenderers were requested to competitively provide their best 'value'. This would mean all tenderer's bids would be based on the same period and price, but 'value' would vary. In the assessment process, period and price would be unnecessary consideration as assessment criteria since all bids would be using the same fixed price and fixed period. Focus for both tenderers and owner would be solely concentrated on which tender provided the better 'value'. While fixing period and price for small projects will usually be straightforward, there would be a need to consider staging large/mega projects which take longer or much longer to deliver. Scoping of each stage of these projects could be considered and developed on the basis of a selected period, say one calendar year, or according to scope convenience. Whichever staging arrangement is selected, the concept of fixing the owner’s project period and price would be applied to each stage, with contract renewal (re-competed or continued) at the end of each stage variously to the same, revised or new ‘performance’ specification.

*Observation 2: A (public sector) owner should fix the project period and price and use a ‘performance’ specification to call tenders.*

## 44.6 Transfer Design and Construct Risk to Contractor

A current trend is for the use of ‘performance’ based regulations as facilitating innovation when compared to prescriptive regulations [30]. This regulation trend can be extended to an owner using ‘performance’ based specifications to facilitate innovation and to describe ‘an end result, an objective or standard to be achieved, but which leaves the determination of how to reach the result to the contractor’ (Stuyvesant Dredging Co. v. United States, 834F.2d 1576 [Fed. Cir. 1987] in [15]). Where an owner uses ‘design’ specifications, these ‘detail the materials to be employed and the method in which the work is to be performed. The contractor is required to follow them as one would a road map and without deviation’ (L.L. Simmons Co. v. United States, 412F.2d 1360 [Ct. Cl. 1969] in [15]). So if a (public sector) owner wanted to use construction industry’s experience and knowledge and avoid the risks involved in detailing ‘design’ specifications (or by accepting this contractual risk and responsibility in other ways), then the use of a ‘performance’ specification would achieve this.

‘Design and construct’ contracts are where an owner engages a contractor who undertakes both the design and construction of the capability based on an owner’s ‘performance’ specification [3]. Calvert, Gavin, and Hamilton [15] research indicates that the principal consequences of the use of ‘performance’ specifications are that there will be no owner’s warranty of the sufficiency of the plans and specifications, that liability for design failures is shifted from the owner to the contractor, and that risks arising in performance, such as the risk of unforeseen conditions or necessary changes, are shifted to the contractor. These three issues, warranty, design risk and performance risk are not clearly distinguishable, and a shift in the allocation of risk occurs with the use of ‘performance’ specifications. The United States Supreme Court stated the principle as: ‘Where one agrees to do, for a fixed sum, a thing possible to be performed, he will not be excused or become entitled to additional compensation, because unforeseen difficulties are encountered.’ The party that drafts the specifications and designs the product normally runs the risk that those specifications will be possible to perform and that the product will be as required. In a ‘performance’ specification the owner provides some of the design but the contractor is required to complete contract ‘performance’ utilizing the contractor’s own means and methods. When a contract contains ‘performance’ specifications thereby allowing the contractor discretion to select the means and methods, the contractor is not entitled to recover the cost of changing to the correct means or methods, if its initial selection of the means or methods was wrong. Design build is the ultimate 'performance' specification. The contractor assumes responsibility for a total design build.

In this context, the Australian Attorney General was requested to consider contract terms and conditions which could be applied to the Australian government's use of a 'capability' brief which describes the required 'performance' and which transfers the design and construction risk to the Contractor. The Australian Attorney General suggested terms and conditions as follows:

'Acknowledgement': 'any inaccuracy or mistake however arising shall neither affect the contractor's obligation to complete the work under the contract nor entitle the contractor to payment of any extra moneys whatsoever';

'Acceptance' of drawings and specifications: 'after acceptance of the contractor's tender, the contractor shall expeditiously prepare and complete all other documentation';

Liability remains with the contractor until completion of the contract: 'No approval, direction or assistance given to the contractor in respect of specification or designs or other data produced shall relieve the contractor of responsibility under the contract for the correctness of all such designs, drawings, specifications and other data created or supplied for the purposes of the contract';

Warranty of sufficiency and fitness for purpose: 'the contractor warrants the sufficiency and fitness for its purpose of all designs, drawings, and specifications prepared pursuant to the contract for use in the execution of the work'; and

Variations cause or delay: 'the contractor shall not be entitled to claim from the Principal any damages, loss, loss or expense or extra costs incurred by the contractor in respect of cause or delay'.

These clauses clearly and specifically transfer the design and construct risk from the owner to the contractor, and should be included in a project's General Conditions of Contract.

*Observation 3: An owner should use the Australian Attorney General's clauses in the General Conditions of Contract, and 'performance' rather than 'design' specifications to describe the end result, objective or standard to be achieved, leaving the determination of how to reach the result to the contractor.*

## 44.7 Methodology

'What has changed is the interpretation of the ideas and problems that confront the construction sector globally and the methodological pluralism approaches available to resolving them' ([28, p. iii], [37]). The inductive methodology chosen for this research is but one way of interpreting construction industry problems at the interface between an owner and the construction industry. Induction suggests that nothing can be known with certainty except that which is actually observed, and unlike deductive arguments, inductive reasoning allows for the possibility that the conclusion is false, even if all the premises are true [47]. Critics of this approach claim that it is essentially descriptive and does not really explain anything as it fails to uncover the causes of the generalized observations.

This research started with several observations and will end with conclusions based on empirical case study use of the observations. It assumes that such observations may provide a basis for the derivation of knowledge and experience. General conclusions and insights that evolve may contribute to theory, and in doing so gather empirical data that is replicable. The longitudinal case study was undertaken by the researcher as project manager.

## 44.8 Method

The theoretical artefact based on the observations will incorporate the observations that early competitive engagement of construction industry advisors will assist the owner with the development of the capability brief 'performance' requirements, the period and price to be fixed, and assist through all phases to contract completion. Registration of interest will be followed by shortlisting of interested parties to the three to five best with tenders requested from these. Tenderer's bids will be required to contain all method and material details such as drawings, specifications, programme of work, progress payments, bills of quantity, timings and so on. Contract award will be based on best 'value' since price and period will be fixed for all tenders, that is, the best 'value' for the fixed price and fixed period. The contractor will implement its offer assisted as appropriate by the advisor acting as a 'project verifier' ([3], p. 8), who will liaise and moderate project development and contract variation issues at the owner/contractor interface. The contractor will be paid by the owner according to the contractor's progress payments for work satisfactorily completed. Once in contract, negotiation of contract variations will be undertaken within the fixed price and fixed period limitations, with both owner and contractor assisted and moderated as necessary by the advisor in the capacity of 'project verifier'. The owner with industry advisor advice will manage, monitor and moderate the contractor through to successful contract completion, close off the contract and the defects liability period.

## 44.9 Case Study: Collection of Empirical Data

The owner (defence) provided an accommodation facility for 24 Senior Non Commissioned and Warrant Officers at HMAS Cerberus, a RAN shore station in Victoria, Australia as the test case. The owner (defence) competitively engaged third party industry advisors from John Holland Group, an Australian global construction engineering company to assist its project manager. The pre-contract award project ‘performance’ brief, period and price estimates were developed by the owner and the industry advisor based on precedent owner (Defence) method and material ‘design and construct’ projects and Defence Scales and Standards of Accommodation. Based on these criteria, the project period and price were calculated by the advisor’s quantity surveyors from John Holland Group to be a pre-contract award project planning and development period of 4 months, a construct period of 8 months, and an estimated price of AU$0.891 m. These criteria were included in the owner’s ‘performance’ specification. The 4 month pre-contract award period comprised the time usually taken to develop the defence detailed design brief through all the regulated processes (capability brief, detailed design brief, Expressions of Interest (EoI)/Invitation to Register Interest (ITR), Request for Tender (RFT), tender assessment and contract discussion) to contract award. The 8 month post-contract award period was the time estimated by the quantity surveyors for construction of the project using the usual detailed design and construct method. Regulated Government Scales and Standards set maximum specifications for floor areas, common use clothes washing and drying facilities, twin share bathroom and toilet, rudimentary paths and car-parking facilities and other details, within a design to cost target of AU$27,500 per person. This AU$27,500 per person included the cost of the specified building areas, desk, bed and wardrobe. In addition, an allowance of 10 % i.e. AU$2,750 per person was permitted for specified non fixed furniture, fittings and equipment, and an additional allowance of 25 % i.e. AU$6,875 per person for the balance of all other works. These data were used in the ‘performance’ specification as minimum requirements, and so also provided the basis for ‘value’ comparisons to be made between the use of ‘performance’ specifications where the contractor carries the design and construction risks, and ‘detailed design and construct’ specifications where the owner carries the design and construction risks. For ‘detailed design and construct’, the owner (defence) uses the General Conditions of Contract based on AS2124 [21] with the ‘detailed design brief’ as Special Conditions. For the use of the capability brief ‘performance’ requirements, the Australian Attorney General’s contract clauses were included in the same AS2124 General Conditions of Contract, with the capability brief ‘performance’ requirements (fixed price, fixed period and the ‘performance’ brief) attached as Special Conditions instead of the ‘detailed design and construct’ requirements.

Thus, for the trial case study, the price (AU$891,000) and period were fixed at the same period and price estimated as if a detailed design and construct method was to be used (4 months preparation and 8 months for construction), with a seven page ‘capability’ brief ‘performance’ requirements setting the minimum criteria to be met by the contractor. Tenderers were required to competitively and innovatively provide a set of design drawings and documentation sufficient to accurately define and quantify the project, including a statement substantiating the design, a location/site plan, floor plans and matching elevations and sections, finishes schedule and materials specifications, a project delivery bar chart and resource schedule, cash flow chart, landscaping, life cycle costing and a fixed lump sum price with no rise or fall.

When the owner (defence) called for Expressions of Interest (EoI), 49 Expressions were received. Five companies were shortlisted on the basis of financial capacity, resource capacity; previous experience; designer's experience; sub-contractors; and insurance/indemnity strengths. Two of the five were global/national corporations, two were national/regional, and one was regional/local. Defence then requested tenders from these five using the capability 'performance' brief, fixed period and fixed price. Tenderers were also advised that the advisor's company would not be permitted to bid for the contract, and had signed an agreement with the owner (Defence) to this effect. The five tenderers were fully briefed pre tender about the risk arrangements, the 'performance ' specification and the fixed period and price, and the way in which the tender assessment would be based on best 'value' offered, not on price. On close of tenders, each tenderer made post tender closure presentations to the owner (Defence) and the advisor which were assessed as follows:

Tender 1: Comprised a Leighton Contractors P/L consortium who provided acceptable proposal specifications, finishes, schedules and a life cycle cost analysis. However, there were a number of caveats which mitigated against award of the contract. These were that the consortium's 'design to cost' targets did not include site or common services costs, design costs or the project manager's fees and costs, and that the engagement would be a project management engagement i.e. one in which Leighton would be appointed as consultants on a fee plus reimbursement of costs basis to manage the calling of public tenders and the letting of all trade contracts on behalf of the owner (Defence). The tender was rated non-compliant.

Tender 2: Meldrum Burrows & Partners tender submission provided architectural sketch plans of their proposal but little else. The expectation was that further work, plans and other details would be provided upon further discussion and negotiation. This tender was rated non compliant.

Tender 3: The Thiess Consortium provided acceptable proposal specifications, finishes, schedules and a life cycle cost analysis, but provided a detailed design and construction specification tender approach, not the 'performance' specification approach required by the owner (Defence). This tender was rated non compliant.

Tender 4: The Civil and Civic Consortium proposed two alternative methods of project delivery, firstly, project management with lease/end buy-out to accommodate the existing budget, or secondly, a project management lump sum proposal to accommodate full budget allocation over two financial years. The former option did not meet tender criteria so was unacceptable. The latter option required Civil and Civic to be commissioned for a lump sum to develop the concept design (Stage 1) to a point where a contract price was agreed prior to commencement of construction (Stage 2). The lump sum for Stage 1 was to be included in the lump sum price for the entire project which would be agreed when the design reached a sufficient level of completeness prior to the commencement of Stage 2. This tender was rated non-compliant.

Tender 5: Buxton Consolidated (Vic) P/L Consortia met all tender requirements in detail, understood the 'performance' specification and fixed price and period requirements, the contractual arrangements and risk implications for this form of contracting. This tender was rated compliant.

Tender Result: The Buxton Consortia was awarded the contract.

The owner (defence) and Buxton Consortia's interface productivity improvements included the selection of the best 'value' tender assessment not being complicated by variations in period or price, or delayed by 'trade-offs' or further contract negotiations; assessment and award of the contract by the owner (Defence) with advisor assistance taking 1 day, including all tenderer's presentations. There were no appeals. The pre-contract award work was completed within 2 months rather than the 4 months estimated when using the usual detailed design and construct processes – a significant productivity improvement on the usual detailed design and construct processes. Once awarded the 8 month AU$891,000 contract, Buxton Consortia set to work without delay and completed the works within 7 months (1 month earlier than contracted) to price and without dispute – again, a significant productivity improvement on the usual detailed design and construct processes.

Initially there was expressed disbelief from the tenderers that the owner (Defence) would stay with the fixed price and fixed period arrangement, as there had been no previous experience of such. The different approach clearly required open mindedness and change management, acceptance of new ways of doing business, and innovative responses. At the pre-tender detailed briefings, none of the tenderers expressed concerns about the use of capability brief 'performance' requirements, inclusion of the Australian Attorney General's contract clauses, or with any of the processes including the use of industry advisors by the owner. On receipt of the tenders, it became clear that some of the tenderers either misunderstood the defence contractual intention or simply chose not to comply.

The owner/contractor better 'value' performance brief productivity was measured by the benefits above that which would have been achieved using the standard 'detailed design and construct' model. These benefits included a motel style individual unit for each occupant with its own bathroom, toilet, washing machine, tumble dryer, bar fridge and tea making facilities, carpet, steam iron and ironing board (instead of shared facilities), car wash and parking, all provided within the $891,000 design to price and period target. This suggests the conditions which provide for a Pareto-efficient development [35] of public infrastructure were achieved, where Pareto optimality in this case refers to achieving better quality at the same cost. The Contractor sought and was granted a contract variation to finish 1 month ahead of schedule. Other productivity improvements included competitive tenderer innovation achieved through early engagement of construction industry advice leading to improved expression of the owner's capability 'performance' requirements; rapid tender evaluation and outcome; and use of contract clauses which transferred design and construction risk to the contractor using the same price and period had the project been delivered using the standard 'detailed design and construct' model.

## 44.10 Conclusions

The (public sector) owner competitively engaged construction industry advisors from early in the 'capability' brief development stage through to contract completion to provide experienced, current construction industry advice and to assist the owner and contractor to manage the project. The construction industry advisors assisted the (public sector) owner through the invitation to register; tender selection, assessment and contract award process. By being involved in the development of the 'performance' brief from the owner's capability brief, the advisor became aware of the owner's stakeholder and user's needs. This assisted in providing the owner with current construction industry experience and knowledge so improving the 'value' translation of the owner's capability brief into 'performance' terms. That there were 49 responses to the owner's Invitation to Register Interest indicated significant marketplace interest in and understanding of the project. By the owner and advisor estimating and then fixing project time and cost for all bidders meant tenderers had no choice but to concentrate solely on the performance 'value' they could competitively and innovatively offer within these criteria. This in turn enabled quicker turn around for tender assessment and outcome since the period and price did not need consideration. This process was completed in half the time and half the transaction costs usually taken for a project of this nature when using standard regulated processes. The advisor continued to provide both owner and contactor with ongoing advice and moderation throughout the construction process; assisted in maintaining good relationships between the contracting parties; and negotiated contract variations within the fixed price and period as they occurred on site. This resulted in the owner's representative (project manager) needing to visit the site only once a fortnight, enabling his time to be spent on other projects, reducing project administration, and minimizing or eliminating delays waiting for decisions. Having a reliable, trustworthy advisor on site had a two way effect: the owner relied on the advisor's professional advice to keep within the owner's project management policies; to be kept informed of progress on site and payment for work satisfactorily achieved. The contractor could rely on the advisor for a current and appropriate construction industry understanding of the design and construction requirements and problems, 'reasonableness' when variations were proposed, and advice with respect to the owner's 'value' and 'performance' requirements.

By fixing the project period and price estimates developed by the advisor's quantity surveyors, and using a 'performance' specification to call tenders, this abbreviated the regulated process where the owner usually went on to develop a detailed 'design' brief using internal resources. Detailed 'design' brief was found to be unnecessary because the tenderers were in as good or better position to interpret the owner's needs and innovatively develop a suitable design build response to the owner's 'performance' brief.

The (public sector) owner's use of the Australian Attorney General's clauses in the General Conditions of Contract, and 'performance' rather than 'design' specifications as Special Conditions, moved the contract design and construct risk to the contractor. The selected contractor understood and accepted these arrangements, so becoming responsible for the project design and build, and associated risks.

Post contract award, productivity improvements for the contractor included familiarity with its own competitive submission enabling completion of the work 1 month earlier than required by the contract (12.5 % earlier) thereby gaining access to payment for the work satisfactorily 1 month early providing additional profitability and improved reputation. For the owner, access to the building was provided 1 month earlier than contacted.

Future research will involve undertaking further case studies to test the efficacy of the capability 'performance' brief application to larger/mega projects in the global construction industry. The capability 'performance' brief model is generic in nature and in time may be applied to other industries.

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# Chapter 45
# Construction and Analysis of the Structural Important Degree for the Fire Fault Tree of High-Rise Building Fire Accidents

**Yilang Huang, Xiaoli Yan, and Chao He**

**Abstract** The causes and influencing factors for fire accidents of high-rise buildings are analyzed in this paper. The fault tree is built with high-rise building fire accidents as the top event, then the minimal cut sets and the minimal radius set which affect the top event are provided. Furthermore, coefficient of the structural importance degree is calculated by using Boolean algebra calculation method, determining the main factors which affecting high-rise building fire accidents. Finally, the corresponding measures to prevent high-rise building fire accidents are put forward.

**Keywords** High-rise building • Fault tree analysis • Structural importance degree • Influence factors

## 45.1 Introduction

In recent years, because of the diverse functions and the important role that high-rise buildings play, they appear more and more often in big cities. But once fire accidents occur in these buildings, it spread quickly and is hard to put out, resulting in great difficulties in evacuation. Therefore, massive losses of lives and properties

Y. Huang (✉)
School of Management Studies, Shanghai University of Engineering Science,
1000 Wenhui Road, Songjiang University Town, Songjiang, Shanghai, China
e-mail: cecil1908@163.com

X. Yan • C. He
School of Management Studies, Shanghai University of Engineering Science,
333 Longteng Road, Shanghai, China
e-mail: yanxiaoli821@163.com; hechao27@163.com

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are caused by fire accidents. For example, in the "11.15" fire accident which happened in Jing'an district, Shanghai in 2010, 58 people were killed and 71 people were injured seriously. With the rapid development of economy, a large number of high-rise buildings will be established in big cities. Once fire accidents happen, the consequences of accidents will be more serious. To prevent the fire accidents of high-rise buildings, it is especially significant to improve the safety management system.

The Fault Tree Analysis (simpled as "FTA") is an important analysis method of safety system engineering. It adopts deductive method to analyze the causation of accident and finds out every potential risk factor of system in detail, which provides basis to safety design, safety management and safety controlling [1]. It is built with high-rise building fire accidents as the top event in this paper, through the analysis of the high-rise building fire. After analyzing the occurrence mechanism of high-rise building fire, the sequence of the main reasons and secondary reasons is given. The coefficient of the structural importance degree is calculated by using Boolean algebra calculation method, which provides the basis for the corresponding safety measures.

## 45.2 The Basic Theory of FTA

### *45.2.1 Introduction to the FTA Method*

FTA is one of the most important analysis methods of safety system engineering. In this method, logical reasoning is used to identify and evaluate the risks of various systems. Not only the direct cause of accidents can be analyzed, but also the potential causes of accidents can be deeply revealed. FTA is a kind of analysis method of inverse time sequence, which starts from the result of the accident, seeks the reason and time of the result event (known as the top event). The method aims in forming a variety of reasons for the result, then constructing according to the logical relationship and looking for ways to prevent the outcome measures. The causation of accident could be described obviously by FTA. This method has the advantages of intellectual clarity and strong logicality, and can be used in qualitative analysis and quantitative analysis [1].

FTA was first raised by US bell telephone institute in the militia type missile launch controlling system in 1961. FTA was used to evaluate the risk of nuclear power plant accident by the United States atomic energy commission in 1974, and the famous "Mr. Johnson report" was published at the same time. Since then, FTA is widely accepted and used in many areas. In China, the research of FTA was researched in 1978. Now, FTA has been widely using in lots of departments and enterprises, a large number of achievements have been achieved.

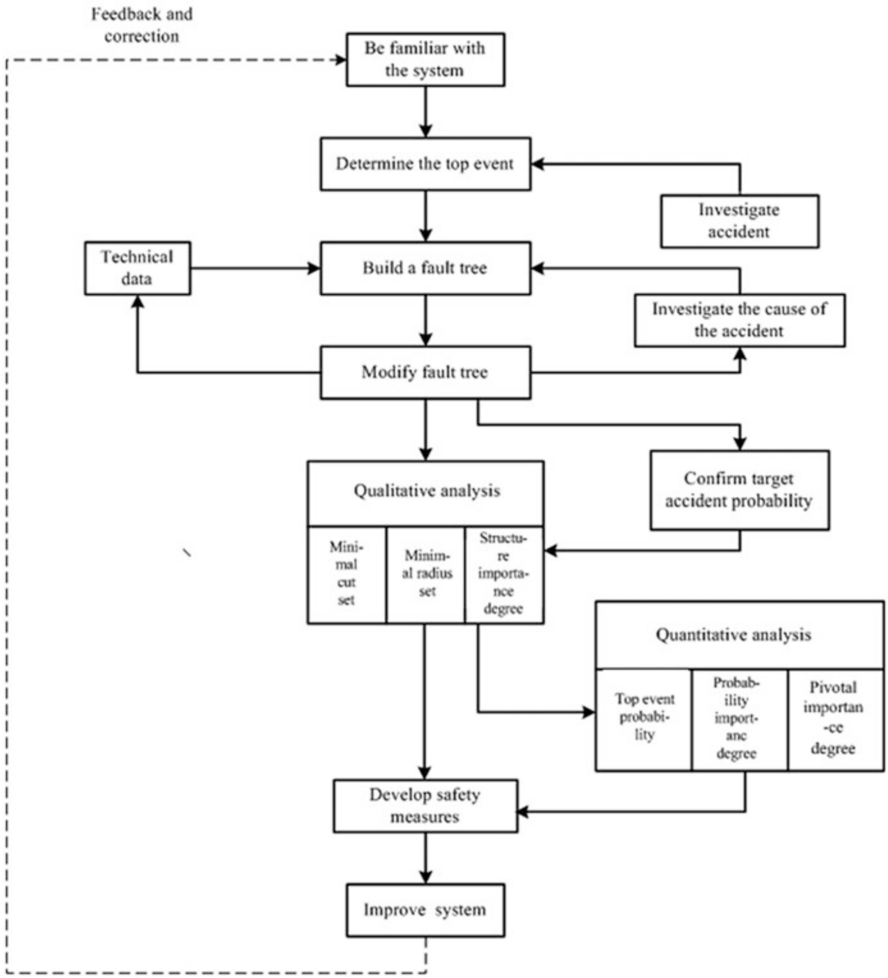


**Fig. 45.1** Procedure of the FTA

## 45.2.2 FTA Procedure

Each FTA varies from the nature of the object system and the purpose of the analysis, while the procedure of analysis is also different. The user should determine the analysis program according to the actual needs and requirements. Generally speaking, the general procedure of the FTA are: be familiar with the system, investigate the accident, determine the top event, investigate the cause of the accident, draw the fault tree, qualitative analysis and quantitative analysis, make safe measures [2–4]. The procedure of the FTA is shown in Fig. 45.1.

## 45.3 Constructing the Fault Tree of High-Rise Building Fire Accidents

According to the principle of FTA, the "high-rise building fire accidents" must be the top event at first. After that, the different reasons which cause the top event should be investigated and analyzed. Normally, human factors and material factors are direct factors, while management factors and environmental are indirect factors. After the top event and all sorts of reasons that lead to the top event are figured out, the corresponding event is connected from top to bottom by the proper logic gate. Then set the event which cause the original top event as the new top event, take the similar approach to analyze next event down until the most basic event. Then a high-rise building fire fault tree is built in this way. High-rise building fire fault tree is shown in Fig. 45.2:

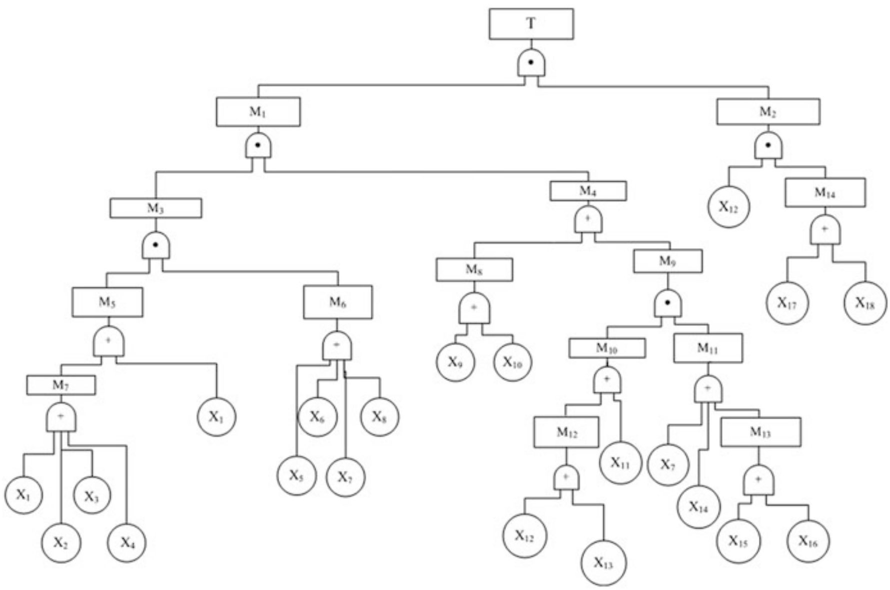


**Fig. 45.2** High-rise building fire fault tree

**Table 45.1** Event type of the high-rise building FTA

| Table | Event type | Symbol | Event type |
|---|---|---|---|
| T | High-rise building fire accident | $X_3$ | Relevant administrative departments do not play an appropriate role |
| $M_1$ | First time to put out fire is missed | $X_4$ | Emergency plan does not play a role |
| $M_2$ | Fire control facilities doesn't work | $X_5$ | Transferring to safe areas needs a long time |
| $M_3$ | People evacuation failure | $X_6$ | There is insufficient emergency exits in the building |
| $M_4$ | The fire is out of control | $X_7$ | Fire spreads quickly |
| $M_5$ | People lack evacuation abilities | $X_8$ | Evacuation indicators are missing |
| $M_6$ | Building lack evacuation ability | $X_9$ | Fire isolation doors lose their work |
| $M_7$ | The management system needs to be improved | $X_{10}$ | Automatic alarm system fail/have not been installed |
| $M_8$ | Building fire prevention abilities are insufficient | $X_{11}$ | Fire equipments don't work |
| $M_9$ | Building fire extinguishing abilities are insufficient | $X_{12}$ | Automatic spray equipment fail/have not been installed |
| $M_{10}$ | Self-rescuing is not timely | $X_{13}$ | People do not know how to use fire controlling facilities |
| $M_{11}$ | Fireman can't put out the fire | $X_{14}$ | Fire water shortage |
| $M_{12}$ | Fire equipments don't work | $X_{15}$ | Building fire channels are narrow |
| $M_{13}$ | The firemen arrive late | $X_{16}$ | Fire protection system management is not good |
| $M_{14}$ | Fire extinguishers and other fire equipments don't work | $X_{17}$ | Fire equipments lack daily management |
| $X_1$ | Fire drills don't work | $X_{18}$ | High-rise building fire control configuration is too low |
| $X_2$ | Fire rules are not properly executed | | |

Eighteen basic events have considered in this fault tree and each symbol of basic event is shown in Table 45.1 [5, 6]

## 45.4 Qualitative Analysis of High-Rise Building FTA

### *45.4.1 The Minimal Cut Set and the Minimal Radius Set*

The purpose of the qualitative analysis based on fault tree structure is to find out the way how fault tree determine the top event model, the cause and influence degree, providing alternative measures to improve the system security. The minimal cut set and the minimal radius set of the fault tree is got in the qualitative analysis. The minimal cut set is the set of the basic events which can cause the top event, the minimal radius set is the set of basic events which can not cause the top event. Both of them can be known though calculation. The result is shown as follows:

$\{X_1X_7X_{12}X_{17}\}, \{X_1X_7X_{12}X_{18}\}, \{X_2X_7X_{12}X_{18}\}, \{X_3X_7X_{12}X_{18}\}, \{X_4X_7X_{12}X_{18}\},$
$\{X_2X_7X_{12}X_{17}\}, \{X_3X_7X_{12}X_{17}\}, \{X_4X_7X_{12}X_{17}\}, \{X_1X_5X_9X_{12}X_{17}\},$
$\{X_2X_5X_9X_{12}X_{17}\}, \{X_3X_5X_9X_{12}X_{17}\}, \{X_4X_5X_9X_{12}X_{17}\}, \{X_1X_6X_9X_{12}X_{17}\},$
$\{X_1X_8X_9X_{12}X_{17}\}, \{X_2X_6X_9X_{12}X_{17}\}, \{X_2X_8X_9X_{12}X_{17}\}, \{X_3X_6X_9X_{12}X_{17}\},$
$\{X_3X_8X_9X_{12}X_{17}\}, \{X_4X_6X_9X_{12}X_{17}\}, \{X_4X_8X_9X_{12}X_{17}\}, \{X_1X_5X_{10}X_{12}X_{17}\},$
$\{X_2X_5X_{10}X_{12}X_{17}\}, \{X_3X_5X_{10}X_{12}X_{17}\}, \{X_4X_5X_{10}X_{12}X_{17}\}, \{X_1X_6X_{10}X_{12}X_{17}\},$
$\{X_1X_8X_{10}X_{12}X_{17}\}, \{X_2X_6X_{10}X_{12}X_{17}\}, \{X_2X_8X_{10}X_{12}X_{17}\}, \{X_3X_6X_{10}X_{12}X_{17}\},$
$\{X_3X_8X_{10}X_{12}X_{17}\}, \{X_4X_6X_{10}X_{12}X_{17}\}, \{X_4X_8X_{10}X_{12}X_{17}\}, \{X_1X_5X_{12}X_{14}X_{17}\},$
$\{X_1X_5X_{12}X_{15}X_{17}\}, \{X_2X_5X_{12}X_{14}X_{17}\}, \{X_2X_5X_{12}X_{15}X_{17}\}, \{X_3X_5X_{12}X_{14}X_{17}\},$
$\{X_3X_5X_{12}X_{15}X_{17}\}, \{X_4X_5X_{12}X_{14}X_{17}\}, \{X_4X_5X_{12}X_{15}X_{17}\}, \{X_1X_6X_{12}X_{14}X_{17}\},$
$\{X_1X_6X_{12}X_{15}X_{17}\}, \{X_1X_8X_{12}X_{14}X_{17}\}, \{X_1X_8X_{12}X_{15}X_{17}\}, \{X_2X_6X_{12}X_{14}X_{17}\},$
$\{X_2X_6X_{12}X_{15}X_{17}\}, \{X_2X_8X_{12}X_{14}X_{17}\}, \{X_2X_8X_{12}X_{15}X_{17}\}, \{X_3X_6X_{12}X_{14}X_{17}\},$
$\{X_3X_6X_{12}X_{15}X_{17}\}, \{X_3X_8X_{12}X_{14}X_{17}\}, \{X_3X_8X_{12}X_{15}X_{17}\}, \{X_4X_6X_{12}X_{14}X_{17}\},$
$\{X_4X_6X_{12}X_{15}X_{17}\}, \{X_4X_8X_{12}X_{14}X_{17}\}, \{X_4X_8X_{12}X_{15}X_{17}\}, \{X_1X_5X_{12}X_{16}X_{17}\},$
$\{X_2X_5X_{12}X_{16}X_{17}\}, \{X_3X_5X_{12}X_{16}X_{17}\}, \{X_4X_5X_{12}X_{16}X_{17}\}, \{X_1X_6X_{12}X_{16}X_{17}\},$
$\{X_1X_8X_{12}X_{16}X_{17}\}, \{X_2X_6X_{12}X_{16}X_{17}\}, \{X_2X_8X_{12}X_{16}X_{17}\}, \{X_3X_6X_{12}X_{16}X_{17}\},$
$\{X_3X_8X_{12}X_{16}X_{17}\}, \{X_4X_6X_{12}X1_6X_{17}\}, \{X_4X_8X_{12}X_{16}X_{17}\}, \{X_1X_5X_9X_{12}X_{18}\},$
$\{X_2X_5X_9X_{12}X_{18}\}, \{X_3X_5X_9X_{12}X_{18}\}, \{X_4X_5X_9X_{12}X_{18}\}, \{X_1X_6X_9X_{12}X_{18}\},$
$\{X_1X_8X_9X_{12}X_{18}\}, \{X_2X_6X_9X_{12}X_{18}\}, \{X_2X_8X_9X_{12}X_{18}\}, \{X_3X_6X_9X_{12}X_{18}\},$
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$\{X_1X_8X_{10}X_{12}X_{18}\}, \{X_2X_6X_{10}X_{12}X_{18}\}, \{X_2X_8X_{10}X_{12}X_{18}\}, \{X_3X_6X_{10}X_{12}X_{18}\},$
$\{X_3X_8X_{10}X_{12}X_{18}\}, \{X_4X_6X_{10}X_{12}X_{18}\}, \{X_4X_8X_{10}X_{12}X_{18}\}, \{X_1X_5X_{12}X_{14}X_{18}\},$
$\{X_1X_5X_{12,}X_{15}X_{18}\}, \{X_2X_5X_{12}X_{14}X_{18}\}, \{X_2X_5X_{12}X_{15}X_{18}\}, \{X_3X_5X_{12}X_{14}X_{18}\},$
$\{X_3X_5X_{12}X_{15}X_{18}\}, \{X_4X_5X_{12}X_{14}X_{18}\}, \{X_4X_5X_{12}X_{15}X_{18}\}, \{X_1X_6X_{12}X_{14}X_{18}\},$
$\{X_1X_6X_{12}X_{15}X_{18}\}, \{X_1X_8X_{12}X_{14}X_{18}\}, \{X_1X_8X_{12}X_{15}X_{18}\}, \{X_2X_6X_{12}X_{14}X_{18}\},$
$\{X_2X_6X_{12}X_{15}X_{18}\}, \{X_2X_8X_{12}X_{14}X_{18}\}, \{X_2X_8X_{12}X_{15}X_{18}\}, \{X_3X_6X_{12}X_{14}X_{18}\},$
$\{X_3X_6X_{12}X_{15}X_{18}\}, \{X_3X_8X_{12}X_{14}X_{18}\}, \{X_3X_8X_{12}X_{15}X_{18}\}, \{X_4X_6X_{12}X_{14}X_{18}\},$
$\{X_4X_6X_{12}X_{15}X_{18}\}, \{X_4X_8X_{12}X_{14}X_{18}\}, \{X_4X_8X_{12}X_{15}X_{18}\}, \{X_1X_5X_{12}X_{16}X_{18}\},$
$\{X_2X_5X_{12}X_{16}X_{18}\}, \{X_3X_5X_{12}X_{16}X_{18}\}, \{X_4X_5X_{12}X_{16}X_{18}\}, \{X_1X_6X_{12}X_{16}X_{18}\},$
$\{X_1X_8X_{12}X_{16}X_{18}\}, \{X_2X_6X_{12}X_{16}X_{18}\}, \{X_2X_8X_{12}X_{16}X_{18}\}, \{X_3X_6X_{12}X_{16}X_{18}\},$
$\{X_3X_8X_{12}X_{16}X_{18}\}, \{X_4X_6X_{12}X_{16}X_{18}\}, \{X_4X_8X_{12}X_{16}X_{18}\}$

From the result it can be found that there are 128 minimal cut set in this high-rise building fire fault tree. The measures how to prevent the top event can be found by analyzing the minimal cut set. In order to find out the minimal radius set, the fault tree is switched into success tree, which is shown in Fig. 45.3.

The result of the minimal radius set can be known though calculation:

$$\{X_1, X_2, X_3, X_4\}, \{X_{12}\}, \{X_5, X_6, X_7, X_8\}, \{X_7, X_9, X_{10}, X_{14}, X_{15}, X_{16}\}, \{X_{17}, X_{18}\}.$$

Each minimal radius set indicates one plan to prevent the top event happen, so the failure can be controlled effectively according to the basic event number of the minimal radius cut, and the best plan can be chosen by considering degree of difficulties in technology, time consuming and money investing [1].

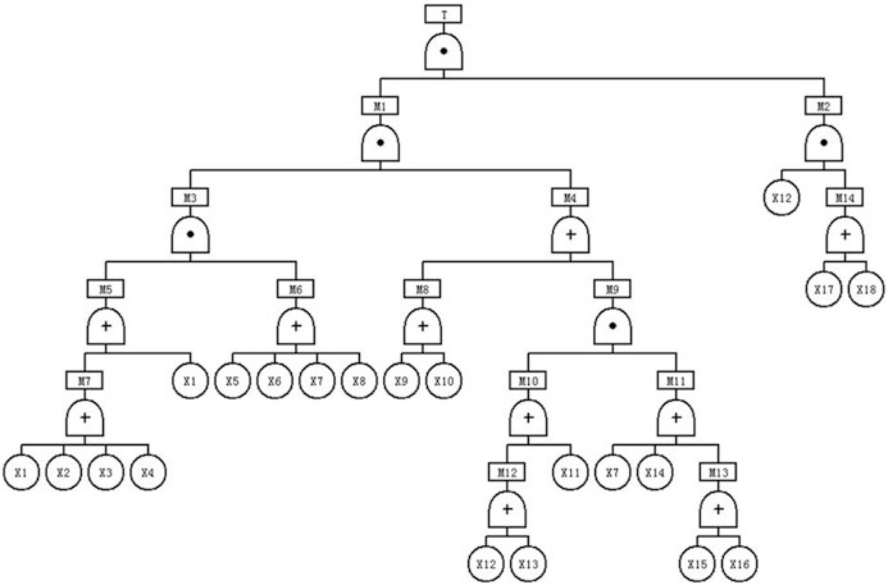


**Fig. 45.3** High-rise building fire success tree

## *45.4.2 Basic Event Structural Importance Degree Analysis*

Structural importance degree is defined as the analysis of the important degree of each basic event from the fault tree structure. Assume the probability of each basic events is not considered or the probability of each basic events is equal, then figure out how this assumption will influence the top event. After the fault tree qualitative analysis, the structural importance degree coefficient and the sequence the coefficient can be calculated, the influence sequence of the basic event to the top event can also be known. There are two ways to analyze the structural importance degree. One is to know how much the structural importance degree is, another is using the minimal cut set and the minimal radius cut to judge. When one basic event keep its state unchanged, there are three types of state that may change the top event:

$$\Phi(0_i, X) = 0 \rightarrow \Phi(1_i, X) = 0, \Phi(1_i, X) — \Phi(0_i, X) = 0$$
$$\Phi(0_i, X) = 0 \rightarrow \Phi(1_i, X) = 1, \Phi(1_i, X) — \Phi(0_i, X) = 1$$
$$\Phi(0_i, X) = 1 \rightarrow \Phi(1_i, X) = 1, \Phi(1_i, X) — \Phi(0_i, X) = 0$$

The first and third type can't explain how the state change of $X_i$ will influence the top event, while the second type can explain the influence of $X_i$, While the basic event $X_i$ makes its state change from 0 to 1 and other basic event keep their state unchanged, that is, if the state of top event change from $\Phi(0_i, X) = 0$ to $\Phi(1_i, X) = 1$, it can be said that the state change of the basic event $X_i$ will determine whether the top event will happen or not. Make all these events add together then multiplied by a coefficient $\frac{1}{2n-1}$, define this as structural importance degree coefficient (N is the number of basic events of the fault tree) [1].

The one approximate formula for calculating the structural importance degree is shown as below:

$$I_{\phi(i)} = \sum_{x_i \in k_i} \frac{1}{2^{n_j - 1}} \tag{45.1}$$

$n_j - 1$—the total event set number of the basic event i and then make the number minus 1;
$I_{\phi(i)}$—the structural importance degree coefficient of the event i

The structural importance degree for each basic event of the high-rise building fire fault tree can be calculated according to one approximate formula, the result is shown as below:

$$I_{\varphi(X1)} = I_{\varphi(X2)} = I_{\varphi(X3)} = I_{\varphi(X4)} = \frac{17}{8}; I_{\varphi(X5)} = I_{\varphi(X6)} = I_{\varphi(X8)} = 5;$$
$$I_{\varphi(X7)} = 1;\ I_{\varphi(X9)} = I_{\varphi(X10)} = I_{\varphi(X14)} = I_{\varphi(X15)} = I_{\varphi(X16)} = 3;$$
$$I_{\varphi(X12)} = \frac{17}{2}; I_{\varphi(X17)} = I_{\varphi(X18)} = \frac{15}{2}.$$

From the result can find that the accuracy of this formula is not high. So we use the quadratic approximate formula to calculate the structural importance degree. The quadratic approximate formula is shown as below:

$$I_{\phi(\mathrm{i})} = 1 - \prod_{x_i \in k_j} \left(1 - \frac{1}{2^{n_j - 1}}\right) \tag{45.2}$$

$I_{\phi(i)}$—the structural importance degree coefficient of the event i
$n_j$ —the total event set number of the basic event i;
$n_j - 1$—The index of number 2

Each basic event structural importance degree of the high-rise building fire fault tree can be calculated according to quadratic approximate formula, the result is shown as below:

$$I_{\varphi(X1)} = I_{\varphi(X2)} = I_{\varphi(X3)} = I_{\varphi(X4)} = 0.890,$$
$$I_{\varphi(X5)} = I_{\varphi(X6)} = I_{\varphi(X8)} = 0.924, I_{\varphi(X7)} = 0.656,$$
$$I_{\varphi(X9)} = I_{\varphi(X10)} = I_{\varphi(X14)} = I_{\varphi(X15)} = I_{\varphi(X16)} = 0.788, I_{\varphi(X11)} = 0.000,$$
$$I_{\varphi(X12)} = 1.000, I_{\varphi(X13)} = 0.000, I_{\varphi(X17)} = I_{\varphi(X18)} = 0.988$$

The high-rise building fire fault tree structural importance degree coefficient sequence for basic events is shown as below:

$$I_{\varphi(X12)} > I_{\varphi(X17)} = I_{\varphi(X18)} > I_{\varphi(X5)} = I_{\varphi(X6)} = I_{\varphi(X8)} > I_{\varphi(X1)} = I_{\varphi(X2)} = I_{\varphi(X3)} = I_{\varphi(X4)} > I_{\varphi(X9)} = I_{\varphi(X10)} = I_{\varphi(X14)} = I_{\varphi(X15)} = I_{\varphi(X16)} > I_{\varphi(X7)} > I_{\varphi(X11)} = I_{\varphi(X13)}$$

From the above results, the basic events $X_{12}$, $X_{17}$, $X_{18}$ for high-rise building fire accident is more important than others.

## 45.5 The Result Analysis and Countermeasures

From the fault tree qualitative analysis, it can be known that to prevent the high-rise building fire accidents that may cause great losses of lives and properties, fire should be put out in case of fire spreading once upon the accident occur. From the qualitative analysis, it can be known that human factors and material factors are two aspects people need to focus on, especially when it refers to large events with important degree coefficient. For example, automatic spray equipments fail to put out fire/have not been installed, fire equipment lack daily management, high-rise building fire control configurations are too low and so on. Strengthening the management of these events can effectively prevent great losses of property caused by the high-rise building fire accident. Relevant countermeasures should be taken as follows:

1. The quantities of fire equipments in the high-rise building especially the civil building fire equipment should be increased, including the automatic alarm, automatic spray equipment, fire escape isolation door, etc.. . .
2. The rescue abilities of fire equipments should be improved for some of them like the aerial ladder and other fire equipments can hardly meet the needs of high-rise building fire accident now.
3. Urban water supply network should be expanded. Big cities with lots of high-rise buildings are often faced with the shortage of fire water supply when fire accidents happen, so it is an urgent problem to expand fire water supply.
4. Safety knowledge and abilities of the residents live in high-rise building should be improved. The administrative departments should encourage the residents to improve their selves-rescuing knowledge and abilities through kinds of ways like attending fire drills, visiting fire museum, etc.
5. The Administrative departments should establish rules and regulations for fire equipments daily inspection, maintenance and set up high-rise building fire emergency plan.
6. Safety inspection for construction materials should be strengthened. The action of using flammable materials as building material or decoration materials should be strictly prohibited.

7. The administrative departments should strengthen the safety training of high building construction and decoration workers. Workers without professional certificate should be prohibited to get work.
8. The high-rise buildings should be inspected strictly before they are put into operation.

## 45.6 Conclusion

The fault tree model of the safety system engineering is used to analyze the fire accident of high-rise building and the minimal cut set and the minimal radius set of the fault tree are obtained. A detailed analysis is made about the qualitative analysis of the high- rise building fire fault tree. Events with strongly influence on fire accident of high-rise building are determined through the qualitative analysis. Conclusions can be drawn from the calculation and analysis:

1. As one of the most important research methods of safety system engineering, FTA plays an important role in safety design, safety management and safety controlling. It is feasible and reliable to use fault tree method in the research of high-rise building.
2. Building fault tree and success tree are the premise conditions to analyze the structural important degree coefficient of each basic event structure. Through the analysis of the structural importance coefficient of each basic event can we make sequence for the corresponding safety control measures to reduce the probability of high-rise building accidents.
3. More accurate results can be achieved by using the quadratic approximate formula to calculate the sequence of the basic event structural importance degree than just using the one approximate formula. The quadratic approximate formula can find important influence factor more precisely when some influence factors are complex.

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# Chapter 46
# Building and Operation of Construction Supply Chain Information Integration Management Mode Based on Building Information Model

**Jianjian Bao, Zhenmin Su, and Shaojun Jin**

**Abstract** Construction supply chain management and Building Information Model are emerging management tools and transformative technology tools in the construction fields. Information is the core elements of Building Information Mode, and it's also the foundation of construction supply chain operation. The paper attempts to apply Building Information Mode to construction supply chain information integration management, and build a BIM-based construction supply chain information integration management model. Then the paper discuss the operation of the model from the integrated perspective of design, procurement, construction and operation, and giving the analysis of advantages of BIM-based construction supply chain information integration management at last.

**Keywords** Building Information Model • Construction supply chain • Construction projects holistic • Information sharing

Supply chain involves many participants, having characteristics such as wide sources of information, large quantity; strong liquidity and complex exchange [1]. Participants in the construction supply chain often have their own information systems, which are different from each other in structures, platform, and formats and so on [2]. The smooth flow of information between the participants has been a concern in construction industry. Only with the smooth and efficient information flow, logistics, cash flow and construction process of the project can be efficiently and unimpeded [3]. This article attempt to put BIM into information management of construction supply chain, aimed at changing the "information island" phenomenon due to the backward information sharing mode, dispersed storage and serious

J. Bao (✉) • Z. Su
College of Civil Engineering, Nanjing University of Technology, Nanjing 211816, China
e-mail: bjjnjgydx@163.com

S. Jin
Jiangsu Construction Engineering Group, Nanjing 210036, China

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erosion. In order to realize the integration management of construction supply chain information and improve the utilization efficiency of information in the construction project.

## 46.1 The Connotation of Construction Supply Chain and Building Information Model

Construction supply chain refers to the effective demand from the owner, regard the owner or the engineer as the core unit, and rely on the controls of information flow, logistics, capital flow to put the designer, construction general contractors, subcontractors, material and equipment suppliers together into a whole chain structure. Construction supply chain includes logistics chain and information chain, capital chain, knowledge chain of construction industry, which are highly integrated on the longitudinal and transverse and together constitute the construction project of the value-added chain. Chain information flow in the mode of construction supply is used to reflect and describe the information of operation status of construction supply chain, all in technical, organization, management, economics and other related types [4]. Construction projects in the whole life cycle will produce large amounts of information continually. The flow of information led to the generation of value.

Building Information Model as a construction project's digital representation of the physical and performance, is not only a design tool, but also a platform for teamwork. Team members share project-related information by the sharing information sources of Building Information Model, as provide basis for decision-making for the related project life cycle, and support collaboration and coordination of team members. Building Information Model technology integration all the information of the construction project during the whole life cycle from design, construction to the end-of-life, which is always integrated in a there-dimensional model database [5].

Construction project logistics and capital flow are expand closely around the flow of information, and only the information flows efficiently, can all the factors in the supply chain be harmonious and balanced, and the can construction activities be stable and high-efficiency. Building Information Model is aiming at addressing the issues of management and exchange of information between different stages of the project, different actors and different software applications. As a central information stage platform, Building Information Model can ensure all the participants of construction supply chain to gain necessary messages in any stage at all times [6]. Based on information integration management of BIM building supply chain, participants can guarantee the information to be refreshed, accessed, added, changed and deleted without delay. They can also extract information and use it to analysis and apply information according to their actual needs.

## 46.2 The Design of BIM-Based Construction Supply Chain Information Integration Management Model

Information flow in construction supply chain means the flow of information between supplier and demander. It is also viewed as the basis of operation in material flow and capital flow, composed of the collection, storage, exchange and application of information. The objective of information integration management is to transfer, share and utilize information better. To make information flow smoothly at high pace among different parties and different phases involved in the project, this paper proposes an information integration management system based on BIM and solves the problem that information presents highly discrete distribution in construction project implementation. The integrated system makes the information integrated seamlessly as well as evenly and smoothly in each enterprise in the supply chain, and achieve the goal that the model is built for one time, used for many times and saved forever in project information management (Fig. 46.1).

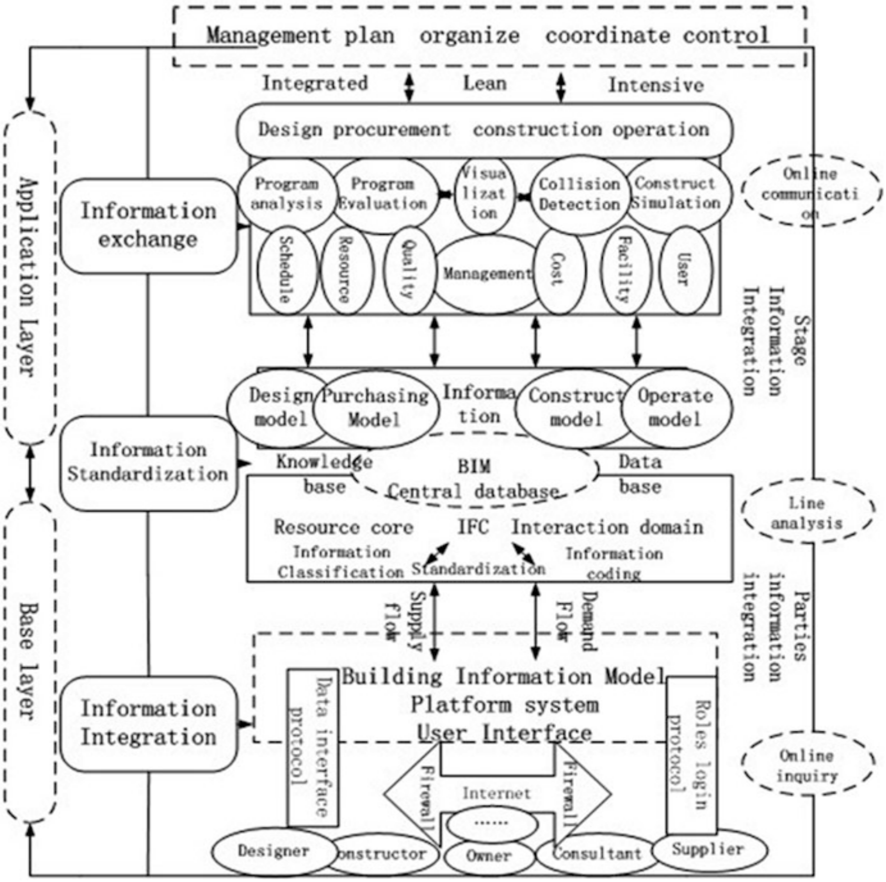


**Fig. 46.1** BIM-based construction supply chain information integration management model

Information integration management system can be categorized into two levels: the fundamental level and the application level. At the fundamental level, we concentrate our efforts on data collection, data process and data storage. At the application level, we focus on data exchange and interoperability. Information storage is source of data and information of BIM central database, at the same time, it is the input source of all parties in the supply chain, including data summary that BIM generates automatically and information that is input from outside, so that all participants can add, extract, update and modify relevant information by storage system. Information process means that information integration management platform can classify and standard the information in construction supply chain based on BIM with the index of the IFC system and information classification standard to unify and specify the format of the information storage. Information exchange is defined that information of various disciplines and application software integrates with all sorts of models developed originally by information interoperability related elements (e.g., IFC, IDM) after the information is input to BIM center database to enable the information sharing and modification with no obstruct by IFC data transfer format [7]. Information application is that information in construction supply chain is applied in all phases (i.e. design, procedure, construction and operation) in the integration management system. Another information application is the function block that BIM is used in the construction supply chain, which covers major aspects of the function of CSC. To make a plan, organization, coordination and control for construction project, all parties involved in the project can exchange, inquire information, which is provided by information integration management platform, and communicate online.

## 46.3 The Operation of BIM-Based Construction Supply Chain Information Integration Management Model

The objective of information integration management is to make the information accumulated apply into the project better. Workflow is required to have a high coordination in construction supply chain, which covers all phases (i.e. design, procedure, construction, and operation) [8]. The operation is that all parties is connected by the Internet so that they can send operational request (e.g. enquiry or information change) with the help of core technology (e.g. Project Information Portal PIP and browsing – service B/S).and all parties can store, update, modify and apply relevant information as they demand in the BIM center database. Information is collected by System Application Server and integrated to feed back to users, serving users to execute and the total project life cycle to be done (Fig. 46.2). The operation is applied to all phases involved in the construction project.

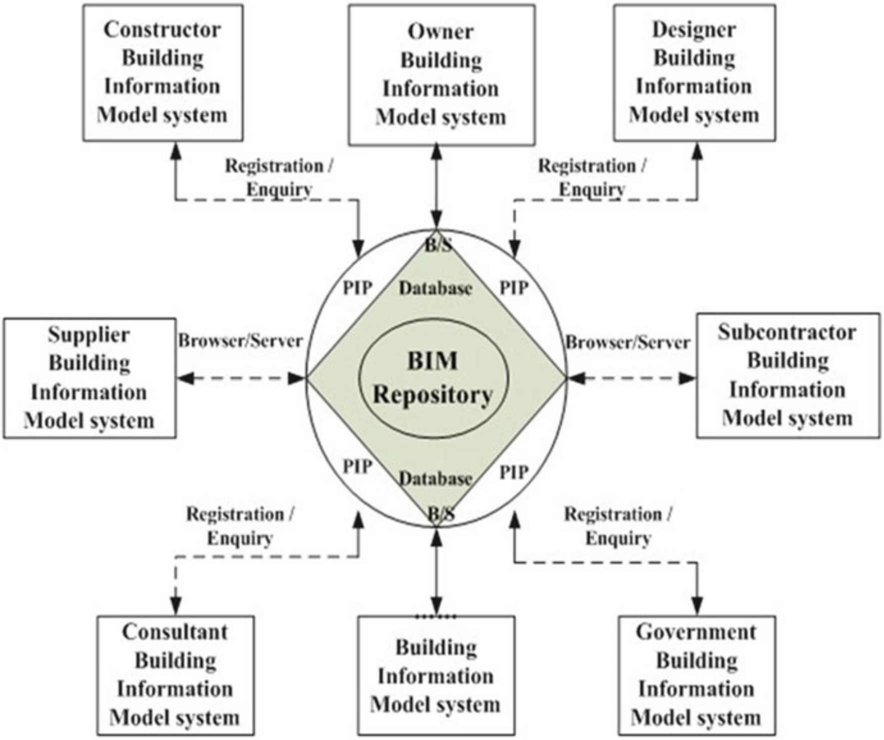


**Fig. 46.2** The operation of construction supply chain information integration management model based on Building Information Model

### *46.3.1 Operation in Design Phase*

Design team's work consists of design definition, model establishment, accomplishment of building program, design deeping and engineering documents generating. BIM can save time and reduce cost for design because it provides a standard and integrated database about design, schedule and budget, updated automatically [9]. The open resource platform helps the integrated system work in practice, integrate between design and construction at the organizational level and meet the demand of massive information at the technical level (Fig. 46.3).

Firstly, the investor of project can access the compliance of layout, field, illumination, safety, ergonomics, acoustics, grain, color and specification by using information of model to bring out site analysis, project procurement, collision detection and norm inspection to satisfy the demand of the integration of design and construction (e.g. information storage, sharing and exchange) [10]. Secondly, to make the design model full and accurate by detecting and eliminating collisions that occur among all kinds of system inside, the system, regarded as a center of massive information, provides an integrated platform for architecture design, structural

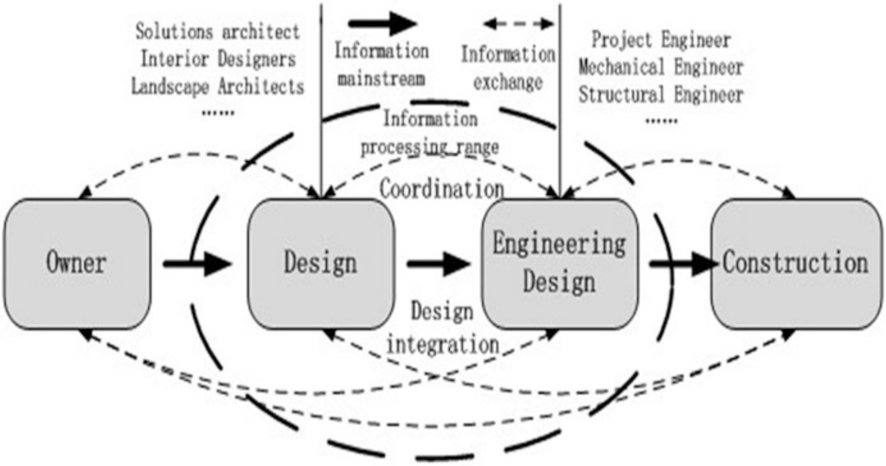


**Fig. 46.3** Design and construction information exchange

**Table 46.1** Analysis of design and construction model in information integration management model

| Function | Content | Schematic design phase | Concept phase | Construction documents design phase |
|---|---|---|---|---|
| Sustainability | Carbon emission | ● | ● | ● |
| | Energy saving | ● | ● | ● |
| Comfort | Day lighting | ○ | ● | ○ |
| | Ventilation | ● | ○ | ○ |
| | Noise field | ● | ○ | ○ |
| Security | Structural calculation | ○ | ● | ● |
| | Fire service | ● | ● | ● |
| | Traffic flow | ● | ○ | ○ |
| Model checking | Collision conflict | ○ | ● | ● |
| | Quantities | ● | ● | ● |
| | Specification inspection | ● | ● | ● |

● Detailed analysis items
○ General analysis items

design, electric design and HVAC design at the same moment. Finally, construction can be simulated and feasibility can be tested by Pipeline conflict inspection, fire safety inspection and norm inspection to make design and construction integrated depending on actual demand of consumers truly, and to maximize the value of consumer (Table 46.1) [11].

### 46.3.2 Operation in Procure Phase

A wide range of resource and a large number of material are needed in a construction project. As a result, whether the procure is done effectively and economically or not affects the value of project directly. Information in integration management system makes up a big database, which can present the kinds of materials, the number, and the size of components so as to calculate the quantity and estimate cost automatically and correctly. To improve the productivity for latter work and arrange for procure and supply, designing scheme is integrated with quantity calculation and cost estimation to compare the cost of all kinds of schemes in design phase.

As a calculable platform containing real physical properties, information integration management system in construction supply chain is based on BIM, of which foreground is a system while background is database. BIM can analyze the drawing before generating reliable schedule for construction and demand plan for resource so as to aggregate the information about schedule, demand for resource and cost of construction. The information of demand for resource will change as model view is modified at any time [10]. BIM can provide collection of demand information visually for supplier to supply labor, machinery, resource on demand and in time. Meanwhile, a new technology, especially work flow of materials admission, and usage will be simulated by BIM, which reflects potential obstruct before we take relevant measure to control, contributing to dispatching all subcontractors and suppliers and establishing flow.

### 46.3.3 Operation in Construction Phase

Construction is the critical stage from design to construction product, which involves the longest construction period and the largest investment. Information integration management system based on BIM for Construction Supply Chain can simulate construction, control schedule and material dramatically, manage construction site, track material and construct digitally, with high efficiency to make fully preparation for construction site and allocate labor, material and machinery properly. Site manager can learn the flow of construction in advance and ease the difficulty level in practice with the vision of virtual construction for some workflow that requires new technology. Additions, Information integration management system can be integrated with information technology used for security control such as PFID, infrared ray, laser mapping and video camera in order to inspect, control and alert safety hazard for construction (Fig. 46.4). As an integrated technology, Information integration management system is used to analyze cost, productivity, feasibility and security for construction.

Information integration management system based on BIM make the operation simple and efficient with the help of massive information, which is used to record

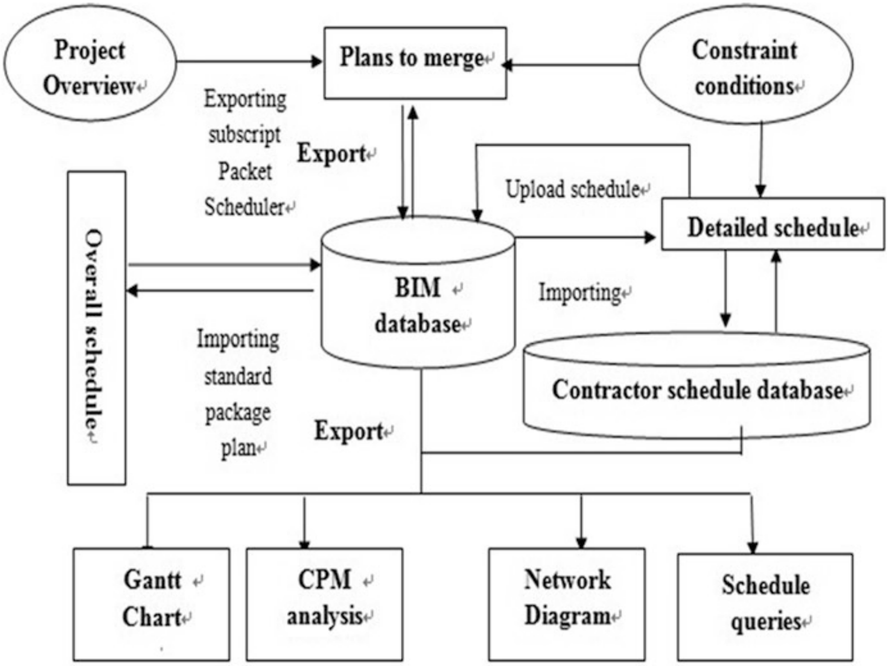


**Fig. 46.4** Multi-agent scheduling system flow chart of Information Integration Model

spatial position, the amount, the size and the performance of infrastructure on site compared to abstract, deficiency and no association in 2D drawing. Managers can arrange for the construction site layout, demonstrate construction process in the system, optimize construction flow and critical process and reduce the waste in construction phase by the use of BIM virtual construction. Disaster and emergency plan can be imitated with the help of technology, such as simulation, real time and results generated by hazard analysis software, making rescuer acquire the information of emergency stops in time and in accuracy and conduct rescue work in order to improve the productivity and minimize the loss [10].

## 46.4 The Analysis of Advantages of BIM-Based Construction Supply Chain Information Integration Management

This paper attempts to apply Building Information Mode to construction supply chain information management, aimed at achieving the collection and storage, consolidation and processing, analysis and collation, exchange and sharing of information with no paper, high efficiency and timely between node enterprises in the construction project supply chain, which makes information on the value of construction projects appeared even more. Then the BIM-based construction supply chain information integration management model has the following advantages:

1. The system contributes to construction chain supply information integration management. The BIM-based construction supply chain information integration management model can provide a platform and organization for large construction project supply chain information, a open site for storage, transfer, share of information so as to integrate highly information among all parties in the chain, which increases the atmosphere of trust among the parties with the project value best. It's guaranteed that all parties inquire information they need in any phase at any time on the information integration management platform [9].
2. The system improves Life cycle management of construction supply information. The information generated by all phase of project will not vanish instantly or become ineffective, of which some can be used repeatedly [11]. The BIM-based construction supply chain information integration management model can avoid bits and pieces of information produced by isolated phase in the traditional construction model, which not only helps the construction process, but also improve the application of operation phase after construction process [12]. The integration model break out the barriers of construction project management greatly and integrate various information about all phases and specialty in order to integrate the information in a wider range and make the information modeled for one time, utilized for many times and saved forever [13].

## 46.5 Conclusions

As a transformative technology in the construction industry, the essence of BIM lies in the information, the core lies in the model and the application lies in alternation, which can achieve vertical and horizontal integration of the information management. The achievement of BIM-based construction supply chain information integration management must also rely on a deeper study of BIM-related concepts and support of core technologies. With the development of the construction industry, under the action of various factors of theory-oriented, demand traction, technology-driven and so on, Building Information Model will certainly to obtain the widespread application through the total life cycle of construction project.

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# Chapter 47
# Research of the Investment Departure Early Warning Model of Infrastructure Projects Based on BP Neural Network

**Li Wang**

**Abstract** The construction and investment on infrastructure projects are becoming hotter all around China in the new century. The infrastructure projects of China are showing some unbalance while they promote the regional social and economic development and create excellent benefits for economic development. This paper tried to give out a guide of model and practice about the infrastructure projects investment departure based on neural network. Fist, this paper defined the six early warning indexes—the cost performance index, the schedule performance index, the investment variance, the schedule variance, the risk rate of investment variance and the risk rate of schedule variance. Then, input the historical data of multiple stages to the pre-learning neural network model, we could get the deviation degree of investment in infrastructure projects. Data examples showed that the model was valid.

**Keywords** BP neural network • Infrastructure projects • Early warning indexes • Early warning model

## 47.1 Introduction

Along with rapid development of the urban economy construction, the infrastructure construction not only is increasing vigorously, but also has extremely important social and economic meaning. It promotes the regional economic development, environmental protection and reduces poverty. Obviously, if effectively improve the service of infrastructure constructions, they can create excellent benefits for social

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L. Wang (✉)
College of Architecture and Civil Engineering, XiHua University, XiHua 610039, China
e-mail: 349547398@qq.com

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welfare; conversely, major mistakes of the infrastructure constructions not only damage and weaken the social productive forces, but also reduces the quality of the production. In recent years, China has increased investment in various infrastructure projects [1], the risk of investment in infrastructure construction is also growing, such as the investment out of control, which makes the government have to strengthen investment risk management and adopt the best risk control system. Previous study on infrastructure construction risk focused on the construction engineering risk and infrastructure construction operation risk while this paper unites the government governance of infrastructure construction with the infrastructure construction itself inside the environmental change of regional society and economy to study the infrastructure construction investment risk structure, risk inducements and their early warning management system [2].

The infrastructure construction is a project with high risks because it is characterized by large investment, long time of difficult building work, and complex techniques. In addition, it involves a variety of people and is easily affected by the environment. Therefore, the risk analysis of infrastructure projects, we should pay more attention to the new risk factors. In view of this, we should develop and improve the currently risk analysis methods which make the government and investors identify problems and take the necessary measures to transfer or keep away the investment risks.

The twentieth century, there gradually appeared kinds of the modern risk research methods, such as Delphi method, fuzzy mathematical method, analytical hierarchy process (AHP), Monte-Carlo method and probabilistic method etc. However, there are some drawbacks of these methods themselves, which development and improvement should be required further study [3]. In our country, the research of economic early warning has been gradually carried out in recent years. In the 1980s, the research and application of the early warning system has experienced a process which from macroeconomic early warning to the corporate warning, from qualitative-based method to both qualitative and quantitative method, and from the point to the state [4]. Macroeconomic and macro-financial early warning is a research focus, and its theoretical system and method tools are also standardized and systematic. Gu Hai-bin has done a lot of research about them. Liu Zhi-qiang has concluded four methods of foreign financial early warning. Qiu Pei-qun holds that the method of early warning includes index system method, early warning model and comprehensive scoring method. Cui bin thinks that indicators should be selected by adopting both qualitative and quantitative method and he has given six principles to be followed [5].

Based on the fully study about a variety of influencing factors of resistors and capacitors, considering many influencing factors including environment that the project schedule encountering, cost and schedule performance, the investment variance, the schedule variance, the risk rate of investment variance and the risk rate of schedule variance, so that the mathematic model of investment departure online testing based on BP neural network is established [6–8]. Using the better fault tolerance and self-learning, self-organization, adaptive capacity and a strong non-linear processing capability of neural network, through multiple sets of test samples for offline network training, the mathematical model of a multisensory information fusion has been established. This mathematical model overcomes the single sensor detection and the problem of low early warning accuracy with single-curve fitting method [9]. Using multi-sensor early warning indexes and neural network methods of data processing, comprehensive considering environmental impact factors and the characteristics of the target sensor, investment departure early warning accuracy has been great improved [10].

## 47.2 Methodology

In recent years, in view of artificial neural networks its strong nonlinear mapping abilities, some applications have appeared in the area of the investment departure early warning of infrastructure project. Artificial Neural Networks (Artificial Neural Networks, ANN) were called neural network or connection model (Connectionist Model) by the majority of scholars; ANN simulated behavior characteristics of animals in the nature of the brain neural network and processed information by distributed and parallel ways [11, 12]. Depending on the complexity of the network system, ANN constantly adjusted (revised) internal connection of the relationship between individual nodes, and achieved the results of effective processing information finally. ANN has not only the ability of self learning but also certain self-adaptive ability. First, ANN got mutual correspond to the number of learning samples in advance, namely, input and output data; and then, ANN analyzed potential rules of the learning samples between input and output; finally, according to the study of the law, ANN could calculate the output results with a new input data or work samples (test sample) [13]. The whole process of above-mentioned study analyses was usually referred to as "training".

### *47.2.1 BP Neural Network*

The basic network topology of BP Neural Network is shown in Fig. 47.1. A BP neural network has three or more layers including input layer, middle layer (hidden layer) and the output layer as the figure shows [14]. In the neural network, upper and lower layers are completely connected through the different transfer functions, but in each layer there is no connection between neurons. When a learning sample is put into the network, neuron active values spread from the input layer through the middle layer to the output layer and receive the input response in the output layer of the neural network. Next, according to the direction that reduces the error between the target output and the actual output, the network corrects the connection weights layer after layer from output layer through the middle layer finally back to the output layer [15]. That is, BP neural network carries forward the propagation after got the learning sample. If the error between the output and the target were greater

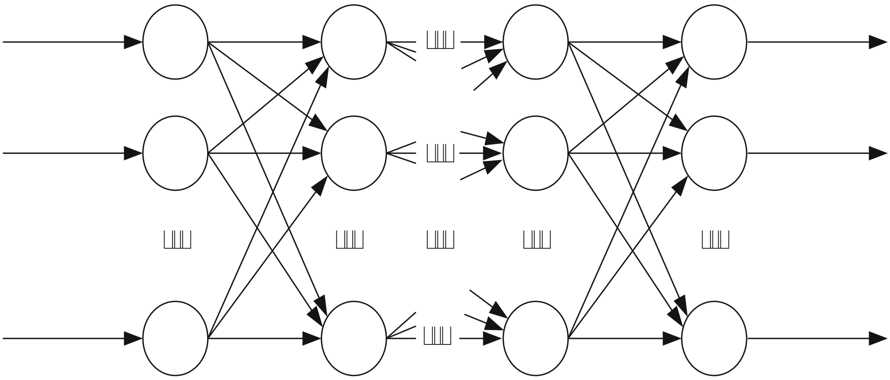

**Fig. 47.1** Schematic diagram of the basic network topology of BP neural network

than the expected threshold value, the forward propagation had transferred to a back-propagation and the error signals were returned along the connecting passage by modifying the weights of the various levels neurons weight in order to make the error signal becomes small gradually. This algorithm is called "error back propagation algorithm", namely BP algorithm. With the error back propagation to be continued, the accuracy rate of BP neural network responding to the study sample increased gradually [16–18].

Specifically, assuming that we input samples evaluation index information ($x_1, x_2, \ldots, x_n$), and calculate the actual output $y_j$.

$$Y_i = 1\Big/\left[1 + \exp\left(-\sum_{i=0}^{n} W_{ij}x_i\right)\right] \tag{47.1}$$

Where $n$ is the number of input node $j$, and $x_i$ is the input value of input node $i$, and $W_{ij}$ is the weight from input node I to node $j$, particularly when $i$ is 0, $W_{ij}$ and $x_i$ respectively represent threshold and 1.

Compared with the known output and calculated output, adjust the weight and threshold of nodes in the $K$ layer.

$$W_{ij}(t+1) = W_{ij}(t) + \eta\delta_j x_i + \alpha\big(W_{ij}(t) - W_{ij}(t-1)\big) \tag{47.2}$$

Where $W_{ij}$ is the connected weight and threshold from node $i$ to node $j$ in $K$-$1$ layer, and $x_i$ is the output of node I, and $\eta$ ($0<\eta<1$) is the learning coefficient, and $\alpha$ ($0<\alpha<1$) is the impulse coefficient. $\delta_j$ is the value that has the relation with the bias, for the output nodes.

$$\delta_j = y_i(1 - y_i)(d_j - y_j) \tag{47.3}$$

Where, $y_i$ and $d_i$ are actual output expectation of node $j$. For the nodes in hider layer, since the outputs are hard to compare, it can be reversely calculated.

$$\delta_j = x_j(1 - x_j)\sum_{i=0}^{m} W_{ij} \tag{47.4}$$

Where $x_j$ is the actual output of node $j$, and m is the number of output nodes of node $j$.

The algorithm is an iterative process, and the eight $W_{ij}$ will be adjusted in each round. The iterative process doesn't stop until the error between the expected output and calculated output reaches an accuracy value. After learning training finished, the valuation model is established [19, 20].

### 47.2.2 The Model Input Factors

In order to better describe the model input factors, we should define the following mathematical symbols:

Suppose that $t_1, t_2, \ldots, t_N$ is the construction period of infrastructure projects
Suppose that $C_i^*$ is the plan investment in the i-th work scheduled;
Suppose that $C_i^o$ is what the plan investment for work performed in the i-th work scheduled;
Suppose that $C_i$ is Actual investment in the i-th work scheduled;

When construction progress reached the i-th work scheduled, we defined the plan investment for Work Performed as $C_{BP}(t_i)$:

$$C_{BP}(t_i) = EV(t_i) = \sum_{j=1}^{i} C_j^* \tag{47.5}$$

Where, $EV(t_i)$ is Earned Value.

When construction progress reached the i-th work scheduled, we defined the Actual investment for Work Performed as $C_{AP}(t_i)$:

$$C_{AP}(t_i) = AC(t_i) = \sum_{j=1}^{i} C_j \tag{47.6}$$

Where, $AC(t_i)$ is Actual Cost.

When construction progress reached the i-th work scheduled, we defined the plan investment for work being performed as $C_{BS}(t_i)$:

$$C_{BS}(t_i) = PV(t_i) = \sum_{j=1}^{i} C_j^o \tag{47.7}$$

Where, $PV(t_i)$ is planning value.

To effectively measure investment variance in infrastructure projects, this paper defines six early warning indicators—cost performance index, schedule performance index, investment variance, schedule variance, risk rate of investment variance and risk rate of schedule variance, etc.

$$\text{Cost performance index}: CPI(t_i) = \frac{EV(t_i)}{AC(t_i)} = \frac{C_{BP}(t)}{C_{AP}(t)} \tag{47.8}$$

$$\text{Schedule performance index}: SPI(t_i) = \frac{EV(t_i)}{PV(t_i)} = \frac{C_{BP}(t_i)}{C_{BS}(t_i)} \tag{47.9}$$

$$\text{Investment variance}: \Delta_C(t_i) = AC(t_i) - EV(t_i) = \sum_{j=1}^{l} C_j - \sum_{j=1}^{l} C_j^* \tag{47.10}$$

$$\text{Schedule variance}: \Delta_T = EV(t_i) - PV(t_i) = \sum_{j=1}^{l} C_j^* - \sum_{j=1}^{l} C_j^o \tag{47.11}$$

$$\text{Risk rate of investment variance}: R_C(t_i) = \frac{\Delta_C(t_i)}{EV(t_i)} = \frac{\Delta(t_i)}{C_{BP}(t_i)} \tag{47.12}$$

$$\text{Risk rate of schedule variance}: R_T(t_i) = \frac{\Delta_T(t_i)}{PV(t_i)} = \frac{\Delta_T(t_i)}{C_{BS}(t_i)} \tag{47.13}$$

### *47.2.3 The Pre-treatment of Input Data*

Using proportional compression method to complete the input data preprocessing, the basic formula is as follows:

$$T = T_{\min} + \frac{T_{\max} - T_{\min}}{X_{\max} - X_{\min}}(X - X_{\min}) \tag{47.14}$$

Where $X$ is original data, $X_{\max}$ is the maximum value among the original data, $X_{\min}$ is the minimum value among the original data; T is the transformed data. As the value of $T_{\max}$ is 0.9~1.0, $T_{\min}$ will be 0.5~0.8.

After got the final results, the reducing formula of the experimental data is:

$$X = X_{\min} + \frac{X_{\max} - X_{\min}}{T_{\max} - T_{\min}}(T - T_{\min}) \tag{47.15}$$

### *47.2.4 The Early-Warning Model Based on BP Artificial Neural Networks*

Taking the risk rate of investment variance as an example, that this paper built early warning model of neural network is shown in Fig. 47.2. For several other indicators,

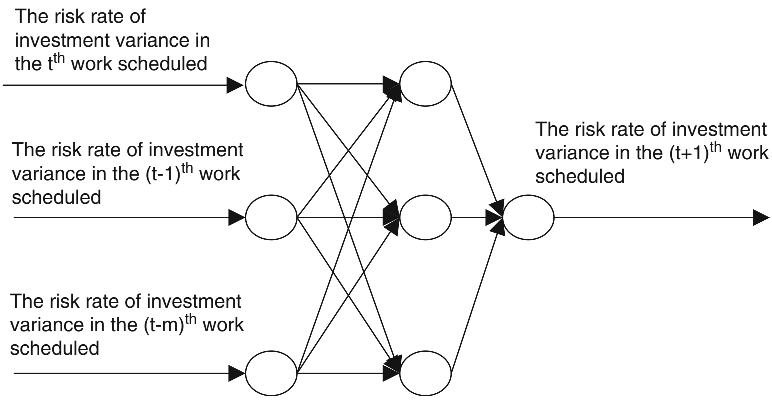


**Fig. 47.2** The early-warning model based on BP artificial neural networks

we can also build the corresponding early warning model in accordance with the method used in Fig. 47.2.

## 47.3 Data Instance

With the increasingly development of economic globalization and regional economic integration, we put forward higher requirements of transportation ability between Guangdong and Hong Kong. The economic contact of the international community is increasingly close between Guangdong and Hong Kong, the inertia of growth of Transportation Network Traffic has already nowadays become a trend that shows the characteristic and can't converse of economic development in this area. The new special line for passenger transport is imperative. More importantly, it will be the connection between HK and major cities such as Beijing, Shanghai and effectively link up with the national high-speed rail network systems. It is of vital realistic and long-term significance that the relationship of Hong Kong Economy and Economic Integration with the Mainland will be strengthened. And therefore, the government has to implement the Hong Kong's section of the construction of the project as soon as possible to connect Hong Kong city as soon as possible.

In this paper, the author put the section of "Guang-Shen-HK" high-speed rail project as an example. Suppose that the contract price is RMB 170 million which accounts for 12.3 % of the overall project price. This section began construction from February 2010, and we got some data such as Table 47.1 by September 2010. The Table 47.2 shows the investment risk of this section contract.

Taking the plan value of the Construction Company as input vector (P) and the risk rate of investment variance (T) as output vector to set up artificial neural networks from February 2010 to September 2010, the results indicate that BP can

**Table 47.1** The data of the section contract from February 2010 to September 2010 (Unit: one hundred million Yuan)

| Time | Plan of this month | Actual performed of this month | Accumulative actual performed since starting | Actual performed account for plan performed | Project schedule | Contract price after alteration |
|---|---|---|---|---|---|---|
| 2010.2 | 0.088 | 0.060 | 0.060 | 0.68 | 0.69 | 0.87 |
| 2010.3 | 0.094 | 0.072 | 0.672 | 0.77 | 0.78 | 0.86 |
| 2010.4 | 0.092 | 0.053 | 0.725 | 0.58 | 0.85 | 0.86 |
| 2010.5 | 0.096 | 0.063 | 0.788 | 0.66 | 0.90 | 0.87 |
| 2010.6 | 0.077 | 0.022 | 0.810 | 0.29 | 0.89 | 0.90 |
| 2010.7 | 0.077 | 0.026 | 0.836 | 0.34 | 0.89 | 092 |
| 2010.8 | 0.067 | 0.039 | 0.875 | 0.59 | 0.93 | 0.92 |
| 2010.9 | 0.059 | 0.018 | 0.883 | 0.31 | 0.96 | 0.91 |

**Table 47.2** Calculation table on the investment cost of the section contract (Unit: one hundred million Yuan)

| Time | Quantity of the project change of this month | Investment variance (Accumulative change) | Earned value | Risk rate of investment variance |
|---|---|---|---|---|
| 2010.2 | | −0.161 | 0.76 | −0.21 |
| 2010.3 | −0.014 | −0.175 | 0.85 | −0.21 |
| 2010.4 | 0 | −0.175 | 0.90 | −0.19 |
| 2010.5 | 0.01 | −0.165 | 0.95 | −0.17 |
| 2010.6 | 0.037 | −0.128 | 0.93 | −0.14 |
| 2010.7 | 0.02 | −0.108 | 0.93 | −0.12 |
| 2010.8 | 0 | −0.108 | 0.97 | −0.11 |
| 2010.9 | −0.008 | −0.1 | 0.99 | −0.12 |

fast realize convergence approaching a function. According to the trained neural network, we can predict that the plan value is 5.8 million Yuan and the risk rate of investment variance is −0.15 of this section contract in October 2010. According to the five-step threshold of the risk rate of investment variance: (−0.1, 0, 0.1, 0.2, 0.3), the author comes to the conclusion that the risk rate of investment variance is very small.

$$P = [0.088, 0.094, 0.092, 0.096, 0.077, 0.077, 0.067, 0.059] \tag{47.16}$$

$$T = [-0.21, -0.21, -0.19, -0.17, -0.14, -0.12, -0.11, -0.12] \tag{47.17}$$

## 47.4 Conclusion

This paper proposes the investment departure early warning model of infrastructure projects based on ANN. Fist, this paper defined the six early warning indexes—the cost performance index, the schedule performance index, the investment variance, the schedule variance, the risk rate of investment variance and the risk rate of schedule variance. Then, input the historical data of multiple stages to the pre-learning neural network model, we could get the deviation degree of investment in infrastructure projects. Data examples showed that the model was valid.

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# Chapter 48
# Evaluation Indicators for the Efficiency of Metro Systems from a Socio-economic-technical Perspective

**Liyin Shen, Liudan Jiao, Jingyang Zhou, and Weijian Ren**

**Abstract** Metro systems, defined as a kind of major urban infrastructure project, has been considered as an important method of sustainable transportation mode in particular to those newly developed cities where policy makers and planners need solutions to cope with problems of severe traffic congestion and pollution. Governments especially in developing countries have been investing huge amount of resources on the development of metro systems. In line with this, the efficiency of metro systems has attracted increasing interests between governmental officials, professionals and academics. A number of metro systems have been appreciated with good performance, such as New York City Subway, Paris Metro, London Underground, Tokyo Metro, MTR of Hong Kong, and others. Some of these systems were recommended as the benchmark to plan new metro projects or evaluate existing ones. It appears nevertheless that there is little study investing what are the methods for effectively evaluating the performance of metro system. This paper presents four indicators for the evaluation of the performance of Metro systems. Data are collected from worldwide metro systems and used to demonstrate the application of these indicators. These four indicators can demonstrate technical and socio-economic performance of Metro systems in individual cities. Empirical data from 181 cities in 54 nations are used for analysis. The paper concludes that LEN/POP, RID/LEN, RID/POP and FAR/GDP are efficient indicators to evaluate the efficiency of Metro systems from the socio-economic-technical perspective.

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L. Shen • L. Jiao (✉) • W. Ren
School of Construction Management and Real Estate, International Research Centre for Sustainable Built Environment, Chongqing University, Chongqing, China
e-mail: 396732441@qq.com

J. Zhou
School of Construction Management and Real Estate, International Research Centre for Sustainable Built Environment, Chongqing University, Chongqing, China

Department of Engineering Management,
Shandong Jinan Jianzhu University, Shandong, China

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**Keywords** Performance evaluation • Metro system • Sustainable urban development • Socio-economic indicator • Technical indicator

## 48.1 Introduction

With the expansion of modern urban areas, cities with high population density suffer from severe traffic congestion which creates a series of problems, such as air pollution, over consumption of fossil fuels, climate change etc. [11]. To cope with those challenges which threaten the prosperity of human society in long run, namely sustainability, research efforts have been devoted to find solutions. Sustainable development, accordingly, has been adopted as the solution to guide our strategies and policies. Besides building construction and operation, transportation sector consumes huge amount of energy each year. This is especially true to the cities relying on private vehicles heavily [7]. The goal of environmental sustainable development cannot be achieved without the integration of sustainable transportation model. Petroleum-based motor vehicle system, however, has been argued an unsustainable way to provide transport and mobility [15]. Therefore, to develop metro system has been considered as an effective solution to urban transportation. Metro system provides mass transportation without uncertainty rooted from traffic congestion.

Metro system has been playing important role in relieving the pressure of transportation especially in some densely populated cities, such as Tokyo, New York, Hong Kong etc. And it has prosperity in developing Asian nations [9]. Previous study also suggests other merits of metro including low economic and environmental costs [4]. The development of city gives birth to the Metro systems, which in turn, reshapes the city fabric. The development of metro systems, serves magnet, orientates the further growth of urban areas.

There have been more than 180 rail transit systems globally in 54 nations, providing more than 10,000 km of routes in the world. Without doubt, there will be more cities to embrace their own rail rapid transit systems in the near future. And most of the newly developed metro systems will be located in newly emerging economies such as China and India. Meanwhile, some cities are participating in the process of extending and upgrading their previous systems. However, in-depth study and research on the efficiency of metro systems are deserved to reduce the risk of such resource intensive projects. Installation of metro systems requires intensive capital investment. It was suggested that the cost of metro route ranges from US$15 million to 0.3 billion per km, with no guarantee of sound financial returns [1, 8, 14]. Furthermore, most systems need government subsidy. In order to encourage more citizens to use metro, municipal government of Beijing subsidize €216 million per year to keep the fare as low as €0.15. Decision makers should take into account that there would be tradeoff between investment on rail rapid transit and other public interests. In this sense, to evaluate the efficiency of rail rapid transit serves an important issue. Otherwise, limited public resources might used in low efficiency and against the intended objective of increasing the overall welfare of society.

Comprehensive literature review was conducted for investigating the indicators to evaluate the efficiency of metro systems in the world. A preliminary list of indicators is identified first in the process of searching for literatures. Then discussions are conducted on the adequacy of indicators, thus a list of effective indicators are confirmed. Secondly, the application of the indicators will be demonstrated through using data. These data were collected through searching for relevant websites. Finally the calculation results on these effective indicators will be presented and discussed.

## 48.2 Identification of Evaluation Indicators

Efficiency is defined as the quality of doing something well and effectively, without wasting time, money, or energy. Various indicators have been introduced to evaluate the performance of metro systems from technical, financial and socio-economic aspects [2, 3, 6, 10, 12, 16]. Typical indicators discussed in the literature studies are listed in Table 48.1.

The literature review has led to the identification of ten variables to depict the performance of Metro systems. These indicators are listed in Table 48.2.

One of the key variables adopted in this project is the annual ridership of the entire metro system. Urban residences are likely to use a system more often when it offers convenience, timeliness, and reliability for an affordable fare. The desire to use mass transit is best represented by annual per capita use (the annual number of trips) in a city divided by a city's population [5]. The ridership varies spatially and temporally. As the main users of Metro systems are commuters, the ridership in weekdays is much larger than that of weekend. Spatially, ridership through different lines or stations distributes unevenly. New York City Subway for example gained quite wide range of ridership through time and space. According to Ridership by Subway Station 2009, out of 422 stations (Ridership of metro systems), Aqueduct Racetrack attracted only 27,004 passengers per year. There were 52 people per weekday, 143 people in Saturday and 106 people in Sunday. Aqueduct Racetrack is a raceway and attracts people only when racing days coming. By contrast, the station in Times Square in 42th Street serviced 58,099,313 people per year. There were 181,224 people per weekday, 120,113 per Saturday and 97,617 per Sunday recorded.

In order to get an overall picture of 181 Metro systems of the world which located in different geographic and economic regions, annual ridership of the whole system rather than ridership of individual line or station were selected as a key variable in this paper. There are few special cases where data have been collected in different ways. The figures of Bangkok and Copenhagen are the sum of data from two operating companies respectively. In Bangkok, BTS Skytrain is an elevated rapid transit system operated by Bangkok Mass Transit System Public Company Limited (BTSC). And MRT, sometimes referred to as the Bangkok Metro, is Bangkok's underground metro system operated by joint venture of both government and a private company Bangkok Metro Company Limited (BMCL). In Denmark, S-train network is a combined urban rail and suburban rail network of

**Table 48.1** Typical indicators for evaluating metro efficiency

| Indicator | Author |
|---|---|
| Vehicle km/capita<br>Seats km/capita<br>Frequency on the network and network density | Bresson |
| Network length<br>Number of staff<br>Number of train cars<br>Passenger<br>Trips and car-kilometers | Jain |
| Revenue vehicle hours per dollar of operating expense<br>Vehicle miles per peak vehicle<br>Vehicle hours per employee<br>Vehicle miles per maintenance employee<br>Vehicle miles per accident<br>Unlinked passenger trips per revenue vehicle hour<br>Operating revenue per operating expense | Fielding G. J. |
| Operational cost,<br>Number of equivalent vehicles<br>Number of employees<br>Number of passengers transported | Sampaio |
| Employees<br>Fleet<br>Fuel<br>Network length<br>Service area population<br>Passenger kilometers | Yu |
| Average cost per veh-hr or veh-km<br>Vehicle-hrs or km<br>Accidents per 1,000 veh-km<br>Revenue/cost ratio<br>Revenue veh-hr/total veh-hr<br>Maintenance workers per vehicle | NERA |

**Table 48.2** Variables for evaluating the performance of metro systems

| Variable | Implication |
|---|---|
| STA | Number of stations |
| TransSTA | Number of transfer stations |
| LIN | Number of lines |
| LEN | Length of system, in km |
| RID | Annual ridership |
| FAR | Fare, in EURO |
| POP | Population of the city, in million |
| popDEN | Population density of the city, population per km$^2$ |
| GDP | Per capita GDP of the city |
| YEAR | Operation years |

Metropolitan Copenhagen and Copenhagen Metro is a rapid transit system serving Copenhagen, Frederiksberg and Tarnby in Denmark. One assumption of this paper is that the more population in a given city, the more Metro system service is needed. Accordingly, more lines/stations and annual ridership would be expected. The demographic data like population and population density were introduced to serve as the base for comparison of performance between various Metro systems.

From the perspective of passengers, fare of Rail Transit system is the key factor that influences their choice of transportation. Cheaper fare encourages more people to choose metro to move in the urban area. For example, after the fare down turn adjustment in 2006, the rate of citizens relying on metro raised 15 % in the following year in Beijing, China (Beijing municipal commission of development and reform, 2010). Living standards of different nations of the world vary a lot. One simple example is that one 550 ml bottle of cola costs €0.72 in Hong Kong and €0.32 in mainland China. Simply adopting GDP would mislead the conclusion, if not totally wrong. Per capita GDP adjusted by Purchasing Power Parity or PPP (GDP ppp) helps to eliminate this error. In addition, different cities in one nation would vary a lot as well. It is not reasonable to regard all cities as the same. For example, the figure in Shanghai, China passed €5,500 while the figure in Chengdu, China was just over €3,800. Passengers in Shanghai would feel cheaper as the fare of both cities were €0.33.

## 48.3 Selection of Effective Evaluation Indicators

The indicators in the previous searching present a comprehensive profile on evaluation of the performance of metro system. It is considered that relative measures are more effective for assessing the system performance. By using the ten variables in Table 48.2, eight relative indicators can be generated: number of transfer stations per station (transSTA/STA), number of stations per line (STA/LIN), number of stations per kilometer of system (STA/LEN), length of system per million population (LEN/POP), number of stations per million population (STA/POP), annual ridership per million population (RID/POP), annual ridership per kilometer of system (RID/LEN), and ratio of fare to per capita GDP (FAR/GDP). These relative indicators are listed in Table 48.3:

**Table 48.3** Relative indicators for the evaluation of metro system

| Indicator | Implication |
|---|---|
| transSTA/STA | Number of transfer stations per station |
| STA/LIN | Number of stations per line |
| STA/LEN[a] | Number of stations per kilometer of system |
| LEN/POP[b] | Length of system per million population |
| STA/POP[b] | Number of stations per million population |
| RID/POP | Annual ridership per million population |
| RID/LEN | Annual ridership per kilometer of system |
| FAR/GDP | Ratio of fare to per capita GDP |

This study selects the four variables for further analysis, namely LEN/POP, RID/POP, RID/LEN and FAR/GDP.

## 48.4 Data Collection and Analysis

Besides official websites of each metro system, some websites relevant to metro system of the world are also searched as the reference for cross comparison. In this way, most updated and accurate data can be collected. All data of annual ridership in this study are referred to the most updated official websites of operation companies. And fare data are from a report of UBS. As fare policies in different places of the world varying, the fare of Metro system charges for ten stations from official websites was selected as one variable in this project [13]. All fares based on local currency were converted to Euro. Most updated data of official demographic census were collected from different cities. As a research, the basic information for analysis is presented in Table 48.4.

As there is no difference between LEN/POP and STA/POP, LEN/POP is selected as the indicator. Traditionally, researches on public transportation introduce per capita length of network to exam abundance of roads in a city. Thus, cross-sector comparison can be conducted. There is less correlation between LEN and POP at the first glance. In reality, however, it would take years even decades to establish a well-organized and managed network. That is to say, the newly constructed Metro systems, especially one opened for just 1 year or 2, are still in their infant stage and their data probably divert the inherent pattern. Further study base on the operation years has been carried out to get more insight about the relationship between LEN and POP. The range of LEN/POP is from 0.62 to 285.33. There are 6 out of 20 cities from the U.S. Western European nations make much effort on providing people adequate Metro system recourse to meet their daily needs. Dense population nations, especially Asian countries, provide relatively less per capita Metro system recourse, as shown in Table 48.5.

The range of RID/LEN of the world Metro systems is from 0.14 to 13.97, as shown in Table 48.6. And the average RID/LEN is 3.77.

The range of RID/POP of the world Metro systems is from 1.76 to 675.34, as shown in Table 48.7. And the average RID/POP is 115.03; 86 % Metro systems gain RID/POP from 1.76 to 203.84. People in European cities rely on Metro system

**Table 48.4** Selected websites of RTSs of the world

| Website | Description |
|---|---|
| http://mic-ro.com/metro | A non-profit database, a virtual grid of thousands of chunks of data |
| http://www.cityrailtransit.com | Provides information about rail-based transit networks within cities, bringing practical information as well as rail transit maps |
| http://www.urbanrail.net | Gives a general overview of each city's metro system and links you to other relevant sites |

**Table 48.5** Top 20 LEN/POP Metro system of the world

| No. | Country | City | LEN/POP |
|---|---|---|---|
| 1 | USA | Washington | 285.33 |
| 2 | UK | Newcastle | 263.79 |
| 3 | USA | Saint Louis | 203.89 |
| 4 | USA | San Francisco | 203.54 |
| 5 | France | Lille | 197.83 |
| 6 | Puerto Rico | San Juan | 156.36 |
| 7 | USA | Boston | 156.15 |
| 8 | Chile | Valparaiso | 153.57 |
| 9 | USA | Atlanta | 146.67 |
| 10 | Sweden | Stockholm | 127.35 |
| 11 | Canada | Vancouver | 119.83 |
| 12 | Spain | Bilbao | 116.00 |
| 13 | Japan | Tama | 114.29 |
| 14 | Switzerland | Lausanne | 105.38 |
| 15 | Norway | Oslo | 105.08 |
| 16 | Portugal | Oporto | 98.64 |
| 17 | France | Paris | 97.26 |
| 18 | Belgium | Charleroi | 87.50 |
| 19 | Spain | Madrid | 87.12 |
| 20 | USA | Miami | 83.72 |

**Table 48.6** Top 20 RID/LEN Metro system of the world

| No. | Country | City | RID/LEN |
|---|---|---|---|
| 1 | Brazil | Sao Paulo | 13.97 |
| 2 | North Korea | Pyongyang | 11.33 |
| 3 | Egypt | Cairo | 10.69 |
| 4 | Japan | Tokyo | 10.38 |
| 5 | Czech Republic | Prague | 9.90 |
| 6 | Hungary | Budapest | 9.00 |
| 7 | Belarus | Minsk | 8.65 |
| 8 | Argentina | Buenos Aires | 8.63 |
| 9 | Italy | Rome | 8.49 |
| 10 | Venezuela | Caracas | 8.43 |
| 11 | Iran | Tehran | 8.42 |
| 12 | Ukraine | Kiev | 8.41 |
| 13 | France | Lyon | 8.14 |
| 14 | Russia | Moscow | 7.92 |
| 15 | Ukraine | Kharkov | 7.88 |
| 16 | India | Kolkata | 7.65 |
| 17 | Russia | Saint Petersburg | 7.53 |
| 18 | China | Hong Kong | 7.50 |
| 19 | Greece | Athens | 7.46 |
| 20 | Austria | Vienna | 7.31 |

**Table 48.7** Top 20 RID/POP Metro system of the world

| No. | Country | City | RID/POP |
|---|---|---|---|
| 1 | France | Paris | 675.34 |
| 2 | France | Lyon | 520.83 |
| 3 | Czech Republic | Prague | 468.00 |
| 4 | France | Lille | 416.52 |
| 5 | Sweden | Stockholm | 369.88 |
| 6 | USA | Washington | 356.33 |
| 7 | Portugal | Lisbon | 316.07 |
| 8 | Japan | Osaka | 314.32 |
| 9 | Austria | Vienna | 300.12 |
| 10 | Germany | Munich | 263.91 |
| 11 | Spain | Bilbao | 248.57 |
| 12 | Japan | Tokyo | 242.89 |
| 13 | Italy | Milan | 242.75 |
| 14 | Russia | Moscow | 236.13 |
| 15 | Germany | Nuremberg | 230.00 |
| 16 | USA | Boston | 223.08 |
| 17 | Spain | Barcelona | 222.84 |
| 18 | France | Rennes | 219.00 |
| 19 | Canada | Vancouver | 202.41 |
| 20 | China | Hong Kong | 199.72 |

**Table 48.8** Top 20 FAR/GDP Metro system of the world

| No. | City | Country | Fare/GDP |
|---|---|---|---|
| 1 | Stockholm | Sweden | 13.34 |
| 2 | Hiroshima | Japan | 11.27 |
| 3 | London | United Kingdom | 10.60 |
| 4 | Nagoya | Japan | 10.55 |
| 5 | Brasilia | Brazil | 10.53 |
| 6 | Copenhagen | Denmark | 10.33 |
| 7 | Bangkok | Thailand | 10.01 |
| 8 | Sydney | Australia | 9.94 |
| 9 | Fukuoka | Japan | 9.87 |
| 10 | Osaka | Japan | 9.87 |
| 11 | Sapporo | Japan | 9.87 |
| 12 | Sendai | Japan | 9.87 |
| 13 | Belo Horizonte | Brazil | 9.58 |
| 14 | Rio de Janeiro | Brazil | 9.22 |
| 15 | Sao Paulo | Brazil | 9.10 |
| 16 | Kyoto | Japan | 8.87 |
| 17 | Frankfurt | Germany | 8.65 |
| 18 | Munich | Germany | 8.65 |
| 19 | Chengdu | China | 8.64 |
| 20 | Guangzhou | China | 8.45 |

more. US cities, although possessed so much Metro system recourse, take only the 6th and the 16th place. 3 Asian cities, Osaka, Tokyo and Hong Kong, can be found in the top 20.

**Table 48.9** Bottom 20 FAR/GDP Metro system of the world

| No. | City | Country | Fare/GDP |
|---|---|---|---|
| 1 | Mexico City | Mexico | 1.33 |
| 2 | Minsk | Belarus | 1.46 |
| 3 | New York | USA | 1.53 |
| 4 | Baku | Azerbaijan | 1.90 |
| 5 | Beijing | China | 2.01 |
| 6 | Buenos Aires | Argentina | 2.08 |
| 7 | Singapore | Singapore | 2.29 |
| 8 | Taipei | Chinese Taipei | 2.33 |
| 9 | Daejeon | South Korea | 2.40 |
| 10 | Seoul | South Korea | 2.45 |
| 11 | Incheon | South Korea | 2.68 |
| 12 | Gwangju | South Korea | 2.68 |
| 13 | Hong Kong | China | 2.72 |
| 14 | Kharkov | Ukraine | 2.84 |
| 15 | Cairo | Egypt | 2.97 |
| 16 | San Francisco | USA | 3.15 |
| 17 | Daegu | South Korea | 3.31 |
| 18 | Warsaw | Poland | 3.37 |
| 19 | Baltimore | USA | 3.38 |
| 20 | Kuala Lumpur | Malaysia | 3.42 |

The range of FAR/GDP of the world Metro system is from 1.33 to 13.34. And the average FAR/POP is 5.78, as shown in Tables 48.8 and 48.9.

## 48.5 Conclusion

This paper selected four effective indicators for evaluating the performance of metro system including LEN/POP, RID/LEN, RID/POP and FAR/GDP. The application of these indicators is effective, which was evidenced by using the data collected from 180 metro systems in the world. Most of the Metro systems in the world are still in their early operation phases. It is anticipated that more and more systems will come into operation in the near future, especially in the newly emerging economies. Due to the varied development phases and socio-economic situations across nations, policy makers and planners should take other systems as reference rather than copying the practice from better RTS performance of Metro system such as Tokyo, NYC, and Hong Kong etc. as the benchmark. Metro systems in Japan and Hong Kong provide the role models operating in population dense regions and the counterparts in France and Spain give good reference for those less densely populated urban areas. To the newly emerging economies like China and India, they should expand their network to strike a balance between limited resources and to restructure of transportation pattern.

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# Chapter 49
# A Study on the New Method to Educate Construction Engineers of Subcontractors and General Contractors Through Internships in Japan

**Hitoshi Mihara, Takuro Yoshida, Masato Urae, and Tetsuo HOJO**

**Abstract** There are many ways in which internship programs are run. Further study and analysis are required to identify new issues from the standpoints of commitment and mutual understanding among educational institutions and companies, which have recently been found to have differences. This study takes the first step forward in accomplishing this task. In particular, by focusing on the analysis and assessment of the comments portion of the questionnaire, we were able to elucidate new issues and findings. This information allowed us to propose a new training method and its contents. The objective of this study is to, first, clarify the current training of construction supervisors at universities and other educational institutions that offer a degree in architecture in Japan, second, assess the extent to which internship-based training has proliferated among educational institutions and companies such as general contractor and subcontractors that participate in the training by studying the contents and effects of training, third, gauge how such training has improved the image of the construction industry among the youths who have yet to be employed by a company or become an apprentice, and fourth, propose a new internship-based training method and its contents on the basis of the results of the study. The method and contents of the survey are as follows. The subjects of the study comprised representatives of universities offering architecture degrees in Japan, as well as companies such as general contractors and subcontractors accept interns. Referencing "A Survey on the Training of Production Engineers at Construction Sites Focusing on Internships in the Academic Year of

H. Mihara (✉) • T. HOJO
Department of Construction, Monotsukuri Institute of Technologists, Gyoda, Saitama, Japan
e-mail: mihara@iot.ac.jp; Hojo@iot.ac.jp

T. Yoshida
School of Architecture, Kogakuin University, Shinjuku, Tokyo, Japan
e-mail: yoshida@cc.kogakuin.ac.jp

M. Urae
Department of Architecture, Toyo University, Kawagoe, Saitama, Japan
e-mail: urae@toyo.jp

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2011 (January 2012 to April 2012)," which targeted college and graduate students who participated in internships during the 2011 academic year, we analyzed and assessed the current state of internships as well as the comments portion of the questionnaire, and conducted interviews.

**Keywords** Construction supervisors • General contractors • Subcontractors • Internship • Building work process supervisors • Educate construction engineers

## 49.1 Introduction

There are growing numbers of universities and other educational institutions that integrate internships into their curriculum and adopt pedagogies through which they allow students to earn credit. However, no investigation has yet been conducted to determine how students who expect to work at construction sites as work process supervisors and architectural professionals exploit internship opportunities, or what kinds of training and career guidance companies that accept interns provide. Since the 1996 academic year, the website of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has published statistics on internships that have been integrated into the curriculums of universities and other educational institutions. Those statistics show that, as of the 2007 academic year, 68 % of the universities in Japan offered internships, and that such a number is increasing. For these reasons, in order to further promote future internship programs and other on-site human resources training in the construction industry, it was considered imperative to survey and analyze the internship programs offered by universities with architecture departments along with the four major construction industries (general contractors, subcontractors, home builders, and contractors), and to present the results.

## 49.2 Objectives of the Research

The objective of this survey and research effort was to gain a better understanding of the implementation of internship programs at universities with architecture departments, and in the four major above-mentioned construction industries. In addition, to further promote the development of internship programs in general, and specialized construction fields in the Japanese construction industry in particular, this research was conducted to produce a set of fundamental documents that would help foster construction work process supervisors and architectural professionals in these fields, and thus contribute to the development of the construction industry. The major objective of this paper is to gain an understanding of the status of internship programs offered at universities with architecture departments and in the general and special construction fields.

## 49.3 Summary of Previous Research Related to This Topic

The following provides a summary of previous research related to this topic: Previous research (2) and (3) summarized the internship programs offered at universities with architecture departments across Japan. Previous research (4) discussed the long-term internships offered by universities and other educational institutions aimed at fostering new architectural professionals. Previous research (5) clarified the pedagogies used in internship-based education programs conducted in collaboration with organizations related to specialized industries, along with their contents.

## 49.4 Research Methodology

### *49.4.1 Summary of Research Methodology*

In this research, a questionnaire survey targeting universities with architecture departments and the major construction industries was conducted to determine the status of their internship programs. The responses were collected as data, cross-tabulated, and then analyzed. Finally, the results drawn from them were presented.

### *49.4.2 Subjects of the Survey and the Number of Responses*

In terms of educational institutions, the survey covered 229 architecture departments at national, public, and private universities with architecture departments and four major types of construction industries (general contractors, subcontractors, home builders, and contractors) comprising 723 companies and 37 organizations. A total of 61 universities with architecture departments responded, thus providing a collection rate of 26.6 % (Table 49.1).

Among the four major types of construction industries, the number of companies that responded and their collection rates were 25 general contractor companies at 17.3 %, 97 subcontractor companies at 26.2 %, 11 contractor companies at 7.5 %, and four homebuilder companies at 20.0 % (Table 49.2).

### *49.4.3 Method of Sampling the Subjects in the Four Types of Construction Industries*

Among the four types of construction industries, “general contractors” were sampled from among a total of 145 member companies of the Japan Federation of

**Table 49.1** The number of universities with architecture departments that responded and the collection rate

| | University | Responded | Collection rate |
|---|---|---|---|
| University with architecture department | 229 | 61 | 26.60 % |

**Table 49.2** The number of companies in the four construction industries that responded and the collection rate

| Types | Companies | Responded | Collection rate (%) |
|---|---|---|---|
| General contractors | 145 | 25 | 17.3 |
| Subcontractors | 370 | 97 | 26.2 |
| Home Builders | 188 | 11 | 7.5 |
| Contractors | 20 | 4 | 20.0 |
| Total | 723 | 137 | 18.9 |

Construction Contractors. "Subcontractors" were sampled from among a total of 370 member companies and 37 member organizations of the Association of Construction Industry Specialists. "Contractors" were sampled from among the top four companies in each of the 47 prefectures, or a total of 188 companies, according to the ranking (by prefecture) of newly built housing compiled by Nikkei Home Builder's "2011 National Survey of Home Builders." "Homebuilders" were sampled from among a total of 20 major, semi-major, and medium-sized homebuilders. As for subcontractors, 37 organizations were asked to arbitrarily select ten companies through unions and other organizations and to send them the questionnaires.

### 49.4.4 Research Items

In the survey conducted on national, public, and private universities with architecture departments, subjects were asked to fill in the name of their undergraduate and graduate departments, as well as the name of their majors and courses offered. In addition, they were asked to enter the academic levels at which internship programs are offered, the number of participating students, and the types of laboratories they belonged to. In the survey conducted on universities and companies, subjects were asked to fill in the dates during which internship programs are offered and their length. Other questions covered the status of employment, how internships help students get jobs, internships offered by companies, and other items. The subjects were also invited to share their comments.

### 49.4.5 Dates of the Survey

The survey was conducted from January 20, 2012, to May 10, 2012. The first batch of questionnaires was sent to universities with architecture departments on January

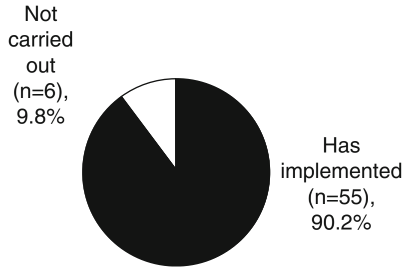


**Fig. 49.1** Internships offered

20, 2012. The first deadline for returning the questionnaires was April 27, 2012. To improve the collection date, a reminder was sent to the universities with architecture departments on April 20, 2012 (along with the second batch of questionnaires). The final deadline for returning the questionnaires was May 10, 2012. The questionnaires sent to companies from the four major construction industry types were mailed on March 20, 2012, and the deadline for returning the questionnaire forms was April 27, 2012.

### *49.4.6 Method of Distributing and Collecting the Questionnaires*

The questionnaires were sent by postal mail to the universities and companies and responses were returned to the Mihara Lab of the Institute of Technologists via postal mail and via online methods (e.g., email). Among the construction industries, ten subcontractors were chosen arbitrarily by unions and other organizations, which also handled questionnaire distributions.

### *49.4.7 The Availability of Internships at Universities*

Of the 61 universities that were asked whether they offered internships, 55 universities, or 90.2 %, responded that they do. Respondents who provided no answer were considered to not offer internship programs. Figure 49.1 shows the status of internships offered.

### *49.4.8 Summary of Respondent Companies*

(a) Four Types of Construction Industries
Table 49.3 shows the number of responses received from among the four types of construction industries and their percentages. Subcontractors responded the most, followed by general contractors, contractors, and homebuilders.

**Table 49.3** The number of responses received from among the four types of construction industries and their percentages

| Types | Companies | Responded | Collection rate (%) |
|---|---|---|---|
| General contractors | 145 | 25 | 17.2 |
| Subcontractors | 370 | 97 | 26.2 |
| Home Builders | 188 | 14 | 7.5 |
| Contractors | 20 | 4 | 20.0 |
| Total | 723 | 140 | 19.4 |

**Table 49.4** The breakdown of the number of responses received according to the area of specialization

| Industry types | Numbers | Industry types | Numbers |
|---|---|---|---|
| Scaffolding and earthwork | 5 | Reinforcement placing | 7 |
| Plumbing | 11 | Electronics | 1 |
| Metal fittings | 2 | Carpentry (shuttering carpentry) | 14 |
| Steel structures | 8 | Waterproofing | 7 |
| Plastering | 13 | Special concrete | 5 |
| Gardening | 24 | Number of companies responded | 97 |

(b) The Composition of Subcontractors (Specialized Construction Industry)
Table 49.4 shows the number of responses received from subcontractors.

Landscaping companies responded the most, followed by companies specializing in formwork, painting, piping, steel structures, reinforced steel, waterproofing, scaffolding and earthwork, and special concrete.

## 49.5 Survey and Analysis of Subcontractors

### *49.5.1 The Significance and Objectives of Internships at Subcontractors*

In terms of the significance of accepting interns, the top reason provided by all subcontractors was that the company could “Make a social contribution by helping the young determine their career paths and aptitudes” (80.8 %). This was followed by the responses that the company could “Provide an opportunity that helps students determine their career paths” (76.9 %), and “Help students learn things that cannot be taught in the classroom” (73.1 %). In summary, it is clear that the respondents strongly felt that their companies could make social contributions and allow students to learn things outside the classroom. In contrast, the top reason given by all universities was that internships could “Provide an opportunity that

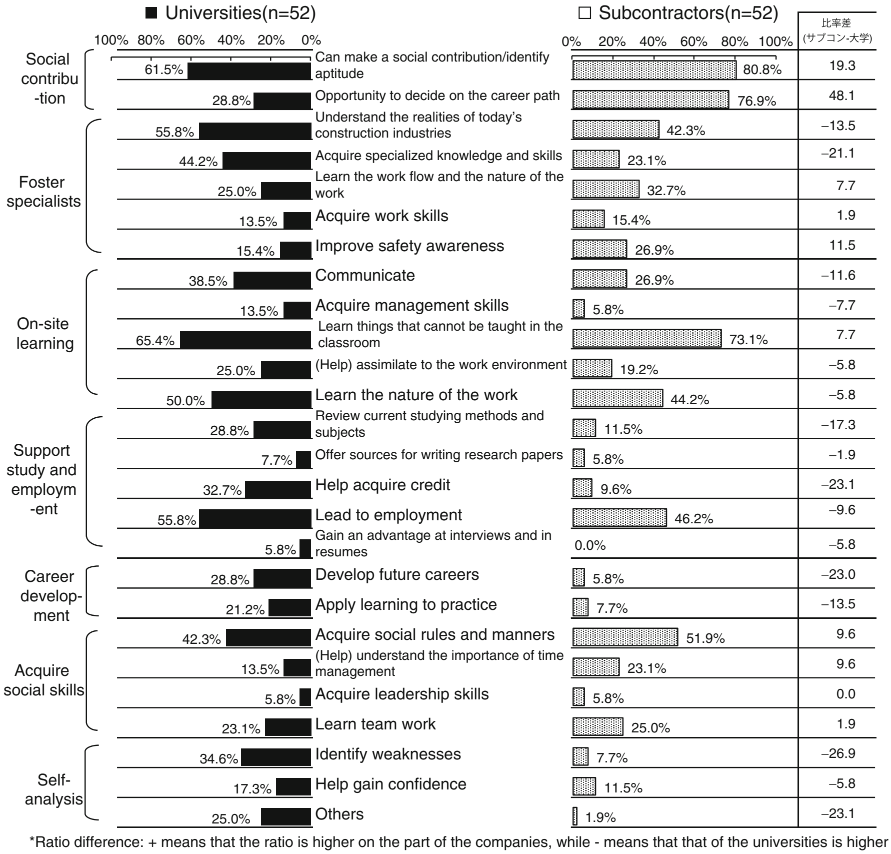


**Fig. 49.2** The significance and objectives of internships

helps students determine their career paths" (48.1 %). On the other hand, more universities than subcontractors responded that internships "Allow students to acquire specialized knowledge and skills" and that they "Allow students to understand the realities of the construction industry." The research found subcontractors felt strongly that internships offered opportunities to help students determine their career paths and were less expectant that they would help foster future human resources. Furthermore, although both universities and companies expected the internship programs to "Lead to employment for the young" at a comparative level, the difference between them being only 9.6 %, when comparing between general contractors and subcontractors, it was found that more subcontractors expected internships to impact the student's recruitment than general contractors, based on the responses received for the same question (Fig. 49.2).

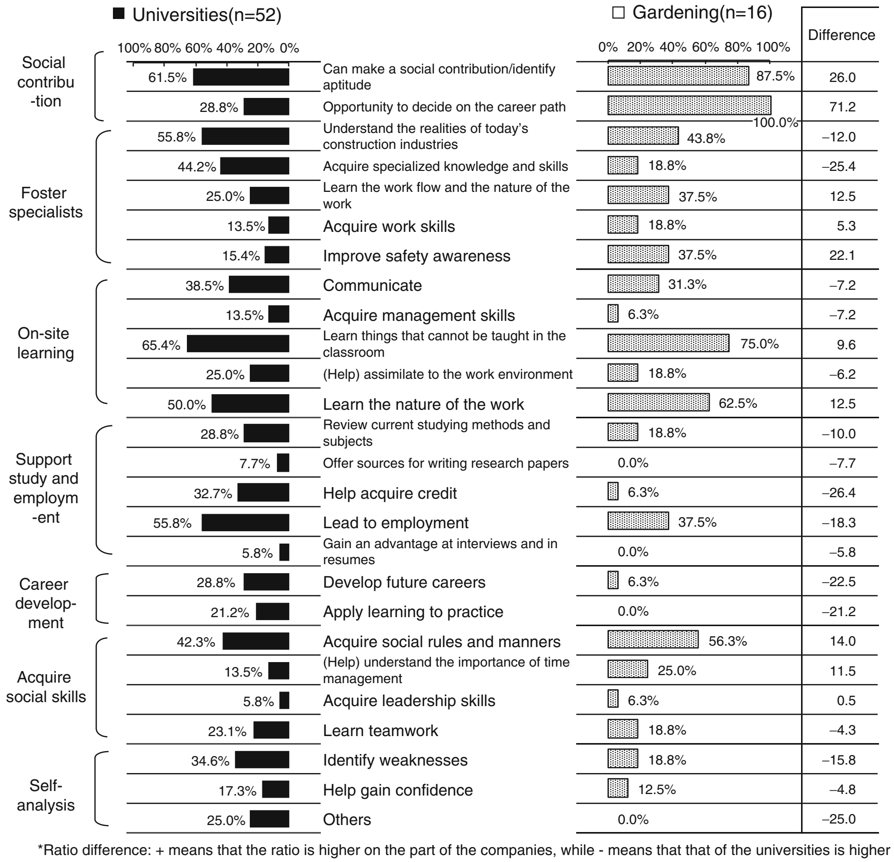


**Fig. 49.3** Comparison between universities and landscaping companies in their views on the significance and objectives of internships

### 49.5.2 *The Significance and Objectives of Internships in Each Specialized Construction Field*

Here, the study made a comparison between universities and each of the two construction fields with the highest number of respondents regarding the significance and objectives of internships.

(a) Landscaping (24 respondents)
In landscaping, 16 out of the 24 respondents gave their answers regarding "The Significance and Objectives of Internships." All respondents answered that internship programs could "Provide an opportunity that helps students determine their career paths." This was followed by respondents who answered that internships could "Make a social contribution by helping young people determine their career paths and aptitudes" (87.5 %). The difference with university respondents was large, at over 25 %, thus indicating that landscaping companies feel strongly that they could make social contributions by accepting interns (Fig. 49.3).

Compared to universities, fewer landscaping companies responded that internships allow students to “Acquire specialized knowledge and skills,” a difference of 25.4 %. Moreover, fewer landscaping companies than universities responded that internships could “Lead to employment for the young,” a difference of 18.3 %. This indicates that, compared to universities, landscaping companies felt less strongly regarding the impact of accepting interns.

(b) Piping (11 respondents)
In the field of piping, 10 respondents out of 11 gave their answers regarding “The Significance and Objectives of Internships.” The high number of responses indicates that the companies could “Make a social contribution by helping the young determine their career paths and aptitudes” and thus allow the students to “Learn things that cannot be taught in the classroom.” These were followed by the response that internships provide an “Opportunity to decide on a career path.” Compared to universities, only 44.2 % of the companies responded that internships could help students.“ Acquire specialized knowledge and skills,” and only 25.8 % responded that the programs could “Lead to employment for the young.” The research found that piping companies feel more strongly that they can make social contributions than create employment opportunities through internships (Fig. 49.4).

### 49.5.3 Interns Accepted by General Contractors and Subcontractors

This section discusses interns accepted by general contractors and subcontractors.

(a) Interns accepted by general contractors
A total of 92 % of general contractors that responded said they accepted interns, thus indicating that the majority is in favor of the program (Fig. 49.5). Among the educational institutions that dispatch interns to companies, “Colleges” (85.7 %) account for the most, followed by “Graduate schools” (33.3 %) (Table 49.5). In terms of the internship durations, 57.1 % lasted “About 8–14 days,” indicating that about 60 % of general contractors accept interns for 1–2 weeks (Table 49.6).

(b) Interns accepted by subcontractors
Among subcontractors, 62.5 % accepted interns (Fig. 49.6). This was about 30 % less than general contractors. Among the educational institutions that dispatch interns to companies, “Technical high schools” (50.0 %) account for the most, followed by “Colleges” (34.6 %) (Table 49.7). In terms of the duration of internships, 40.1 % lasted “About 1–3 days,” followed by “About 4–7 days” (28.8 %). This reflected the fact that there are many students that attend technical high schools, thereby shortening the internship period (Table 49.8).

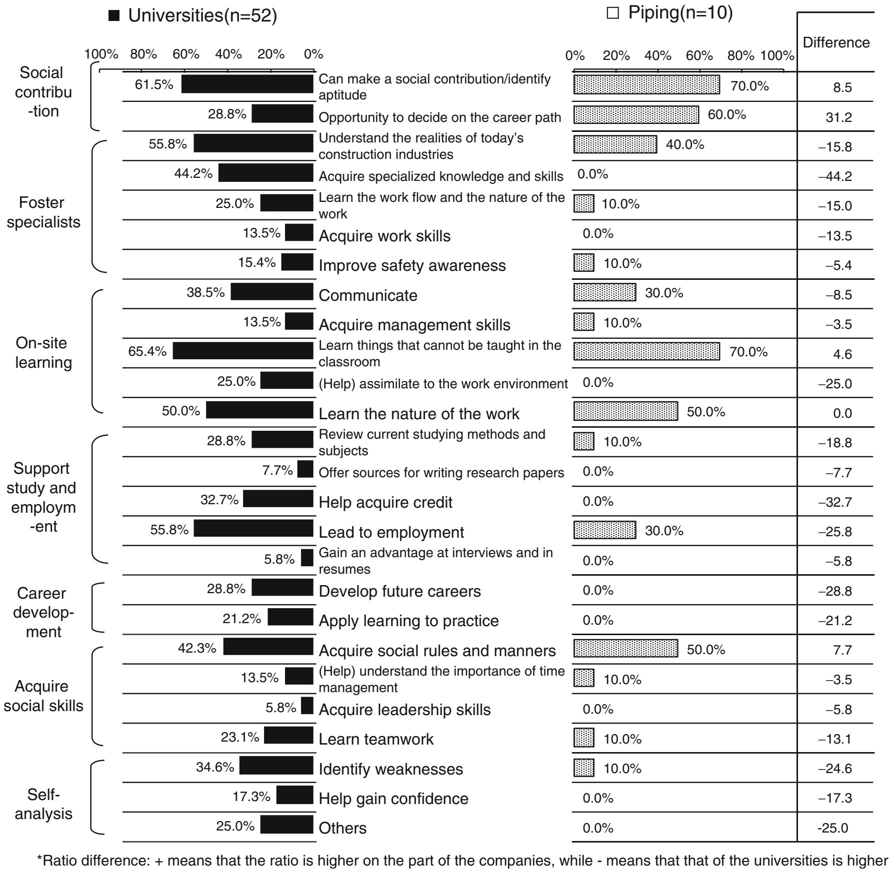


**Fig. 49.4** Comparison between universities and piping companies in their views on the significance and objectives of internships

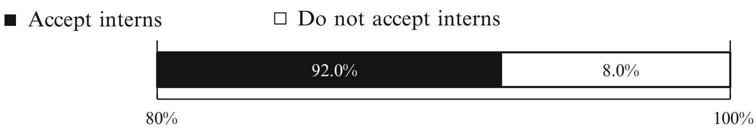


**Fig. 49.5** Acceptance of interns by general contractors (n = 25)

**Table 49.5** Educational and training institutions that offer internships at general contractors (%)

| (%) | Universities | Graduate schools | Technical high schools | Polytechnic college | Middle schools | Vocational schools | Junior colleges | Agricultural high schools | High schools | Technical junior colleges | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|
| General contractors (n = 21) | 85.7 | 33.3 | 23.8 | 14.3 | 4.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 19.0 |

**Table 49.6** Number of internship days spent at general contractors (%)

| (%) | 1–3 days | 4–7 days | 8–14 days | 15–21 days | 22−28 days | 29−35 days | 36−42 days | 44−49 days | 50−56 days |
|---|---|---|---|---|---|---|---|---|---|
| General contractors (n = 52) | 19.0 | 19.0 | 57.1 | 14.3 | 4.8 | 0.0 | 0.0 | 0.0 | 0.0 |

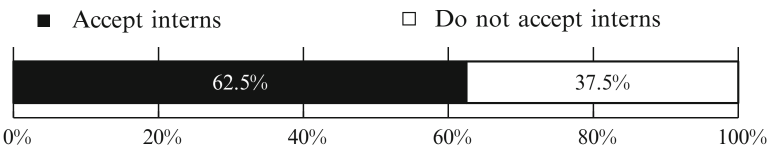


**Fig. 49.6** Acceptance of interns by subcontractors (n = 96)

### *49.5.4 The Impact of Internships at General Contractors and Subcontractors*

This section discusses the impact of internships at general contractors and subcontractors.

(a) The impact of internships at general contractors
In terms of the impact of internships, among general contractors that accept interns, the highest number of companies (28.6 %) responded that “Accepting interns helped invigorate the company” and “The internship program led to the direct hire of graduates.” However, only 9.5 % of the companies said, “The internship program had no impact on the company,” which is a low figure when considering the number of companies responding (Fig. 49.7). In terms of the reasons that directly led to the company’s hire of students, over 60 % answered that “The company was able to identify the aptitude of those graduates that would be useful once they entered the company,” which is a large figure when considering the number of companies responding (Fig. 49.8).

(b) The impact of internships at subcontractors
In terms of the impact of internships, among the subcontractors that accept interns, the highest number of companies, or 38.5 %, responded “Accepting interns helped invigorate the company.” This was followed by response, “The internship program led to the direct hire of graduates” (31.6 %), around the same figure compared to the overall mean (30.8 %) for all companies (Fig. 49.9). In terms of the reasons that directly led to the company’s hire of students, 46.7 % answered that via internships, “The company was able to identify the aptitude of the graduates that would be useful once they entered the company” (compared to the mean among all companies of 45.8 %) and 45.8 % answered, “The company was able to hire the graduates they wanted” (compared to the mean among all companies of 40.0 %). These figures were a somewhat higher when compared to those that account for all companies (Fig. 49.10).

**Table 49.7** Educational and training institutions that offer internships at subcontractors (%)

| (%) | Technical high schools | Universities | Vocational schools | Agricultural high schools | Polytechnic college | High schools | Graduate schools | Junior colleges | Middle schools | Technical junior colleges | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Subcontractors (n = 52) | 50.0 | 34.6 | 11.5 | 11.5 | 7.7 | 7.7 | 5.8 | 3.8 | 1.9 | 0.0 | 13.5 |

**Table 49.8** Number of internship days spent at subcontractors (%)

| (%) | 1–3 days | 4–7 days | 8–14 days | 15–21 days | 22−28 days | 29−35 days | 36−42 days | 44−49 days | 50−56 days |
|---|---|---|---|---|---|---|---|---|---|
| Subcontractors (n = 52) | 40.4 | 28.8 | 13.5 | 3.8 | 0.0 | 0.0 | 9.6 | 3.8 | 0.0 |

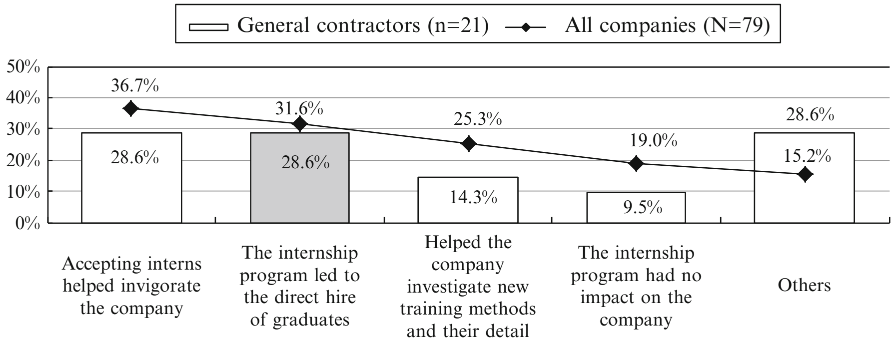


**Fig. 49.7** The impact of internships at general contractors

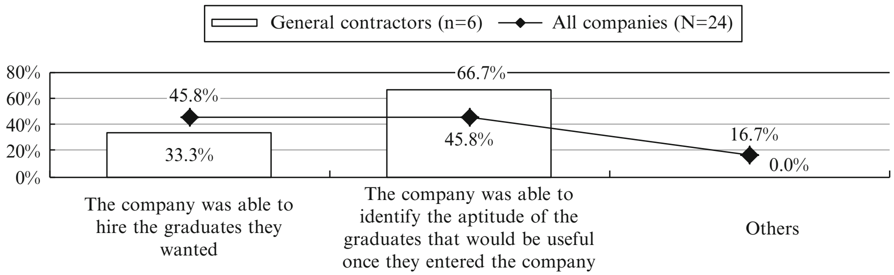


**Fig. 49.8** Reasons leading to direct hire at general contractors

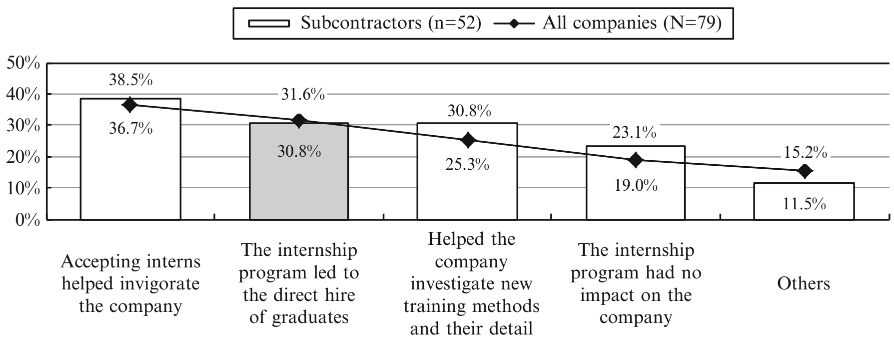


**Fig. 49.9** Reasons leading to direct hire at subcontractors

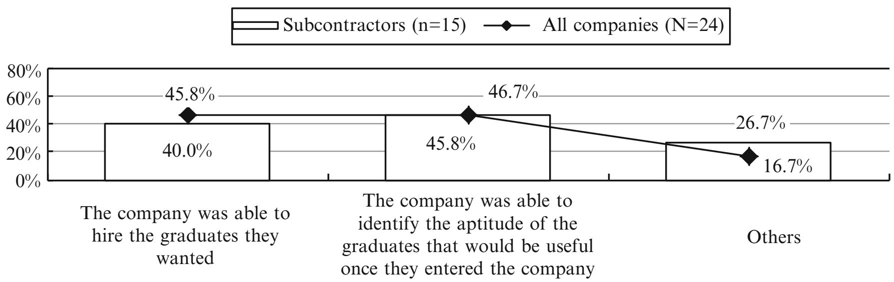


**Fig. 49.10** Reasons leading to direct hire at subcontractors

## 49.6 Summary

Among all companies, a sizable number responded that they “Accept interns” (56.8 %). In terms of the impact of the programs on companies that accept interns, the highest number of responses indicated that “Accepting interns helped invigorate the company” (36.7 %), confirming the advantages that the programs offer to companies. Meanwhile, among the companies that do not accept interns, the highest number of responses indicated, “There is no framework in place to accept interns” (44.9 %), followed by companies that answered, “There are constraints against accepting interns” (48.8 %). These responses reflect the fact that hindrances to accepting interns can be attributed to the companies themselves. As for general contractors, 92.0 % offer internships, indicating that almost all general contractors accept interns. In terms of educational institutions that dispatch students to internships, “Colleges” (85.7 %) accounted for the majority, followed by “Graduate schools” (33.3 %), indicating that many institutions of higher learning offer the programs. A total of 57.1 % of the internships are held over “8–14 day periods,” meaning that about 60 % of general contractors accept interns for 1–2 weeks. In contrast, fewer subcontractors accept interns at 62.5 % compared to general contractors. In terms of educational institutions that dispatch students to internships, “Technical high schools” (50.0 %) accounted for the majority, followed by “Colleges” (34.6 %). A total of 40.1 % of the internships are held over the period of “1–3 days” (40.1 %) followed by “About 4–7 days” (28.8 %), reflecting the fact that many of the students attend technical high schools, thereby shortening the internship period. In terms of educational institutions that dispatch students to internship programs at general contractors, “Colleges,” “Juniors,” and “A period of about 8–14 days” accounted for the majority. In terms of the significance of internship programs, the companies answered that they could “Make a social contribution by helping the young determine their career paths and aptitudes,” and “Provide an opportunity that helps students determine their career paths.” In summary, the respondents espoused the viewpoint that they could contribute to society and education by accepting interns. In addition, by offering first-hand opportunities to “Understand the job,” the companies hope to promote a positive corporate image. In this regard, the companies consider internships to be an integral part of their operations, and many of them plan to continue offering the programs. In terms of educational institutions that dispatch students to internship programs at subcontractors, “Technical high schools,” “Sophomores,” and “A period of about 1–3 days” accounted for the most answers. In terms of the significance of internship programs, the companies answered that they could “Make a social contribution by helping the young determine their career paths and aptitudes,” and “Provide an opportunity that helps students determine their career paths.” The respondents espoused the viewpoint that they could play a part in society and education, as was also the case for universities. In addition, the companies embraced the objective of providing first-hand opportunities to “Help students learn things that cannot be taught in the classroom.” In particular, subcontractor tasks and operations tend to be divided due to specialization. As such, it is difficult for students to experience all types of jobs during a single internship. Nonetheless, the study found that internships offered students noteworthy opportunities to experience jobs through on-site tasks.

## 49.7 Conclusions

The previous study reported that while some companies offer internships with the objective of making a social contribution, their impact on employment was smaller than universities expect. This paper sought to comprehend the implementation of internships at universities with architecture departments, subcontractors, and some general contractors. It elucidated the relationship among them along with the pedagogical methods used in internships and their contents, and identified areas for improvement. The research was conducted to produce a set of fundamental documents that would help further promote future internship programs. It is our hope that the study will be used in determining the methods and contents of on-site human resources training in the construction industry in the future.

This research was led by the Working Group (chief investigator: MastoUrae) on the Education of Technicians in the Field of Construction and Production of the Subcommittee on the Study of the Future of Architectural Education of the Committee on Architectural Education of the Architectural Institute of Japan. It was funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) KAKENHI program ("Study on the Training of Construction Professionals through Internships," April 2011 to March 2014; research representative: Hitoshi Mihara).

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# Chapter 50
# Green Design of a Public Building in Shenzhen

**Cong Xiong, Yan Zhou, and Jian Liu**

**Abstract** The numerical simulation technology is widely used to predict the temperature, wind, sunshine and solar radiation distributions and energy-saving effects of green buildings in the design stage. How the computer software to aid the optimization design of the green building are discussed in this study, taking a public building in Shenzhen as example. The simulation results are used to evaluate whether the building design meet the national standards and regulatory requirements.

**Keywords** Software • Green building • Design • Simulation • Optimization

## 50.1 Introduction

With the development of computer hardware and software, the building design has entered into information age [3]. The traditional architectural design is a monomer design process, it cannot integrate various aspects of the architectural aesthetics, function, form, comfort, economy [5]. A survey shows that the total output value of the Chinese construction industry in 2010 achieved 9.5206 trillion Yuan, accounting for 23.9 % of gross domestic product, and it consumes nearly 30 % of the national energy [4]. In order to promote sustainability development of the construction industry, green building design and construction have become the inevitable trend.

The 12th Five-Year Plan of Shenzhen City stipulated that Shenzhen shall establish basic perfect government guidance, market-driven building energy-saving and

C. Xiong (✉) • Y. Zhou
College of Civil Engineering, Shenzhen University, Shenzhen 518060, China
e-mail: congealicy@126.com; 287541555@qq.com

J. Liu
Ecological Technology Institute of Construction Engineering, Shenzhen University, Shenzhen 518060, China
e-mail: liujian@szu.edu.cn

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**Table 50.1** General models and software for green building design

| Serial number | building model | Building energy simulation | Wind environment simulation | Sound environment simulation | Light environment simulation |
|---|---|---|---|---|---|
| 1 | Autodesk | BECS | PHOENICS | Cadna/A | Ecotect |
| 2 | Bentley | Dest | Fluent | | Radiance |
| 3 | Nemetschek Graphisoft | Epuest | Ventplus | | Lights cape |
| 4 | Gery Technology Dassaut | HASP | COMIST | | Sunshine |
| 5 | | Energy Plus | Natvent | | TArch |
| 6 | | ESP-r | CONTAMW | | |
| 7 | | DOE-2 | BREEZE | | |

standardized operation mechanism of green building development. Green building construction shall be fully promoted from the present demonstration projects, and construction scale shall be area development and not just single green building to create a comprehensive low carbon and ecological livable environment [7].

The Chinese Evaluation standard for green building (GB/T50378-2006) define green building as that the building can save resources (including saving land, saving energy, saving materials and water conservation) in the ultimate during the whole building life cycle, reduce pollution, provide healthy, comfortable, safe and efficient space, and make it harmonious coexistence with natural environment [2]. The evaluation standard for green building (GB/T50378-2006) stipulated the concrete requirements for building energy efficiency, indoor and outdoor wind environment, indoor and outdoor sound environment, lighting, solar radiation and sunshine [2]. For the public buildings, Chapter 5 of GB/T50378-2006 lists the requirements from the viewpoints of Section and the outdoor environment, energy saving and energy utilization, water saving and water resource, material saving and material resource utilization, indoor environment quality and operations management. For instance, Article 5.1.6 stipulates that the ground noise shall meet the provisions of the Environmental quality standard for noise (GB3096); Article 5.1.7 stipulates that the pedestrian speeds around the buildings shall be lower than 5 m/s, and shall not affect the comfort of outdoor activities and building ventilation; Article 5.2.1 gives the thermal performance index of retaining structure in line with national energy-saving standards for public buildings; Article 5.5.7 regulates that the architectural and structural designs shall consider natural ventilation measures; Article 5.5.11 regulates that the indoor day lighting coefficient of more than 75 % main function space of office buildings and hotels shall meet the requirement of the Standard for delighting design of buildings (GB/T50033). For residence buildings, Chapter 4 of GB/T50378-2006 also gives detailed provisions from six aspects same as the public buildings.

Because of the complex structure and the surrounding environment, the green building design cannot be accurately done by using traditional calculation method. Therefore, it is necessary to find a new computation method. In this study, computational fluid dynamics is used to simulate the parameters of the green building such as energy saving and environmental issues and optimize the green building design to meet the green building evaluation criteria (Table 50.1).

## 50.2 General Software for Green Building Design

### *50.2.1 Type of Computer Simulation*

Building information modeling (BIM) is an integration model which includes design, construction and management functions [6]. BIM can improve the accuracy, integrity, controllability and efficiency of architectural design, effectively solve the repeatability of the original architectural design and create three dimensional images of construction diagrams. The integration of green building design with BIM technology helps the designers to fully grasp the whole building data and information. Building Energy-saving simulation is usually done by the basic error control system (BECS) [11]. BECS can check the building energy efficiency whether to meet the standards or not, and create the building envelope thermal indicators to calculate the various forms of energy consumption of the building. When the results do not meet national standards, the building structure shall be adjusted. PHOENICS is a kind of ventilation software developed by CHAM UK, it is the world's first set of commercial software of computational fluid dynamics and calculation of heat transfer [9]. PHOENICS can simulate three-dimensional compressible and incompressible flow, and it can consider the influences of viscosity, density, and temperature changes. Cadna/software are usually to predict the environmental noise level. Cadna/A is an environmental noise calculation, evaluation and prediction software [8]. Cadna/A has passed the certification of the State Environmental Protection Administration. TArch sunshine simulation analysis program is often used to simulate the building sunshine state [10]. Autodesk Ecotect Analysis (Ecotect) software is used to predict the building radiation and lighting distribution [1]. Ecotect is assistance design software, and it has comprehensive analysis ability. Solar radiation is one of the important indicators to evaluating the indoor environment. Strong radiation will not only affect the heat change of the buildings, but also have adverse effects on human health. These building models and software can predict the building energy conservation, air environment, acoustic environment, light environment and solar radiation, optimize the green building design.

### *50.2.2 Green Building Simulation Process*

Green building simulation analysis is a continuous feedback design process. The green building design integration for using computer simulation software, The organic combination of the formation of human and computer, to ensure that the green building integrity and the degree of integration. Figure 50.1 is a cycle simulation of green building process. As can be seen in the figure, green building design and computer simulation is a continuous cycle, continuous feedback process.

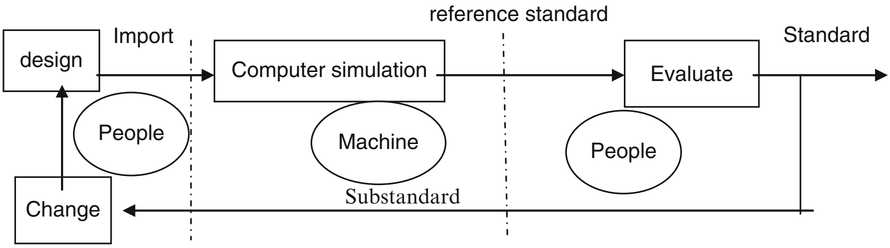


**Fig. 50.1** People an computer division map

**Fig. 50.2** Image of the building for case study

## 50.3 Green Design

### *50.3.1 Project Overview*

The case study project is located in Guanlan Town, Bao'an District, Shenzhen (latitude 22° 33 min, east longitude 114° 06 min). The land area is 147,595.15 m$^2$, total architectural area is about 300,000 m$^2$. The project consists of 10 high buildings, 1 eight story building and 56 low-rise residential buildings. The building for the case study is a comprehensive public building with leisure, entertainment and office purposes. The architectural area is about 6,000 m$^2$. The foundation works include high-strength prestressed precast concrete pipe piles and natural foundation. The building consists of three frame structure on the ground and one underground garbage. Part of the exterior wall of the case study building is glass curtain wall. Figure 50.2 shows the image of the building drawn by BIM.

**Table 50.2** Building envelope structure

| Structure | Materials |
|---|---|
| Flat roof deck | Reinforced concrete (40 mm thick) + extruded polystyrene board (35 mm thick) + cement mortar (20 mm thick) + clay ceramist concrete ($\rho = 1{,}600$, 50 mm thick) + Reinforced concrete (120 mm thick) + cement mortar (10 mm thick) |
| External wall | Cement mortar (25 mm thick) + Reinforced concrete (200 mm thick) + cement mortar (20 mm thick) |
| Floor | Cement mortar (20 mm thick) + Reinforced concrete (120 mm thick) + extruded polystyrene board (35 mm thick) + cement mortar (10 mm thick) |
| External window | Ordinary aluminum alloy window + low-E insulating glass |

## 50.3.2 Energy-Saving Simulation

BECS is used to simulate the energy consumption of the case study building. The external structure for computation is shown in Table 50.2.

The energy efficiency design standard of the public buildings in Shenzhen (SZJG29-2009) stipulates that the external envelope structure energy consumption of public building shall reduce by 50 % to ensure the indoor thermal comfort conditions. The energy consumption calculation results by BECS show that the construction of the Prescriptive indicators does not meet the requirements of SZJG29-2009. The performance indicators meet the requirements of SZJG29-2009. BECS energy simulation to extract data for the reference to the energy consumption of the building 113.09 kWh/m$^2$, design building energy consumption of 110.19 kWh/m$^2$, using the formula of energy-saving "(113.09*2-110.19)/(113.09*2) "to get the energy-saving rate was 65.6 %, greater than 50 %, to meet standards requirements of SZJG29-2009.

## 50.3.3 Wind Environment Simulation

### 50.3.3.1 Outdoor Wind Environment Simulation

The near-surface wind velocity, pressure and the direction are affected by the building shape, scale, position and topography. Shenzhen in the hot summer and warm eastern region, the summer in a dominant season, the local summer outdoor average wind speed of 1.5 m/s, maximum easterly wind direction is SE. Put the BIM model into the PHOENICS ventilation software, set of construction parameters to simulate and optimize.

Figure 50.3 shows the outdoor wind velocity distribution at 1.5 m above the ground calculated by PHOENICS. Figures 50.4 and 50.5 show the windward and leeward wind pressure distributions around the building in summer. The outdoor average wind velocity at the pedestrian height (1.5 m above the ground) is 1.3 m/s

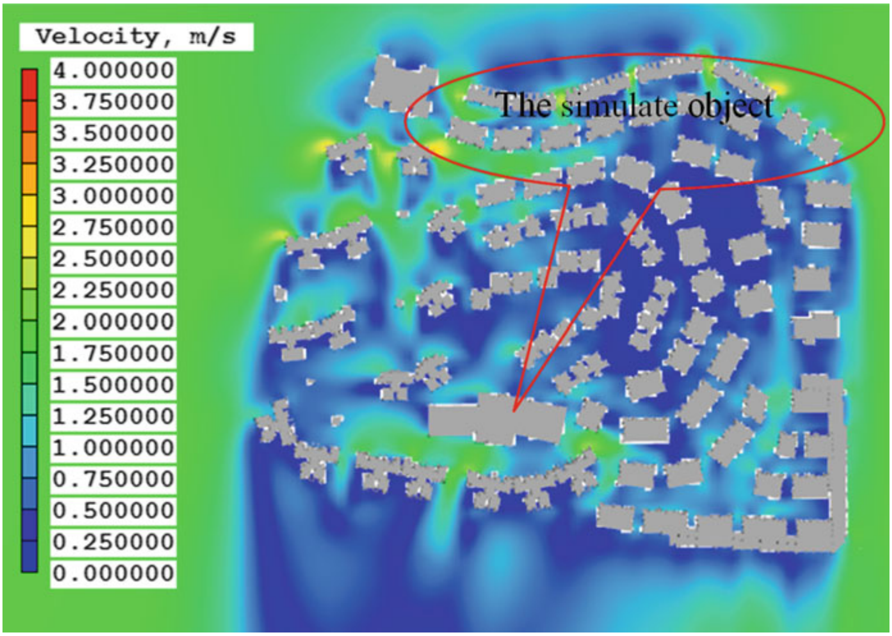


**Fig. 50.3** Outdoor wind velocity distribution at 1.5 m above the ground

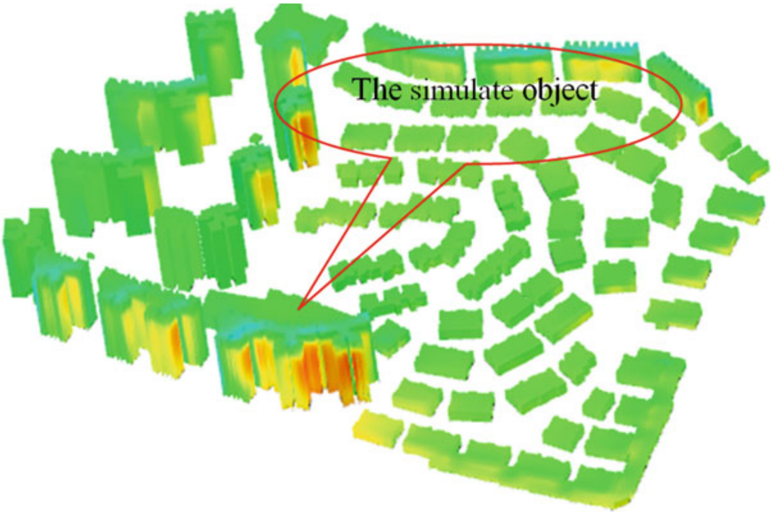


**Fig. 50.4** Building windward wind pressure distribution in summer

in summer. The wind velocity amplification factor is 0.81, and maximum velocity is less than 5 m/s. The air pressure difference in the windward and leeward of the building is 3 Pa. These parameters conform to the comfort and safety needs of outdoor activities in summer stipulated in the evaluation standard for green building.

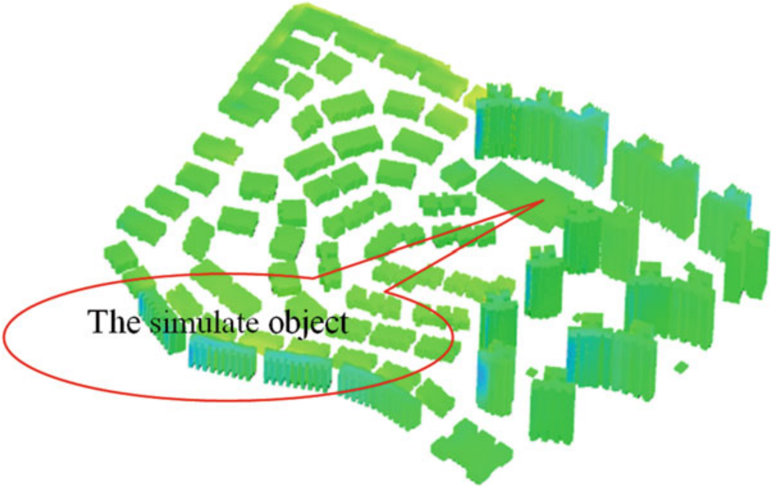


**Fig. 50.5** Building leeward wind pressure distribution in summer

#### 50.3.3.2 Indoor Air Environment Simulation

The wind differential pressure of the building windward and leeward will determine quality of indoor environment and indoor wind velocity. Air age is an important indicator of indoor environment evaluation. According to the calculated pressure difference of the outdoor wind environment, the conditions for indoor environment are set as (1) the open area of outer windows = 50 %, (2) the opening area of glass curtain wall = 10 %, (3) closing the doors. Figure 50.6 is the schematic of calculation model of indoor air environment. Figure 50.7 shows the indoor wind velocity distribution at first floor, and Fig. 50.8 shows the indoor air age distribution at first floor. The indoor air age of all rooms of the building are less than 180s, they belong to good indoor air quality according to the evaluation standard for green building.

### *50.3.4 Acoustic Environment Simulation*

The case study building is located in the residential area, the noise control shall be done according to 2 stage standard values stipulated in the Environmental quality standard for noise (GB3096-2008), that is, the maximum environmental noises shall exceed 60 dB (A) on the day and 50 dB (A) at night.

Figures 50.9 and 50.10 show the sound pressure level distributions of ground floor on the day and nighttime calculated by Cadna/A.

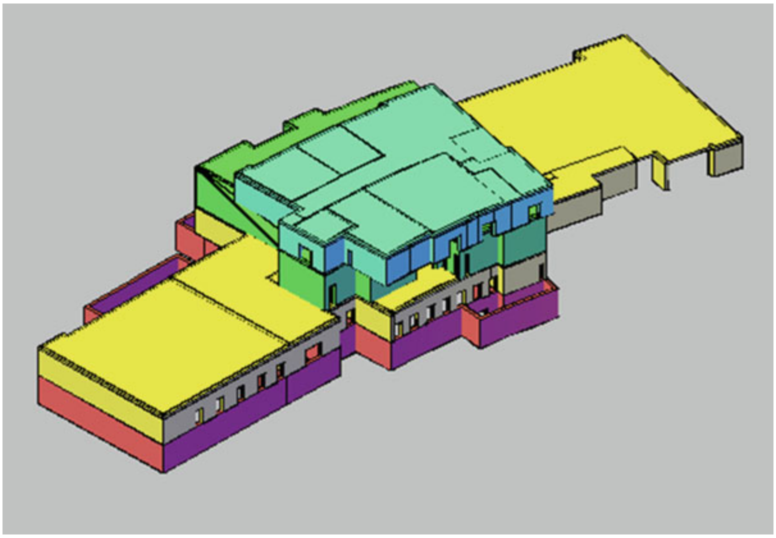

Fig. 50.6 Schematic of calculation model of indoor air environment

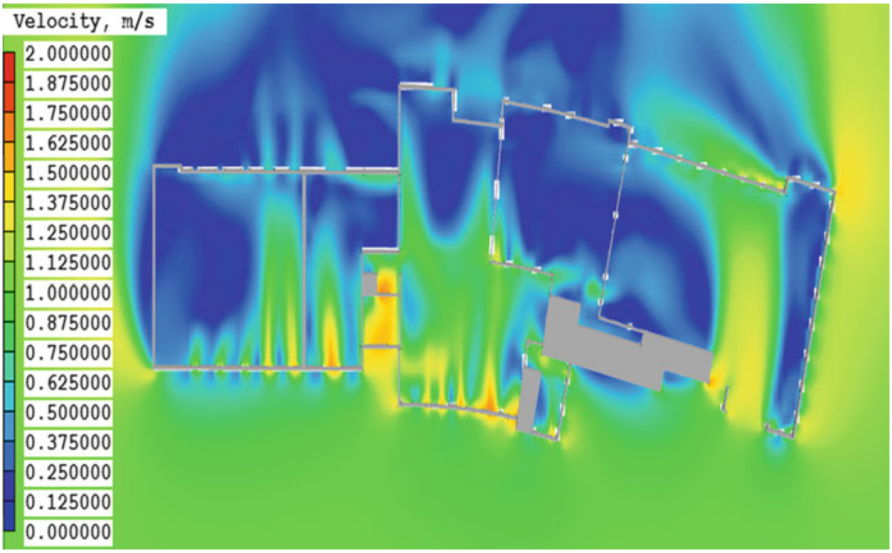


Fig. 50.7 Indoor wind velocity distribution at first floor

The outdoor noise of the building is less than 56B on the day, and less than 46 dB at night, which meet the requirements of GB3096-2008. The noise values in southwest side are relatively large, green belt separation shall be designed in the area to reduce the noise.

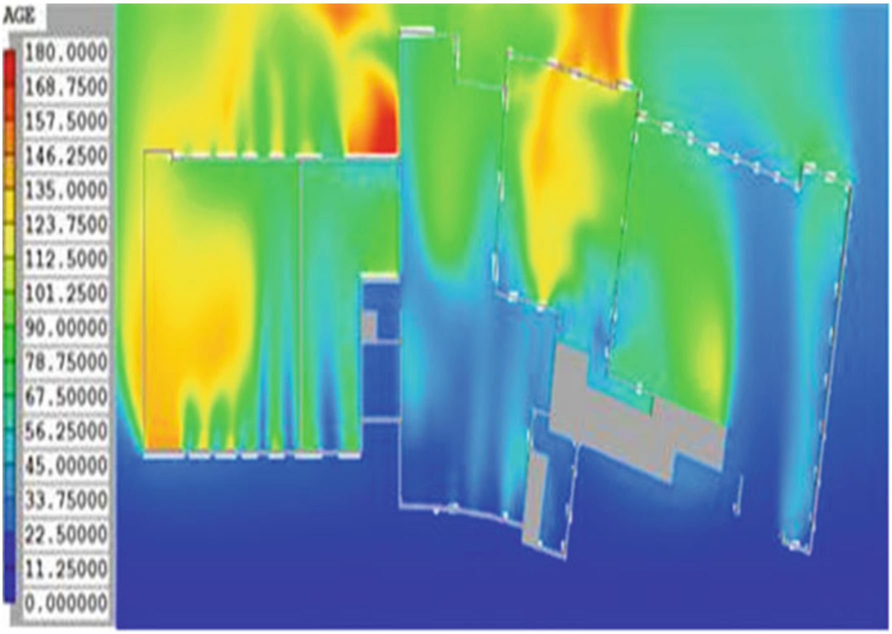


**Fig. 50.8** Indoor air age distribution at first floor

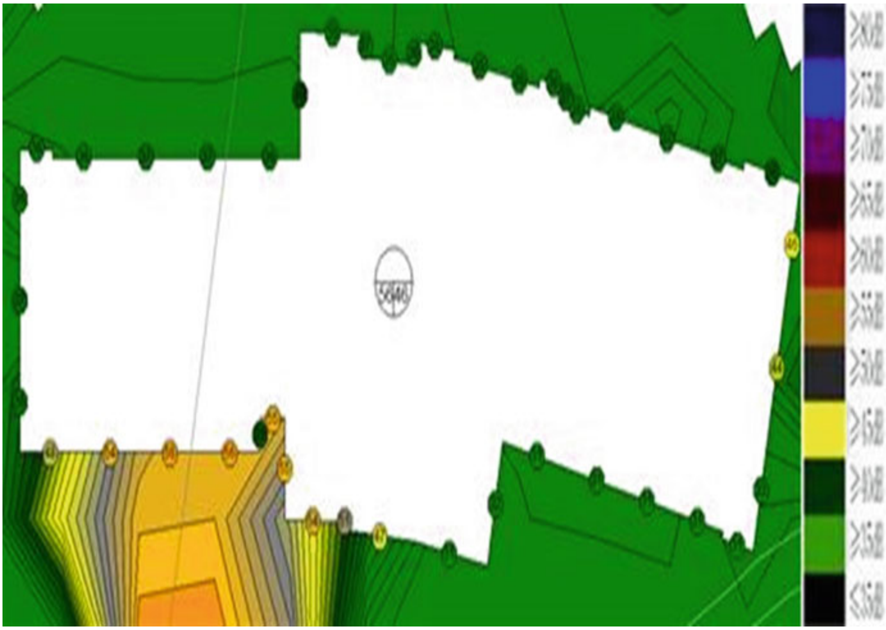

**Fig. 50.9** Sound pressure level distribution of ground floor on the day

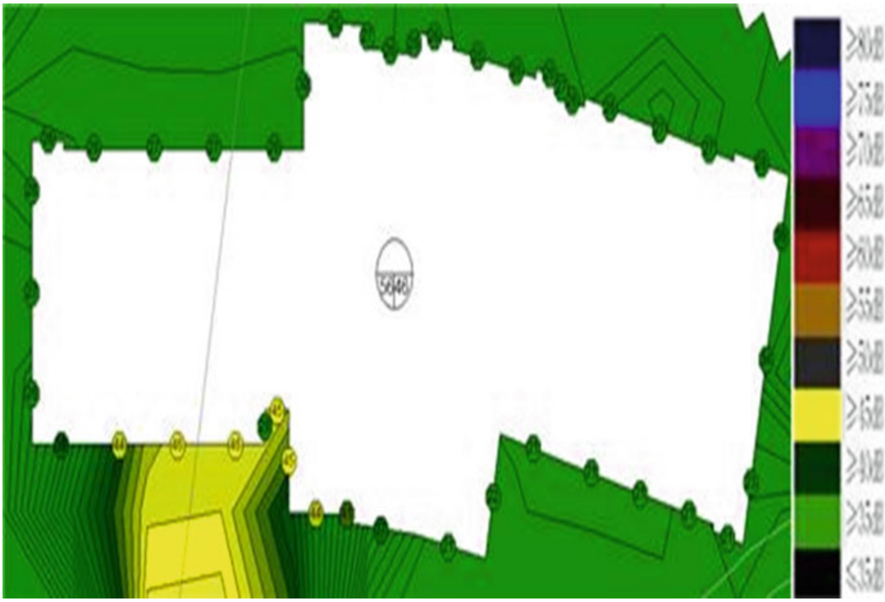

**Fig. 50.10** Sound pressure level distribution of ground floor at night

## *50.3.5 Light Environment Simulation*

### 50.3.5.1 Sunshine Simulation

The computational grid is 2 m, Three sunshine hours which determined by Code for Urban Residential Area Planning and Design (GBJ50180-93), are used as input. Figure 50.11 depicts the sunshine simulation results by TArch. The simulation results indicate that the most disadvantaged sunshine is at sill height, and there is no significant occlusion between the buildings. Therefore, the case study building does not affect the sunshine of the surrounding residential buildings.

### 50.3.5.2 Radiation Simulation

The calculation elevation is 0.8 m above the ground. Using ecological construction master simulation analysis of the building located at the height of 0.8 m. Figure 50.12 shows the radiation amount of the ground floor without shutters by Ecotect v5.5. Because part of the building adopts glass curtain walls, the radiation amounts are larger, and the shutters shall be installed on the part of the glass curtain walls. Figure 50.13 shows the radiation amount of the ground floor with shutters. It can be found from Figs. 50.12 to 50.13, the shutters can effectively improve the indoor thermal environment.

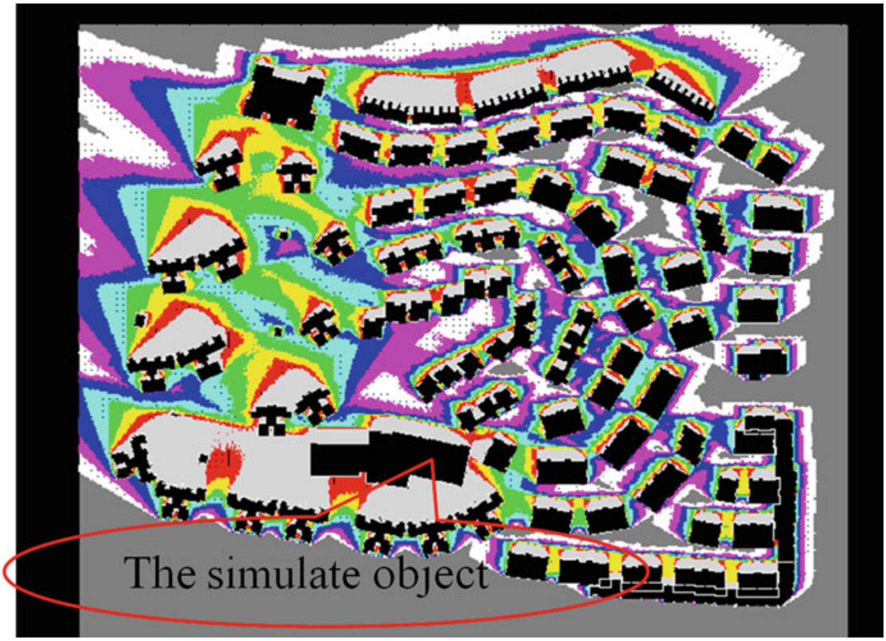


**Fig. 50.11** Sunshine simulation results

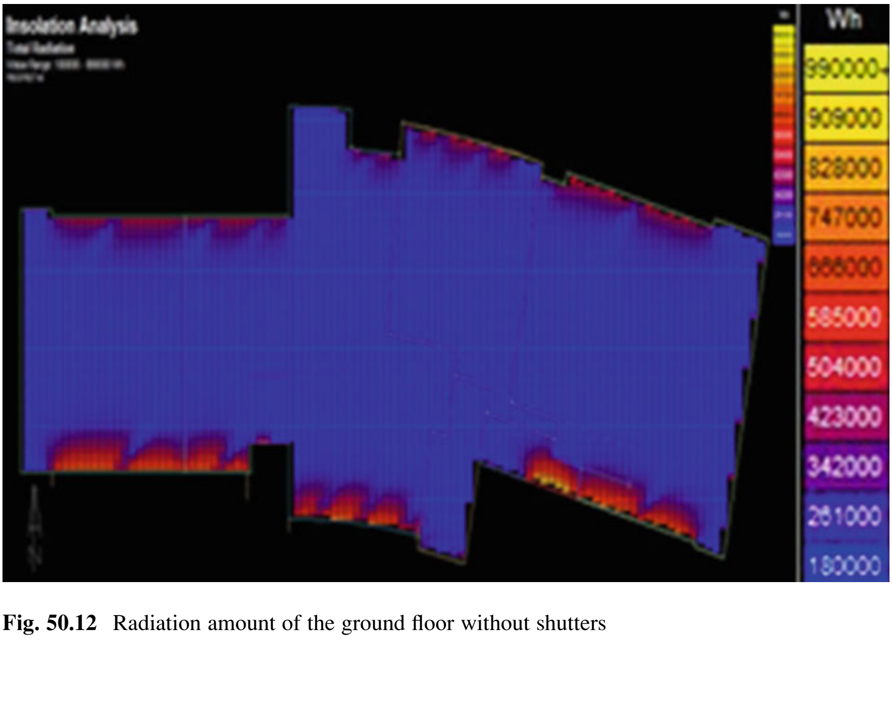


**Fig. 50.12** Radiation amount of the ground floor without shutters

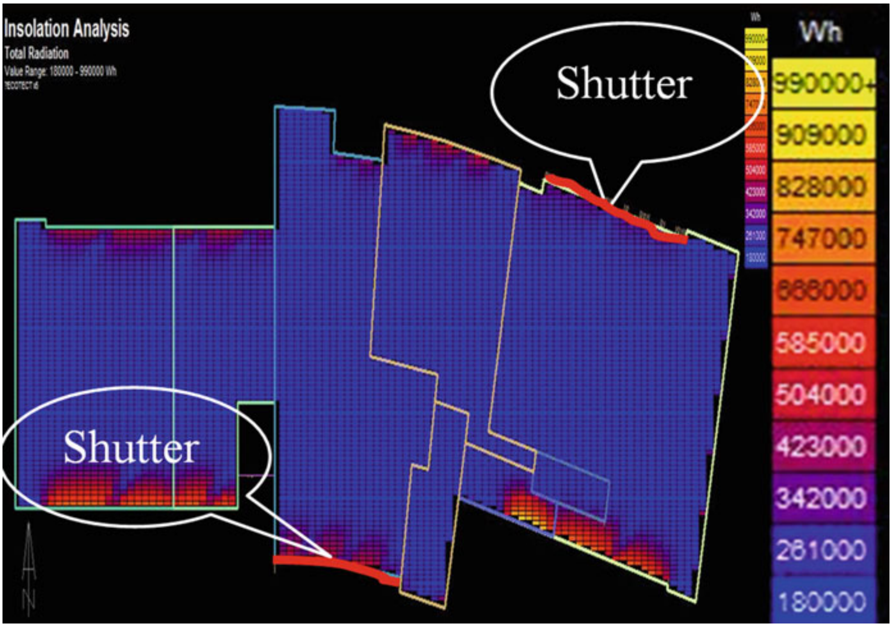


**Fig. 50.13** Radiation amount of the ground floor with shutters

#### 50.3.5.3 Daylight Simulation

Shenzhen is located in Class III light climate zone, the outdoor illumination of the natural presence sector is 5,000 (lx), translucent glass window factor is 0.8, wall reflection coefficient is 0.6, the ground reflection coefficient is 0.4, and the roof reflection coefficient is 0.8. The lighting analysis elevation is set at 0.8 m above the ground according to the Standard for daylight design of buildings (GB/T50033). Figure 50.14 shows the calculated daylight factor. The minimum daylight factor is 2.4 % in the function room, which meets the requirements of GB/T50033.

## 50.4 Conclusions

This paper takes a green building in Shenzhen as an example, discusses the design process by means the computer software. These software can provide the usable information such as the building energy efficiency and the quality of the built environment to the designers, and help the designers optimize the green building design.

Computer simulation is a continuous feedback process of green building information, is a combination of the overall process of building performance simulation and architectural design, to provide the basis for the entire green building by

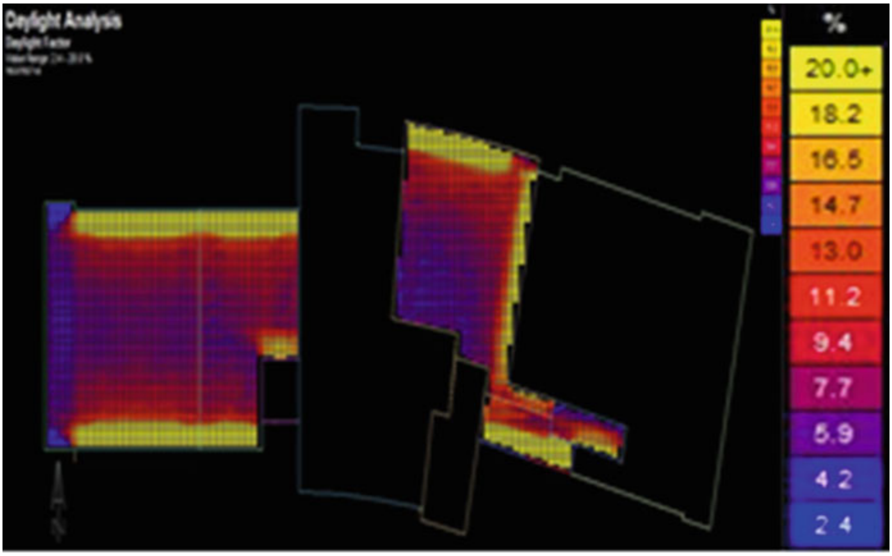


**Fig. 50.14** Daylight factors

computer simulation. Green building performance simulation not only enables us to get a visual show, but also lay a solid foundation for optimization of the design stage of the green building program. With the growing importance of building energy efficiency and the quality of the built environment, computer integrated simulation analysis will gradually become an important and indispensable tool for green building design process.

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# Chapter 51
# Evaluating the Effectiveness of Construction and Demolition Waste Management Strategies

**Zezhou Wu and Ann T.W. Yu**

**Abstract** Construction and demolition (C&D) waste management, as an important aspect of sustainable development, has become a hot research topic. Many researchers and organizations have been conducting related research in recent years, and have proposed several waste management strategies on both regional level and project level. However, what are the most effective strategies have not been investigated. To fill up this research gap, this study firstly conducted a thorough literature review to summarize the existing C&D waste management strategies. Then, a questionnaire survey was employed to evaluate the effectiveness of these strategies according to the practical experiences of construction practitioners. The results show that the practitioners regard the current C&D waste management is not applied well. And four most effective C&D waste management strategies are examined, namely "effective on-site management", "establishment of competitive recycling market", "issuance of incentive policies", and "reasonable and proper design".

**Keywords** Construction and demolition waste • Management strategies • Effectiveness evaluation

## 51.1 Introduction

The construction industry has been considered to be a primary contributor to the generation of waste. A huge amount of construction and demolition (C&D) waste is generated in different countries every year. It has been reported that the quantity of C&D waste generated from the urbanization and city renewal in Mainland China

Z. Wu (✉) • A.T.W. Yu
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, Hong Kong
e-mail: wuzezhou88@gmail.com; ann.yu@polyu.edu.hk

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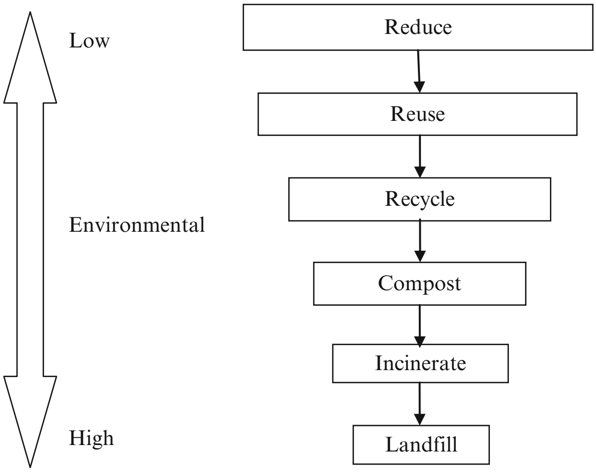
**Fig. 51.1** Waste disposal hierarchy [7]




represented more than 30 % of municipal solid waste [18]. In Hong Kong, the annual generation of C&D waste was 1,216,000 tons in 2011, which accounts for one quarter of total wastes [3]. If these wastes are dealt with improperly, damage will be cast to land, water and atmosphere. Thus, there is an urgent demand to deal with the C&D waste appropriately.

In order to give a guideline for minimizing C&D waste, Peng et al. [7] proposed a hierarchy model explaining the strategies for dealing with C&D waste, see Fig. 51.1. The model groups the C&D waste management strategies into six levels: reduce, reuse, recycle, compost, incinerate and landfill, impacting the environment from low to high. "Reduce" refers to avoiding generating waste at source. It is considered as the most efficient strategy for waste minimization. "Reuse" means directly moving wastes from one place to another as resources. "Recycle" is to change the wastes into other products after processing. These three strategies constitute the "3R principles" in circular economy theory, and should be considered as priorities when selecting waste disposal measures [7].

Based on the hierarchy model, many C&D waste management strategies have been proposed, for example waste disposal charging scheme, prefabrication, on-site and off-site sorting, selective demolition. These measures are all regarded effective on increasing the effectiveness of waste management. However, how well these measures work and which measures are regarded the most effective in practice are still unknown.

This research aims at identifying the existing C&D waste management strategies through a comprehensive literature review, investigating the perceptions of practitioners in both Mainland China and Hong Kong, and exploring which strategies are regarded the most effective from practice perspective.

## 51.2 Research Methodology

### *51.2.1 Identification of C&D Waste Management Strategies*

To identify the existing C&D waste management strategies, a literature review was conducted. Based on the previous literature, 14 existing C&D waste management strategies were identified. The sources of these measures are shown in Table 51.1.

### *51.2.2 Questionnaire Survey*

In order to evaluate the effectiveness of the C&D waste management strategies, a questionnaire survey was conducted in this study. During the questionnaire design, three brief interviews were conducted with professionals in the construction industry, to get more practical knowledge of C&D waste management strategies in industry. The main questions discussed in the interviews were: (1) do they pay attention to waste management during the construction or demolition process; (2) which strategy have they applied in their experiences; (3) which C&D waste management strategies are regarded effective based on their experiences and knowledge.

A questionnaire was subsequently designed, which consists of three main parts: general information, perception of C&D waste management and an evaluation of the effectiveness of C&D waste management strategies. In order to improve the quality of the questionnaire, a specialist was consulted on the structure and content of the questionnaire before distribution officially.

**Table 51.1** Identified C&D waste management strategies and sources

| No. | C&D waste management strategies | Sources |
|---|---|---|
| 1 | Reasonable and proper design | [9, 12] |
| 2 | Effective on-site management | [5, 9] |
| 3 | Implementation of on-site sorting | [10, 15] |
| 4 | Implementation of bar-code system | [2] |
| 5 | Education and training | [6] |
| 6 | Establishment of competitive market | [6] |
| 7 | Increase of disposal fee | [16, 17] |
| 8 | Advanced construction tools | [5] |
| 9 | Effective purchase management | [1] |
| 10 | Implementation of prefabrication | [4, 14] |
| 11 | Implementation of selective demolition | [8, 11] |
| 12 | Use of geographic information system (GIS) | [13] |
| 13 | Issuance of incentive polices | [6] |
| 14 | Publicity of the importance of C&D waste management | [6, 9] |

The questionnaires were distributed to a sample of professionals in different disciplines, which include architect, engineer, project/construction manager, quantity surveyor and site worker in two regions, including Mainland China and Hong Kong. The data collected was used to make a comparison between the C&D waste management strategies in these two regions. The questionnaires were distributed to Mainland China and Hong Kong in different versions. The simplified Chinese was used for professionals in Mainland China, and, traditional Chinese was used for respondents in Hong Kong. The two questionnaire versions are identical in content.

The questionnaires were distributed to 100 professionals through email, 70 copies in Mainland China and 30 copies in Hong Kong. Finally, 68 questionnaires were received. Among all these returned questionnaires, 4 were not properly completed, so the valid response rate is 64 %. Of these valid questionnaires, 11 questionnaires came from Hong Kong and 53 were from Mainland China.

### *51.2.3 Data Analysis*

In order to evaluate the relative ranking of the effectiveness of C&D waste management strategies, a five level scale (1-least effective, 3-neutral, 5-most effective) was used to indicate the judgment of the respondents on the effectiveness of the C&D waste management strategies based on their practical experiences. In terms of each strategy, the scores were converted into relative effectiveness indexes (REI) based on the Eq. (51.1).

$$\mathrm{REI} = \frac{\sum \mathrm{Vi}}{\mathrm{AN}} \tag{51.1}$$

where Vi is the value of the effectiveness given to each measures in response i; A is the highest score, in this study, $A = 5$; N the total number of responses; and REI is the relative important index, $0 \leq \mathrm{REI} \leq 1.0$.

## 51.3 Results and Discussion

### *51.3.1 Profile of the Respondents*

Figures 51.2, 51.3, 51.4, and 51.5 indicate the profile of the sample. Figure 51.2 shows the basic information of respondents. Nearly half of the respondents (44 %) are project/construction managers. Figure 51.3 shows that 62 % of the respondents have more than 5-year experience in construction industry. Figure 51.4 shows almost half of the firms (48 %) involve in residential projects. Figure 51.5 shows that nearly 3/4 of the respondents firms (73 %) handled the contract price of projects worth over 50 million. Similarly, nearly 3/4 of the respondents firms (73 %) have more than 50 employees.

Fig. 51.2 Roles in construction

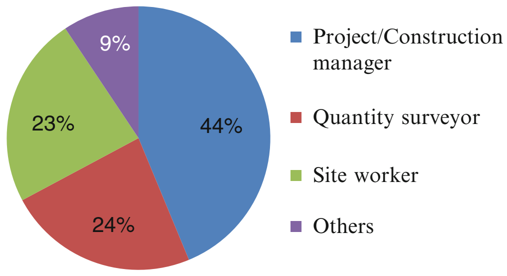



Fig. 51.3 Working duration

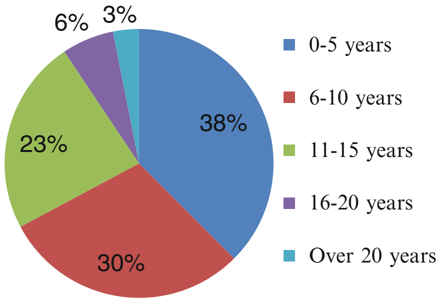



Fig. 51.4 Project types

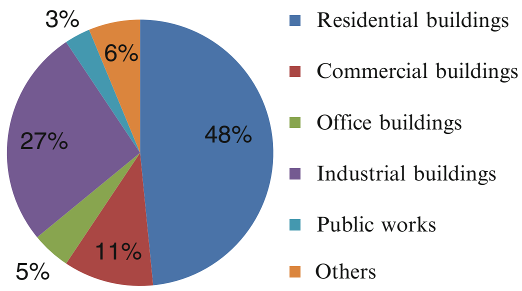



Fig. 51.5 Contract sum

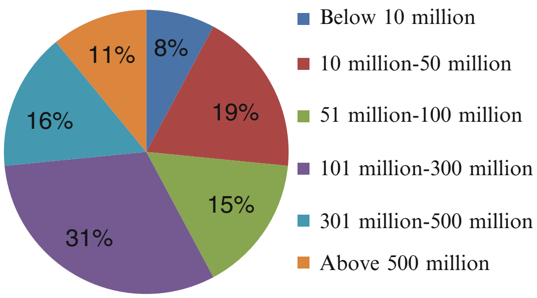


**Table 51.2** Willingness of C&D waste management

| | Designer | Contactor | Client | Government |
|---|---|---|---|---|
| Mean value | 2.69 | 3.06 | 3.58 | 4.15 |

**Table 51.3** C&D waste management levels from practitioners' perspective

| | Good | Neutral | Poor | Total |
|---|---|---|---|---|
| Mainland China | 0 | 15 (28 %) | 38 (72 %) | 53 |
| Hong Kong | 0 | 3 (27 %) | 8 (73 %) | 11 |

Based on the profile of respondents, it is clear that these respondents themselves have rich experience in construction industry and serve for large companies.

### *51.3.2 Perception of C&D Waste Management Strategies*

Table 51.2 illustrates the waste management motivation of different stakeholders. The higher mean value, the more willingness to minimize C&D waste. The utmost mean value is 5, which means a stakeholder has the strongest willing to manage C&D waste. From Table 51.2, it can be seen that the government is the most willing stakeholder to implement C&D waste management. This is because the government has a higher level of environmental awareness; they must consider the sustainability of regional development. From the perspective of economy, the contactor has neutral willingness of implementing C&D waste management, because managing C&D waste would increase construction costs. The designers care little about C&D waste management, because whether saving or wasting materials have little influence on their benefits.

Table 51.3 describes the current level of C&D waste management from practitioners' perspectives. It is obvious that no respondent in both Mainland China and Hong Kong regards the current C&D waste management level is good. Coincidently, the views of C&D waste management level are similar in Mainland China and Hong Kong: nearly three quarters of respondents in these two regions considered the current C&D waste management was poorly implemented.

### *51.3.3 Evaluating the Effectiveness of C&D Waste Management Strategies*

Based on the findings of previous publications, 14C&D waste management strategies were identified and listed for evaluation. The ranking of the evaluation result is shown in Table 51.4. Overall, the 14 identified measures were all regarded useful. Even the last one of the ranking got a REI of 0.58, which means it is also considered effective. The highest ranked measure is "effective on-site management". Through effective on-site management, the materials can be arranged and used properly. "Establishment of competitive recycling market" is reckoned as the second effective measure. This is more related to the economic consideration. The recycled

**Table 51.4** Evaluation of C&D waste management strategies

| C&D waste management strategies | REI | Ranking |
|---|---|---|
| Effective on-site management | 0.85 | 1 |
| Establishment of competitive recycling market | 0.77 | 2 |
| Issuance of incentive policies | 0.76 | 3 |
| Reasonable and proper design | 0.76 | 3 |
| Implementation of on-site sorting | 0.74 | 5 |
| Implementation of prefabrication | 0.74 | 5 |
| Education and training | 0.74 | 5 |
| Advanced construction tools | 0.71 | 8 |
| Effective purchase management | 0.70 | 9 |
| Increase of disposal fee | 0.70 | 9 |
| Publicity of the importance of C&D waste management | 0.69 | 11 |
| Implementation of selective demolition | 0.67 | 12 |
| Implementation of bar-code system | 0.60 | 13 |
| Use of geographic information system (GIS) | 0.58 | 14 |

materials should have promising beneficial potential, and then the contractors have the interest to spend labor and money for recycling.

It is interesting to find out that "issuance of incentive policies" is more effective than "increase disposal fee". This may be due to the stakeholders concern more about what they will get than what they will lose. "Reasonable and proper design" is considered as a good way to reduce waste at source. According the disposal hierarchy model, it is a measure of the most recommended strategy. "Implementation of on-site sorting" helps to avoid mixed pollution among materials, and gain benefits from selling valuable wasted materials. "Implementation of prefabrication" can reduce the production of unavoidable surplus materials on site, and now has got mutual application in some developed countries or regions.

Besides above-mentioned management strategies, "education and training" is also important for waste minimization. Because in real cases, a great deal of wastes generated due of the unawareness of environment. Also, advanced materials tools can help construction workers work more efficiently with less waste. "Implementation of bar-code system" and "use of geographic information system (GIS)" are less effective compared with other measures. This, to some extent, may result from the fact that they are not applied widely in construction industry.

## 51.4 Conclusions

As construction industry is one of the primary polluters to the environment, the management of C&D waste is an important issue. Many C&D waste management strategies have been proposed and implemented in the industry. This paper has identified the main 14C&D waste management strategies in literature, investigated the current perception of practitioners, and examined the effectiveness of the identified measures.

From the questionnaire survey, the results show that the government is the most desired stakeholder to implement waste management strategies in construction industry. The level of C&D waste management is regarded not qualified in both Mainland China and Hong Kong. Four most effective C&D waste management strategies are examined, they are “effective on-site management”, “establishment of competitive recycling market”, “issuance of incentive policies”, and “reasonable and proper design” respectively.

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# Chapter 52
# Estimating the Amount of Building-Related Construction and Demolition Waste in China

**Weisheng Lu**

**Abstract** With the deepening of the economic reform in China, a large volume of construction activities, which in turn will lead to a huge amount of building-related construction and demolition (C&D) waste when new structures are built and when existing structures are renovated or demolished. However, it is an enigma why such statistics of waste generation are absent from the literature in spite of their importance to C&D waste management. This paper aims at estimating the amount of building-related C&D waste in China. It is estimated that approximately 2.19 billion tons of building-related C&D materials were generated in China during 2011even without considering the amount from renovation of existing buildings. It should be recognized that the estimates have some level of uncertainty, and the results should be viewed in that light.

**Keywords** Construction and demolition waste • Estimate • China

## 52.1 Introduction

The importance to estimate the amount of construction and demolition (C&D) waste has long been emphasized by policy makers, researchers, practitioners, and the like. For example, the U.S. Environmental Protection Agency (USEPA) [23] stated that one of the reasons to estimate the amount of C&D materials generated is to target materials for reduction, reuse, and recovery as part of its Resource Conservation Challenge, which is a national effort to conserve natural resources and energy by managing materials more efficiently. This resonates with Lu et al. [13] who asserted that waste generation rate is one of the most useful variables

W. Lu (✉)
Department of Real Estate and Construction, The University of Hong Kong, Pokfulam, Hong Kong
e-mail: wilsonlu@hku.hk

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that lies at the core of many efforts for understanding waste management (WM) in the construction sector. The cliché that 'you cannot improve what you cannot measure' offers a rationale for the research conducted to estimate the amount of C&D waste. Likewise, Li et al. [11] emphasized that the information of C&D waste generation is a prerequisite to developing appropriate solutions for managing waste.

For some regions where data of C&D waste have been collected and released in a systematic way, estimation of waste generation is unnecessary; published statistics clearly tell the overall quantity of waste generation in the regions. For example, Eurostat [7] reported that the generation of construction waste in EU-27 countries reached 857.16 million tons as of 1 January 2010. The Department for Environment Food & Rural Affairs (Defra) [6] in the UK reported that total construction waste generated in 2010 in England was 77.38 million tons. In Hong Kong, the latest figures show that solid waste ending up at landfills reached 13,458 tons per day (tpd) in 2011, of which 25 % is construction waste (HKEPD 2012). Australian Bureau of Statistics (ABS) also started to report the total C&D waste generation. The Year Book Australia [1] shows that total construction waste generation was 5,577,200 tons in 2009.

Estimation of C&D waste generation has long been due in China. Researchers in the country still cite an outdated approximate waste generation rate of 500–600 ton per 10,000 $m^2$ provided by Lu [12] 10 years ago, who, without describing the study's methodology but based on a rule-of-thumb [13]. Guo [9] reported that waste generated is around 100 million tons from new construction, and 500 million tons from demolition. There are other estimates, which vary considerably from one estimator to another. The biggest problem is that most of them point to similar sources without proper substantiation. No statistics have been officially published, despite that *Administration of Urban Construction Garbage* was promulgated in 2005 and the Ministry of Housing and Urban-rural Development (MOHURD) (formerly the Ministry of Construction) has required collection of national-wide C&D waste data recently.

The aim of this research is to estimate the C&D waste generation in China. The estimate can be used to raise people's awareness of WM, and to set up a baseline against which the effectiveness of future WM initiatives can be benchmarked. Owing to the erratic data availability, in particular the data for public work projects, such as roads, railways, bridges, utilities, piers, and dams, this research focuses on building-related C&D waste only. The rest of the paper is structured in four sections. Section 52.2 is a literature review of previous studies in estimating C&D waste, with a special consideration given to their methodologies. Section 52.3 describes the methodology. Analyses and results are reported in Sect. 52.4. The data sources are elaborated. When there is a lack of data, alternative approaches such as proxies are introduced. Conclusions are finally drawn in Sect. 52.5.

## 52.2 Literature Review

### *52.2.1 Estimation of Overall C&D Waste Generation Amount on a Regional Level*

Researchers have estimated overall C&D waste generation amount in various regions. For example, Cochran et al. [5] explored the accounting, generation, and composition of building-related C&D waste in Florida, US. Bergsdal et al. [2] projected C&D waste in Norway using a methodology that can be described in three steps. First is to estimate the amount of activities ($m^2$/year) of (1) construction, (2) renovation, and (3) demolition of buildings. Second step is to determine the specific waste generation factor (kg/$m^2$) for different fractions of solid waste related to each type of activity. The third step is to calculate the overall waste generation projection (tons/year) of materials outflow from building stock, on the basis of defined development scenarios. Other similar research mainly include Hsiao et al. [10], Reinhart et al. [18], Müller [14], Wang et al. [25], and so on.

Estimation of overall C&D waste generation amount on a regional level is neither rocket science, nor does it necessarily involve sophisticated mathematical models. One can estimate the overall amount by multiplying the total construction activities (e.g. construction, renovation, and demolition) with the average amounts of waste generated (e.g. waste generation rates) per activity. The challenge is the collation and analysis of robust and detailed data sources for construction activities, and average amounts of waste generated at job sites. Normally, national statistical data will cover parts, if not all, of construction activities, while the average amounts of waste generated per construction activity can be derived from the estimation of C&D waste generation on a project level.

### *52.2.2 Estimation of C&D Waste Generation on a Project Level*

Estimating C&D waste generation on a project level has also attracted considerable research (e.g. [3, 8, 20–22]). Lu et al. [13] conducted a comprehensive review of the research, in particular the waste generation rate (WGR) as an index for measuring C&D waste generation on a project level. In addition to its functionalities for benchmarking WM practices, raising people's awareness of WM, and assisting contractors in developing effective C&D WM strategies, WGR can also help estimate the overall C&D waste generation on a regional level. As aforementioned, one can estimate the overall amount by multiplying the total construction activities with the WGR.

Encouragingly, Chinese researchers have also started to investigate C&D waste generation on a project level, which is critical for the estimation of the amount of building-related C&D waste in China as a whole. For example, Lu et al. [13] investigated WGRs by conducting on-site waste sorting and weighing in four construction projects in Shenzhen, South China. The results revealed that WGRs ranged from 3.275 to 8.791 kg/m$^2$, and miscellaneous waste, timber for formwork and false work, and concrete were the three largest components amongst the generated waste [13]. Li et al. [11] developed a construction waste generation index model for quantifying waste generation per gross floor area based on mass balance principle for building construction in China. A newly constructed residential building in Shenzhen is used as case study to illustrate the model, and the waste generation of this case is 40.7 kg/m$^2$. Of that amount, concrete represented 43.5 %, timber formwork 18.7 %, steel bar 9.8 %, brick and block 8.4 %, mortar 8.4 % and tile 1.2 % [11]. The research opened a window through which the overall C&D waste generation amount can be possibly estimated.

## 52.3 Methods and Materials

In China, homes and non-residential buildings are sold by areas (m$^2$). They are mostly high-rise buildings, predominantly adopting composite structure of steel and concrete using cast in-situ technologies, although low waste technologies such as full steel structures, and prefabrication have been adopted by some landmark office buildings and exemplar residential buildings respectively. It is thus legitimate to combine the residential and non-residential buildings together in estimating the total amount of building-related C&D waste in China.

The methodology to estimate the amount of building-related C&D waste in China can be described in Eq. (52.1):

$$W_t = W_c + W_d + W_r \tag{52.1}$$

Where $W_c$ is the waste generated from construction of buildings, $W_d$ is the waste generated from demolition of buildings, and $W_r$ is the waste generated from renovation of buildings. $W_c$, $W_d$, and $W_r$ can be further elaborated in Eqs. (52.2), (52.3), and (52.4):

$$W_c = CV \times WGR_c \tag{52.2}$$

$$W_d = DV \times WGR_d \tag{52.3}$$

$$W_r = RV \times WGR_r \tag{52.4}$$

Where $CV$ is total building construction volume (m$^2$), and $WGR_c$ is waste generation rate (ton/m$^2$) in building construction; $DV$ is the total building demolition (m$^2$), and $WGR_d$ is waste generation rate (ton/m$^2$) in building demolition; $RV$ is total building renovation (m$^2$), and $WGR_r$ is waste generation rate (ton/m$^2$) in building renovation.

## 52.4 Analyses and Results

### *52.4.1* $W_c$, CV, *and* $WGR_c$

*China Statistical Yearbook on Construction* publishes annual construction data, including the total building construction floor areas (CFA) under construction, and CFA completed. The data over the past 5 years was retrieved and tabulated in Table 52.1. The fact that China publishes overall building CFA further confirms the above consideration to combine residential and non-residential buildings in estimating their waste generation. Resonating with the method adopted by Niu [16], the CFA under construction can be treated as CV.

In this study, the WGR pf 40.7 kg/m$^2$reported by Li et al. [11] is adopted as the $WGR_{c,}$ which is waste generation rate (kg/m$^2$) in building construction.

By using Eq. (52.2), the total waste generated from construction of buildings in 2011 is estimated as $W_c = CV \times WGR_c = 851{,}828.12 \times 10{,}000\ \text{m}^2 \times 40.7\ \text{kg/m}^2 = 346{,}694{,}044.84$ tons.

### *52.4.2* $W_d$, DV, *and* $WGR_d$

There are a large number of demolition activities in China. It is not only concerning environment or conservation, but also a social issue that has caused widespread discontent in China. A considerable portion of new buildings are built on demolished sites. Qiu [17], the Vice Minister of MOHURD, said that new buildings are demolished after 25–30 years even though the designated service life is 50 years or longer. This massive demolition causes severe problems relating to sustainability. However, no national or provincial statistical data on demolition has been released, except for Shanghai (Table 52.2).

By plotting the Shanghai data in Fig. 52.1, a strong correlation between overall demolition areas and building CFA completed is observed. Older buildings are demolished to make way for the new developments. Land cost is increasing sharply; land owners are under pressure to build quickly on demolition sites. Using curve fitting on the Shanghai data, a formula can be formed in Eq. (52.5)

**Table 52.1** Building CFA under construction, and CFA completed in China (2007–2011)

| Year | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Building CFA under construction (10,000 m$^2$) | 482,005.52 | 530,518.63 | 588,593.91 | 708,023.51 | 851,828.12 |
| Building CFA completed (10,000 m$^2$) | 203,992.68 | 223,592.02 | 245,401.64 | 277,450.22 | 316,429.28 |

Data source: NBS of China [15]

**Table 52.2** Building demolition, CFA under construction, and CFA completed in Shanghai (2007–2011)

| Year | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Overall demolition areas (10,000 $m^2$) | 825.00 | 1,028.53 | 927.63 | 585.70 | 333.83 |
| Building CFA under construction (10,000 $m^2$) | 16,040.50 | 18,055.00 | 19,069.90 | 22,996.81 | 24,885.79 |
| Building CFA completed (10,000 $m^2$) | 6,090.22 | 5,723.90 | 5,719.93 | 6,217.15 | 5,984.74 |

Data source: Shanghai Statistical Bureau [SSB] [19]

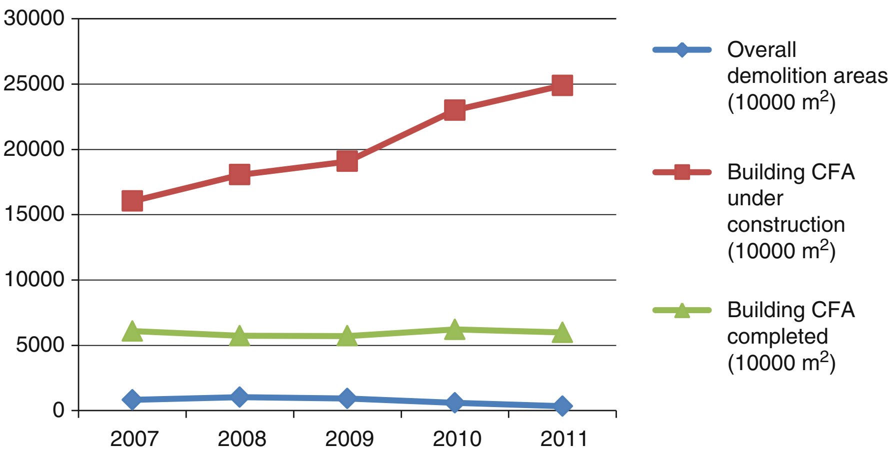


**Fig. 52.1** The relationship between CFA under construction, CFA completed, and overall demolition areas

to correlate the relationship between overall demolition areas and building CFA completed per year:

$$y = 0.3593x + 2.3178 \tag{52.5}$$

Where $y$ is the overall demolition areas in one region in a particular year, and $x$ is the building construction floor areas completed in the same period in the region. The goodness of fit is shown as an $R^2 = 0.9813$, indicating a very good fit between the two variables.

Equation (52.5) will then be used to estimate the demolition areas in China as a whole. Using the national-wide building CFA completed areas tabulated in Table 52.1, the estimated overall demolition areas in China from 2007 to 2011 can be illustrated in Table 52.3.

In an attempt to extrapolate waste generation rate in demolition ($WGR_d$), Zhu [26] summarized that there are two approaches: (a) demolition site investigations, and (b) based on material balance principle. Certainly, it is straightforward to

**Table 52.3** Estimated overall demolition areas in China (2007–2011)

| Year | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Estimated overall demolition areas (10,000 $m^2$) | 73,296.89 | 80,338.93 | 88,175.13 | 99,690.18 | 113,695.36 |

measure $WGR_d$ by weighing the total waste generated and dividing it with the GFA of the demolished building. However, no solid research has been reported to measure $WGR_d$ using this approach in China. Alternatively, one can estimate $WGR_d$ based on material balance principle, by assuming that materials used in a building will keep unchanged during its service life, and largely becoming waste after demolition. Zhu [26] cited a Normal Building Construction Brief Manual [24], in which the building materials reference tables specified the major materials such as steel, timber, and cement used in buildings. He converted the materials into weight and estimated that the $WGR_d$ for multi-stories masonry structure buildings, multi-stories building with shops, and multi-stories framework structure buildings are 1,274.9 kg/$m^2$, 1,211.1 kg/$m^2$, and 1,070.9 kg/$m^2$ respectively [26]. Another studies by Chen [4] estimated the waste generation rate on-site, reporting a $\mathrm{WGR_d}$ of 1,321.7 kg/$m^2$ in masonry structure, 1,755.1 kg/$m^2$ for steel concrete structure, 905.3 kg/$m^2$ for brick and wood structure, and 878.9 kg/$m^2$ for steel structure. It can be seen that the results from Zhu [26] and Chen [4] are consistent.

In order to reduce the variations, this study averages the $WGR$ in different types of buildings from the two sources of Zhu [26] and Chen [4], and adopts it as the $WGR_d$ for estimating the overall demolition waste in China. That is:

$$\begin{aligned} WGR_d &= (1{,}263.9 + 1{,}198.1 + 1{,}052.9 + 1{,}321.7 + 1{,}755.1 + 905.3 + 878.9)/7 \\ &= 1{,}196.57\ \mathrm{kg/m^2} \end{aligned}$$

By following Eq. (52.3), the overall demolition waste in whole China in 2011 is estimated as:

$$\begin{aligned} W_d = DV \times WGR_d &= 113{,}695.36 \times 10{,}000\ \mathrm{m^2} \times 1{,}196.57\ \mathrm{kg/m^2} \\ &= 1{,}360{,}444{,}569\ \text{tons} \end{aligned}$$

### *52.4.3* $\mathbf{W_r}$, **RV**, *and* $\mathbf{WGR_r}$

Renovation is defined by USEPA [23] as improvements and repairs to existing buildings. Renovating existing buildings in China is not much different from that reported in USEPA [23]; it consists of both C&D wastes as old materials are removed and new materials are added. One can use building CFA completed in Table 52.1 as a proxy to estimate renovation activities in new buildings. The challenge is to determine the annual renovation activities in existing buildings in China. Various sources reported that renovation takes place every 6–10 years in hotels, offices, and other non-residential buildings, and every 10 years in private residential buildings (e.g. Huang 2011). But it is extremely difficult to derive the data of renovation of

**Table 52.4** Estimated amount of building-related C&D waste generated in China in 2011

| Source | Construction | Demolition | Renovation | Totals |
|---|---|---|---|---|
| Tons | 429,321,372 | 1,360,444,569 | 395,536,600 | 2,185,302,541 |
| Percent (%) | 19.6 | 62.3 | 18.1 | 100 |

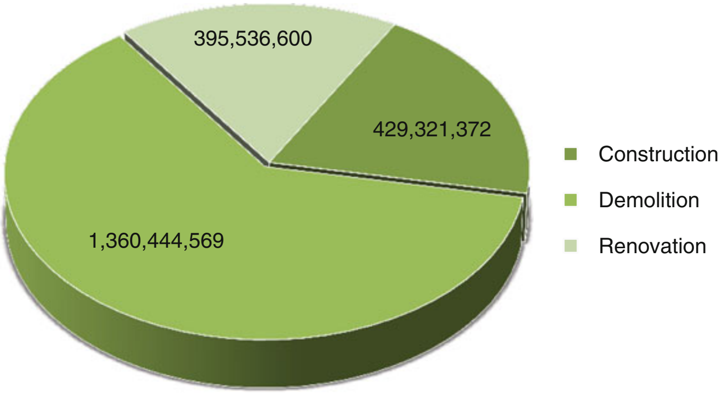


**Fig. 52.2** Contribution to the C&D waste stream by each activity in 2011

existing buildings in China. Thus this portion is not considered in this study. In this case, the renovation volume of new buildings is $RV_{2011} = 3{,}164{,}292{,}800\ m^2$.

In recent years, several local governments (e.g. Luoyang, and Tengzhou) have started to publish guideline on the calculation of construction waste generation in new construction, demolition, or renovation. Although rarely they have specified the data sources, they tend to adopt two rule-of-thumb estimates of renovation waste: 0.1 ton/$m^2$ for a home CFA smaller than 160 m, and 0.15 ton/$m^2$ for a home CFA larger than 161 $m^2$. The meaning value 0.125 t/$m^2$or 125 kg/$m^2$will be adopted as waste generation rate in building renovation ($WGR_r$) in this study. By following Eq. (52.4), the overall building renovation waste in whole China in 2011 is estimated as:

$$W_r = RV \times WGR_r = 3,164,292,800\ \mathrm{m}^2 \times 125\ \mathrm{kg/m}^2 = 395,536,600\ \text{ tons}.$$

## *52.4.4 Summary*

After careful selection and justifications of data sources from national statistics and typical waste generation during building construction, demolition, and renovation, it is estimated that approximately 2.19 billion tons of building-related C&D materials were generated in China during 2011 without considering the amount from renovation of existing buildings. Table 52.4 summarizes the estimates for C&D materials generation from the construction, demolition, and renovation of buildings in China in 2011. Figure 52.2 provides a breakdown, in percentage of total, of the three building sectors that generate C&D materials.

## 52.5 Conclusions

By adopting a methodology that utilizes national statistical data, and average amounts of waste generated at job sites, this study attempts to estimate the amount of building-related construction and demolition waste in China. It is estimated that approximately 2.19 billion tons of building-related C&D materials were generated in China during 2011 without counting the amount from renovation of existing buildings. Demolition is the largest sector in contributing to C&D waste generation in China, representing 62.3 % of the total waste generated in the year. Accurate measurements of C&D waste are critical, but generally speaking, efforts to improving the measurements are currently hampered by a general lack of data. Therefore, it should be recognized that the estimates have some level of uncertainty, and the results should be viewed in that light. Nevertheless, it is believed that the estimates contained in this paper reflect and are based on the best data that are currently available.

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# Chapter 53
# Use of z-Tree in Experimental Teaching in Real Estate Courses: Programming and Implementing the Housing Search Experiment

**Yang Zhang and Hong Zhang**

**Abstract** Based on more and more success achieved by experimental methods in economics, finance, and more recently the real estate market, this paper conveys how to use the experimental software z-Tree to facilitate experimental teaching in real estate economics. In order to demonstrate the practicality of using z-Tree in experimental teaching in real estate courses, we designed the housing search experiment, programmed the experiment using z-Tree according to the experimental design, and implemented this experiment by z-Tree in the laboratory. Our intention is to encourage other faculty members to utilize z-Tree so as to improve the effectiveness of teaching.

**Keywords** z-tree • Behavioral and experimental real estate • Experimental teaching methods • Housing search

## 53.1 Introduction

Education in real estate economics aims to provide students with the basic theories of real estate economics and teach students how to apply those basic theories in analyzing phenomena and problems encountered in real estate market. Due to the characteristics of the real estate assets, such as durability, heterogeneous, high transaction costs, immobility, dual attributes (investment and consumption) and so on, the behavior of people as between real estate markets and other markets is distinctive. Moreover, the vast majority of students lack experience in developing

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Y. Zhang (✉)
Department of Construction Management, Tsinghua University, Beijing, China
e-mail: zhang-yang10@mails.tsinghua.edu.cn

H. Zhang
Associate Professor, School of Economics and Management Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China
e-mail: highsky_zh@yahoo.com.cn

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and trading real estate. As a result, we often experience difficulties in teaching the abstract and complex contents of real estate economics using traditional teaching methods.

Multimedia teaching, case teaching, cognition practice, and market research are currently popular teaching methods in teaching real estate economics. However, these methods are hardly for students to participate and experience real process of real estate economics in person. Students always observe and learn real estate economics process as an onlooker and cannot understand it deeply.

To overcome the limitations of these teaching methods, experimental teaching methods were utilized recently. By incorporating experiments into real estate economics courses, students who have not participated in real estate practices can gain practical experience and better understand the economics process. There are two kinds of experiments: pen-and-paper experiment and computerized experiment. As technology has advanced in recent decades, more researchers are shifting away from pen-and-paper instruments in favor of computerized experiments. There are a number of potential advantages of using computerized experiments, including: reduced data entry effort for the researcher, less risk of data entry errors, greater flexibility in the layout and presentation of materials, and so on [1].

Z-Tree (Zurich Toolbox for Readymade Economic Experiments) [3] is one of the most popular experimental software both in studying and teaching. The experiment software z-Tree was developed at the University of Zurich. Z-Tree is specially designed to enable the conducting of experiments without much prior experience. It proved to be extremely easy to use for even a relatively inexperienced designer. The software is stable and allows programming almost any kind of experiment in a short period of time. It is free to download and use for both teaching and research purposes.

Although z-Tree has been used in the education of finance, market, political, and accounting, no colleges or universities to our knowledge are currently utilizing experimental methods and the z-Tree in teaching real estate courses. As far as experimental real estate is concerned, only a fraction of published or working papers [4–6] on experimental real estate can be found.

The purpose of this paper is to present our practice and experience using z-Tree to teach real estate economics and encourage others to follow suit and provide the basis for future exploration in this instructional method. To our knowledge, this is one of the earliest attempts to use the z-Tree in the experimental teaching of real estate economics.

## 53.2 Housing Search Experiment

### *53.2.1 Hypothesis and Basic Data*

We hypothesized that all houses in the experimental market had met with the buyer's basic requirements. All attributes of the houses were the same except attribute A and attribute B. Attributes A and B may represent the house's story, age, or any other attribute. The quality of attributes A and B was equally divided into a range of ten levels from 0 to 1. We relabeled attributes A and B using integers 1–10.

### 53.2.2 Design of the Experiment

Based on the experimental economics methods and the features of housing search, we designed the experiment, as shown in Table 53.1.

## 53.3 Programming the Experiment with z-Tree

A complete z-Tree program normally includes five areas of content: treatment, stage, screen layout, box, and items. Treatment contains stages, stage contains screen layout, screen layout contains boxes, and box contain the items.

### 53.3.1 Treatment

The treatment is represented by a tree structure called the stage tree. A treatment is constructed as a sequence of stages. Before we started constructing the stages, we set up some parameters for the treatment. In the background, we entered the number of subjects, the number of groups, the number of periods, and how points earned are translated into the local currency. We opened this dialog either by double clicking the BACKGROUND element in the stage tree or by first selecting this line and then choosing 'Info...' from the Treatment menu [2]. The following dialog appears in Fig. 53.1.

We set the number of subjects to 4 and the number of groups to 1. We had no repetition and therefore we set the number of paying periods (# paying periods) to 1. Because our experiment was designed for teaching, we used credits instead of money to incentive the students. Other blanks were all filled in by entering the number zero.

### 53.3.2 Stages in the Experiment

In our experiment, we designed four stages, as shown in Fig. 53.2. Each stage is designed for one broker. Therefore the structure and contents of the four stages are similar.

### 53.3.3 Screen Layout

The screen layout for students is illustrated in Fig. 53.3.

The screen layout consists of five areas. The upper area is the period time display area. Here, subjects can see the remaining time of the current period. Two areas on

**Table 53.1** Design of housing search experiment

| Content of experiment | | | Definition of the content | Attributes | Unit | Rules of value setting | Value |
|---|---|---|---|---|---|---|---|
| Market structure | Objects | Buyer | Person that purchases and searches houses | Number | Person | At least one buyer in each period, otherwise the search cannot occur | 1 |
| | | | | Basic requirements | – | Play by computer | – |
| | | Broker | Person that recommends houses to buyers | Number | Person | (1) At least one broker, otherwise no broker in the market; (2) at most, six broker, because one buyer cannot search with too many brokers meanwhile | 4 |
| | | | | Basic requirements | – | Play by students | – |
| | Subjects | House | Houses which can be recommended by brokers | Number | Suit | One buyer can only buy one house | 1 |
| Rule of search | Information | | Buyer response to recommended houses | Content of response | – | Price, levels of attributes A and B of the current most satisfactory house | – |
| | Search institution | | The process of searching houses in the market | Search method | – | Multi-attribute Reverse Auction | – |
| | | | | Rules for stopping searching | – | Searching will continue until the buyer is satisfied or the period time is over-they will buy if no new house can replaces the recommended option for 60 s | – |
| | Experimental Money | | Experimental currency | Type | Point | Consistent with the real housing market | – |

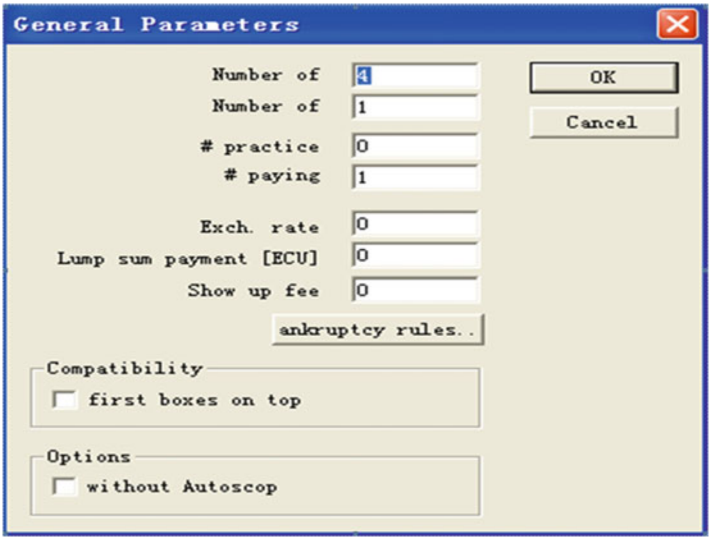



**Fig. 53.1** General parameters of the treatment

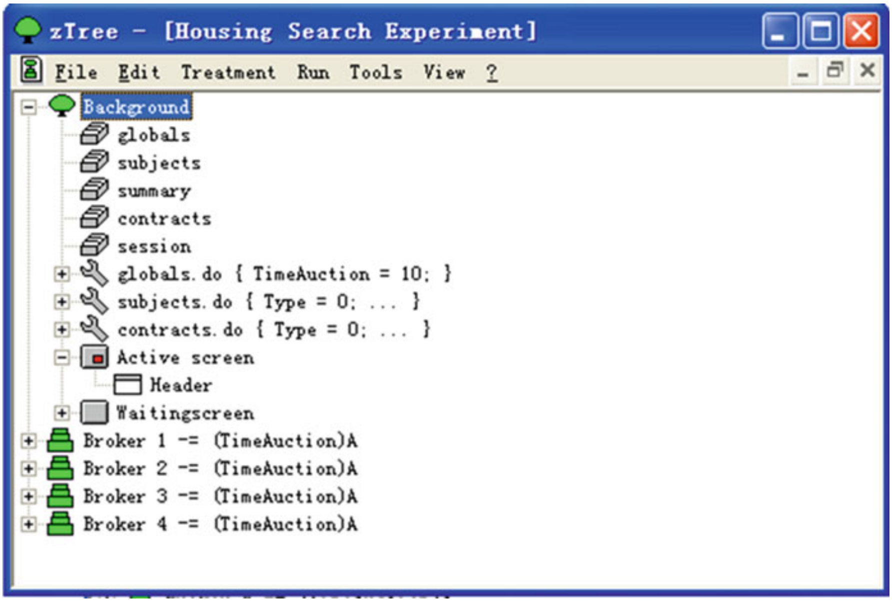



**Fig. 53.2** Stages of experiment

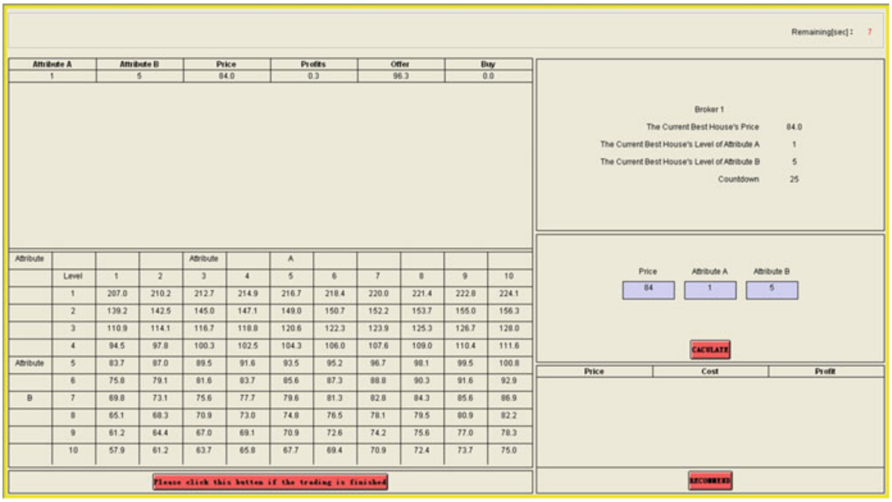



**Fig. 53.3** Screen layout of experiment

the middle and lower right hand sides are the recommending areas. Subjects key in the house price, the levels of attribute A and B into the text areas which are entitled "Price", "A", and "B" separately. Then the subjects can calculate their earnings by clicking the "CALCULATE" button and recommend a house by clicking the "RECOMMEND" button. The price and attribute information of the recommended house will be listed in the upper left hand side areas and sorted in chronological order. When the recommended house is the current best house, the house information and the name of the broker who recommended it will be displayed in the upper right hand side area. The 60 s countdown will also be displayed in the upper right hand side area. The countdown will end if no new recommended house can replace the current best house within 60 s or it will be restarted if a newly recommended house replaces the current best house before the 60 countdowns to zero. The left bottom area is designed for displaying the information of the sellers' reserve prices. Subjects can use this information to modify previous recommendations to try to replace the current best house.

### *53.3.4 Box Types*

Five kinds of boxes are used at this stage to support the screen layout. They are the head box, the stand box, the contract box, the contract creation box, and the grid box, as shown in Fig. 53.4

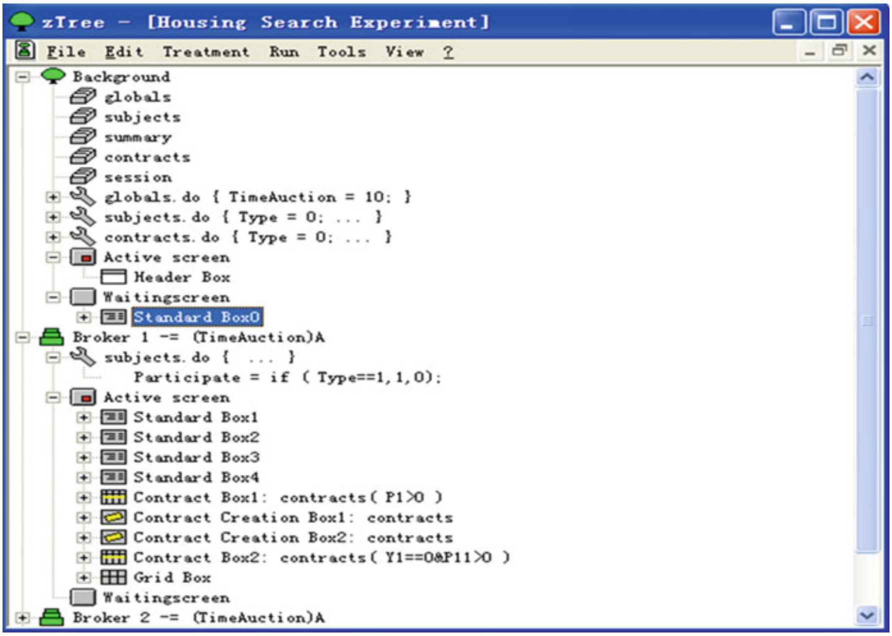



**Fig. 53.4** Experiment box types

The header box is used for displaying the remaining time. The standard box types 1, 2, 3, and 4 are used for displaying the countdown time in the upper right hand side area of the screen layout. The contract box types 1 and 2 are designed for separately listing the recommended house's information in the low right hand side area and the upper left hand side area. The contract creation box types 1 and 2 are used for brokers to leave the experiment and to recommend a house. The grid box contains all the information of houses that can be recommended by brokers.

### *53.3.5 Items*

Items are used for displaying and reading in variables. An item contains the name of the variable and information on how to display it. We call an item an 'input item' if the checkbox Input is checked. In this case, subjects must make an entry. We call an item an output item if the checkbox Input is not checked. The items CACULATE and RECOMMEND are given in Fig. 53.5. Details of other items can be found in the appendix experimental code.

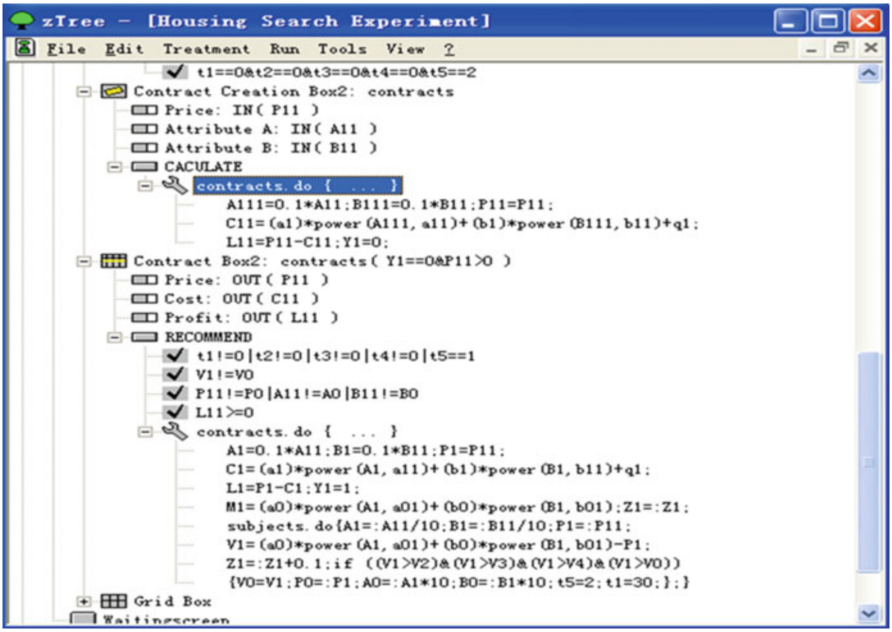



**Fig. 53.5** Items of experiment

## 53.4 Implementing Experiments with z-Tree

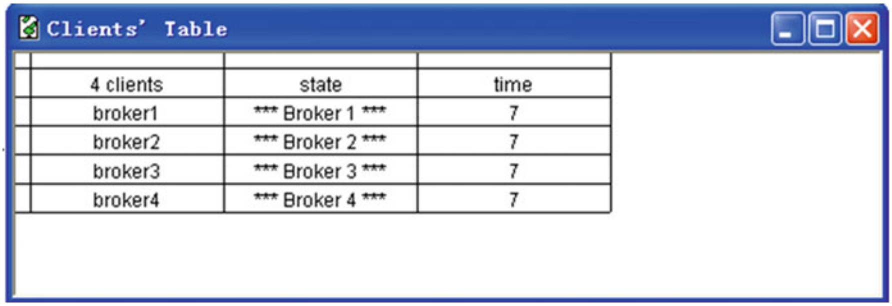
### *53.4.1 Steps of Experimental Implementation*

Experimental implementation generally includes: grouping student, reading the experimental instructions, dealing with students' question, testing before the experiment, implementation of training experiments, implementation of the formal experiment, collection of experimental results, questionnaire surveys after the experiment and interviews, etc. Experimental conduct is controlled by teachers; a lab assistant can be arranged where necessary.

The steps of implementation of training, as well as formal experiments, are as follows: start-up of the teacher PC, start-up of the student PC's, starting the treatment, observing the course of the experiment, colleting the experimental data, and switching off of machines.

### *53.4.2 Control of Experiment*

The experiment in started by switching on the experimenter PC, logging in and starting "z-Tree". Z-Tree has a window that displays which clients have started



Clients' Table

| 4 clients | state | time |
|---|---|---|
| broker1 | *** Broker 1 *** | 7 |
| broker2 | *** Broker 2 *** | 7 |
| broker3 | *** Broker 3 *** | 7 |
| broker4 | *** Broker 4 *** | 7 |

**Fig. 53.6** Clients' table

up and established contact. This information is displayed in what is called the clients' table, as showed in Fig. 53.6. The clients' table shows which clients are connected to the teacher's PC. It also contains information on the state of the clients and the time.

The client column indicates the name of the client. This would generally indicate the name of the subject PC. If a client is no longer connected, the name appears in brackets. If a client with the same name should reconnect, he can continue at the same place where the previous subject left off. The caption underneath the heading 'Clients' table' indicates the number of clients currently connected. The 'state' column is indicating the status of student. For example, the word "Ready" is displayed when the student is waiting for the next treatment or for the next questionnaire. The time column displays the time remaining for subjects.

### *53.4.3 Collection of Experimental Data*

The experimental data were created in the course of the experiment and collected automatically by z-Tree. The "xls" file was generated using the teacher's computer. This file contains all tables shown in the course of the session. As the tables are stored chronologically, you need some preparation to work with them. The first column contains the treatment number, the second the name of the table and the third column contains the period variable. It is advisable to sort the whole file using these three columns. Then the tables can be copied into separate tables, as shown in Fig. 53.7.

The "xls" file can easily be used for data analysis. However, there are tools in the tools menu that facilitate this process considerably. These commands allow us to separate the different tables into separate files and merge similar files into a larger file for analysis.

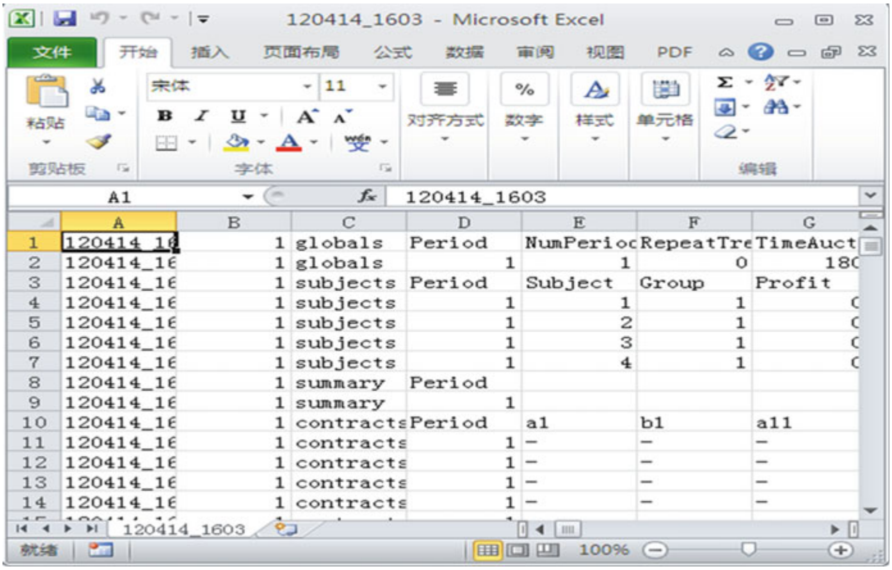



**Fig. 53.7** Screen shot of the “xls” file

## 53.5 Conclusions

We introduced the experimental software z-Tree into the teaching of real estate economics. Specifically, we designed the housing search experiment, programmed the experiment by z-Tree according to the experiment design, and implemented this experiment by z-Tree in the laboratory. We explored the possibility of using z-Tree to facilitate the experimental teaching of real estate economics. While the application of z-Tree in real estate experimental teaching is still in its infancy stage, the application of z-Tree and other computerized methods for conducting experiments, such as web programming and linked spreadsheets, merits further investigation towards improving the teaching methodologies.

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# Chapter 54
# An Assessment of the Correlation Between Indoor Environmental Quality and Productivity in a University Building: Occupants' Perspective

**C.O. Aigbavboa and W.D. Thwala**

**Abstract** Indoor environmental quality (IEQ) is important to the health, comfort, and well-being of building occupants. It is believed that poor IEQ is associated with a number of different phenomena, most notably, the Sick Building Syndrome (SBS), Building-related Illness (BRI), and Multiple Chemical Sensitivity (MCS), which, of course, have major effects on productivity. This paper presents results of a post occupancy survey response to indoor environmental quality (IEQ) in a university building in Johannesburg, South Africa. The paper assesses the correlation between IEQ and the occupants' productivity in a University building. The primary data for the study was collected through a structured questionnaire survey distributed to a sample of 75 occupants of the building in Johannesburg South Africa. Findings from the survey revealed that the occupants of the building are not satisfied with the IEQ of the building. Also revealed was that the IEQ with a particular reference to the noise level, affects the productivity and performance of the occupants. Since building occupants are a rich source of information about IEQ assessment and its effect on productivity, the study can be used to assess the performance of an educational building, identify areas needing improvement, and provide useful feedback to designers and operators about specific aspects of the building design features and operating strategies that need improvement. This study adds to the knowledge on higher education building IEQ.

**Keywords** Indoor environmental quality • University Building • Post occupancy evaluation • Productivity

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C.O. Aigbavboa (✉) • W.D. Thwala
Department of Construction Management and Quantity Surveying,
University of Johannesburg, Johannesburg, South Africa
e-mail: caigbavboa@uj.ac.za; didibhukut@uj.ac.za

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## 54.1 Introduction

This paper deals specifically with Indoor Environment Quality (IEQ) and its effect on occupant productivity in a university building which is owned and occupied by the Faculty of Engineering and Science of the University of Johannesburg. The specific aim of the study reported herein is to assess the correlation between IEQ and the productivity of occupants' in the building. The evaluation is based on occupant questionnaire data with regards to specific IEQ elements such as the indoor air quality, thermal comfort and distraction from noise. The assessment of the building is derived from the behaviour of building occupants; behaviour in this context being a broad term covering not only the occupants' actions and responses but also attitudes, feelings, expectations, values and beliefs. In this regards, it is useful to think of the user-environment relation as vital and interactive, meaning that part of the occupant's environmental experience includes the consequences of any occupant behaviour that may occur. The reason why the study adopted this method in order to meet the research objectives is that, the building occupants' are not passive vessel subjected to the built environment statically, as input. The occupant's experience of the environment is itself sharpened by the activities being performing in that environment, which Vischer [22] referred to as 'transactional'.

Indoor Environmental Quality (IEQ) denotes all environmental factors that affect the health and well-being of building occupants [3] which refers to the overall comfort of a building's interior and the comfort and health of its occupants. IEQ includes indoor air quality (IAQ), including, environmental tobacco smoke, carbon dioxide monitoring, indoor chemical and pollutant sources, thermal comfort, daylight, ventilation effectiveness and views. However, IEQ consists of many more complex factors that may have an effect on the occupants, for example, noise, ergonomics, quality of the artificial lighting and the spectrum of paints used amongst others [8]. Indoor Environmental Quality (IEQ), occupants' health and productivity in workplaces have emerged as 'somewhat vexing questions' [15] making it worthy of investigating with a view to understanding users' perspectives. Extensive study have been carried out on the relationship between IEQ and occupants' comfort, and workplace productivity [12]. There is also a growing acceptance in the sustainable environment community [11], that energy efficient building may be a vital tool by which these issues can be resolved [2]. A range of IEQ features are of concern, including ventilation, air quality, temperature, humidity, natural and artificial lighting and noise. These attributes when not rightly conditioned in the building have been related to cause health problems related to human activity such as the sick building syndrome-building related illnesses (SBS-BRI) that could reduce the workplace productivity. The concept of worker productivity has been applied to a whole range of desired behavioural outcomes in the context of work. The study by Commission for Architecture and the Built Environment – CABE (2005) on the effects of environment characteristics on workers' productivity found that there is confusion about what productivity means, hence this has made it difficult to identify how environmental conditions affect worker performance. Despite the findings from the study, this does not make research on IEQ effects on productivity to be irrelevant, but it does justify the reason while such research should be conducted. There are at least three types of productivity that are influenced by IEQ. They are individual, group, and organizational productivity. Each category denotes a variation in scale of IEQ influence [21, 22].

Previous research has found that it is a much higher cost to employ people than it is to maintain and operate a building, hence, spending money on improving the work environment is the most cost effective way of improving productivity because a small percentage increase in productivity of 0.1–2 % can have dramatic effects on the profitability of the company [7]. This is because productive environments are healthier and leaner in terms of energy consumption, gains in productivity offer energy reductions many times those offered by operation, construction and design respectively [16]. Hence, healthy buildings will increase productivity [5]. Previous research has also shown that the quality of office space can affect the productivity, health and comfort of workers. For example, Evans and Stecker [10] in their study found that both severe and continuous exposure to uncontrollable environmental features, like noise, crowding, traffic congestion, or air pollution, can produce ‘learned helplessness’ in adults as well as in children. Another study by Wright et al. [23] on worker productivity, found that psychological well-being (PWB) was positively related to job performance. In their study, they defined PWB as that which measures the ‘pleasantness dimension’ of individual feelings. Kamaruzzaman et al. [14] informs that employees’ performance and competence are very much dependent on indoor environmental surrounding and factors such as concentration and alertness is vital for a good work performance even though there are personal and external factors that could disturb depending on the physical and mental health of an individual. The more comfortable workers are, the more productive they will be when other features are in place.

## 54.2 Method

This research focuses on the relationship between productivity and the indoor environment in a university building. The data used in this paper were derived from both primary and secondary sources. The primary data was derived from a structured occupants’ questionnaire survey which was distributed to a sample of 75 occupants of the office building. The questionnaire survey was administered to both full-time and part time academics and non-academics staffs. The respondents were selected based on the fact that they have been being resident in the building for a minimum of 3 months and have a personal or shared working space in order to meet the research objectives. Using a simple stratified random sampling technique, the seven floor building was separated into five different levels by selecting the 2nd, 3rd, 4th, 5th and 6th floors respectively. All respondents on each selected floor had an equal chance to be drawn and occur in the sample. All academics and non-academic staffs on the selected floors were chosen as the sample frame. This process was essential to obtain true representativeness of the entire sample. Out of the 75 questionnaires sent out, all were received back representing 100 % response rate and all were usable. A 5-point Likert type scale was used to determine the occupants' levels of satisfaction with their environment and on the effect of the IEQ elements to their productivity. The next section of the article presents the findings from the survey and some discussion.

## 54.3 Findings and Discussion

### *54.3.1 Background Information*

From the occupants questionnaire survey revealed that 63.30 % of the respondents hold a full-time working contract with the university while 37.00 % informed they are on a part-time fixed contract. This assessment was done to assure the researcher that the respondents' responses in the survey on IEQ effect on productivity will be based on a genuine motive. A further confirmation to ascertain the credibility of the intended findings investigates the respondents' professional classification. Finding on this aspect revealed that 24.00 % of them are Senior Lecturers, 46.60 % are Lecturers, 12.6 % are Senior Lectures, while a further 12.00 % are Professors and the rest were administrative staff.

### *54.3.2 Thermal Comfort*

Hence, when the occupants were assessed on the conditions of the thermal comfort characteristics of the building with regards to the building temperature; 9.33 % of the respondents informed that the building is too cold in summer, 18.67 % revealed it is slightly cold, while 38.67 % indicated it is warm; a further 22.67 % also inform the building is hot and a further 10.67 % claim it is very hot. When the respondents were further asked of the temperature during winter, 48.00 % indicated it is too cold, while 18.67 % informed it is slightly cold, 21.33 % informed it is warm, while only 6.67 % informed that it is hot and 5.33 % that it is very hot. Furthermore, the occupants were assessed on their level of control over the thermal temperature in their office space, it was found that 16.67 % of the occupants' have no control over the thermal temperature, while 29.17 % have a slight control, 33.33 % have control and 20.83 % have a full control over the thermal temperature during summer and in winter. Consequently, when the occupants were asked of the effect of the thermal temperature on their productivity, findings revealed that 25.33 % of the indicated it has no effect on their productivity; while 17.33 % said it has a minor effect, while a further 17.33 % were neutral about it. But a further 21.33 % indicated it has a moderate effect on their productivity and 18.67 % informed it has a major effect.

The findings on the effect of thermal comfort on productivity correspond with previous research findings on the control of the thermal temperate in building. For instance, it has been found that when occupants have a control over the thermal temperature in their office space, their productivity is enhanced [21]. Also, the research findings agrees with the findings of the research carried out on Dutch office buildings which revealed that negative thermal effect on productivity can be reduced by 34 % when individual workers can control their own thermal environment [19]. Similar studies in UK office study also indicate that self-estimation of productivity are significantly higher in such cases [20]. While Wyon and Wargocki [24] found that 30 % of sick leave are due to Sick Building Syndrome which can be reduced if the workers could control their own thermal environment.

### *54.3.3 Indoor Air Quality*

Furthermore, when the building occupants were asked about the freshness of the air in the building, 5.33 % indicated that the air is very stale, while 17.33 % said the air is stale, and 38.67 % were neutral towards the quality of the air. However, 25.67 % did indicate that the air is fresh, while only 12.00 % stated that the air is very fresh. Also, when the respondents were also asked about the air quality in terms of its humidness, 5.33 % of the respondents indicated that the air was too humid, while 14.67 informed that it was humid, 49.33 % were neutral towards the dryness of the air. However, 25.33 % of the respondents revealed that the air is dry and 5.33 % said that the air is too dry. The primary reason for the assessment of this attribute was in line with the research of Abdou et al. [1], who informed that indoor pollutant levels frequently exceed outdoor levels. Although, because people spend more time outdoors than indoors but people in industrialized countries and career personal spend more than 90 % of their lifetimes indoors [6]. Clements-Croome [6] further informs that in United State of America, the total time staying indoors for an average working person is 23 h and 15 min per day or 97.7 % of his or her lifetime. Hence, when the IAQ is not adequate, pollutants, such as bacteria, viruses and carcinogens, will directly affect the health of the occupants while others, such as the air odours and dusts, can cause significant discomfort, feelings of unpleasantness, disgust and distaste among workers, thereby leading to lower productivity.

Furthermore, when the respondents' where asked the effect of the building IAQ on their productivity, 20.27 % informed that it has no effect on their performance, while 14.86 % indicated a minor effect, 22.97 % were neutral, while 25.68 % said it has a moderate effect on their performance and a further 16.22 % indicated it has a major effect on them. Although the significance of IAQ on productivity is modest in the university building as the findings has shown; however, Hess-Kosa [13] revealed that poor IAQ can make the building occupants experience health effects such as flu like symptoms, dermatitis, irritation, systemic toxicity, headache, fatigue, chest tightness etc., that will slow down the productivity of the workers if not checked. Additionally

Wyon and Wargocki [24] and Dorgan and Dorgan [9] found that productivity suffers a setback of 6–10 % in SBS buildings due to unhealthy IAQ.

### *54.3.4 Distraction from Noise*

The building occupants were further asked about the distraction from noise in the building. Findings revealed that 8.00 % indicated it was not significance, 18.67 % stating it is slightly significance, while 33.33 % were neutral about the noise distraction. A further 28.00 % indicated that it is significance and 12.00 % said it is very significance. When the occupants were asked of the effect of the noise on their productivity, 14.67 % indicated no effect, 17.33 % said it has a minor effect and likewise neural about the noise distraction. However, 26.67 % indicated that it has a moderate effect on their productivity and a further 24.00 % revealed it has a major effect on their efficiency. When the occupants that indicated moderate and a major effect distraction were further asked the type of noise which brought the distraction, 100.00 % of the occupants indicated humanly generated noise as the source of concern. Human generated noise includes noise from human conversation and from students walking through the office lobbies. While the occupants informed that machine noise has no impact on their efficiency. This agrees with NyunLing and Cheung Chan [17] findings that noise generated from human brings about much distraction compare to all other generated noise within the office buildings because the generated noise are audible and can be understood. This type of noise is also termed noise-based annoyance, which brings about a feeling of resentment, displeasure, discomfort, dissatisfaction or offence that occurs when noise interfere with someone's thoughts, feeling or daily activities [18]. Although it has not conclusive that noise generated in the office affect occupants' physical health except after an extensive exposure. But studies have shown that it brings psychosomatic distraction and displeasure to the occupants which may reduce affect their productivity [4] as also confirmed from the current study.

## 54.4 Conclusion

In conclusion, the study assessed IEQ's and the findings from literature revealed that there is a correlation between occupants' productivity in the university building and the IEQ elements. The findings suggest that there is considerable evidence that buildings have far reaching impacts on human well-being and on workplace performance. Although the empirical study is based on a relatively small sample, the findings provide an understanding into the effects of the assessed IEQ on a typical university building occupants.

Findings in this study are of vast policy implications. Firstly, it is clear from the result that the IAQ affects the workers' productivity which is a major component of

IEQ. The policy implication is that future design and construction of university buildings should be responsive to the occupants' need for adequate and quality air circulation. This is because previous research has shown that occupants spend up to 90 % or more of their working time indoors. Secondly, 'noise-based annoyance', which brings about a feeling of anger, discontentment, uneasiness, or offence to the workers through noise interference with thoughts, feeling and daily activities, should be eliminated through the use of acoustic materials in order to make the office building conducive for the occupants. To this end, university office buildings where higher academic learning is processed should be designed with good acoustic properties in order to handle the nuisance caused by noise.

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# Chapter 55
# Measurement and Impact of the Real Estate Developers' Monopoly Power: Evidence from the Major Cities in China

**Fan Yang and Hongyu Liu**

**Abstract** A housing market is generally considered as a monopolistic competition market. However, there is still lack of research on the degree and impact of developers' monopoly power, especially on the city level. To fill in the gap of housing market structure research, three indices are utilized to measure monopoly power of developers from the aspects of market concentration and developers' pricing power on the city level. Based on the data from the major cities in China, the monopoly power of developers and its influencing effects are empirically analyzed. The results show that the pricing power of developers in one housing market is considerably different from that in the other markets though the market concentration is similar across the major cities. It is also found that monopoly power has significant influence on housing markets. In the market with higher monopoly power, supply elasticity is usually smaller, the growth of housing price is faster and the problem of housing unaffordability is more serious.

**Keywords** Monopoly power • Market structure • Developer • Housing market

## 55.1 Introduction

There are two critical features of housing market structure: the one is that there are quite a number of competitive developers in one market, although barriers to entry exist due to the large scale of capital demand and the necessary qualifications of developers; the other is that housing projects are differentiated due to the fixity of housing locations so that each project monopolizes a small region to some extent. Therefore, housing markets are generally considered to be monopolistically competitive [1]. In such markets, the study of the monopoly power of developers is

F. Yang (✉) • H. Liu
Hang Lung Center for Real Estate, Tsinghua University, Beijing 100084, China
e-mail: f-yang09@mails.tsinghua.edu.cn

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of great importance. The degree of monopoly power cannot only impact the decision making behavior of developers but also impact the housing market price and social welfare accordingly.

In the previous research, the impacts of the degree of developers' competition and monopoly are studied from theoretical and empirical analysis. The results show that: (a) market competition may reduce the waiting time of developing a land parcel [2], (b) developers would hold relatively less cash and investment more if they are facing the pressure of competition from the others [3], (c) developers can use pricing power to obtain more monopoly premium if their projects have high degree of monopoly power, [4] and etc. In these studies, the monopoly power of developers is measured by the quantity of the adjacent projects or the Lerner Index (LI) of a project, which are all micro-level measurement. The impact analysis, accordingly, are also micro level based. How to measure the degree of the market power of developers on macro level (e.g., city level or industrial level)? What is the difference of developers' monopoly power across different cities? What are the impacts of developers' monopoly power on the housing market? These questions are still waiting to be answered.

This paper mainly focuses on the city level study of developers' monopoly power based on the new data set of the new housing transaction records from the major cities in China. In Sect. 55.2, we propose three indices to measure the monopoly power of developers. Sections 55.3 and 55.4 give empirical analysis on the measurements, regional differences and impacts of monopoly power. Section 55.5 concludes the paper and discusses policy implications.

## 55.2 Measurements of Monopoly Power

Economists have tried various ways to measure the monopoly power of the suppliers. However, "*monopoly power is in essence multidimensional, each of these measures deals with only one dimension either of market structure or of performance*" said by Encaoua and Jacquemin [5]. Based on that, the measurements of monopoly power can be mainly categorized into two kinds of indices, i.e., indices measuring the degree of market concentration and indices measuring the pricing power of suppliers.

### *55.2.1 Indices of Market Concentration*

"*Measures of market concentration*", mentioned by Scitovsky [6], "*try to express the number and size distribution of competitors in terms of a one-parameter index, which could be regarded as a direct measure of the degree of oligopoly*". The representative indices are the Concentration Ratio ($CR_n$), Herfindahl-Hirschman Index (HHI) and Entropy Index (EI) [5].

Though the indices are easy to be understood, it should be emphasized that they have limitations in application. As criticized by Lerner [7], these indices are inappropriate to measure the degree of monopoly if we are interested in its economic and social applications over price and social loss. He illustrated this point of view with an extreme example, i.e., when a single firm controls all the commodity supply but the demand is infinitely elastic, this firm does not have any pricing power in the market although the indices of $CR_n$ and HHI are equal to 1. To deal with this problem, the indices that could measure the pricing power of suppliers are then proposed.

### 55.2.2 Indices of Pricing Power

The representative indices for measuring the pricing power of suppliers are the Bain Index (BI) [8] and Lerner Index (LI) [7]. LI is a more widely used index, representing the margin between the market price and the marginal cost. Since the marginal cost data can hardly be obtained, LI is always deduced based on the pricing theory of monopoly suppliers and it can be written by an equation regarding the price elasticity of demand (ε) as shown in (55.1).

$$LI = -\frac{1}{\varepsilon} \tag{55.1}$$

Note that the LI as in (55.1) is a micro-based index which represents the monopoly power of a single firm and then the question comes, i.e., how to calculate the LI of an industry on macro level if the average marginal cost of the industry cannot be estimated?

To solve this problem, Encaoua and Jacquemin [5] present several forms of aggregate degree of monopoly power, i.e., the arithmetical and geometrical weighted means of all the firms' Lerner Indices. Moreover, Cowling and Waterson [9] indicated that the average mark-up of price over marginal cost, i.e., Lerner's measure of monopoly power for an industry, is negatively related to the industry price elasticity of demand and positively related to the industry HHI and the sensitivity of the industry's supply with respect to a firm's scheduled production. These studies shed light on the measurement and its complexity of the pricing power for an industry.

### 55.2.3 Monopoly Power Measurement Used in Housing Markets

In the research on measuring developers' monopoly power in housing markets, the indices of concentration and those of pricing power, as mentioned in Sects. 55.2.1 and 55.2.2, are used and some other specific indicators for housing markets are also proposed. These indices used in housing markets are introduced and commented as follows.

As for the market concentration indices, CRn and HHI are only calculated for housing markets on the national or provincial level due to the unavailability of the city level data [10]. However, a housing market is always bounded to a city rather than a province or a country because of its accessibility. Thereby, the monopoly power analyses on the national or provincial level are not that significant.

As for the pricing power indices, LI is also used in the housing markets and it is approximated by (55.1) [11]. Due to the lack of micro data, the price elasticity of housing demand is generally estimated from the log linear regression of quantity demanded with respect to housing price based on macro time series data. Nonetheless, using macro data leads to simultaneity problems and hence leads to unreliable results. Another problem is that (55.1) is not suitable to be applied on macro level calculation of LI even if the demand elasticity is accurately estimated. In addition, the estimation of demand elasticity in housing market is always larger than $-1$ according to most of the micro studies [12, 13]. If the demand elasticity of the market is over $-1$, using (55.1) as the calculation for the market aggregate LI is not appropriate because the LI value must be within 0–1.

As for the housing market specific indices, the number of the projects around one specific project [2] and the project's LI calculated from the demand elasticity of a single project [4] are proposed on micro level studies. All of these studies try to emphasize the importance of competition on the project level. It is generally deemed as a special characteristic of housing markets that the products' differentiation and the feature of monopoly are mainly determined by the immovability of each project's location rather than the differentiation among developers. Therefore, housing projects are the basic units of monopoly competition in housing markets and they should be paid more attention in the monopoly power research of housing markets in future.

In summary, though various measures of monopoly power are used in the studies of housing markets, there is still lack of research on the characteristics and impact of developers' monopoly power, especially on the city level. To fill in this gap, we proposed three indices in this paper to analysis the monopoly power on city level based on the data from the major cities in China. These indices are the number of developers within a city, the city's HHI for projects and the city's price elasticity of housing demand. The former two indices evaluate the market concentration and latter one evaluates the pricing power of developers.

## 55.3 Analysis on the Degree of Monopoly Power in Housing Markets

### *55.3.1 Analysis on Housing Market Concentration*

In this paper, market concentration is measured by the indices of the number of developers and the HHI for projects as shown in Table 55.1. The former index

**Table 55.1** The indices of market concentration

| City | Number of developers | HHI for projects | City | Number of developers | HHI for projects |
|---|---|---|---|---|---|
| Sanya | – | 0.184 | Yinchuan | 206 | 0.030 |
| Lanzhou | 527 | 0.186 | Zhengzhou | 1,049 | 0.029 |
| Ningbo | 737 | 0.128 | Suzhou | – | 0.026 |
| Kunming | 883 | 0.112 | Xian | 522 | 0.023 |
| Qingdao | 1,074 | 0.091 | Nanjing | 744 | 0.021 |
| Huhehaote | 238 | 0.087 | Wuxi | – | 0.019 |
| Hangzhou | 1,398 | 0.078 | Wuhan | 1,423 | 0.019 |
| Shijiazhuang | 526 | 0.081 | Changchun | 458 | 0.018 |
| Shenzhen | 618 | 0.064 | Shanghai | 3,247 | 0.017 |
| Harbin | 803 | 0.056 | Xining | 305 | 0.017 |
| Xaimen | 629 | 0.045 | Guangzhou | 1,261 | 0.015 |
| Fuzhou | 662 | 0.056 | Jinan | 582 | 0.014 |
| Guiyang | 879 | 0.055 | Chengdu | 1,559 | 0.013 |
| Taiyuan | 661 | 0.046 | Chongqing | 2,391 | 0.012 |
| Haikou | 189 | 0.045 | Shenyang | 1,384 | 0.009 |
| Nanchang | 524 | 0.041 | Urumqi | 347 | 0.011 |
| Beijing | 3,173 | 0.035 | Hefei | 666 | 0.009 |
| Beihai | – | 0.032 | Tianjin | 1,279 | 0.008 |
| Nanning | 750 | 0.033 | Changsha | 910 | 0.007 |
| **Average** | 989 | 0.047 | | | |

represents the quantity of competitors in a housing market and a market is usually considered to be competitive if the number of competitors in the market exceeds 200. Under such criterion, we can conclude that all the major cities have the feature of competition from the aspect of the number of competitors. However, as mentioned in Sect. 55.2.3, housing projects are the basic units of monopoly competition in housing markets rather than developers. Thus, the index of the number of developers should be used as auxiliary information for showing housing market characteristics and HHI for projects seems more important.

In the past, HHI was calculated for a group of firms. Due to the importance of projects as claimed in Sect. 55.2.3, the index of HHI for projects, i.e., sum of the squares of the market shares of projects in a city, is used in this paper. The average monthly HHI for projects in 2011 in the 38 major cities are computed as shown in Table 55.1. According to the general criterion of HHI, most of the major cities are not concentrated (HHI $< 0.1$, showing a high level of competition). The HHI increases as the market scale decreases because the smaller cities are likely to be monopolized by a few projects. That is why the cities of Sanya, Lanzhou, Ningbo and Kunming with HHI $> 0.1$ show the features of weak oligopoly. However, if we extend the time period to a quarter or a year and consider the substitution effects of projects sold in different months, the HHIs will reduce sharply and all cities will show the features of non-concentration.

### *55.3.2 Analysis on the Pricing Power of Developers*

As derived by Cowling and Waterson [9], the market LI (on macro level) is determined by the price elasticity of market demand, market HHI and the sensitivity of the market supply with respect to a developer's supply. Since the sensitivity is hardly estimated, we assume that the sensitivity is the same across different cities. In addition, it can be seen from Table 55.1 that the HHI values are all very small and the differences across cities are not so significant (if we extend the time period, the differences are even less). Therefore, it is assumed that the aggregate LI is mainly reflected by the market demand elasticity in this paper. The larger the demand elasticity is, the higher the degree of developers' monopoly power is.

For better estimation and description for demand elasticity, the micro data of housing transactions from the major cities in China are utilized here. The basic regression equation of demand elasticity is given by (55.2) [13].

$$\log Q = c + \eta \log P + \rho \log I + \mu \tag{55.2}$$

where c is a constant, P is the housing price per unit area, Q is the floor area of each housing unit, I is the family disposable income, $\mu$ is a stochastic item, $\eta$ is the regression coefficient representing the price elasticity of housing demand and $\rho$ is the income elasticity.[1]

Due to the heterogeneity of housing units, the prices of different housing units with different quality must be primarily standardized to make them comparable with each other. First, we use the hedonic price model to estimate the prices for different housing characteristics as shown in (55.3).

$$PT = c + \sum_{n=1}^{N} \beta_n X_n + \alpha Q + \mu \tag{55.3}$$

where PT is the housing price for the entire housing unit, c is a constant, $X_1, X_2, \ldots, X_N$ are N quality characteristics of a housing unit, $\beta_1, \beta_2, \ldots, \beta_N$ are the corresponding characteristic prices of the N quality characteristics, Q is floor area

[1] In a more accurate regression model, interest rate and price of other investment opportunities should be involved in the right-hand side of (55.2). However, in this paper, we estimate the price elasticity for each month based on the monthly transacted records so the other independent variables can be omitted.

of a housing unit and μ is a stochastic item. Then, the prices of different housing units with different quality characteristics are standardized by (55.4).

$$PT_{ad} = PT - \sum_{n=1}^{N} \beta_n \left(X_n - X_n^*\right) \tag{55.4}$$

where $PT_{ad}$ is the standardized price and $X_1$*, $X_2$*, …, $X_N$* are the quality characteristics of the standardized housing unit. By using $PT_{ad}$, the price elasticity of market demand can be estimated from (55.5).

$$\log Q = c + \eta \log(PT_{ad}/Q) + \rho \log I + \mu \tag{55.5}$$

The monthly micro data from the transaction records of the new commodity housing in the main cities of China are collected from the data set of the Housing Price Index developed by Tsinghua University (THU) and the Ministry of Housing and Urban–rural Development (MOHURD). The sample data include the information of housing quality characteristic, i.e., housing floor, building floor, decoration level, time on market, the scale and location of the associated project, and etc. However, the data set lacks the information of families such as disposable income. To solve this problem, we assume that the more expensive the housing unit is, the higher the income level of the corresponding family is. 5–10 income dummies are therefore constructed to categorize the income levels of families based on the total transacted price of housing units. These income dummies are then used as the income proxy variables to do regressions in Eq. (55.5).

Limited by the availability of data, the 40 major cities except Wenzhou are studied. As the housing purchase restrictions enacted in 2010 might impact the housing demand and its elasticity greatly, we choose the monthly transaction records from January to June in 2010 as our data base. Table 55.2 shows the results of monthly average housing demand elasticity within the 6 months.

The five cities with positive elasticities, Guangzhou, Nanjing, Fuzhou, Sanya and Beijing, are usually considered as the most undersupplied areas in China. In these cities, the housing demand for home-ownership are relatively large. In this regard, we conclude that these cities are all quite inelastic housing markets. The results in Table 55.2 show that developers' monopoly power is relatively higher in the super start cities, including Beijing, Shanghai, Guangzhou and Shenzhen, and is relatively lower in the cities of Yinchuan, Xining and Tianjin.

The average housing demand elasticity based our estimation is −0.24. This result is similar to that of Zheng's research where the price elasticity is estimated as −0.505 for urban housing market in China based on micro data [12]. However, her sample only covers provinces of Liaoning, Guangdong and Sichuan. The housing supply in the major cities is relatively in short and the housing purchases are mainly supported by the motivations of home ownership compared with the three provinces. Therefore, it is acceptable that our estimation is larger than the result obtained by Zheng [12]. The same fact is also claimed in Zheng's book [14] where the demand elasticity in China and that in the USA (−0.72 ~ −0.67) are compared.

**Table 55.2** The monthly average price elasticity of housing demand

| City | Elasticity | City | Elasticity | City | Elasticity |
|---|---|---|---|---|---|
| Guangzhou | 0.04 | Ningbo | −0.12 | Chengdu | −0.35 |
| Nanjing | 0.03 | Xiamen | −0.14 | Nanning | −0.36 |
| Fuzhou | 0.03 | Beihai | −0.14 | Haikou | −0.38 |
| Sanya | 0.03 | Guiyang | −0.15 | Shijiazhuang | −0.39 |
| Beijing | 0.00 | Haerbin | −0.16 | Changchun | −0.40 |
| Shenzhen | −0.01 | Hefei | −0.21 | Jinan | −0.46 |
| Hangzhou | −0.04 | Lanzhou | −0.23 | Chongqing | −0.52 |
| Nanchang | −0.05 | Zhengzhou | −0.24 | Yinchuan | −0.53 |
| Dalian | −0.06 | Urumqi | −0.26 | Xining | −0.56 |
| Wuxi | −0.08 | Xian | −0.27 | Taiyuan | −0.71 |
| Shenyang | −0.10 | Wuhan | −0.28 | Tianjin | −0.86 |
| Shanghai | −0.10 | Kunming | −0.32 | **Average** | −0.24 |
| Suzhou | −0.11 | Changsha | −0.33 | | |
| Qingdao | −0.12 | Huhehot | −0.33 | | |

## 55.4 Impact of Developers' Monopoly Power

### *55.4.1 Descriptive Analysis on the Performance of Housing Markets*

As Lerner [7] mentioned, if we are interested in the economic and social applications over price and social loss, the concentration indices are inappropriate. Therefore, we choose the demand elasticity as the main measurement when analyzing the differentiations in market performance with different monopoly power in this section.

In order to reduce the estimation error of the demand elasticity, the main cities are categorized into two groups with the median demand elasticity −0.21. The less elastic group (with high monopoly power) are marked as MP = 1 while the more elastic group (with low monopoly power) are marked as MP = 0.

Table 55.3 shows the differences of the market performance between the two groups. The annual growth of housing prices is calculated from the Housing Price Index developed by THU and MOHURD. The housing supply elasticity is from the study of Liu and Yang [15]. Housing affordability index (HAI) and price to income ratio (PIR) are two main indicators of housing affordability. HAI reflects the purchasing power of the family with median income comparing to the median price of housing units. The higher HAI is, the higher housing affordability is. PIR reflects how many years a family with average income should take to buy a housing unit with average price. The longer it takes, the lower housing affordability is.

Comparisons in Table 55.3 indicate that in the markets of high monopoly power, growth of housing price is relatively larger, housing supply is less elastic and housing affordability is lower.

**Table 55.3** The differences in the market performance

| | MP = 1 | MP = 0 |
|---|---|---|
| Annual growth of housing prices from 2006 to 2012(%) | 16.91 % | 14.62 % |
| Housing supply elasticity – stock elasticity | 0.57 | 0.54 |
| Housing supply elasticity – flow elasticity | 1.28 | 1.83 |
| Average housing affordability index from 2003 to 2011 | 56.72 | 70.80 |
| Average price to income ratio from 2003 to 2011 | 9.10 | 7.22 |

**Table 55.4** The influencing effect of monopoly power on the supply elasticity

| Independent variable | Model 1 | | Model 2 | |
|---|---|---|---|---|
| ΔRoad98-10 | 2.14** | (2.15) | 2.15** | (1.99) |
| Gov | −1.42*** | (−2.96) | −1.71*** | (−2.90) |
| LDEV | 1.53* | (1.78) | 2.16** | (2.26) |
| GDPPC98 | 2.73 | (1.31) | 1.98 | (0.88) |
| Area98 | −87.54* | (−1.63) | −109.87* | (−1.85) |
| ΔPop98-10 | 0.23 | (−0.57) | 0.37 | (−0.85) |
| MP | | | −2.37** | (−2.41) |
| Pseudo R2 | 0.3141 | | 0.4084 | |
| Log likelihood | −26.23 | | −22.63 | |
| LR statistic | 24.03*** | | 31.24*** | |

Note: ***significant at the 1 % level, **significant at the 5 % level, *significant at the 10 % level. Values in parentheses are z-statistics

## *55.4.2 Regressions Analysis on the Supply Elasticity*

To validate the influencing effect of monopoly power while eliminating the impact of other factors, this section gives the regression analysis on housing supply elasticity. The influencing effects of monopoly power on housing markets can be largely explained if it has significant influence on the supply behavior. Generally, in the housing markets with lower supply elasticities, rapid growth of housing price and price bubble are more likely to exist [16].

In our previous study [15], the determinants of housing supply elasticity were investigated based on the hypotheses derived by Capozza and Helsley [17] and the empirical study of Wang [18]. In that paper, we tested the influencing effect of geographic feature (IDEV, the developable land ratio estimated by Wang [18]), infrastructure and public service (Road98-10, the growth of road area per capita from 1998 to 2010), government regulation (Gov, index of government market intervention), and other control variables of Area98 (urban built-up area in 1998) and GDPPC98 (GDP per capita in 1998). In this paper, we apply the same simple multivariable discrete choice model and the same data set but introduce a new independent variable of MP. The dependent variable is the level of supply elasticity with 0 as the least elastic group, 1as the medium elastic group and 2 as the most elastic group.

As we predicted, Table 55.4 shows that the monopoly power has net significant negative influence on the supply elasticity when the other factors are controlled and the monopoly power variable alone increases the Pseudo R-square by 9.43 %.

## 55.5 Concluding Remarks

This paper seeks to study the monopoly power of developers on the city level. Three indices, i.e., the number of developers, HHI for projects and price elasticity of market demand are utilized for measuring the monopoly power of developers from the aspects of market concentration and pricing power. Based on the data from the major cities in China, the developers' monopoly power and its influencing effects are empirically analyzed. The results show that the pricing power of developers in one housing market is considerably different from that in the other markets though the market concentration is similar across the major cities in China. High monopoly power of developers may cause the decrease in developers' sensitivity of supply with respect to housing price and result in less elastic housing supply. As for the housing price, in the markets with higher monopoly power, the growth of housing price is faster and the housing affordability is lower.

To promote the degree of healthy and stable development of housing markets and increase the affordability of housing, the government should pay more attention to the monopoly power of developers. In the markets with low supply elasticity and fast growth speed of housing price, regulations of enhancing the degree of completion and restricting the pricing power of developers should be considered.

Note that this paper only tests the impact of monopoly power on housing markets on the macro level. On such level, it is difficult to deeply understand the influencing mechanism. Should the significance of the influencing effects of monopoly power be mainly attributed to developers' behavior and subjective preference? In this regard, the pricing and supply features of developers with different monopoly power are worth studying on the micro level in future.

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# Chapter 56
# A New Horizon for Construction Waste Management Research from a Complex Adaptive System Perspective

**Zhikun Ding, Jinchuang Wu, Jiayuan Wang, and Hongtao Wang**

**Abstract** Besides significant contributions to the economy development, the construction industry has been generating a large amount of solid waste, which exerts a great adverse impact on the environment. In the last decades, construction waste management (CWM) gradually draws extensive attention worldwide. This study firstly presents a review of the CWM research topics and approaches. Then some of their shortcomings are demonstrated, such as (1) lack of a system analysis in view of CWM as a complex adaptive system (CAS); (2) neglection of the heterogeneity, autonomy, adaptability of the stakeholders and the interactions between them; (3) a dominant top-down research paradigm cannot provide a good interpretation for the relationship between microscopic agents' behavior and macro-policy. Thirdly, a complexity analysis of CWM is conducted with an introduction of CAS and a theoretical analysis of CWM about its CAS characteristics. Finally, it reveals the great potential of agent-based modeling to address CWM issues from bottom-up.

**Keywords** Construction waste management • Complex adaptive system • Agent-based modeling

## 56.1 Introduction

Along with the rapid development of urbanization and accelerating pace of urban renewal, the quantity of construction waste increases significantly. As Zou Xin mentioned, the amount of construction waste in China had accounted for about 40 %

Z. Ding (✉) • J. Wu • J. Wang
Department of Construction Management and Real Estate, College of Civil Engineering, Shenzhen University, Shenzhen 518060, China
e-mail: ddzk@szu.edu.cn; jinchuangwu@163.com; wangjy@szu.edu.cn

H. Wang
China Construction Fourth Engineering Division Corp, LID, Shenzhen branch, Shenzhen, China

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of the total municipal waste, with its annual production of 40 million to 50 million tons [1]. At present, nearly two-thirds of the cities in China are surrounded by garages, and more than 500 million square meters of land is occupied. While awaring its negative impacts including land depletion and deterioration, energy consumption, solid waste generation, dust and gas emission, noise pollution, and consumption of non-renewable natural resources [2], which greatly hinders the sustainable development of human society, many researchers devote themselves to the study of CWM by adopting diverse approaches to discuss different research topics ranging from C&D waste generation, reduction, reuse, recycling to assessing the effectiveness of CWM. Based on the analysis of the current research on CWM, a new horizon from a CAS perspective associated with the agent-based modeling approach is suggested to capture the complexity and adaptability of CWM system. This paper unfolds in four sections, the first of which is a brief review of the current research about the main research topics and approaches. The second section focuses on the deficiency of the existing research. Then in the third section the complexity analysis of CWM is put forward on the basis of CAS, which highlights the complexity and adaptability of CWM. And the last section comes to the conclusion that CWM system is a CAS and a bottom-up modeling approach such as agent-based modeling is necessary.

## 56.2 A Review of C&D Waste Management

The term "C&D waste" is generally used to refer to the solid waste generated in the construction sector. More specially, the term is defined as the waste which arises from construction, renovation and demolition activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation [3]. To better undertake CWM issues, it's vital to have a systematic thinking to understand the research topics from C&D generation, reduction, reuse, recycling to assessing the effectiveness of CWM. The review is not intended to be complete but rather to focus on those aspects we consider to be particularly typical & important and some of the topics may be intertwined with each other.

### *56.2.1 C&D Waste Management Research Topics*

#### 56.2.1.1 C&D Waste Generation

Research on C&D waste generation mainly focused on the causes, amount, composition and the rate of waste generation. Throughout the life cycle of construction projects from inception to construction and demolition, Yuan Hongping stated that the origins of C&D waste should be classified into the following ten categories: contractual, design, procurement, transportation, on-site management and planning, material storage, material handling, site operations, residual, and other causes [4]. Even though the origins and causes of C&D waste were diverse, Wang Jiayuan et al. emphasized the environmental awareness of stakeholders and the importance of benefit-driven in the market. However, the awareness of stakeholders is difficult to accurately quantify, and the internal mechanism of how the human factors such as cognitive, emotional, psychological, behavioral discrepancy of stakeholders affect the decision making in CWM is hard to interpret. Thus, the method of analyzing heterogeneity of stakeholders is very important. Fortunately, Agent-based modeling which has been widely used in social sciences by focusing on the agent interaction can provide a guidance. Another aspect of C&D waste generation was the amount of waste in different countries and regions which attracted general attention and was well described as Yuan Hong et al. did [5]. Apparently, CWM issues should be taken seriously and effective CWM strategies should be adopted. To better solve the CWM problems, it's vial to figure out the composition of C&D waste and the waste generation rate (WGR). C&D waste includes a wide range of materials depending on the source of the waste, namely excavation materials (e.g. earth, sand, gravel, rocks and clay), road building and maintenance materials (e.g. asphalt, sand, gravel and metals), demolition materials (e.g. debris including earth, gravel, sand, blocks of concrete, bricks, gypsum, porcelain and lime-cast), as well as other worksite waste materials (e.g. wood, plastic, paper, glass, metal and pigments) [6]. Based on critical literature review, Weisheng Lu et al. summarized the different approaches for measuring waste generation and investigated WGRs by conducting on-site waste sorting and weighing in four ongoing construction projects in Shenzhen [7]. All the efforts to investigate C&D waste generation do lay down a solid foundation for CWM using agent-based modeling method.

#### 56.2.1.2 Three "Rs" Principle in CWM Strategies

The 3Rs principle which refers to reduce, reuse and recycling is the principal method to addresses the key challenges of CWM.

**C&D Waste Reduction.** Reduction is considered as the most effective and efficient method for managing C&D waste. From the perspective of environmental behavior theory, Tan Xiaoning et al. analyzed the factors affecting the behaviors of construction waste reduction and established a model on critical factors. The construction worker's behaviors of C&D waste reduction were analyzed from attitudinal, personality, cognitive and situational angles [8]. The important role of human factors in CWM drew increasing attention of scholars. As Yuan Hongping stated, research efforts were mainly committed to the investigation of practitioners' (designer, contractor, worker) perceptions of CWM and attitudes on CWM performance [5]. However, to have a further understanding of how human factors play a part in CWM, a bottom-up research paradigm which better explain the emergent phenomena should be emphasized. And agent-based modeling which is well known as a typical modeling approach from bottom-up deserves an introduction to be applied in CWM. Besides the environmental awareness of practitioners, the benefit incentive in the market is also important to motivate the practitioners to take waste reduction measures in designing or construction. Based on a case study and interview data, Begum conducted a benefit-cost analysis about the economical feasibility of waste reduction, and then analyzed the highest cost that constructors are willing to pay in the construction project and the economic principles for constructors' decision-making behavior [9]. Similar studies were undertook by Shen Li-yin et al., based on a case study in Hong Kong, he conducted a benefit analysis on replacing in situ concreting with precast slabs for temporary construction works and identified the cost-saving by such a reduction technology [10]. The basic economic parameters related to CWM such as transport costs, entrance fee in reception field, are available in the economical research, which makes it possible to conduct economic evaluation using agent-based modeling.

**C&D Waste Reuse.** Reuse means using the same material in construction more than once, including using the material again for the same function and new-life reuse for a new function. Zhang Qingping maximized the use of waste generated from the construction of Shanghai world Expo Park to produce renewable products (e.g. using the concrete to make waterproof materials, regeneration of porous bricks or concrete blocks) [11]. Via mailed standard questionnaire, Ling and Leo conducted a survey and found that there are three important factors affecting the reuse of timber formwork, namely, the workers' attitudes, the workers' efficiency, and formwork stripping process [12]. The significant role of stakeholders played in CWM is over and again underlined which provides evidence for promoting the use of agent-based modeling to investigate the agent's influence on the system.

**C&D Waste Recycling.** The C&D waste is characterized by its very high recovery potential since total waste recycled can reach 80 % [13]. When reduction and reuse become difficult, recycling is recommended. The concern on human factors in recycling is available in the previous literatures. On-site construction waste sorting (CWS) is always regarded as one of the most significant measures of increasing the rates of reuse and recycling. Through a case study with data collected via a literature, non-participant observations, and interviews, Yuan Hongping pointed out that project stakeholders' attitudes were regarded as the most critical factors in undertaking on-site CWS [14]. But such a qualitative research couldn't present the details about how the stakeholders' attitudes affect their on-site CWS behaviors, which will no doubt contribute to better recycling. At the same time, the importance of stakeholder interaction was demonstrated when Knoeri conducted a survey about Stakeholders' decision-making with the analytical hierarchy process (AHP). He found that the decision of most stakeholders about which material to recycle and apply was primarily influenced by the recommendation or specification from the previous stakeholder [15]. However, it isn't clear whom the stakeholders interaction with, when and where. Therefore, a bottom-up simulation method (e.g. agent-based modeling) capturing the interaction complexity would be a promising way to assess the sustainability of future CWM development.

#### 56.2.1.3 The Macro Policy Research About C&D Waste Management

The major concerns of the CWM macro policy research are the economic and managerial policies including "construction waste charging scheme", "publicity and education for the stakeholders", "on-site construction waste sorting" etc. The charging scheme is not only intended to provide an economic incentive for stakeholders to reduce waste but also to encourage reuse and recycling of wasted material thereby slowing down the depletion of limited landfill and public filling capacities [16]. It's concluded that stakeholders should be well informed of the importance to conduct CWM and a rational waste management plan is essential. Meanwhile, the workmen on- site should be trained so as to improve their work efficiency of sorting, reusing, recycling construction waste. Nevertheless, it's difficult to quantify how the stakeholders' compliance with such policies can affect C&D waste reduction in projects. And it's almost impossible to undertake an experiment in the real word because of time consuming and high cost. Hence, computer simulation which can quantify the policy implementation effect is needed.

#### 56.2.1.4 Assessing the Effectiveness of C&D Waste Management

Effective C&D waste management should concentrate on the balanced development of economical viability, environmental sustainability, and social harmony. Therefore, the evaluation of C&D waste management should include its economic, environmental and social performance. However, the majority of efforts assessing C&D waste management were just from an economic, environmental or social aspect separately without a comprehensive or holistic perspective. For instance, Duran et al. developed a model to assess the economic viability of creating markets for recycled C&D waste under different economical scenarios [17], while Gui Ye et al. developed a model for evaluating the environmental performance of CWM by using a system dynamics approach [18], and Yuan Hongping adopted the system dynamics approach to evaluate the social performance of CWM [19]. To pursue a sustainable development, the comprehensive evaluation of CWM performance is indispensable. Based on the literature review and semi-structured interviews, Yuan Hongping identified the key indicators affecting the effectiveness of CWM including economic, environmental and social performance, and designed a qualitative framework for CWM effectiveness assessment [20]. The endeavor of the previous researchers on the evaluation of CWM will definitely provide a guide for assessing CWM effectiveness in future modeling.

### *56.2.2 C&D Waste Management Research Methods*

It is clear from the foregoing critical review of relevant literature that varieties of data collection and analysis methods were applied by different researchers, but most of them are based on reductionism which followed the top-down research paradigm. A full appreciation of data collection and analysis methods adopted in existing research will contribute to an effective CWM research. Since CWM is closely related to construction practice, empirical approaches such as case study, interview, and questionnaire appear to be the most appropriate methods for collecting research data. Besides, in previous studies researchers tended to use simple descriptive and statistical analysis methods for data analysis. It is found that major data collection methods were case study, survey, review and experiment etc. and the major data analysis methods were statistical analysis, cost-benefit analysis and simulation etc. [5]. In recent years, the system dynamics approach which dealt with the complexity (e.g. interrelationship, dynamics and feedback) of a system has been applied. However, it's a top-down modeling methodology which cannot provide a good interpretation for how the microscopic agents' behavior would result in the emergent phenomena (e.g. how does the stakeholders' attitude or behavior affect the effectiveness of CWM). On the contrary, agent-based modeling is able to capture the interaction complexity and explain the emergent phenomena.

## 56.3 Limitations of Existing Research

### *56.3.1 Lack of a System Analysis in View of CWM as a Complex Adaptive System (CAS)*

In fact, the existing research topics in the literature cover the different subsystems of CWM system which should be regarded as a complex adaptive system including waste emission subsystem (e.g. involving the C&D waste generation topic), management policy subsystem (e.g. involving the CWM strategies and macro policy research topics), and social, economic, environment evaluation subsystem (e.g. involving the topic of assessing the CWM effectiveness) etc. However, most researches failed to consider the full waste management cycle i.e. from the waste reduction to final disposal. And the processes of CWM have been treated separately from a static perspective, regardless of the dynamic and interdependent nature of the CWM system as a whole. Even though system dynamics methodology is a systematic approach that deals with the complexity – interrelationships and dynamics – of any social, economic and managerial system [21], it seems to be inadequate when a deep interpretation for the driving forces between adaptive stakeholders' attitude or behavior and the diversity of the management effectiveness emerging outside CWM system is needed.

### *56.3.2 Neglection of the Heterogeneity, Autonomy, Adaptability of the Stakeholders and the Interaction Between Them*

It's well known that construction stakeholders are government officials, designers, contractors, supervisors, on-site workers etc. In the existing research, they were generally treated as homogeneous and passive i.e. making decisions according to the common goal on the basis of the overall interests while, in fact, most of them are self-organized and make decisions proactively in pursue of self-interest maximization. Meanwhile, the intelligent agents (e.g. stakeholders) can not only interact with each other and the surroundings, but also learn from history or experience to be adaptable (a risk-prone agent may turn into risk-neutral or risk-averse after several risky experiences). But the interaction and adaptability are rarely addressed in the research which leads to the gaps between the micro agents and macro phenomenon and makes it difficult to conduct policy analysis. For example, although source separation, landfill charging, publicity and education are recommended all the time, researchers haven't reached an agreement about how to assess their performance.

### *56.3.3 A Dominant Top-Down Research Paradigm Cannot Provide a Good Interpretation for the Relationship Between Microscopic Agents' Behavior and Macro-policy*

Conventional research approaches applied in CWM are based on reductionism by following a top-down research paradigm, which holds that a complex system is nothing but the sum of its parts, and that an account of it can be reduced to accounts of individual components, while holism takes the complex system to be one whose properties are not fully explained by an understanding of its components or that the whole is more than the sum of its parts. In addition, they are based on the assumption of linearity, static, decomposability and extrapolation which simplify the complexity of CWM. However, CWM system is a complex adaptive system with highly nonlinear, dynamic, interactive, uncertain characteristics. Hence, it's really difficult to capture the emergence from the interactions between microscopic agents (e.g. stakeholders) and their environment (e.g. macro-policy).

## 56.4 The Complexity Analysis of C&D Waste Management

### *56.4.1 A Brief Introduction of CAS*

CAS was originated from investigations into the adaptation and emergence of biological systems. The field of CAS concerns itself with systems composed of individual, interacting components and the adaptive mechanisms that such systems exhibit. The defining characteristic of CAS is the ability to adapt to a changing environment. Complex adaptive systems learn over time to effectively respond to novel situations. CAS also has the ability to self-organize and reorganize their components in ways better suited to surviving and excelling in their environments [22]. John Holland, a pioneer in the field of complex adaptive systems, identifies the properties and mechanisms common to CAS, which is shown in Table 56.1 [23].

**Table 56.1** The properties and mechanisms common to all CAS

| Properties or mechanisms | Descriptions |
|---|---|
| Aggregation | Allows groups to form |
| Nonlinearity | Invalidates simple extrapolation |
| Flows | Allow the transfer and transformation of resources and information |
| Diversity | Allows agents to behave differently from one another and often leads to robustness |
| Tagging | Allows agents to be named for later identification |
| Internal models | Allow agents to reason about their worlds |
| Building blocks | Allow components and even whole systems to be composed of many simpler components |

## *56.4.2 The CAS Characteristics of Construction Waste Management*

### 56.4.2.1 Aggregation in CWM System

In CWM system, stakeholders can unite as different groups with multi-agents which will form the different hierarchical structures or subsystems via aggregation. For instance, those (e.g. designers, contractors, or on-site workers) who contribute to the waste generation can aggregate as waste generation layer, or the waste emission subsystem; those who collect and transport waste can be treated as logistics layer or the logistics subsystem; those who handle the waste reduction, reuse, recycling and disposing issues should be regarded as waste disposing layer or the integrated disposing subsystem; those who make waste management plan or policy will aggregate as waste management control layer or the management policy subsystem. Hence, different types of agents in the CWM can aggregate varieties of hierarchy or subsystems with specific functions.

### 56.4.2.2 Nonlinearity in CWM System

Nonlinearity which means that small causes can have large impacts invalidates simple extrapolation. On one hand, the agents related to CWM have the mechanism of self-reinforcement and self-organization with the characteristic of path dependence; on the other hand, they also have the mechanism of learning and adaptation. All these mechanisms are nonlinear, in such a situation, simple extrapolation is invalid. Besides, when the adaptive agents change their behavior according to the environmental change (e.g. contractors that previously didn't adopt waste reduction techniques will change their decision to adopt such techniques if the new decision is more beneficial when the governmental policies change), they are independent and active rather than passive and mechanical. The little change of their behavior will make a big difference to the outcomes as a whole.

#### 56.4.2.3 Flows in CWM System

In CWM system, there exists abundant waste flow, capital flow and information flow and all of them interact with each other which contribute to the complexity of CWM system. From C&D waste generation, sorting, reuse, recycling to disposal; it's easy to observe the flow of waste. But the capital flow and information flow are generally ignored. In fact, a good transportation and disposal of waste is based on the stability of capital flow and the capital flow is reflected during waste flow. In addition, information flow (e.g. the record of C&D waste composition, amount, policy information etc.) between the stakeholders is the key factor that influences the decision-making. Whether the information is complete has a great effect on the result of decisions. In order to better deal with construction waste management problems, it's essential to know about the waste flow, capital flow and information flow in CWM system.

#### 56.4.2.4 Diversity in CWM System

Diversity in CWM system results from the differences of the agents and builds a foundation for the evolution of CWM. First of all, multi-types of agents are involved in CWM system including waste emission agents, waste disposal agents, waste management agents etc. Furthermore, the management strategies (e.g. economic measures, legislative methods, publicity and education etc.) are diverse as well. Different agents make different decisions with respect to the same government policy. In addition, due to the development of science, diverse waste-reducing, waste-reusing, waste-disposal methods are available. All the above increase the diversity in CWM system.

#### 56.4.2.5 Tagging in CWM System

Every agent (e.g. stakeholders) in CWM system can be named for later identification. Based on the object-oriented programming, the agent's attributes and behaviors can be tagged using programming language so that all of them can be identified during modeling. In the same vein, the information about waste flow and capital flow should be distinguished against each other. Only in this way can the agents identify the surrounding environment. The major effect of tagging mechanism is to guarantee the communication and interaction between agents and environment.

#### 56.4.2.6 Internal Models in CWM System

Internal models refer to the internal mechanism of the agents, which allows agents to reason about their worlds. The attributes and behavior are described in the internal models so that the agents know how to learn, what to do, when and how to change their behavior according to the environment change. For instance, during the interaction with the market contractors will learn to choose the most effective waste management strategy with the lowest cost to purse the benefit maximization and how this process is undergoing is guided by the internal models of contractors. All the stakeholders related to CWM have their own internal models which can be adjusted during their learning, adaptation and evolution.

#### 56.4.2.7 Building Blocks in CWM System

Generally speaking, complex systems are composed of many simple building blocks with different combination modes. For example, in the waste management policy subsystem, the individual policy can be deemed to be the building blocks. Source separation, 3Rs, landfill charging, publicity and education are always recommended as the effective waste management policies. Different combination of the policies will form various waste management strategies according to the context. In the waste disposal hierarchy, it is essential to take the internal models of every policy into account. While in the higher hierarchy such as integrated management hierarchy, all the policies are better encapsulated as the basic policy building blocks without considering the details in the internal models. Both the notion of “internal models” and “building blocks” can contribute to a further understanding of the system hierarchy which enables the system characteristics as a whole to be easily comprehended. With such a mechanism, the content and law in the lower level can be encapsulated as a internal model and participate as a whole the interaction in the upper level, which focus on the interplay between this building blocks and others rather than the details in this building blocks.

As is discussed above, CWM system has many characteristics of CAS. In addition, taking the uncertainty, openness, dynamic and evolution into account, CWM system is really complex, which allows for a new horizon for CWM and a promising approach to capture the interaction complexity between stakeholders and environment from bottom-up.

## 56.5 Conclusions

Considerable research endeavors has been made to handle CWM issues in the last decades. It has been well acknowledged that human factors play an important role in the whole procedure of CWM ranging from C&D waste generation, reduction, reuse, recycling to assessing the effectiveness of CWM. However, the existing research approaches with reductionism following a top-down research paradigm failed to capture the dynamics and evolution, nonlinearity, uncertainty and emergence in CWM from a CAS perspective. Hence, the deep relationship between the individual stakeholders’ attitude or behavior and the emerging overall behavior as a whole are difficult to interpret. In order to bridge the gap between microscopic behavior and macro phenomena, this paper proposes a new horizon for CWM research from the CAS perspective and comes up with the idea that a bottom-up simulation method such as agent-based modeling is necessary.

For further research on the human factors in CWM, one promising route might be to model the interaction of construction stakeholders using agent-based modeling approaches combined with the classical theories of CAS, project management, organizational behavior and game theory. In addition, genetic algorithms, neural network, swarm intelligence and cellular automata will bring a big difference in capturing the learning ability and adaptation of the stakeholders. Once the attributes, behavior rules and relationship of stakeholders associated with their economic, social and environmental circumstances are modeled, an artificial society is created which could act as laboratories to explore how the interactions between stakeholders and their surroundings contribute to the dynamic evolution of CWM and how some waste management strategies (e.g. source separation, landfill charging, publicity and education) become effective during CWM.

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# Chapter 57
# How the Administrative and Market Forces Influence Organization Evolution – A Case Study on Megaproject Management

**Yun Le, Zhao Zhai, and Jianxun Xie**

**Abstract** Since the megaprojects- invested by the government, regulated by market, monitored by the public- play an increasingly important role in Chinese construction field, the top-down design of management organization is gaining more attention. Indeed, the role of the government in the construction process is direct and powerful. But its side effect is that government administration may cause some deviant behaviors. However, entirely conforming to the market rules might result in lower efficiency and vested interests damage. Therefore, a systematic analysis of coordination between administration and market forces is desperately needed. In this paper, an empirical case-study of a megaproject, which is still under construction in a provincial capital city, will be conducted. As the owner is a government-sponsored enterprise, managers face the problem that the organization should adjust dynamically to balance different kinds of forces. The process of organization evolution will be the focal point. And another emphasis will be the multi-factorial influences that the local state and market forces have exerted.

## 57.1 Introduction

Few would deny that megaprojects construction is an issue of economic and social development of China. From the first Five-Year Plan period, the government has invested multi-trillion RMB on megaprojects, which are characterized as complex, political-uncertain, environmentally-sensitive [1, 3]. Involving a large number of partners [12], these megaprojects, such as the manned space flight, the Three Gorges, high-speed Railways usually bring profound influence to national image. For convenience of research we limit the scope of megaprojects to large-scale infrastructure projects, such as railways, hydraulic engineering, urban development

Y. Le • Z. Zhai (✉) • J. Xie
Department of Economics and Management, Research Institute of Complex Engineering and Management, Tongji University, Shanghai, China
e-mail: Nicky-mary@163.com

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and construction, etc. The past three decades have witnessed a surge in the development of megaprojects construction. It's also a period that the construction institution converts from planned economy to socialist market economy. In the institution today, stable organization should be established to operate megaprojects. In fact, the perspective, that increased implementation of market mechanism bring failure in construction to some extent, is widely recognized. It not only reduces the efficiency, but also damages public interest. This paper will try to answer the following questions by investigating literature and evolution of a project-based organization in construction industry in present social context.

How do construction institutional systems evolve in the process of social development?

How do megaproject organizations form in the process of institutional system evolvement?

## 57.2 Point of Departure

As many megaprojects have the attributes of public goods and constitute natural monopolies [6], the macro-economic system exerts great influence on them.

### *57.2.1 Evolution of the Construction Context*

In planned economy period, state controlled all the process of production, supply, and distribution, without markets and private property [15]. The paternalistic nature of the socialist system thus legitimized the government's dictatorship and centrality of power [5], and central planning led to a misallocation of both investment goods and of current inputs and outputs [11]. There is no doubt that the construction industry at that period was at the booming and extensive age. In that period, government usually established construction headquarter (CH) as the management unit when an megaproject was announced. Government officials were the main leaders of the CH, who could take full charge of administrative means to mobilize masses.

From late 1970s, China launched its reform and opening-up policy, which introduced competition into the planned economy. In this novel institutional systems, which are still under development and transformation, the megaprojects are put at higher level of uncertainty and risks [4, 7]. Since then, the debate between those who would retain a dominant role for governmental control and those who would move to genuine market economy has never stopped. Considering the specificity of Chinese economic development, macro-economic control of government is still essential. And this situation leaded to a bureaucratically manipulated market# instead of a full-fledged market. In early 1980s, Lubuge hydropower station, which sponsored by the World Bank, firstly introduced modern project management into China. The government set up a special administration to be project manager, and introduced several foreign-funded company through international biding. Also, this project was constructed in terms of FIDIC's contract condition. Until today, Lubuge is still considered as a remarkable milestone during the process of project management modernization. Since more and more private firms involved in megaprojects construction, fair competition among construction industry has established gradually.

Facing global financial crisis in 2008, Chinese government unveiled Four Thousand Billion Stimulus Plan, and then reform to pro-growth policy. Most funds were invested on railways, high-speed railways, expressways. And waves of megaprojects construction have emerged. Local governments set up some companies to take charge of local construction, which will be the focus of next chapter.

### *57.2.2 Institutional Context and Organization*

Institutions influence the delivery of projects and have a significant impact on project performance [7]. In china, the dual system of administrative and market forces influence mega-project organization, particularly in the current context of transition toward the market economy. Nowadays, three theoretical perspectives dominate scholar studies of project-based organizations: contingency-based approach and resource-based approach and institutions-based approach [13, 14]. In contingency-based view, if construction context become more complex, organizations must find ways to develop their information-processing and problem-solving capacities. Different from contingency approaches, resource-based view focuses more attention on the internal attributes and capabilities of organizations. Large complex projects should have dynamic capabilities to cope with the "changing regulatory environment" [2].

Recently, more and more organization researchers pay attention to the mutual effect between the organizations and their context. Mike Peng and his colleagues have been calling for the development of "an institution-based view" of business strategy to supplement existing 'industry-based competition' and 'firm-specific resources and capabilities' [9, 10]. Scott and colleagues have developed the institutional perspective to inform the strategic decision making of project-based organizations, describe the application of institution to multiple levels [13]. In megaprojects construction the organization governance has moved towards the institution theory. Because the evolution of context is contingent upon social context, different social networks possess different sets of institutions [8].

## 57.3 Evolution of Megaproject Organizations – A Case Study

Longitudinal investigation is one of the most important ways to study the evolution of organization structure. This chapter will investigate an empirical case study, which is a finance and business center with ancillary facilities (covering about

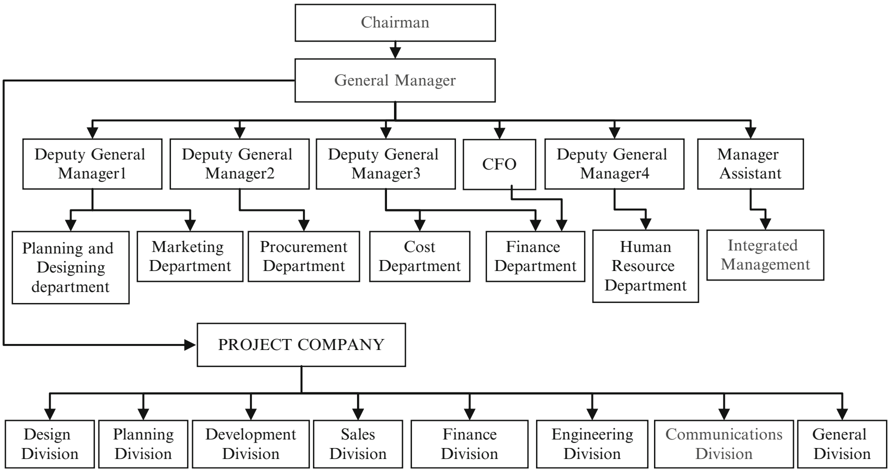


**Fig. 57.1** The organization of first stage – project company

51 ha, with total floor area of 2,902,518 $m^2$, including 829,448 $m^2$ underground) in a provincial capital city. To describe the evolution process of the organization structure. *Project A*, *enterprise B* and *city C* will be taken as the substitutes of the project, the enterprise who is operating it and the place of the megaproject respectively. This paper put emphasis on the project-based organization instead of the firm itself.

### 57.3.1 Background

B is a state-owned enterprise, established in 2005 to be responsible for the constructions in Hi-Tech Industry Development Zone (HDZ) in city *C*. The enterprise separated administrative functions from business operations. However, in fact, the boundary is not that clear. Until 2010, *B* had possessed abundant experience in public and residential construction. In this process the government's role in construction is decision maker, supervisor and implementer.

In 2010, local government started a megaproject *A* to accommodate burgeoning urbanization. Firm *B* was taken for granted to be a dominant role in construction process. At first, the organization structure was built in similar to the old system (see Fig. 57.1), in which the *project company* was the manager of project A.

### 57.3.2 The First Change of Organization

In principle, megaprojects had to proceed in four stages: decision-making (feasibility study and conceptual design), design (preliminary design and detail design),

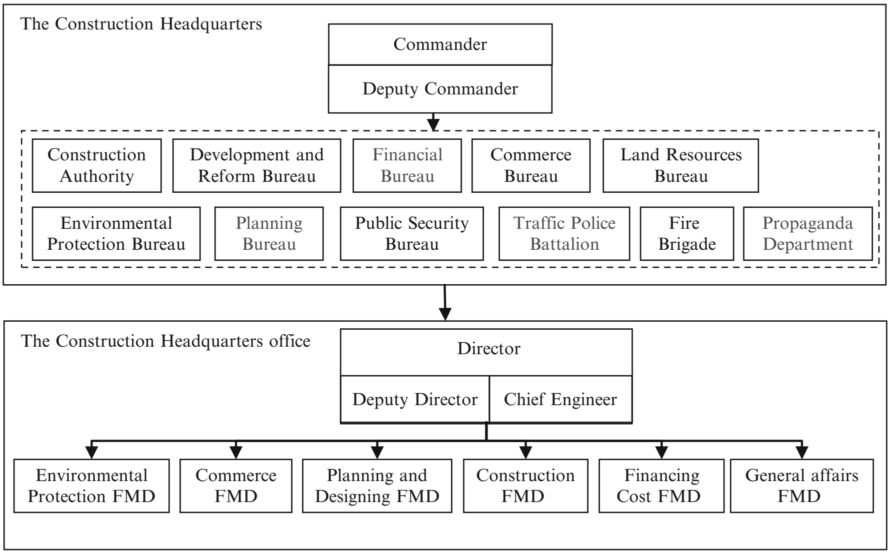


**Fig. 57.2** The organization of second stage –construction headquarter

construction (bidding, construction, supervision, and inspection), and operation. Until 2012, A was still undergo between decision-making stage and design stage: two design institutes had started their preliminary design, which predicated on conceptual design. However, Planning Bureau in *C* had not approved yet. This unique phenomenon reflected the exceptions to the rule. However, in most cases others did the same as well.

In order to accelerate the construction pace, in April 2012 government created the construction headquarter (CH), consisting an office and 6 Function Management Divisions (FMDs). The vice director of HDZ Management Committee (MC) is the commander of CH. The secretary of the Political and Legislative Affairs Committee and chairman of *B* are all named the deputy- commanders. Most of the other CH members were government officials, who come from Propaganda Department, Fire Brigade, Traffic Police Battalion, Public Security Bureau, Planning Bureau, Environmental Protection Bureau, etc.

Other than the CH, construction headquarters office (CHO) was the operator of project *A*. Both the director and chief engineer were from firm *B*. and one FMD comprised 2–3 government officials and 2–3 departments of firm B. To some extent, this complex organization structure reflected the tradition of Chinese project construction. And it could afford integrated governmental resources to make decision. Conversely, multiple-management in construction stage might bring about some delay, and keep changing the deadline constantly. Figure 57.2 represents the organization of the government agencies discussed above.

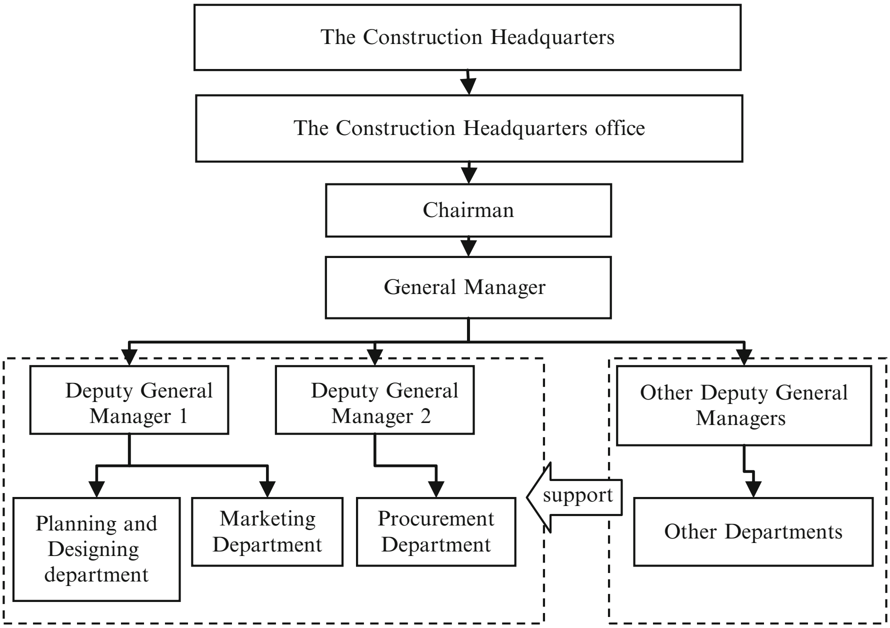


**Fig. 57.3** The organization of present

### 57.3.3 The Second Change of Organization

Since the establishment of CH and CHO, the conceptual design passed audit in October. And the preliminary design was nearly accomplished in the end of 2012. Upon design stage completion, the government's role would be shifting toward being a pure supervisor. As a result, the main management is expected to be firm B again. In Fig. 57.3, it shows that the construction headquarter is less able to influence A.

### 57.3.4 Discussion of Transforming

Factors that influence organization reform can be divided into the external and internal factors. External factor is consist of institutional environment and external technique change, while internal factor includes the strategy and scale of organization, as well as internal technique level. The characteristics of every stage in the transforming of project A construction organization are shown in Table 57.1.

**Table 57.1** The transforming process of organization

| | First stage | Second stage | Current stage |
|---|---|---|---|
| Who is the manager? | Project company of firm B | The construction headquarters | Firm B |
| Governance model | Company | CH + company | Company |
| Why transform | Strategic policy of government official | Schedule target | The construction steps in the right track |
| Strategy of firm B | Combining centralization and decentralization of power | Centralization management | Focusing on the key construction project |
| Role of government | Sponsor of B | Direct participant | Supervisor |
| Role of market | Promoting power of organizational establishment | The administrative force is greater than the market force | Constructing by following the market regulations |

## 57.4 Conclusions

This paper tried to articulate the evolution of construction context in China. And an empirical case is studied to associate the organization change to context change. An interesting phenomenon, that organizational model is not entirely adapted to context, can be discovered. It is generally recognized that the construction headquarter model, which originated from planned economy, should be avoided in the wake of deepening institutional reform. But the fact is CH model is still the preferred choice to promote the construction of project, especially facing the tight schedule.

As the description over a short period of time only captured phenomena rather than mechanism, this paper move one step further to investigate the drives of organizational change and how different environment forces influence them. Sustained attention to this empirical case would be paid to discover the role transition of actors in organizational network under different organization models, and the interaction of organization in institutional context.

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# Chapter 58
# Investment-Cash Flow Sensitivities: Evidence from China Listed Real Estate Operating Companies

**Jiawei Lu and Shenghua Jia**

**Abstract** Modigliani and Miller (Am Econ Rev 48(3):261–297, 1958) suggested the investment-cash flow irrelevance theorem under perfect information. But substantial empirical evidence documents strong influence of cash flow on firms' investment spending under imperfect information. This makes cash flow play an important role in business enterprise operation. This paper explores the relationship between investment expenditure and internal and external cash flow of China listed real estate operating companies during 2008–2011. Real estate operating companies are faced with both rapid growth opportunity and severe financial constrain in China. The results of this paper provides more evidence to help understand the investment behavior of real estate companies.

**Keywords** Corporate investment • Cash flow • Real estate operating company

## 58.1 Introduction

Recent years have witnessed the rapid growth of China's real estate market. The scale of investment in real estate development has increased exponentially (Fig. 58.1), leading to the increasing importance of real estate market to China's economic growth.

Investment scale in real estate development is the predictor variable of future housing supply. As the home price in China appreciated rapidly in recent years, many scholars examined the relationship between real estate investment and home price of China's housing market using the macro economy data [6, 7, 11]. However, relatively little research has been done on the determinants of real estate investment expenditure.

J. Lu (✉) • S. Jia
Center for Real Estate Study, School of Management, Mailbox 2071 of No.3 West Building, Xixi campus, Zhejiang University, China
e-mail: lujiawei@zju.edu.cn

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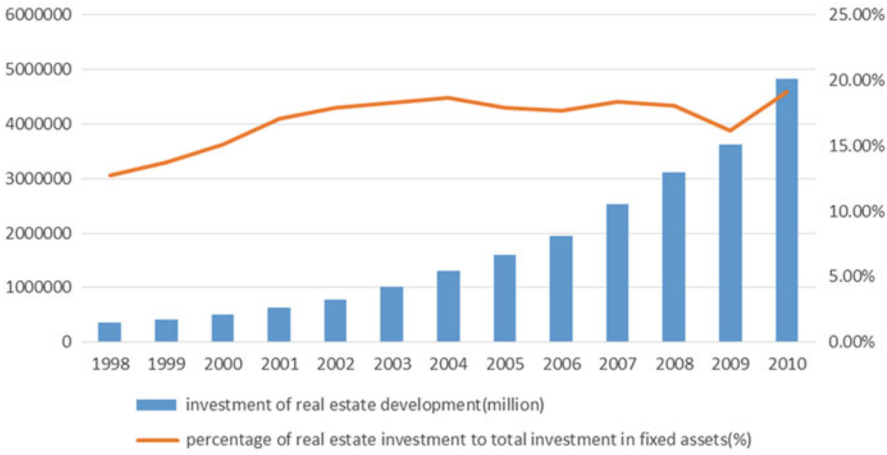


**Fig. 58.1** Investment scale of real estate development in China, 1998–2010

This paper focuses on the firm-level real estate development investment expenditure and aims to find out the mechanism of Chinese real estate operating companies' investment behaviors. The firm-level evidence provided by this paper will complement the macro economy level research and help get a deeper understanding of the real estate investment.

The remainder of this paper is organized as follows. We discuss related research in Sect. 58.2 and our data and methods in Sect. 58.3. Our main empirical results are presented in Sect. 58.4. Finally, concluding remarks are made in Sect. 58.5.

## 58.2 Literature Review and Hypothesis Development

Modigliani and Miller [8] suggested the investment-cash flow irrelevance theorem under perfect information. In perfect and complete capital markets, companies can finance as much as they need, thus investment expenditure only depends on the investment opportunities that have positive NPV (net-present-value).

However, financial structure may be relevant to the investment decisions of companies facing uncertain prospects that operate in imperfect or incomplete capital markets [1, 4, 5, 10].

According to the pecking order theory [10], firms will prefer internal funds to external funds because of cost advantage. The literature documenting the sensitivity of firms' investment to fluctuations in their internal funds, initiated by Fazzari et al. [3], is large and growing. The relationship is most prevalent among firms that are identified as facing financial constraints. The relationship between cash flow and investment spending (after controlling for the investment opportunity using Tobin's Q) is inconsistent with both the Modigliani and Miller [8] irrelevance theorem and the Myers [9] static trade-off theories of financial behavior. China's real estate operating companies are faced with severe financial constraints due to the strict macroeconomic regulatory. Thus, hypothesis I is put forward:

*Hypothesis I: Investment expenditure of real estate operating companies are positively related to internal cash flow.*

But the feasibility of pecking order to Chinese firms is controversial [2, 12, 13]. Previous researches have documented the importance of external funds (including equity capital and debt capital). To capital-intensive firms, such as real estate operating companies, the availability of external funds is also influential to firm's investment behavior. Thus, hypothesis II is put forward:

*Hypothesis II: Investment expenditure of real estate operating companies are positively related to external cash flow.*

The cost of capital differentiate seriously between internal funds and external funds for real estate development companies because of the rigorous regulation exerted by Chinese government. In order to control the housing price, Chinese government limits the capital availability of real estate operating companies from the bank and from the stock market. Under such market circumstance, firms rely its investment expenditure more on the internal funds than external funds. Thus, hypothesis III is put forward:

*Hypothesis III: Investment expenditures of real estate operating companies are more sensitive to its internal fund than external fund.*

## 58.3 Data and Measures

### *58.3.1 Sample*

To explore the relationship between corporate investment expenditure and cash flow, we construct a panel of Chinese public real estate operating companies during the period 2008–2012. Our sample contains information on firms' financial reports collected from China Stock Market & Accounting Research (CSMAR) Database.

To select a clean sample, we deleted any observations that have missing data. Further, we deleted observations that were in financial distress (ST/*ST etc.). The resulting data set is an unbalanced panel, which includes 495 observations from 107 firms during 2008–2012.

### *58.3.2 Variable Measures*

#### 58.3.2.1 Dependent Variable

$Invest_{i,t}/K_{i,t-1}$. $Invest_{i,t}$ denotes the investment expenditure of firm $i$ in year $t$. $Invest_{i,t}$ is the sum of cash paid for the purchase and construction of fixed assets, intangible assets and other long term assets; net cash paid for the acquisition of subsidiaries and other business entities, and cash paid for equity investment and debt investment. $Invest_{i,t}$ is divided by the total asset of last year ($K_{i,t-1}$) to control the firm size.

#### 58.3.2.2 Explanatory Variables

$CF_{i,t}/K_{i,t-1}$. $CF_{i,t}$ denotes the internal fund of firm $i$ in year $t$. $CF_{i,t}$ is the net cash flow from operating obtained from the statement of cash flow. $CF_{i,t}$ is divided by the total asset of last year ($K_{i,t-1}$) to control the firm size.

$Finance_{i,t}/K_{i,t-1}$. $Finance_{i,t}$ denotes the external fund of firm $i$ in year $t$. $Finance_{i,t}$ is the net cash flow generated by financing activities obtained from the statement of cash flow. $Finance_{i,t}$ is divided by the total asset of last year ($K_{i,t-1}$) to control the firm size.

#### 58.3.2.3 Control Variables

$Salegrow_{i,t-1}$, is the increase rate of business revenue of firm $i$ in year ($t-1$). $Salegrow_{i,t-1}$ denotes the investment opportunity.

$ROAi,t-1$ is the return on assets of firm $i$ in year $(t-1)$, which denotes the profitability.

$Leveragei,t-1$, denotes the debt-to-assets ratio of firm $i$ in year $(t-1)$. Debt-to-assets ratio characterizes the financial state of the firm and will influences the firm's investment behavior.

$Cash_{i,t}/K_{i,t-1}$. Cashi,t denotes the currency fund of firm $i$ in year $t$. $Cashi,t$ is divided by the total asset of last year $(Ki,t-1)$ to control the firm size.

$Sale_{i,t-1}/K_{i,t-1}$. $Salei,t-1$ denotes the revenue of the main operations of firm $i$ in year $(t-1)$. $Salei,t-1$ is divided by the total asset of last year ($Ki,t-1$) to control the firm size.

### 58.3.3 Econometric Model

$$\frac{Invest_{i,t}}{K_{i,t-1}} = a_0 + a_1\frac{CF_{i,t}}{K_{i,t-1}} + a_2\frac{Finance_{i,t}}{K_{i,t-1}} + a_3 Salegrow_{i,t-1} + a_4 ROA_{i,t-1} + a_5 Leverage_{i,t-1} + a_6\frac{Cash_{i,t}}{K_{i,t-1}} + a_7\frac{Sale_{i,t-1}}{K_{i,t-1}} + \varepsilon_{i,t}$$

## 58.4 Empirical Results

The descriptive statistics of all the variables are presented in Table 58.1.

Table 58.2 listed the Pearson correlation coefficient matrix of the variables. The results suggest possible relationship between firm's investment expenditure and corresponding internal and external funds. Thus the further analysis is feasible.

The results of Breusch-Pagan test and Hausman test suggest that fixed-effects framework will be more appropriate. Estimates for the major coefficients or variables of interest are reported in Table 58.3 below. The analyses were done with STATA 12.

The estimated coefficient on internal fund (CFi,t/Ki,t−1) is positive and statistically significant at the 0.01 level, suggesting that hypothesis I is supported. The ability of earning cash flow from the operating activities exerts significant influence on the firm's investment behavior.

As predicted, the estimate coefficient on external fund (Financei,t/Ki,t−1) is positive and statistically significant at the 0.01 level, suggesting that hypothesis II is supported. Firms that have easier access to external financial resources are capable to enlarge its investment scale.

Last but not least, the coefficient of internal fund (CFi,t/Ki,t−1) is larger than that of external fund (Financei,t/Ki,t−1). Hypothesis III is supported, implies that in the obscure atmosphere of Chinese real estate market, development companies are prudent when using external fund. And as a whole, real estate development companies prefer the low-cost internal fund when making investment decisions.

## 58.5 Discussion

The purpose of this paper is to detect the underlying mechanism of investment behaviors of real estate developers when facing financial constraints.

The analysis of data collected from China public real estate development companies during period 2008–2012 shows that firm's investment decision are heavily subject to the financial status, thus investment expenditures of real estate

**Table 58.1** Descriptive statistics on related variables

| | Mean | Standard deviation |
|---|---|---|
| $Invest_{i,t}/K_{i,t-1}$ | 0.088 | 0.346 |
| $CF_{i,t}/K_{i,t-1}$ | −0.020 | 0.207 |
| $Finance_{i,t}/K_{i,t-1}$ | 0.074 | 0.256 |
| $Salegrow_{i,t-1}$ | 13.376 | 159.026 |
| $ROA_{i,t-1}$ | 0.038 | 0.050 |
| $Leverage_{i,t-1}$ | 0.605 | 0.172 |
| $Cash_{i,t}/K_{i,t-1}$ | 0.143 | 0.101 |
| $Sale_{i,t-1}/K_{i,t-1}$ | 0.288 | 0.205 |

N = 495

**Table 58.2** Pearson correlation matrix

| | $Invest_{i,t}/K_{i,t-1}$ | $CF_{i,t}/K_{i,t-1}$ | $Finance_{i,t}/K_{i,t-1}$ | $Salegrow_{i,t-1}$ | $ROA_{i,t-1}$ | $Leverage_{i,t-1}$ | $Cash_{i,t}/K_{i,t-1}$ | $Sale_{i,t-1}/K_{i,t-1}$ |
|---|---|---|---|---|---|---|---|---|
| $Invest_{i,t}/K_{i,t-1}$ | 1 | – | – | – | – | – | – | – |
| $CF_{i,t}/K_{i,t-1}$ | 0.049* | 1 | – | – | – | – | – | – |
| $Finance_{i,t}/K_{i,t-1}$ | 0.085* | −0.627* | 1 | – | – | – | – | – |
| $Salegrow_{i,t-1}$ | −0.010 | 0.007 | −0.045 | 1 | – | – | – | – |
| $ROA_{i,t-1}$ | 0.126* | 0.285* | −0.096* | 0.029 | 1 | – | – | – |
| $Leverage_{i,t-1}$ | −0.214* | 0.154* | −0.036 | −0.016 | −0.013 | 1 | – | – |
| $Cash_{i,t}/K_{i,t-1}$ | 0.262* | −0.116* | −0.0350 | 0.045 | 0.194* | −0.097* | 1 | – |
| $Sale_{i,t-1}/K_{i,t-1}$ | 0.030 | 0.026 | 0.043 | 0.065 | 0.274* | 0.096* | 0.0890* | 1 |

*Significant at the 0.1 level

**Table 58.3** Estimates on investment expenditure of real estate operating companies

| Variable name | Coefficient | Standard error | T statistics | P value |
|---|---|---|---|---|
| $CF_{i,t}/K_{i,t-1}$ | 0.377*** | 0.115 | 3.28 | 0.001 |
| $Finance_{i,t}/K_{i,t-1}$ | 0.337*** | 0.084 | 4.02 | 0.000 |
| $Salegrow_{i,t-1}$ | −7.22E-06 | 0.0004 | −0.02 | 0.985 |
| $ROA_{i,t-1}$ | 0.157 | 0.386 | 0.41 | 0.685 |
| $Leverage_{i,t-1}$ | −0.540*** | 0.161 | −3.35 | 0.001 |
| $Cash_{i,t}/K_{i,t-1}$ | 0.635*** | 0.228 | 2.78 | 0.006 |
| $Sale_{i,t-1}/K_{i,t-1}$ | −0.015 | 0.091 | −0.16 | 0.871 |
| constant | 0.305*** | 0.108 | 2.82 | 0.005 |

***Significant at the 0.01 level; Adjusted $R^2$ is 0.4062

firms operating in incomplete capital markets are sensitive to the availability of both internal funds and external funds. The capital-intensive feature of Chinese real estate companies are significant. The significant influence of firms' debt-to-assets ratio (Leveragei,t−1) to investment expenditure confirms this finding.

However, the empirical results of this paper indicates that China real estate developers' investment expenditure are made regardless of firms' respective operating condition. Firms tend to expand investment scale regardless of its poor ROA and sales performance. There may exist possible inefficient investment behavior of those sample firms. The housing bubbles may be spurred by the over-investment and further lead to the rise of housing price of China. The sustainable development of China's real estate market calls for rational investment behavior.

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# Chapter 59
# Status Analysis and Trend Prediction for the Labor Costs of Chinese Construction Industry

**Guiwen Liu and Yanbo Diao**

**Abstract** Chinese huge low-cost labor force provided motive power for the development of construction industry in the past decades. However, Chinese labor costs soar quickly in recent years, which bring pressures to construction enterprises. In order to analyze the problems of rising labor costs of Chinese construction industry in depth, a questionnaire survey is conducted among construction workers and project managers. According to the result of the investigation and statistical data, the rising actuality and influence factors of labor costs in Chinese construction industry are analyzed comprehensively. Then the medium and long term prediction of labor cost is carried out by using GM (1, 1) grey model. The results show that the average pay of Chinese construction workers rose quickly over the past 5 years. Changes of supply–demand relation of labor force, soaring prices and the rapid economic development, and other aspects are the reasons causing the labor costs increase. The average daily pay of Chinese construction workers will keep rising in coming years, and will achieve 337 RMB yuan by 2020. The research results present valuable reference basis for construction enterprises to grasp the development trend of labor costs and takes steps to address the labor cost pressures.

**Keywords** Construction industry • Labor cost • Questionnaire survey • GM (1, 1) grey model

G. Liu • Y. Diao (✉)
Department of Construction Management and Real Estate, Chongqing University,
No. 174 Shazhengjie, Shapingba, Chongqing, China
e-mail: gwliu@cqu.edu.cn; dyb0820@163.com

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## 59.1 Introduction

Construction industry is one of pillar industries of Chinese national economy. The added value of construction industry accounts for 6.8 % of GDP. The employment number of construction industry stands at nearly 40 million. Therefore, construction industry has a great influence on the economic development and employment level of China. The process of construction needs large quantities of manual labour, due to the character and the technical level of China's construction industry. The share of labor cost in construction cost is about 10–20 % in China, which is significantly lower than that in developed countries, because China is blessed with abundant and cheap workforce. To some extent, the huge low-cost labor force was an important motive power promoting the vigorous development of Chinese construction industry in the past decades. However, Chinese labor costs soar quickly in recent years. According to the statistics, the wage of urban workers in construction companies began to accelerate since 2003, with increasing at annualized rates of more than 10 %. In 2011, the average annual income for urban workers in construction companies has nearly tripled as compared to 2003. Eighty-percent of construction workers are peasant-workers. The wages of peasant-workers began to rise quickly since 2004, and jumped the most 26.5 % in 2008 [1]. Labor force is one of the critical factors for the construction process. The increase of labor cost can bring cost stress and other influence to construction companies. Therefore, it is important to study the present situation and influence factors of Chinese construction labor costs, and accurately predict the change trend of labor cost. The study can present valuable reference for construction enterprises to grasp the condition of industry development and take steps to deal with the labor cost pressures.

## 59.2 Literature Review

The academic circles generally consider that labor cost is one of the most important influential factors for labor productivity. McKenzie and Harris (1984) are the first to bring forward that a moderate wage hikes could encourage employees, so that to help company to improve labor productivity [2]. Paul (2004) believes that the less obvious increase of labor cost is one of reasons why labor productivity growth of American construction industry went into reverse [3]. Aynur and Serdar (2004) study the construction labor productivity in Turkey by questionnaire survey applied to planning engineers, site managers, sub-contractors, architects and consultants. They get the conclusion that worker's salary income is the chief factor which has influence on labor productivity [4]. Rodrigo etc. (2011) take a questionnaire survey analysis of workers and midlevel employees in a Chilean construction company. The main findings indicate that one of the most important factors affecting productivity is workers' salary. Salary expectations are found to be the main reason for turnover and work enthusiasm [5].

In china, the problem of construction labor cost didn't attract attention of the society initially before. The shortage of peasant-workers happened in construction industry in 2004, which resulted in the notable increase of construction labor cost. Since then, some scholars started to study the construction labor cost of China. Si and Xu (2007) analyze the factors which inhibit the sustainable development of construction industry, in the background of peasant-workers shortage. They point out that the development mode of low cost and high competition ability is one of the most factors inhibit the sustainable development of construction industry [6]. Zhu et al. (2007) draw a conclusion that the labor cost will keep a rising trend, according to the research on the average wage and salary, work condition, employee fringe benefits and the proportion of labor cost in construction cost [7]. Liu and Liang (2009) test the long-term equilibrium relation between workers' wages and labor productivity of Chinese construction industry. The results indicate that the increase of labor cost will increase productivity, and then improve the development potential and international competitiveness of Chinese construction industry [8]. Liu and Qin (2010) conclude that there are significant positive relationships between salary and labor productivity of Chinese construction industry based on linear analysis [9]. Ran and Zhai (2010) measure the relative contribute rate of effective factors to China's construction industry in 2006 and 2007. The result indicates that human capital has become the first important factor in the development of China's construction industry [10]. Zhou and Zhao (2010) research the influence of minimum wage on the employment of China's construction industry. Research findings indicate that a 10 % increase in minimum wage result in a 1.3 % age point decrease in employment levels of construction industry [11].

So far, there have been few studies on the construction labor cost of China. Past researches concentrate on the relationship between wage and labor productivity. The research of influencing factors and developmental tend of Chinese construction labor cost are still in blank field. Construction labor costs are rising rapidly in China. Many construction firms have said that the fast-rising labor costs bring heavy pressure to them. Based on this background, a questionnaire survey is conducted among construction workers and project managers. This paper first analyze the rising actuality and influence factors of labor costs in Chinese construction industry, according to statistical data and the results of the investigation. Then the medium and long term prediction of labor cost is carried out by using GM (1, 1) grey model. The research achievements are expected to help construction companies to accurately grasp the growing trend of labor cost and make rational employees' rewards.

## 59.3 Current Situation of Labor Cost in Chinese Construction Industry

### *59.3.1 The Circumstance of the Labor Cost Increasing*

According to the statistics, the labor costs of Chinese construction increased obviously during the past 5 years. The national average wages of construction workers increase by 80.3 % from 2008 to 2013, with an average annual growth of 13 %. The carpenters show a highest wage growth at 95.7 % among all type of jobs, while the welders experience the lowest wage growth at 64.4 %.

The wage growth rate of construction workers vary significantly from year to year. Affected by the financial crisis, Chinese construction workers wages experienced a slightly slower growth in 2008, with an average growth of 9 %. As the financial crisis deepened in 2009, the average wage reduced by 2.8 %. As the economic growth resumed, the average wage of construction workers began to grow rapidly. The increasing rate was 24.3 % in 2010 and 23 % in 2011 respectively. The wage growth of construction workers began to slow from 2012. In 2012, the average wage of construction workers represented a 6.5 % increase over the previous year. The slow increase had lasted till the first quarter of 2013.

The wage growth rate of construction workers also vary significantly from province to province. Construction workers wages of 13 provinces increased more rapidly than the national average. Construction workers wages of seven provinces more than doubled from 2008 to 2013. Inner Mongolia represented a highest wage growth at 188 % during the past 5 years. Average wage of construction workers increased slowly in Hunan and Hainan province, with the growth rate of less than 10 % for 5 years. In Guangdong province, the wages of construction workers remained constant for the past 5 years.

### *59.3.2 The Investigation of Construction Labor Cost*

Questionnaire investigations are carried out among construction workers and project managers in order to deeply understand the current situations of construction labor costs. The questions involve in the basic information of workers, salary income, the shortage of workers and the reason for labor cost increase etc. 543 effective questionnaires are collected.

According to the results of the inquiry, 45 % of construction workers earn 3,000–5,000 RMB yuan a month, 26 % of workers say their average monthly salaries are between 2,000 and 3,000 RMB yuan, 21 % of workers earn 5,000–8,000 RMB yuan. There are large income gap between skilled workers and unskilled workers. The carpenters are the highest earning earners, with an average wage of 5,000–8,000 RMB yuan, and the maximum income at 15,000 RMB yuan a month. Unskilled workers earn the lowest, with an average wage of 2,000–3,000 RMB yuan, and the minimum income at just a few hundred yuan a month. Sixty-two percent of workers feel satisfied with their earning, while 38 % of workers are dissatisfied with the wages. Forty-four percent of workers say their expectation salary is 5,000–8,000 yuan, and 16 % of workers state their expectation salary is more than 8,000 yuan. Seventy-one percent of the workers say they earned less than 2,000 yuan 5 years ago, with a minimum income at 200 yuan a month. Eighty-one percent of project managers think the wages of construction workers increase exceedingly fast in recent years. Ninety-two percent of project managers say that labor cost record the fastest growth rate among various costs in construction. The rapid growth of labor cost brings the increase of construction cost, and shrinks the profits, which puts stress on construction companies, especially on small and medium-sized enterprises. Some project managers point out that the undesirable increase of labor cost might result in bad consequences such as cutting corners and quality degradation.

## 59.4 The Cause of Labor Cost Increase

There are many factors influencing the growth of construction labor cost. The major factors are analyzed in this paper, on the basis of investigation.

### *59.4.1 The Changes of Supply–Demand Relation of Labor Force*

Changes of supply–demand relation of labor force is the root cause of labor cost increase in Chinese construction industry. There were a large number of rural labors went out for works in urban areas in the past decades. Most of construction workers come from these peasant-workers. Chinese construction labor costs linger on a lower level in a long-term due to the large number and continuously increasing of peasant-workers.

However, changes have taken place in labor market. Peasant-workers are gradually being in short supply. It's estimated that there will be 7.3 million working-age populations go out to work in urban areas, cannot meet the need of the rapid development of urban economy [12]. Because of the poor working conditions, low security, long working hours, and low welfare, the new generation peasant workers are reluctant to be engaged in construction, which exacerbates the shortage of construction workers. The investigation results show that most of the workers are not satisfied with the work. Ninety-five percent of respondents don't want their kids to be a construction worker. Meanwhile, the demand for construction labor is increasing, with the development of urbanization and the increasing of volume of engineering construction in China.

The results of questionnaires indicate that, 78 % of construction projects have the problem of labor shortage. The changes of supply–demand relation will lead to the rise in labor cost, based on the demand–supply theory. Almost all the project managers believe that the shortage of labor has a great influence on labor cost growth.

### 59.4.2 The Rise of Prices Level

With the rapid development of economy, prices rise fast in recent years. Rapid price rises promote the increase of Chinese labor cost. The Consumer Price Index (CPI) suggests that the prices of food, medical, education and other aspects rise quickly, which is closely related with people's life. Some consumer prices increase faster than income. Moreover, the housing prices have increased to excess in recent years. As the prices rise, the demand for higher salaries became more intense. Ninety-four percent of the respondents say that rapid price rises is the reason of labor cost increase.

### 59.4.3 The Rapid Development of Economy

The rapid development of economy drives the increase of labor cost. Since China's reform and opening-up, Chinese economy has experienced 30 consecutive years of stable growth. China is raising its economic status in the world in the last decade. The economic growth of China is stronger than expected. China has now become the second largest economy in the world, and account for 10 % of world GDP. China has also adopted a new economic development approach, and extends the benefits of economic development to all people. The workers income levels have greatly improved accordingly. According to the investigation, 92 % of project managers hold that the fast development of economics promote the rising of Chinese labor costs.

### 59.4.4 The Enforcement of Wage and Social Security Policies

Chinese government focuses on the fulfillment of policies in income distribution and social security. A stricter minimum wage regulation was issued in 2004. The frequency of minimum wages adjustment is quickened in each province. The new labor contract law became effective on 1 January 2008, which made a significant step forward in protecting employees' rights. The labor costs increased markedly after the enforcement of the new labor contract law. In addition, China's social security system is being further perfected. Companies play an important role in social security system. More than 73 % of social insurance expenses of employees are paid by the companies (Xin 2010) [13]. Meanwhile, the nonstandard employment is improving, as workers are much more aware of their legal rights at the workplace. In the investigation, 42 % of the project managers agree that the perfection of social security system promote the increase of labor cost. 94 % of project managers approve that the enhancement of rights consciousness lead to the growth of labor cost.

### 59.4.5 Technology Progress

To a certain stage of economic development, industrial structure will have to adjust and optimize. Construction companies need to produce products with high technology and high added value to take the place of products with low cost and low added value. Educational training and talents introduction are important actions for companies to heighten technology level. Thus the labor costs are raised. Workers wages will further increase when labour quality is enhanced. Based on the results of investigation, 53 % of project managers suggest that technology progress brings higher labor cost.

## 59.5 Prediction of Labor Cost

The medium and long term prediction of labor cost is carried out by using GM (1, 1) grey model. Grey model has the advantage of less input data and high computational accuracy. A better prediction can be obtained by using GM (1, 1) grey model.

### 59.5.1 The Modeling Process of GM (1, 1)

The modeling process of GM (1, 1) is summarized as following:

Let the original data be denoted as the time sequence below:

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

where, $x^{(0)}(k) \geq 0$, $k = 1, 2, \ldots, n$.

The 1-AGO sequence of $X^{(0)}$ is expressed as the following sequence:

$$X^{(1)} = \left\{x^{(1)}(k) \middle| k = 1, 2, \ldots, n\right\}$$

where, $x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i)$, $k = 1, 2, \ldots, n$.

The moving average sequence of $X^{(1)}$ is expressed as the following sequence:

$$Z^{(1)} = \left\{z^{(1)}(k) \middle| k = 2, 3, \ldots, n\right\}$$

where, $z^{(1)}(k) = \frac{1}{2}\left[x^{(1)}(k) + x^{(1)}(k-1)\right]$.

Then the grey differential equation of GM (1, 1) is established as follow:

$$x^{(0)}(k) + \alpha z^{(1)}(k) = \mu \tag{59.1}$$

where, $\alpha$ and $\mu$ represent the developing coefficient and grey action respectively.

Let $A$ denote the vector need to be estimated, Eq. (59.1) is solved by using the least square method. The result is expressed as follow:

$$A = (\alpha, \mu)^T = \left(B^T B\right)^{-1} B^T Y_n$$

where, $B = \begin{bmatrix} -z^{(1)} & (2) & 1 \\ -z^{(1)} & (3) & 1 \\ \vdots & & \vdots \\ -z^{(1)} & (n) & 1 \end{bmatrix}$, $Y_n = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}$.

Then the corresponding white differential equation is established as follow:

$$\frac{dx^{(1)}}{dt} + \alpha x^{(1)} = \mu \tag{59.2}$$

The time respond function of GM (1, 1) can be obtained by solving Eq. (59.2). The result is listed as follow:

$$\hat{x}^{(1)}(k+1) = \left[x^{(0)}(1) - \frac{\mu}{\alpha}\right] e^{-\alpha k} + \frac{\mu}{\alpha} \tag{59.3}$$

where, $k = 0, 1, \ldots\ldots.$

The grey forecasting model of original sequence can be obtained by doing regressive calculation on Eq. (59.3). The result is expressed as follow:

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k) = (1 - e^{\alpha})\left[x^{(1)}(1) - \frac{\mu}{\alpha}\right] e^{-\alpha k} \tag{59.4}$$

where, $k = 0, 1, \ldots\ldots.$

### *59.5.2 The Forecast of Chinese Construction Labor Cost*

2008–2013 data of construction workers average wage are taken as samples to forecast the medium and long term level of labor cost, by using GM (1, 1). The data acquisition in this paper comes from China Engineering Network. The average daily wages of Chinese construction workers are listed in Table 59.1.

**Table 59.1** The average daily wages of Chinese construction workers

| Number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Year | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Daily wage (yuan) | 66 | 69 | 73 | 91 | 107 | 119 |

#### 59.5.2.1 Establish Forecast Model

The original sequence of Chinese construction workers average wage is expressed as follow:

$$\begin{aligned} X^{(0)} &= \{x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), x^{(0)}(4), x^{(0)}(5), x^{(0)}(6)\} \\ &= \{66, 69, 73, 91, 07, 119\} \end{aligned}$$

The 1-AGO sequence of original sequence is expressed as the following sequence:

$$\begin{aligned} X^{(1)} &= \left\{x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), x^{(1)}(4), x^{(1)}(5), x^{(1)}(6)\right\} \\ &= \{66, 135, 208, 299, 406, 525\} \end{aligned}$$

The moving average sequence of $X^{(1)}$ is expressed as following:

$$Z^{(1)} = \{100.5, 171.5, 253.5, 352.5, 465.6\}$$

Then, vector B and vector Y are obtained as following:

$$B = \begin{bmatrix} -100.5 & 1 \\ -171.5 & 1 \\ -253.5 & 1 \\ -352.5 & 1 \\ -465.5 & 1 \end{bmatrix}, Y = \begin{bmatrix} 69 \\ 73 \\ 91 \\ 107 \\ 119 \end{bmatrix}$$

Vector $A = (\alpha, \mu)^T$ is obtained by using the least square method. The result is expressed as follow:

$$A = \begin{bmatrix} -0.1469 \\ 52.3205 \end{bmatrix}$$

Then the forecast model of sequence $X^{(1)}$ is established as follow:

$$\hat{x}^{(1)}(k+1) = 422.1641e^{0.1469k} - 356.1641, k = 0, 1, \ldots\ldots$$

**Table 59.2** Prediction results of Chinese construction workers average wages

| Number | Year | Real wage | Predicted wage | Residual error (δ(k)) | Relative residual (ε(k)) | Relative precision ($P^0$(k)) |
|---|---|---|---|---|---|---|
| 2 | 2009 | 69 | 67 | 2 | 2.90 % | 97.10 % |
| 3 | 2010 | 73 | 77 | −4 | 5.48 % | 94.52 % |
| 4 | 2011 | 91 | 90 | 1 | 1.10 % | 98.90 % |
| 5 | 2012 | 107 | 104 | 3 | 2.80 % | 97.20 % |
| 6 | 2013 | 119 | 120 | −1 | 0.84 % | 99.16 % |
| 7 | 2014 | | 139 | Average residual error (δ(avg)) | Average relative residual (ε(avg)) | Average relative precision ($P^0$(avg)) |
| 8 | 2015 | | 161 | | | |
| 9 | 2016 | | 187 | | | |
| 10 | 2017 | | 216 | | | |
| 11 | 2018 | | 251 | 0.2 | 2.62 % | 97.38 % |
| 12 | 2019 | | 290 | | | |
| 13 | 2020 | | 337 | | | |

Then the forecast model of original sequence is gained as below:

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k), \quad k = 0, 1, \ldots\ldots$$

The prediction results of Chinese construction workers average wages from 2009 to 2020 are listed in Table 59.2.

#### 59.5.2.2 Test the Model Validity

Residual test and posterior variance test are used for checking the model validity.

(a) Residual test
The relative residual errors are less than 10 %; the average relative residual is 2.62 %, less than 5 %; average relative precision is 97.38 %, greater than 95 %. The results of the residual test show that the prediction precision of the model is good.

(b) Posterior variance test
The standard deviations of original sequence and residual error are 2.4819 and 19.2083 respectively. And the variance ratio is 0.13, less than 0.35. The little probability of error is 1, greater than 0.95. The results of posterior variance test show that the prediction reaches the “first class” precision.

The results of model test demonstrate that a better prediction of construction workers wages can be obtained by grey model.

#### 59.5.2.3 The Prediction Result of Construction Workers Wage

Figure 59.1 shows the real wages and the predicted wages of Chinese construction workers. As can be seen from the figure, the GM (1, 1) grey model has rather high

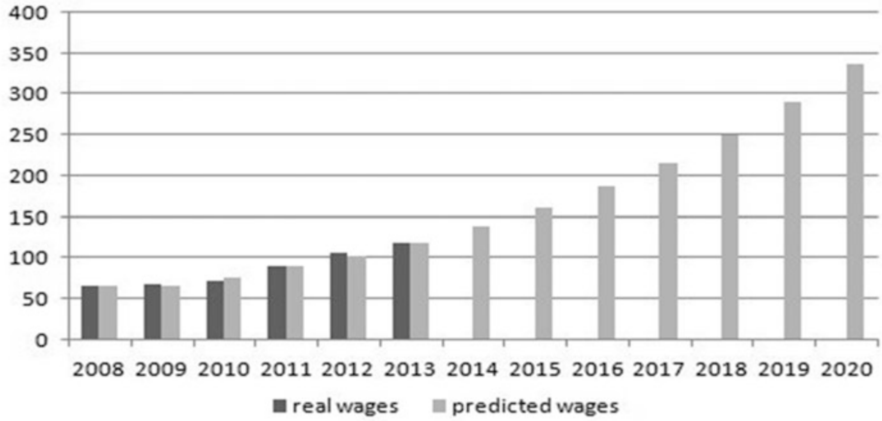


**Fig. 59.1** The real wages and the predicted wages of Chinese construction workers

prediction effect. According to the prediction result, the average daily pay of Chinese construction workers will keep rising in coming years, with a growth rate of 16 % or so. Construction workers will earn 337 RMB yuan by 2020, through 8 h work a day. The survey indicates that the construction workers usually work 10 h a day, and still work in weekend. Therefore, the income of construction workers will be higher, based on the real work time. And the average monthly earning of construction workers will exceed 10,000 RMB yuan by 2020.

## 59.6 Conclusion

Chinese construction labor costs rise quickly in recent years. Chinese construction industry is a labor-intensive industry. Labor costs have a great effect on the competitive force of construction companies. In order to analyze the problems of rising labor costs of Chinese construction industry in depth, a questionnaire survey is conducted among construction workers and project managers. According to the results of the investigation and statistical data, the rising actuality and influence factors of labor costs in Chinese construction industry are analyzed. Then the medium and long term prediction of labor cost was carried out by using GM (1, 1) grey model.

The results show that the average daily pay of Chinese construction workers rose quickly over the past 5 years, with a total growth rate of 80.3 %. The wage growth rate of construction workers vary significantly province to province. Inner Mongolia represents a highest wage growth at 188 % during the past 5 years, while the wages of construction workers remain constant for the past 5 years in Guangdong province. There are large income gap between skilled workers and unskilled workers. The carpenters are the highest wages earners, with the maximum monthly income at 15,000 RMB yuan. Some unskilled workers earn just a few hundred

RMB yuan a month. There are many factors influencing the growth of construction labor cost. The major factors are the changes of supply–demand relation of labor force, soaring prices, the rapid economic development, the enforcement of wage and social security policies and technology progress. The results of prediction indicate that the average daily pay of Chinese construction workers will achieve 337 RMB yuan by 2020, and the monthly earning will over 10,000 RMB yuan.

The study results suggest that the upward trend of Chinese construction labor costs is irreversible for a long time to come. The labor cost growth can promote the improvement of labor productivity and alleviate the recruitment difficulty. However, the rapid growth of labor costs will unavoidably bring tremendous pressure and operational difficulties to Chinese construction enterprises. The research results are expected to present valuable reference for construction enterprises to grasp the development trend of labor costs and takes steps to address the labor cost pressures.

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# Chapter 60
# The Comparison About the Nominated Subcontractor Between China and Foreign Construction Contracts

**Hong Zhang, Fengjiao Sun, and Xingfang Li**

**Abstract** As one of the important subcontracts, nominated subcontractor has been clearly defined in FIDIC, ICE. It also has the similar contents in NEC, even though it has no exactly provisions of nominated subcontracting. However, there are little contents related to nominated subcontractor in China, which makes it have no basement in the real construction case. Hence, this paper aims to find out the shortages about the Chinese nominated subcontractor. To achieve this aims, A comparative analysis about the nominated subcontractor is made, which is based on different construction contracts. Four main contents are found, and there are applicable laws, contract relationship, main contractor's right and responsibility. Eventually, some recommendations are made to improve nominated subcontractor in China.

**Keywords** Nominated subcontractor • Construction contract • Comparative analysis

## 60.1 Introduction

In the construction projects, we have to choose some "unique subcontractors" who have many professional skills for construction such as professional technologies, special equipments and unique methods, to complete the special work, which the general subcontractors cannot afford. As a special subcontracting mode in construction field, even the nominated subcontractor mode has emerged in the

H. Zhang (✉)
Associate Professor, School of Economics and Management Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China
e-mail: highsky_zh@yahoo.com.cn

F. Sun • X. Li
School of Economics and Management Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China
e-mail: 1053707876@qq.com; lixingfang123456@126.com

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construction field frequently, the relevant laws and regulations do not give the nominated subcontractor a rightful status as well as the construction contract in China, which makes the engineering practice be out of line with laws and regulations. Therefore, when to the cases relating to the nominated subcontractor, we have to refer to the international rules. Due to the difference between foreign and domestic laws, a series of problems happened during this process. Here we will mainly refer to FIDIC condition of construction contract (the fourth edition in 1999), ICE condition of construction contract (the seventh edition), NEC contract of construction (the second edition) who are widely used at the present stage all around the word and then make some comparative analysis based on the nominated subcontractor to further understand the way how the international construction contract regulates the right and responsibility in the contract of nominated subcontractor, which provides some more useful foundation for improving nominated subcontractor in China.

## 60.2 An Overview on Nominate Subcontractor

### *60.2.1 The Provisions on Nominated Subcontractor in Each Construction Contract*

The definition of nominated subcontractor is different from each construction contract. In the contract of ICE and FIDIC, the nominated subcontractor is selected by the employer (or the engineer) and signs the subcontracting contract with the main contractor to finish some specific content of the work, which needs some professional technology. Although, There is no clauses about nominated subcontractor in the NEC contract, the main contractor will subcontract some special part of the project to the subcontractor who owns this professional ability, which reaches the nominated subcontracting effect like the FIDIC. So, this subcontractor in NEC is also be called nominated subcontractor. But the nominated subcontractor of NEC style is nominated by the main contractor and has the same status with the common subcontractor. All in all, ICE、FIDIC and NEC squares up to the nominated subcontractor and formulate some reasonable regulation methods for it. However, The《Model text of construction contract》(edition in 1999) (hereinafter referred as to ‘model text’) in China has no clauses about nominated subcontractor and do not reach the nominated subcontracting effect like NEC. Even the new model text draft that will issue in the near future, still do not specify relevant regulations on nominated subcontractor. To some extent, it responses an avoiding attitude toward nominated subcontractor in China. In the Table 60.1, we list the concrete clauses and attitude on nominated subcontractor in ICE, FIDIC, NEC and the model text in China to lay a good foundation for further comparing and analysis.

**Table 60.1** The concrete clauses about the nominated subcontractor

| Contract type | ICE | FIDIC | NEC | China |
|---|---|---|---|---|
| Clause | 25.1 Introduction<br>25.2 Objection to nomination<br>25.3 Engineer's action on objection and determination<br>25.4 Contractor's responsibility for nominated subcontractors<br>25.5 Nominated subcontractor's default<br>25.6 Provisions for payment<br>25.7 Payment to nominated subcontractor | 5.1 Definition of "nominated subcontractor"<br>5.2 Objection to nomination<br>5.3 Payments to nominated subcontractors<br>5.4 Evidence of payments | 26.1 If the main contractor subcontract some part of the project, the main contractor's responsible shall be deemed as no subcontractor<br>26.2 the main contractor shall submit every proposal subcontractor to the project manager<br>26.3 The main contractor cannot nominate any subcontractor before project manager's permission | none |
| Attitude | Face squarely | Face squarely | Face squarely | Avoid |

### *60.2.2 Current Legislation About Nominated Subcontractor in China*

China's law and regulations on provision of nominated subcontracting is quite rough. On the one hand, some departmental rules make prohibitive provisions while does not provide corresponding administrative punishment measures, which makes this prohibitive provisions have no feasibility in practice. The concrete content is showed in the Table 60.2. On the other hand, The relevant judicial interpretations regulate that the employer have to bear fault liability for the nominated subcontractor's default if the employer directly nominates subcontractor to the professional work. So, even the ministry of construction intends to ban the nominated subcontracting in the field of housing construction and Infrastructure project, the employer only takes a little responsibility for the nominated subcontractor's default. Thus, the absence of administrative responsibility is the root cause of the appearance of nonstandard nominated subcontracting.

## 60.3 Applicable Law Comparison

We all know law counts much in every industry, it defends our most fundamental rights and interests. But every country applies to different law system, it is extremely important to study the legal basis for better using diverse construction

**Table 60.2** The concrete content of legislation

| Laws | Attitude | Detailed content |
|---|---|---|
| Departmental rules | Prohibited | In 2003, "construction project bidding procedures" provisions of article sixty-sixth: "the tenderer shall not directly appoint subcontractor." |
| | | In 2004, the "housing construction and municipal infrastructure works subcontracting management approach" the provisions of article seventh: "construction units may not directly nominate subcontracting engineering contractor". Any unit and individual shall not intervene on subcontracting activities according to the law |
| Building law | Not prohibited | "Twenty-ninth Building Law" stipulates: the turnkey contractor may subcontract some part of the project to those subcontracting unit who have appropriate qualifications |
| | | "Twenty-ninth Building Law" stipulates: "Building materials, construction fittings, equipments purchased by project contracting units, The contract issuing unit shall not nominate Production units and suppliers" |
| The relevant judicial interpretation | Avoided | In 2004, the Supreme People's Court promulgated the "the interpretation of the law applicable to construction contract dispute cases" Because the employer directly appointed subcontractor and then caused of quality defects in construction project. The developer shall bear the liability. The contractor is at fault, it shall bear the corresponding liability |

**Table 60.3** Applicable laws and character

| Law system | Character | Contract |
|---|---|---|
| Case law | Follow the precedent principle and emphasize the previous case. And then take the previous case as a foundation | ICE<br>FIDIC<br>NEC |
| Continental law | All cases are performed in accordance with the law which has been established. Everything must have written in regulations and provisions. Emphasize doing everything by rule | China's model text |

contract. It can be divided into two system, "Continental Law" and "Case Law", according to international perspective. The applicable law of each contract and each law system's character are concluded in Table 60.3.

Firstly, China applies to Continental Law, the existing laws are particularly important. Secondly, the current legislation on nominated subcontractor cannot afford the demand of construction industry. All in all, China has falled behind other country in the legal protection of this aspect. If the law cannot regulate the nominated subcontractor comprehensively, some extend of confusion will certainly happened in the construction market.

## 60.4 Comparison of Contract Relationship

### *60.4.1 In ICE and FIDIC Construction Contract*

In ICE and FIDIC contract, As taken account to the professional technology needs of some part of the project, the employer always subcontract this part to the special subcontractor, which the general subcontractor cannot afford it. To avoid obstructing each contractor in the construction site, the nominated subcontractor signs contract with main contractor and obey the main contractor's management during the process of implementation.

### *60.4.2 In NEC Construction Contract*

In terms of the new engineering conditions of contract (NEC), subcontractor clause is not specified in the contract. The reason we still take it out to do comparative analysis lies in: based on the big principle of main contractor taking full responsibility for the entire project, NEC reaches the nominated subcontracting effect by other methods (as the Table 60.1 shown). Although the so-called "nominated subcontractor" does not have any difference with the general subcontractor, as one of Great representative contracts in world, NEC's regulation method of subcontractor has certain authority. Therefore, if the contractor wants to assign a particular subcontractor under the NEC contract, project manager's permission is required [1] (in the NEC project 'project manager is the same as FIDIC' Engineers). Under the NEC's big principle, the nominated subcontractor and general subcontractor basically have the same status. And the contract body is between main contractor and subcontractor.

## 60.5 Comparison of the Main Contractor' Rights Scope

### *60.5.1 In ICE Construction Contract*

On one hand, main contractor has the right of reasonable objection to nomination. In the ICE construction contract, the employer or engineer has the right to select subcontractor as the nominated subcontractor, but this designation is not mandatory. The main contractor may refuse to sign the contract with reasonable evidence. So it is another way to check the nominated subcontractor's qualification, which benefits the project. On the other hand, main contractor has right of terminating the contract. If the nominated subcontractor makes errors in implementation, After obtaining the consent of the engineer, The main contractors can terminate the contract in terms of clauses about terminating contract. The main contractor plays a supervision and management role to subcontractor.

### 60.5.2 In FIDIC Construction Contract

Under the comparison of contract relationship above, main contractor are more like a "agent" of the employer in the FIDIC. And the main contractor will be in charge of managing and supervising nominated subcontractor under the premise of not affecting the personal interests. Up to the nomination, payment, settlement and other important decisions, the employer has power to make decision.

On one hand, main contractor has the right of reasonable objection to nomination. Although the main contractor have no decision right about choosing subcontractor, the main contractor may raise reasonable objection by notice to the Engineer as soon as possible. If the matters are regulated in the FIDIC contract, the objection shall be deemed. In order to avoid risk, the main contractor will check the contents of the contract carefully before signing the contract, including the subcontractor's ability of sufficient competence, resources or financial resources to complete the content of the contract [2]. So it is another threshold to subcontractor' qualification examination, which benefits the project.

On the anther hand, The employer has the right of suspending or refusing to pay the nominated subcontractor. What the subcontractor is paid are generally included in the total contract price. For the nominated subcontractor, the employer puts the temporarily estimated sum of contract into the part of "temporarily estimated price", namely, the subcontractor's expense is prepared in other fund before the contract is signed. And after ensured the subcontracting contract, the subcontractor will be paid by the main contractor who is paid by the employer firstly with the construction making progress. The main contractor can only be charged by general management fee according to the main contract agreed. At the same time, the main contractor has the right to withhold or refuse payment to the nominated subcontractor when providing reasonable evidence or present a written explanation to the satisfaction of the engineer. Enjoying a certain decision on the payment issue is an effective means for the main contractor to manage nominated subcontractor.

### 60.5.3 In NEC Construction Contract

Because of the big principle of main contractor, taking full responsibility for entire project, main contractor should treat any employees and mechanical materials as his own. Therefore, in the NEC contract, nominated subcontractor and general subcontractor are exactly the same on status and regulation. So the main contractor is really has the absolute power of life and death for subcontractor. The specific content are the same with general subcontractor, we do not discuss here.

## 60.6 Comparison of the Main contractor's Responsibility

### *60.6.1 In ICE Construction Contract*

In the NEC contract, main contractor's liability for nominated subcontractor is just like the FIDIC contract. Only one point is different: When main contractor gets reasonable evidence and the project manager also agree to it, the nominated subcontract will be terminated. And the main contractor must take actions to prevent loss expansion of what happened afterwards. Of course, if the termination of the contract bring some extra spending for main contractor, employers should give the main contractor certain supplement.

### *60.6.2 In FIDIC Construction Contract*

As the nominated subcontractor signs contract with main contractor, the nominated subcontractor is the same as general subcontractor in the aspects of contract relationship, management. So the main contractor, of course, has the responsibility of supervision, coordination in the process of construction for the subcontractor. However, the main contractor only bear limited fault liability happened to the default of nominated subcontractor [3]. That is, Unless the main contractor issued the wrong instructions to nominated subcontractor, the main contractor needs to bear limited joint liability. Any other breach of contract to the employers or the third damage and lead to claim or lawsuit, the main contractor do not take any responsibility. (if the general subcontractor breach the contract, the employers will be regarded as a breach of contract by the main contractor, the contractor's responsibility shall be investigated in accordance with the provisions of the main contract). So, to some extent, nominated subcontract reduce the risk of main contractor while relevant profit is reduced too.

### *60.6.3 In NEC Construction Contract*

In the NEC contract, the big principle of the main contractor taking full liability for the entire project decides the main contractor must take no-fault liability for the nominated subcontractor's default. That is, any breach of contract such as safety accident, damaging to the project for negligence and other reasons making damage to will lead the main contractor take responsibility for the breach of contract, no matter the main contractor has fault or not. So to some extent, nominated subcontract increase the risk of main contractor while relevant profit is increased too.

## 60.7 Suggestions on Perfecting the Nominated subcontractor's Regulation Method in China

### *60.7.1 Give the Nominated Subcontractor a Legal and Systematic Status*

Firstly, give the nominated subcontractor a legal and systematic status. Although some relevant laws have few provisions, the rules are not unified. "Some departmental rules" just shows the stand, but there is no binding force. The "Building law" took a more accommodating attitude, whether can nominate subcontractor depends on the employer and contractor's agreement. The relevant "judicial interpretation of" took the attitude of acquiescence. So, nominated subcontractor need a system and legal status to regulate each other. Secondly, clear the penalties and extend scope of legal responsibility the employer shall take for the nominated subcontractor. If it was specifically prohibited, the corresponding punishment measures shall be made, which can improve the feasibility of relevant laws clauses.

### *60.7.2 Specify the Rights and Obligations Beyond the Contract*

The nominated subcontractor always be nominated by the employer in China. The main contractor has no right to object the nomination, can only accept it and sign subcontract with nominated subcontractor. Besides, the employer pay the nominated subcontractor directly, which makes it difficult to manage the nominated subcontractor for the main contractor. Therefore, The rights and responsibility between nominated subcontractor and main contractor are not equal [5].

Refer to the current situation about nominated subcontractor, we could learn from FIDIC and NEC on the relevant provisions and make a series of regulations which suit for China. For example, the subcontractor can be nominated by the employer, but the main contractor must have the right to object the nomination. Under premise of beneficial to main contractor, the nominate subcontract can be signed by the main contractor and nominated subcontractor. Meanwhile, the price of subcontract shall be determined by consultation between main contractor and nominated subcontractor, which has to prohibit the employer's intervention. After the signing the contract, the main contractor takes the nominated subcontractor like the general subcontractor and shall take no-fault responsibility for the nominated subcontractor's breach of contract. The next picture shows the concrete relationships. Finally, because of the imperfect upon the law and regulations on nominated subcontractor in China, "Contract Law" might be referred to on the base of existing laws to ensure the nominated subcontract well implemented.

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# Chapter 61
# The Empirical Study of Commercial Real Estate Market Structure and Performance Based on SCP Theory

**Qunhong Liu and Jing Gao**

**Abstract** Nowadays, although more and more investors pay attention to commercial real estate, they also need to think about its market calmly. This thesis adopts Structure-Conduct-Performance mode. Using degree of market, concentration ratio, HHI index, economies of scale and some other data to analyze commercial real estate market structure, in order to find the characteristics of the market development and potential conflicts in this period. At the same time, commercial real estate market performance has been investigated from the operating profit ratio, returns on equity, etc. Using the empirical regression to study the relationship between market structure and market performance, then confirm it, hence a new policy about commercial real estate industry development to promote the market healthy and stable development.

**Keywords** Structure-Conduct-Performance • Commercial real estate • Industrial policy

Because of the government regulation of the residential real estate, a large number of real estate developers turned to the lucrative field—commercial real estate, for a time, our country set off a commercial real estate development boom. The degree of competition in the commercial real estate market is also rising; the basic framework of the market structure is initially formed. According to the study of SCP paradigm of industrial organization on the market structure, the market structure determines or influences the market behavior to some extent, and thus affect the market performance. That is to say, to improve and enhance the competitiveness of commercial real estate performance largely depends on the structure of the reasonable commercial real estate market. Based on the SCP paradigm, this paper empirically examines the relationship between the changes in the structure of the commercial real estate market and its operating performance in anticipation of suggestions for optimizing

Q. Liu (✉) • J. Gao
Urban Construction College, Jiangxi Normal University, Nanchang 330022, Jiangxi, China

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the commercial real estate market structure, improving business performance, and maintaining the stable development of commercial real estate.

## 61.1 Commercial Real Estate Market Structure Analysis

Commercial real estate is a kind of operating carrier with the development of the tertiary industry. To a country or a region, the more developed tertiary industry is, especially the commercial service industry, the bigger commercial real estate business is, and the more diverse forms of business there are. Defined from a generalized perspective, in addition to industrial and residential property, commercial real estate covers many forms of property, including office buildings, business buildings, commercial streets, shopping centers and many other commercial services business premises. The narrow commercial real estate specifically refers to the commercial services business premises without involving office buildings. Studied in this paper is the narrow level of commercial real estate.

The commercial real estate market structure refers to the characteristics and forms of the relationship between the real estate developers of this industry, and between the real estate developers and consumers [1]. In traditional research, market structure is measured by market concentration, product differentiation, barriers to entry and other indicators. These indicators depict market structure of an industry together.

### *61.1.1 Estimates of Market Concentration*

Market concentration is the most fundamental concept and indicator to reflect the market competition and the degree of monopoly. It refers to the scale and distribution of supply and demand of the seller and the buyer in the market [2]. The corresponding index measure is market concentration. Among many indicators employed to measure the degree of concentration, the CRN value and the HHI index are used in this paper.

*CRn* value is calculated as follows:

$$CR_n = \sum_{i=1}^{n} (X_i/X)$$

X is the total sales or total assets of all enterprises in the market, Xi means the ith enterprises' sales in the market, CRn is the concentration of companies in the market from 1 to i, usually measured by the indicators share of the largest four or eight companies. Market concentration reflects the size of the buyers or sellers of a particular industry or market structure. The lower the degree of industry concentration, the lower the degree of market monopoly and the smaller the market forces;

**Table 61.1** 2004–2008 market concentration of commercial real estate in Tianjin

| | | 2004 (%) | 2005 (%) | 2006 (%) | 2007 (%) | 2008 (%) | Annual average |
|---|---|---|---|---|---|---|---|
| Sales area | $CR_4$ | 7.58 | 13.35 | 13.24 | 9.38 | 8.53 | 10.80 |
| | $CR_8$ | 14.29 | 23.02 | 20.40 | 16.48 | 15.05 | 18.10 |
| Sales revenue | $CR_4$ | 16.98 | 14.10 | 14.90 | 15.50 | 9.88 | 16.44 |
| | $CR_8$ | 28.30 | 24.48 | 23.68 | 26.26 | 17.22 | 27.20 |

Data source: "1990–2010 Tianjin commercial market investment environment white paper"

**Table 61.2** Bain's market structure classification

| Market category | $CR_4$ | $CR_8$ | The number of enterprises |
|---|---|---|---|
| Extreme oligopoly | ≥75 % | — | 1–40 |
| Senior oligopoly | 65–75 % | ≥85 % | 20–100 |
| Above-concentrated oligopoly | 50–65 % | 75–85 % | A large number of enterprises |
| Under-concentrated oligopoly | 35–50 % | 45–75 % | A large number of enterprises |
| Low concentration oligopoly | 30–35 % | 40–45 % | A large number of enterprises |
| Competitive type | <30 % | <40 % | A particularly large number of enterprises |

the higher the degree of industry concentration, the larger the scale, the greater the enterprise market forces and the anticipated returns.

This paper extracted the top 8 from 2004 to 2008 in Commercial Real Estate of Tianjin as a sample of its index measurements (Table 61.1).

Based on Bain's standard of the market structure (Table 61.2) and the commercial real estate market concentration parameters from 2004 to 2008, it is apparent that Tianjin's commercial real estate market is of a competitive type, the main reasons for the low market concentration are: First, the high profits of commercial real estate in 2003 and 2004 attracted more investments; Second, commercial real estate had a lower entry barrier; Third, the government sector lacked relevant laws and regulations to regulate the commercial real estate market. The HHI index is calculated as follows:

$$HHI = \sum_{i=1}^{n} (X_i/X)^2$$

n represents the number of enterprises, Xi represents Sequence I in the size of the enterprises, X is the total scale of the enterprise. In general, the value of the HHI index between 1/n and 1. The larger the HHI value, the higher the degree of market concentration.

In conditions of single competition, the HHI index equals 0, and the n index tends to infinity. While in complete monopoly conditions, the HHI index equals 1, so is the n index. If the enterprises have the same scale in the market, the HHI index is equal to 1/n [3]. The calculation of the HHI values of Commercial Real Estate in Tianjin City in 2004–2008 is shown in Table 61.3 and Fig. 61.1.

As can be seen from Table 61.1 and Fig. 61.1, the HHI valve of Tianjin Commercial Real Estate was getting higher in 2004–2006 and reached the highest peak in 2006. This illustrated that the intensity of competition in commercial real estate market has declined. From the second half of 2006 to the end of 2008, the

**Table 61.3** 2004–2008 HHI value of commercial real estate market in Tianjin

| Years | 2004 | 2005 | 2006 | 2007 | 2008 | Annual average |
|---|---|---|---|---|---|---|
| Sales revenue | 0.0194 | 0.0232 | 0.027 | 0.0243 | 0.0155 | 0.0219 |
| Sales area | 0.012 | 0.0209 | 0.0248 | 0.0148 | 0.0139 | 0.0173 |

Source: Same as above

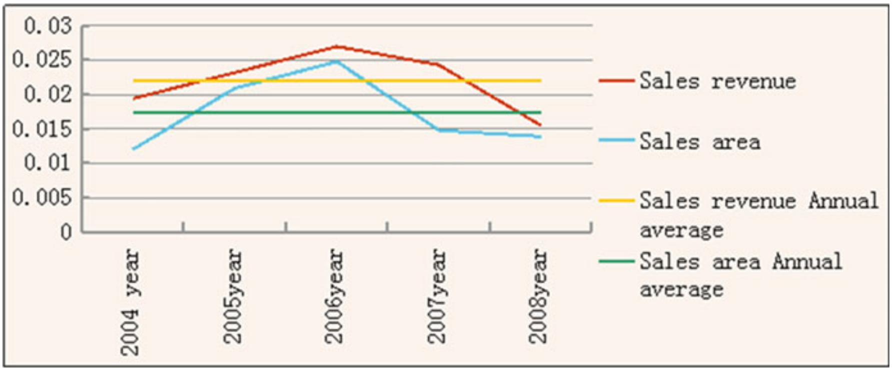


**Fig. 61.1** 2004–2008 line chart of the commercial real estate market HHI value in Tianjin

HHI index continued to reduce; the competition became more intense. This met change characteristics of the competitive market economy.

## 61.2 Commercial Real Estate Market Performance Analysis

Market performance refers to the ultimate economic effect of market operation under certain market structure and market behavior. The commonly used performance indicators include ROA, Lerner index and Tobin q value, etc.

In the paper, the profit margins and the Lerner index are employed to measure the operating performance of commercial real estate in Tianjin (see Table 61.2).

It can be seen from Table 61.2 that the average profit margin of commercial real estate was high in Tianjin from 2004 to 2008, and reached up to 30.06 % in 2007, but plunged to the minimum in 2008. On the one hand, it was influenced by the international financial crisis and its life cycle of the real estate industry; on the other hand, with the influence of the high profits in 2007, the scale of investment in commercial real estate enterprise in the first half of the year continued to increase; The average value of the Lerner index was 0.572 from 2004 to 2008, which indicates that commercial real estate in Tianjin market performance was poor, high profit mainly coming from the higher market price.

## 61.3 The Empirical Analysis of Commercial Real Estate Market Structure

### *61.3.1 Hypothesis of the Relationship Between Market Structure and Performance*

About the relation of market structure and performance are there mainly market power hypothesis and efficient structure hypothesis. Market power hypothesis, includes traditional SCP hypothesis and the relative market power hypothesis, both believing that there is positive correlation between market concentration and performance. But SCP hypothesis holds that a small number of large market share businesses run scale economy, co-operate pricing, monopolize the industry, thus enhancing corporate profits. RMP hypothesis believes that with large market share the enterprises can better achieve product differentiation and monopoly pricing, thereby increasing the profit. Efficient structure hypothesis includes X efficient structure hypothesis and the scale efficiency hypothesis, ESX hypothesis holds that because the companies have achieved X efficiency, lowered cost, they have the high profit level, and can occupy a larger market share and increase market concentration. The ESS hypothesis supports that the scale efficiency helps the enterprise reduce the unit cost of production, promote the profits, occupy a larger market share, thereby increase the market concentration [4].

### *61.3.2 Relationship Among Market Structure, Efficiency and Performance*

On the basis of Berger model, a multiple regression model is created to empirically analyze the relationship among market structure, efficiency and performance in Tianjin commercial real estate industry.

$$ROA_i = \alpha_0 + \alpha_1 CR + \alpha_2 MS + \alpha_3 Xeff + \alpha_4 Seff + \varepsilon$$

ROAi refers to each commercial real estate corporate profit margins; CRi the entire commercial real estate industry CR8; MSI the market share of the i-th commercial real estate enterprise; Xeffi the pure technical efficiency of the i-th real estate enterprise; Seffi the scale efficiency; ε the error term.

Using SPSS15.0 software, putting 2004–2008 125 sample data into the model (1), the following results are arrived at:

$$ROA = -1.279 + 0.721CR_8 + 0.016MS + 1.253Xeff + 0.398Seff$$

$$(-3.152)\ \ (0.379)\ \ (9.792)\ \ (6.004)\ \ (-1.893)$$

$$\text{ad.j}R^2 = 0.637\ \ F = 25.104$$

Each coefficient in the regression equation shows that each variable degree of impact on margins and the value in parentheses as t test value at different levels. From the regression results, the regression equation bears a certain degree of fitness and high significance.

$CR_8$ didn't pass the $\alpha = 0.01$ test, which means in Tianjin commercial real estate does not exist traditional SCP hypothesis. Market share and profit margins shows a significant positive correlation, showing there may exist a commercial real estate in Tianjin RMP hypothesis. However, through the survey it is found that commercial real estate in tianjin homogeneity is stronger, therefore, RMP hypothesis does not hold. Pure technical efficiency and profit margins are positively related, the scale efficiency and the profit margins are positively related, therefore, Tianjin commercial real estate to a certain extent, reflects the efficiency structure hypothesis.

The establishment of the efficiency structure hypothesis also needs market concentration and market share as dependent variables, and pure technical efficiency and scale efficiency as independent variables through two regression equations to calculate. The results are as follows:

$$CR_8 = 21.064 - 1.875Xeff + 1.586Seff$$

$$(-24.509)\,(-2.229)\,(1.526)\,\text{ad.j}R^2 = 0.042\ \ F = 3.695$$

From the regression results, the coefficient of the regression equations did not pass the test, thus does not have explanatory power.

$$MS = 2.433 - 1.926Xeff + 1.820Seff$$

$$(12.572)(-10.164)\ (3.504)\,\text{ad.j}R^2 = 0.682\ \ F = 58.292$$

From the results of the regression the equation has a goodness of fit and high significance; pure technical efficiency and scale efficiency pass $\alpha = 0.01$ test; pure technical efficiency coefficient is negative, which indicates that those pure-technical -efficiency real estate businesses in Tianjin do not occupy a higher market share; The significantly positive correlation between scale efficiency and market share indicate Tianjin high scale efficiency commercial real estate enterprises occupy a higher market share.

## 61.4 Suggestions for the Stable Development of Commercial Real Estate

Firstly, adequately raise the commercial real estate entry barrier to keep sound competition [5] The government can raise the minimum registered capital of qualified enterprises at all levels, enhance the audit approach of the corporate reputation, technology, capital position, and increase commercial real estate entry barrier in order to prevent excessive enterprises to enter the market, and maintain a good market concentration. At the same time, the government needs to perfect the withdrawal mechanism of the industry. For some enterprises of poor qualification and serious violations, mandatory measures should be taken to dispel them out of the real estate market.

Secondly, the government should encourage corporate cooperation to increase the scale efficiency. It is necessary to guide and support the strong enterprises of the commercial real estate to achieve powerful combination through holding shares, mergers and acquisitions, restructuring to form competitive large enterprises. Only by this way can the role of productivity be played. This can also avoid resources waste and loss because of duplication of construction and the excessive competition and finally achieve great scale operation and scale efficiency.

Thirdly, integrate corporate internal resources to improve its profit margins. For the enterprises themselves, the technology of production and management level are important factors in determining the level of business efficiency. Therefore, the enterprises should actively have the effective integration of internal resources to form a unique competitive advantage, and improve the efficiency of business operations. Finally, the enterprise would form a scale matching its own development capabilities to obtain a higher profit margin.

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# Chapter 62
# Research on the Development Strategy of Building Energy Efficiency Service Industry

**Yu Fan and Li Zhang**

**Abstract** Building Energy Efficiency Services is executed by the professional energy service companies (ESCO) that provide energy condition diagnosis, design, financing, transformation of energy-saving projects (construction, equipment installation, debugging) and operation management service. Because of the specialization and the superiority of its technique integration, increasingly, put into practice by many nations. Implementing Building Energy Efficiency Service to pushing energy efficiency retrofit of existing building is an inevitable direction for advancing building energy efficiency on the whole in China.

However, we can find the fact that the domestic building energy efficiency industry developed slowly. The paper analyzes the main obstacles facing the development of building energy efficiency service industry. Such as the energy efficiency benefit main body is not clear, the lack of enthusiasm for energy saving, the lack of understanding of the public, the lack of market demand, the Lack of building energy efficiency standard system and ESCO are small in scale and financing difficulties.

At last the paper comes to the conclusion that on the one hand, the ESCO should to build the exclusive competitive resources, build new marketing ideas and improve the quality of service. On the other hand our government should to build the industrial support policy to promote the building energy efficiency service industry development.

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Y. Fan (✉)
Beijing University of Civil Engineer and Architecture, Beijing 100044, China

Xi'an University of Architecture and Technology, Xian, China
e-mail: fanyu@bucea.edu.cn

L. Zhang
Beijing University of Civil Engineer and Architecture, Beijing 100044, China
e-mail: zhangli@bucea.edu.cn

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**Keywords** Building energy efficiency service industry • Development strategy • Energy Performance Contracting (EPC) • Energy Services Company (ESCO)

## 62.1 Introduction

Since the middle of 1970s in last century, a new energy-saving mechanism – "energy performance contracting" (EPC) based on the market gradually developed in the market economy countries, and "energy services company" (ESCO) has developed rapidly that operation based on this new energy-saving mechanism, especially in the United States and Canada, EPC has been developed into a new energy-saving industry [1]. The essence of EPC mechanism is a kind of investment way that use reduces energy costs to pay for the full cost of energy-saving investment in energy-saving projects. In the traditional way of energy saving investment, all risks and all the profits of energy saving project will be borne by the implementation of energy-saving investment enterprises; in the EPC mode, generally does not require the enterprises invested heavily for energy-saving projects.

Building energy-saving services is executed by the professional energy service companies (ESCO). This service is used to reduce the energy consumption of exist buildings by applying the energy-saving renovation without conduct the damage to the building's original function and comfortable feeling. Building Energy Efficiency Service is the product of Building Energy Efficiency when it is reached a certain phase. Because of the specialization and the superiority of its technique integration, increasingly, put into practice by many nations. In terms of building energy service industry in the United States, building energy-saving Service Corporation or Service Corporation has building energy efficiency service business, accounting for 80 % of all ESCO in the United States of America [2]. These ESCO or is specialized in energy-saving service work, or is dependent on energy saving equipment suppliers and related energy-saving research institutions. ESCO in the United States under the support of the government, the formation of a government guidance, market operation enterprises of building energy saving service mode of operation, to create a huge market of building energy efficiency service.

Building energy efficiency service industry is different from manufacturing industry, mining industry, building industry and other secondary industries, which should be categorized as tertiary industries. Building energy efficiency service includes energy condition diagnosis, design, financing, transformation of energy-saving projects (construction, equipment installation, debugging) and operation management service. Implementing Building Energy Efficiency Service to pushing energy efficiency retrofit of existing building is an inevitable direction for advancing building energy efficiency on the whole in China.

## 62.2 Industry Development Opportunities

During the "12th Five-Year Plan", our Building energy saving and green building facing the new situation and new requirements, to achieve building energy-efficient great-leap-forward development, we must innovate. To promote the building energy-saving and green building work must rely on system mechanism innovation. To make full use of the market mechanism, come into the work situation of government promotion and social forces widely participate in. Make full use of market mechanism, is to guide the construction of energy-efficient market dominated by the government for the progressive development of the market and the government to promote, improve the policies and measures, and strengthen support, basic can give full play to the role of market allocation of resources, enhance the development of the vitality of enterprises, to build an effective mechanism of market competition, increase market financing.

The building ESCO develop rapidly. As of February 2012, the national development and Reform Commission has announced the four batch of ESCO for the record list, a total of 2354, which involves building ESCO accounted for nearly 70 % [3]. To the "Twelfth Five-Year Plan" period building energy conservation will come to the formation of 1.16 t of standard coal energy-saving capacity. The development of green building, strengthening of energy-saving work of new buildings; deepen the heating system reform, the full implementation of heat metering and charging, promote the northern heating areas both building heat metering and energy efficiency retrofit; strengthen the public building energy efficiency supervision system, promote the transformation and energy saving operation management; to promote renewable energy and building integrated application of a series of key work, create the market demand and the tremendous business opportunities for building ESCO.

In 2007, said Qiu baoxing, Vice Minister of ministry of housing and urban–rural development that building energy efficiency in China has great potential by 2020 energy efficiency renovation of existing building investment will reach 1.5 trillions RMB. In addition, according to statistics, in 2020 China's existing urban and rural construction area will increase from 420 to 690 billion $m^2$ [4]. Therefore, over a period of time, there are quite a large number of existing building are not energy- efficient buildings in our country, if the government strictly enforce the building energy efficiency regulations and standards, these buildings will be faced with energy efficiency renovation, which provides great opportunities for building energy-saving service market development.

At present, the building energy saving service industry in China is still in the initial stage, the development of building energy saving service market is not fully. We can find the fact that the main obstacles facing the development of building energy efficiency service industry. Such as the energy efficiency benefit main body is not clear, the lack of enthusiasm for energy saving, the lack of understanding of the public, the lack of market demand, the ESCO are small in scale and financing difficulties and so on.

## 62.3 Industry Barriers

### *62.3.1 The Energy-Saving Benefit Main Body Is Not Clear, Lack of Energy-Saving Enthusiasm*

For new buildings, built for sale, the developer does not bear the cost of energy consumption, on the other hand, the development and construction of energy efficient buildings to increase energy efficiency investments that improve a developer's construction costs, so that developer do not have energy-saving initiative. That built for rent, energy costs passed on to the renter and lease terms often shorter, so the renter lack of power for energy saving reconstruction.

For the existing buildings, in purchase decision-making processes of energy conservation services, although the property energy management department has energy-saving experience and awareness, but lacks the power to implement energy-saving. Because the property company paid under the contract, the number of operation energy consumption has nothing to do with their income. But the owner or occupier directly linked to the interests are individual and the benefits are not unified so they lack of initiative on energy saving. Especially when the energy-saving renovation project may temporarily affect the owners of residential use, energy saving will be weaker.

### *62.3.2 The Low Level of Social Awareness, Lack of Market Demand*

According to the Ministry of construction survey 2006, 81.4 % of the public do not quite understand about building energy saving, which in summer hot and winter warm area (mainly in the South area of air conditioning energy consumption) the proportion is even more than the 90 %.˙ Housing developers and owners usually overestimate the cost associated with building energy saving reform to building projects.

The government should increase the building energy-saving publicity. Strengthen the training of concept and consciousness, to guide consumers understand the building energy consumption, resource shortage, environmental protection and other general knowledge, expanding and extending mature building energy-saving application ideas. Through newspapers radio and television, and other forms of advocacy, communities can also organize various forms of promotional activities such as seminars to guide consumers and enable consumers to understand the importance of building energy conservation, through economic account, so that consumers understand the inevitable rise in the price of conventional energy, such as electricity, gas, building energy efficiency can save the energy consumption in the process of using, enhance the public awareness of energy-saving in order to increase market demand.

### *62.3.3 Lack of Building Energy Efficiency Standard System*

The EPC model is based on the energy metering and measuring clear, which requires the evaluation and identification of energy efficiency in buildings, which is a basic work to promote the construction of energy-saving. Through energy efficiency evaluation and identifies, can provides finds of energy saving service benefits and results for both supply and demand of energy saving service market; can test whether a new building is reached energy saving standard; can encourages real estate development enterprise, and energy saving service enterprise construction efficient of energy saving building; can provides necessary information for consumers purchase decision-making, boot and help consumers purchase high energy effect building; also can provides measure indicators for cashes energy saving incentive policy.

At present, the lack of scientific and uniform application of building energy-saving evaluation system, unable to accurately determine the energy consumption of the building, also failed to verify the implementation of building energy-saving project effect, that effect marketization of building energy-saving.

### *62.3.4 The Scale of the ESCO Is Small and the Financing Is Difficulty*

Because all investments such as energy-saving equipment investment, operation, and management are borne by ESCO, strong financial support or open channel of financing was essential for their survival. Although the quantity of Chinese ESCO, small in scale, the vast majority are small and medium-sized enterprises, credit is not high, quality assets held by enterprises is not many so mortgage ability is limited.

At present, the 90 % of China's commercial banks have called for the project to have cash collateral and mortgages guarantees, leading to those committed to energy efficiency upgrade projects while the market has great potential, there had been a lack of investment interest. Although in recent years the government introduced a series measures to support small and medium enterprises financing, but most of the domestic banks do not focus on the financing of small and medium enterprises. The small and medium enterprise loan application is often difficult to pass the complex examination, such as the lack of collateral, or lack of sufficient cash flow to support. At the same time, most building energy-saving projects recovery period is long, risk is big, do not meet the commercial financial institutions "liquidity, safety, profitability" business principles, the overall efficiency of energy-saving projects is too difficult to obtain commercial financial institutions favored.

### *62.3.5 The Service Level Is Low and Type Is Imperfect*

Building energy efficiency not only relates to building materials and equipment but also many other aspects. Building design and management are an important part of building energy saving, and the participation of domestic companies in these two areas is rarely. Lots of enterprise named building EPCO do not provide energy services actually that is a special type of energy-saving products and construction materials suppliers and some even just the agent of foreign imports of energy-saving building materials. Only a few companies also provide EPC services at the same time provision of energy-saving products and technology, but the service mainly on its own products, content is relatively single, mainly about air conditioning system retrofit and new energy use such as solar and geothermal heat pumps.

## 62.4 Countermeasures and Suggestions

Hold both supply and demand. Market demands come from the enforcement of laws and regulations, the intensity of economic constraints and incentives, the strict administrative supervision, and the extensive of social supervision. Market supply is reflected in the market main body growth, technology material systems and various process equipments. Through the market subject, improve the building energy efficiency market structure, market behavior and market achievements, thus forming the health industry organizations and perfect market rules.

### *62.4.1 Implementation the Energy Efficiency Evaluation Standard*

Objective and impartial evaluation of energy efficiency is one of the keys to renovation project success. Implement energy efficiency evaluation standard in the entire industry is conducive to building energy-saving service market standardization, can enhance the transparency of the project results, and enhance customer confidence.

Widely used in the world is the IPMVP protocol standard at present, our country is also one of the signatories of the agreement, but the implementation effect is not obvious. The reason should have two aspects. one is the set of protocols and standards are detailed and specific, and relates to a variety of mathematical tools, domestic energy saving methods still does not meet the digital mode; the other is currently has no an independent professional third party energy efficiency testing agencies Therefore, building energy-saving industry should enforce the IPMVP protocol standard and establishing the third party energy efficiency testing agencies as soon as possible, and the requirements of energy-saving results of all EPC projects must through the third party verification [5].

### 62.4.2 Improve the Industry Entry Threshold

The real ESCO should also have a comprehensive energy saving technology strength and financing strength. ESCO Not only can design energy-saving renovation project of object-oriented solutions for customers, but also can advance payment in the whole project process, the final cost recovery and extraction of the profits from energy savings cost of project implementation. Therefore, the energy-saving service market should improve industry access threshold, standardize subject within the market, and cultivate the ESCO with comprehensive strength, serve enterprise only provide single technical service as true ESCO subcontractors or be incorporated directly.

### 62.4.3 Positive Fiscal Policy

In the early stage of building energy efficiency market development, the Government puts a certain amount of allocate funds to support energy-saving projects can play a significant role in guiding. Government subsidies include two forms direct subsidies and subsidies on interest payment.

Direct subsidies policy appropriate for Government identified energy-saving research and development, demonstration projects and energy audits of projects. Subsidies for the consumer market can stimulate more consumers select energy-efficient housing, thereby stimulating consumer demand; for developers and construction enterprises can reduce enterprises costs, increase price competitiveness of energy-saving building. The government through the discount loans to the energy-saving investment main body, with a small amount of fiscal expenditure to guide a large number of social funds into the energy field, reaches the expected results.

Discount policy as a form of indirect investment guidance mechanism, not only the risk is low, but also can avoid or reduce financial investment affect on the social capital, can effectively solve the problem of insufficient government investment. Discount objects include the development of enterprises, energy-saving services, and property buyers. Discount rate can be divided into different grades according to the building energy efficiency standard.

At present, State financial subsidies for renewable energy building demonstration projects, and introduced provisions of subsidized loans for existing building energy saving reformation, local states should introduce corresponding subsidy policies as soon as possible. At the same time tax system of EMCO should be adjusted to reduce their tax burden.

### 62.4.4 Loose Monetary Policy

Proposes to give the bank certain autonomy in interest rates, allows bank to charge rate for energy-saving service loans more than the normal construction projects, in order to balance the high risk for energy-saving project loan commitment.

Secondly, establish building energy efficiency financing platform. Government can learn from the experience of foreign developed countries, set up special funds for green building or building energy efficiency fund. Funds by providing loan guarantee, loan interest subsidies and other methods for ESCO with financing support; through publicity, loan risk compensation and other ways to enhance the commercial banks understanding for the project of EPC and enthusiasm of lending, so as to enhance the financing ability of ESCO. The main sources of fund in addition to budget expenditures still should also absorb the social capital and international policies loans, such as bond funds, international investment, the wall materials Innovation Fund and excess energy consumption tax, tariff increases, and so on.

### 62.4.5 Promote the Technology Innovation Through Integration of Industry-University-Research

Technical strength of building energy saving is one of the key for ESCO survival. But a few of ESCO have the real technical R & D and innovative technology, currently in the building energy-saving service industry is the implementation of a single energy-saving technological, also remain in the imitation stage and application of technology Many small and medium-sized enterprises because of funding shortages and the business strategy of short-sighted do not pay attention to the technology products R & D. The enterprise without the core technology is always a follower in the market, follower not to get a higher profit rate. That Causes the enterprise loses competitive advantage and growth has been slow. This is extremely unfavorable to the sustainable development of the whole industry. There must have a sustainable technology innovation to achieve sustainable development of the industry.

Therefore, should promote energy saving technology innovation throughout the industry. Enterprises can be a fixed proportion of total sales in each year into research and development of new technologies and new products, increasing the development of products with independent intellectual property rights, and also establish a close cooperation with the University research institutes to joint research, with the strength of scientific research institutions make major technological programs, significant technological breakthroughs.

### 62.4.6 Culture Building Energy-Saving Composite Talents

Development of building energy saving technology innovation and ESCO will ultimately depend on the cultivation of talents. Due to the limitations of the mechanism of University culture in China, and not directly applicable talents for the society and market, building energy-saving cultivation of compound talents can only rely on the ESCO business training and social re-education.

On the one hand, ESCO should be fully aware of the importance of technological innovation and management talent, devote adequate staff training funds; on the other hand, the government should support the energy-saving and technical personnel further education in colleges and other social education institutions.

Enterprises should explore the scientific incentive mechanism to retain talent in science and technology in the use of high-paying, shares, options and other means at the same time.

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# Chapter 63
# Getting Out of the Land Financial Predicament – A Systematic Thinking

**Pengfei Yang, Dong Zheng, and Enze Cui**

**Abstract** Since the emergence of the land finance, local governments' reliance on land finance is gradually increasing, while a series of corresponding social contradictions and problems becoming more prominent. All angles of analysis reveals that effective measures should be adopted to reverse the situation of local governments' uncontrolled land wealth and blind comparisons of economic indicators. Considering other motivations of local officials' zeal for financial predicament, to completely eliminate the problem of land finance, the government must give up the power of operating lands. Local governments will need a series of politic transitions to eliminate the motivation of land financial, take measures for the existing problems to ensure that economy develops along the right track forward, at the same time, all preparations should be carried out for the development of a service-oriented government.

**Keywords** Land finance • Thinking of reform • Systematic reform

## 63.1 The Emergence of Land Financial Problems

Land finance is the behavior that local government earn money to maintain local fiscal expenditure by selling land use rights, the income received belonging to extra-budgetary revenue is also known as the second fiscal. Mainland China's land transfer system is mainly borrowed from Hong Kong's land leasing system, but Hong Kong's land management and land leasing (namely, land business) belong to different departments, and the land revenue is classified as government-run fund,

P. Yang (✉) • D. Zheng
Business Administration, School of business, Shandong Jianzhu University, Jinan, China
e-mail: ypf901118@163.com

E. Cui
Department of Management Engineering, Shandong Jianzhu University, Jinan, China

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strictly regulated in its use. However, China local governments only follow the example of Hong Kong land management incompletely, thinking about supporting measures or approaches has not been implemented, as a result, the current land finance played a positive role in the simultaneous presence of various concerns and led to many social problems, after 10 years of development lack of constraints and regulation, land financial problems have become policy issues relating politic, economy, society, livelihood and other aspects that have to be solved.

## 63.2 The Objective Evaluation of Land Finance

From the perspective of land finance' essence, this kind of system has its own irrationality: the land premium is the price of land use rights for several years which can be understood as the government's one-time charge to enterprises for several years' land rent. However, the revenue is used up by government departments in a short period comparing to the land tenure, it is generally acknowledged that land resources are non-renewable resources, given the minimum area of arable land-18 million mu, the government is impossible to have land to sell all the time. The current balance of local government's revenue and expenditure supported by land finance would be unsustainable, when the available land for renting exhausts. In addition, both the behavior that governments borrow money from the bank using land as collateral and the behavior that enterprises use bank loans to buy land from local governments, essentially, are all liabilities to the bank. When the government financial problems or commercial operation accidents occur, bank loans will become bad debts. Apparently, this behavior will increase social financial risks and turns to be macroeconomic instability incentives.

Admittedly, in the past 10 years, local governments accumulated large numbers of construction funds through the operation of land. Cities' rapid economic development. Unprecedented improvement of infrastructure construction, continuous improvement of the quality of urban residents' life, economic transformation and development of surrounding rural area, the expansion of the city scale, and the improvement of urbanization level can all be attributed to the land transferring fees. But the land finance posed a number of potential threats to economic and social's prosperity and stability in addition to its great assistance to local governments: Firstly, land finance pushed up land prices, increased the cost of estate developers, which in turn led to the urban housing prices' continuous augment, "difficult to buy a house" had become a problem that residents generally faced. Housing consumption is a rigid demand, so it will inevitably squeeze consumers' outlay in other areas, and produces inhibitory effect on domestic demand. Secondly, local governments lower land requisition compensation standards and sell land at high prices through auction in order to obtain higher yields. In this process, local governments inevitably clashes with the residents on land compensation and other issues. For the governments' powerful position, tragedies caused by forced evictions & demolition continue to be repeated, which had a very bad influence on the whole society.

Even if no serious consequence occurs, many residents, especially farmers have suffered a loss during this progress, their rights are not protected, let alone "live with more dignity." Obviously, from the perspective of the people's livelihood, land finance problems also exist. In addition, land finance result in unfair distribution, widen the gap between urban and rural areas, magnify the gap between rich and poor within the city, overdraw future social benefits, increase the uncertainty of future economic and social development. Extensive utilization of land and serious waste are common issues as well, governments' immoderate land sales seeking revenue endanger arable land red line, unlimited expansion of cities' scale does not conform to the requirements of urban science. Social capital grasped by governments were mostly invested into urban construction industry, stimulate the development of construction industry, real estate industry and other industries, however, goes contrary to the central policy that speed up to transform economic development patterns. Government spending is also lack of oversight regulatory mechanisms, in the past few years, a lot of vanity projects and image projects costing a lot of manpower, material and financial resources can not really bring tangible benefits to the people.

In conclusion, our land finance policy need remediation or reform urgently, to implement the scientific concept of development and ensure the sustainable and healthy development of society and economy, party and government need to think land finance issues deeply and conduct practical attempts at reform.

## 63.3 Analysis of Land Finance Reform

Based on consensus of the reason for land finance's emergence, most scholars have referred that reforming the officials promotion assessment system and balancing local governments' "property rights" and "powers" are two important aspects. There are also many scholars bringing forth a series of rational suggestions aiming at land finance problems, and these suggestions are expected to ease economic and social problems caused by land finance. However, whether it is improvement measures starting from the incentive or reform programs derived from the problems can not fundamentally eliminate the root reason for land financial problems' continuing existence – the fact that governments are authorized to manage and operate land at the same time. So, eliminating land financial incentives does not mean that the government would give up selling land and getting more fiscal income, more scientific evaluation system for local officials and local revenue expansion through land transfer which can be used in many aspects of construction are not conflicting, while giving local governments greater financial power is not the sufficient condition for local governments' giving up seeking extra-budgetary revenue. That is, even if measures are implemented from the incentive level to eliminate local governments' relying on land finance motive, local governments still have the incentive to sell land and get extra-budgetary revenue. Local government as land managers violate market rules will inevitably cause other adverse consequences.

It is not difficult to find out that to cure financial problems thoroughly, the government must withdraw from the land management industry, retaining only its management functions, and turns into service-oriented government. Currently, local governments, at least in the financial aspect has been deeply dependent on land finance, blind Great Leap Forward-style reform would only affect the stable development of economy and society, and even cause serious consequences. So, to get out of the land finance predicament, some systemic reforms are needed to be implemented gradually aiming at fiscal policy loopholes and problems caused by land finance. And these reform measures will lay the foundation for further reformation like the transformation of government functions.

## 63.4 Systemic Reform Cracking Land Financial Problems

### *63.4.1 Eliminate the "Sufficient Condition" of Land Finance*

Despite the foregoing analysis we know that eliminating the two inductions of local government financial dependence on the land is insufficient to solve the current problems, to solve the current problems, inducing cause of the problem is that we still have to face and first solve.

On the one hand, reform the local government performance evaluation system, take these factors into the scope of performance evaluation like city's expenditures for science, education level, cultural undertakings, health protection, urban residents and farmers' welfare. Urban land planning, the city revenue and expenditure planning, price earnings ratio and other indicators can be incorporated into performance assessment system aiming at land finance problems. In addition, local governments should develop long-term development plans of the land market, which is based on fixed number of year of the land and available land resources, ensuring the orderly and healthy flow of urban land resources.

The other hand, adjustments should be made to balance the local governments' "property rights" and "powers", which is mainly aimed at the "property rights." Specifically, local tax structure need to be adjusted, appropriate taxable items should be fixed in the land acquisition, retention, transfer of three links to broaden the tax base, so that local governments have a more stable source of tax revenue. Also, governments should actively promote the property tax based on property prices, adjust the tax of real estate keeping part, improve the speculative property transactions related tax rate at the same time, to increase the cost of estate planning. To further transform government functions, governments should strengthen the function of public management, develop "public finance", weaken the function of grasping economic construction directly.

### 63.4.2 Solve the Financial Problems Caused by Land Versatilely, Paving the Way for the Land Reform

First, reform the "auction" system, make residents have greater rights to speak in the process of implementation. It can also contribute to the democracy and freedom of residents. Land "auction" model in theory prevents land rent-seeking activities partially, but this model led to dramatic premium increases, which in turn has led to rising estate prices, but also in the actual operation even increased land rent-seeking space links in the current case, the "auction" is obviously no longer the ideal way, but become one of the high prices push hands. Therefore, government departments should continue to emancipate the mind attempts to balance effectiveness, efficiency, social impact of land transfer channels. With the cultural level of our citizens and moral improvement, it is necessary to give residents democratic rights that they can participate in decision-making of urban areas development. For example, local governments can sell the land tied with infrastructure construction tasks, so that the contractor gets the price lower. Developers not only need to give the land development schemes, but also gives a set of corresponding infrastructure project development and construction programs. Government and the relevant residents both involved in assessing the schemes. This idea has the following advantages. Firstly, it improves the implementation of the difficulty of the rent-seeking activities to ensure fairness and openness. Secondly, it makes more residents to participate in the development and construction process, which fully embodies the democratic decision-making. It also motivates residents to work together with government. Thirdly, reducing the cost of the developers may reduce prices of property, which promotes social stability. Finally, the model that government is response for infrastructure facility construction is a current shortage, which is seeking to improve the efficiency. The above ideas will package the entire construction project to enterprise. Government only exercises supervisory functions, greatly improving the overall process of human, financial, and material efficiency. They comply with the concept of service-oriented government.

Second, local governments need to regulate the use of extra-budgetary revenue. Specifically, local governments should establish specialized financial fund, all the land premium and some other extra-budgetary funds are included into it and should be used sparingly. Appropriate oversight mechanism must be established, strictly monitor capital flows, to ensure its rational and efficient use.

Finally, we should improve the existing land laws and regulations to promote the transfer of land legislation. Current concept of land expropriation legislation has big disadvantages, which is lack of respect for the rights and interests of collective members, inducing public-private imbalance in the distribution of benefits. We should think broadly, give the market a greater role and give more respects to the rights and interests of human in the future land-related legislation.

### 63.4.3 Substantive Reform for Land Finance

Obviously, to solve the current land finance problems thoroughly, governments must get out of the land market. In the late stage, land finance reform can be roughly divided into two stages: the first stage, local governments will lose the functions of land management, a new government department will be established which is isolating from local governments' revenue and expenditure, only responsible for land management activities; second stage, break through the current bottleneck, re-examine the "surplus due to the rise of price belongs to the public" theory and the provisions relating to land ownership, keep learning experiences of western countries, develop public service-oriented government.

## 63.5 Summary

This paper shows that solving the current "land finance issues" need a series of deep-seated reform. Admittedly, a series of subsidiarity, foreshadowing measures should be implemented in advance. The proposed "systemic reform" recommendations provide a more complete idea for future reform: eliminate the financial reasons that local governments rely on land finance, help local governments cut costs, stable financial revenue and expenditure, reduced reliance on extra-budgetary revenue, and gradually change legislative and other aspects of the concept, and finally the time is ripe to release land management rights from the hands of local governments, develop service-oriented government. Along this line of thought, I believe that our local governments can successfully get rid of dependence on land finance, and get considerable progress and improvement in local development, government efficiency, people's livelihood, economic and other aspects.

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# Chapter 64
# Empirical Analysis on Transfer and Limitation of Land Contractual Management Right–Based on a Survey of 506 Farmer Households in Zhejiang, Jiangxi and Guangxi

**Xiuqing Zou and Mengsi Zhou**

**Abstract** Existing laws have three limitations on transfer of land contractual management right. The survey of 506 farmer households in Zhejiang, Jiangxi and Guangxi provinces indicates that most farmers have the consistence of knowledge of limitation on “transfer being approved by the party giving out the contract in advance” with legislative requirements, but it is not effectively implemented in actual operation. As to limitation on transferee, no matter in cognition of farmers, or in real transfer process, the transferee is not totally limited to farmers engaged in agricultural production and management. For the constraint that the transferor should have stable non-agricultural occupation or stable income source, most farmers agree, but more than half of the farmers have not confirmed the transfer action in practice.

**Keywords** Farmland contractual management right • Transfer • Limitation

## 64.1 Introduction

Article 41 of *Law of the People’s Republic of China on Land Contract in Rural Areas* stipulates that “Where a contractor has a stable non-agricultural occupation or a stable source of income, he may, with the consent of the party giving out the contract, transfer the whole or part of his right of land contractual management to another farmer household engaged in agricultural production and management, and this farmer household shall establish a new contractual relationship with the party giving out the contract, thereupon the contractual relationship on this land between the former contractor and the party giving out the contract is terminated.” From the perspective of right, the transfer of land contractual management right is to transfer

X. Zou (✉) • M. Zhou
School of Tourism and Urban Management, Jiangxi University of Finance and Economics, Nanchang 330032, China
e-mail: zxqing888@263.net

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the whole of part of land contractual management right legally obtained to the transferee (new contractor). As a result, the owner of land contractual management right is changed. Laws have imposed three limitations on transfer of land contractual management right. (1) The transferor (original owner of land contractual management right) should have stable non-agricultural occupation or stable income source. (2) The transfer shall be approved by the party giving out the contract. (3) The transferee is limited to other farmer households engaged in agricultural production and management. If these limitations are reasonable?

People who agree with these limitations believe that these limitations are intended to prevent transferor from having the difficulty in living after transferring land [1], because land contractual management right is the most fundamental living guarantee of farmers. If original contractor has no stable non-agricultural occupation or stable income source, the transfer will lead to social chaos. Thus, it is essential to obtain consent of the party giving out the contract before transferring land contractual management right. Whether the transferee satisfies subject qualification specified by laws and has the capacity of contractual management directly concerns the performance of contractual obligation. Therefore, transferor should make careful examination. Otherwise, it may infringe upon lawful rights and interests of the party giving out the contract [2].

People who object to these limitations contend that limiting transfer of land contractual management right is tantamount to binding owners of land contractual management right to agricultural land. Accordingly, it fails to ensure free job selection and occupation change of owners of land contractual management right [3]. (1) For the nonce, functions of land contractual system have changed from safeguarding survival and solving food and clothing at initial stage to increasing yield and income and promoting economic benefits of land. At this background, it is not proper to overstate survival guarantee functions. (2) It is difficult to determine people who have stable non-agricultural occupation or stable income source, so it lacks operability. (3) As a type of usufructuary right, land contractual management right is independent of the ownership. Thus, to stress “with the consent of the party giving out the contract” is contrary to legal principle. In fact, it leaves much space for allocation of land resource by administrative or quasi-administrative means, but limits free transfer of land contractual management right. (4) No matter industrial and commercial enterprises or urban residents and foreign merchants, as along as they are engaged in agricultural production and subject to control of agricultural land use, land contractual management right also can be transferred to them. Therefore, limiting the scope of transferee will lead to closeness of agricultural land circulation, not be favorable for formation of market price and circulation market of land contractual management right, and not favorable for optimum allocation of land resource.

On the basis of 506 farmer household survey samples in Zhejiang, Jiangxi and Guangxi provinces, I introduced current situations of transfer of land contractual management right, farmers’ attitude and willingness. Finally, I came up with some policy recommendations.

## 64.2 Survey Method and Data Source

On the basis of considering geographical location, socio-economic development, human and land factor, location condition, and resource endowment factors, our research team conducted questionnaire survey in Xinchang County and Shengzhou City of Zhejiang Province in the eastern region, Xingzi County and Shangrao County of Jiangxi Province in the middle region, Teng County and Liuzhu City of Guangxi Province in the western region.

During summer vacation of 2010, our research team and local university students went to the above six counties (cities). With the help of township government, we randomly selected about 50 farmer households, and surveyed them face by face. Finally, we received 576 copies of questionnaire. In the process of data cleansing, review, coding and input, 506 valid copies of questionnaire were confirmed.

## 64.3 Empirical Analysis of Transfer of Land Contractual Management Right and Its Limitations

In these 506 valid copies of questionnaire, 90.7 % farmer households haven't done transfer action, 3.2 % have once transferred in agricultural land, 5.9 % have transferred out agricultural land, and one household have both transfer-in and transfer-out actions. There is a huge difference in agricultural land transfer of three provinces. Among177 valid copies of Jiangxi Province, only one farmer household has agricultural land transfer-out action; among 167 copies of Zhejiang Province, 17.8 % farmer households have transfer action; among 162 valid copies of Guangxi Province, 11.1 % households have transfer action, as shown in Table 64.1.

### *64.3.1 Willingness and Attitude of Farmer Households Without Land Transfer Action*

According to the first limitation of "with consent of the party giving out the contract", we set the question "Is it necessary to get approval of village committee (village collective or the party giving out the contract) before transferring agricultural land?". Statistical analysis (Table 64.2) shows that among 459 farmer households who have not conducted land transfer, 29.4 % believe that it is not necessary, and 70.6 % think it is necessary to get approval of village collective. Among 144 farmer households who have not conducted land transfer in Guangxi Province, as high as 35.4 % households say it is not necessary to get approval of village collective. Therefore, it proves that the understanding of most farmers about the

**Table 64.1** Survey on transfer of agricultural land

| | | Have you transferred in or out agricultural land? | | | | |
|---|---|---|---|---|---|---|
| Province | | Yes | No | Both | Neither | Total |
| Jiangxi | Frequency | 0 | 1 | 0 | 176 | 177 |
| | % | 0 | 0.6 | 0 | 99.4 | 100 |
| Zhejiang | Frequency | 11 | 17 | 0 | 139 | 167 |
| | % | 6.6 | 10.2 | 0 | 83.2 | 100 |
| Guangxi | Frequency | 5 | 12 | 1 | 144 | 162 |
| | % | 3.1 | 7.4 | 0.6 | 88.9 | 100 |
| Total | Frequency | 16 | 30 | 1 | 459 | 506 |
| | % | 3.2 | 5.9 | 0.2 | 90.7 | 100 |

**Table 64.2** Attitude of farmers who have no land transfer action to the limitation of "with consent of the party giving out the contract"

| | | Is it necessary to get approval of village committee (village collective or the party giving out the contract) before transferring agricultural land? | | |
|---|---|---|---|---|
| Province | | Not necessary | Necessary | Total |
| Jiangxi | Frequency | 45 | 131 | 176 |
| | % | 25.6 | 74.4 | 100 |
| Zhejiang | Frequency | 39 | 100 | 139 |
| | % | 28.1 | 71.9 | 100 |
| Guangxi | Frequency | 51 | 93 | 144 |
| | % | 35.4 | 64.6 | 100 |
| Total | Frequency | 135 | 324 | 459 |
| | % | 29.4 | 70.6 | 100 |

requirement of "with consent of the party giving out the contract" is basically consistent with legislative regulation.

According to the limitation of "transferee being other farmer households engaged in agricultural production and management", we set the question "when transferring agricultural land, the transferee can be (multiple choice)?". There are options of "local village farmer households engaged in agricultural production", "other village farmer households engaged in agricultural production", "urban residents" and "industrial and commercial enterprises". Statistical analysis (Table 64.3) indicates that among 459 farmer households who have not conducted land transfer, 87 % farmer households choose "local village farmer households engaged in agricultural production", 46 % select "other village farmer households engaged in agricultural production", 33 and 39 % select "urban residents" and "industrial and commercial enterprises" separately. Jiangxi Province has the highest proportion of households selecting "local village farmer households engaged in agricultural production", up to 95 %; Guangxi Province has the highest proportion of households selecting "urban residents" and "industrial and commercial enterprises", up to 56 % and 60 % respectively. It seems that although transferees are legally limited to farmers engaged in agricultural production, a lot of farmers do not fully realize necessity and importance of such limitation.

**Table 64.3** Attitude of farmer households without land transfer action towards transferee subject

| Province | | When transferring agricultural land, the transferee can be (multiple choice)? | | | | Total |
|---|---|---|---|---|---|---|
| | | Local village farmer households engaged in agricultural production | Other village farmer households engaged in agricultural production | Urban residents | Industrial and commercial enterprises | |
| Jiangxi | Frequency | 162 | 67 | 46 | 50 | 171 |
| | % | 95 | 39 | 27 | 29 | 100 |
| Zhejiang | Frequency | 116 | 51 | 24 | 42 | 136 |
| | % | 85 | 38 | 18 | 31 | 100 |
| Guangxi | Frequency | 110 | 87 | 78 | 83 | 139 |
| | % | 79 | 63 | 56 | 60 | 100 |
| Total | Frequency | 388 | 205 | 148 | 175 | 446 |
| | % | 87 | 46 | 33 | 39 | 100 |

**Table 64.4** Attitude of farmer households without land transfer action towards limitation of transferor's income

| Province | | Is it necessary to confirm that transferor has stable non-agricultural occupation or stable income source? | | Total |
|---|---|---|---|---|
| | | Not necessary | Necessary | |
| Jiangxi | Frequency | 53 | 123 | 176 |
| | % | 30.1 | 69.9 | 100 |
| Zhejiang | Frequency | 28 | 111 | 139 |
| | % | 20.1 | 79.9 | 100 |
| Guangxi | Frequency | 49 | 95 | 144 |
| | % | 34.0 | 66.0 | 100 |
| Total | Frequency | 130 | 329 | 459 |
| | % | 28.3 | 71.7 | 100 |

According to limitation that "transferor (original owner of land contractual management right) should have stable non-agricultural occupation or stable income source", we set the question "Is it necessary to confirm that transferor has stable non-agricultural occupation or stable income source?". Statistical analysis (Table 64.4) indicates that among 459 farmer households who have not conducted land transfer, 72 % think it is necessary, and 28 % think it is not necessary. This shows that most farmers are still very cautious of completely giving up land contractual management right, and the stability of income source influences farmers' decision-making of land transfer.

### 64.3.2 *Actual Situations of Limitation on Agricultural Land Transfer of Farmers with Land Transfer Action*

As for farmer households with land transfer action, we firstly found out if they obtained consent of village committee (village collective or the party giving out the

**Table 64.5** Whether approval is obtained before transferring agricultural land or not

| Province | | Have you obtained the approval of village committee (village collective or the party giving out the contract) before transferring agricultural land? No | Yes | Total |
|---|---|---|---|---|
| Jiangxi | Frequency | 1 | 0 | 1 |
| | % | 100 | 0 | 100 |
| Zhejiang | Frequency | 13 | 15 | 28 |
| | % | 46.4 | 53.6 | 100 |
| Guangxi | Frequency | 10 | 8 | 18 |
| | % | 55.6 | 44.4 | 100 |
| Total | Frequency | 24 | 23 | 47 |
| | % | 51.1 | 48.9 | 100 |

contract). Statistical analysis (Table 64.5) shows that among 47 farmer households who have land transfer action, 51 % have obtained the approval and 49 % didn't gain the approval of village committee. Thus, although it is legally required to gain consent of the party giving out the contract, near half farmers didn't perform this procedure in the real operation, and the reason is to be further surveyed.

As to whether all transferees are farmer households engaged in agricultural production, our survey results indicate that among 47 farmer households who have land transfer action, 43 households select "local village farmer households engaged in agricultural production", 4 households select "other village farmer households engaged in agricultural production", no household choose "urban residents" and "industrial and commercial enterprises". It proves that all transferees of agricultural land transfer are farmer households engaged in agricultural production, but they are not totally limited to local villages. As for the question that "is it necessary to confirm that transferor has stable non-agricultural occupation or stable income source", among 47 farmer households who have land transfer action, 56.2 % farmer households think it is not necessary, and 43.8 % think it is necessary. It shows that more than half transfer action hasn't confirmed "if the transferor has stable income source" in actual practice.

## 64.4 Conclusions and Policy Recommendations

### *64.4.1 Conclusions*

Existing laws clearly stated that contractual management right of agricultural land can be transferred. Nevertheless, agricultural land transfer means total abandoning their contractual land, laws set forth three limitations to transfer of agricultural land. Most farmers have the consistence of knowledge of limitation on "transfer being approved by the party giving out the contract in advance" with legislative requirements, but it is not effectively implemented in actual operation. As to limitation on transferee, no matter in cognition of farmers, or in real transfer process, the transferee is not totally limited to farmers engaged in agricultural production and management. For the constraint that the transferor should have stable non-agricultural occupation or stable income source, most farmers agree, but more than half farmers have not confirmed the transfer action in practice.

### *64.4.2 Policy Recommendations*

1. Allowing transfer of land contractual management right is the necessity of realizing real right and inner necessity of large-scale land operation. However, before perfect establishment of rural social security system, it is necessary to impose certain limitations on transfer of land contractual management right. Yet, such limitation should be constantly changed and should be periodic and show regional difference. For regions with low agricultural land security function, it should allow local legislation to relax limitations in accordance with actual situation, so as to provide farmers with more freedom of independent decision-making; for regions with effective agricultural land security function, it should execute the legal provisions in principle.
2. It is necessary to make clear legislative definition of how the transferor exercises the consent right. The consent right of the transferor is a type of right to know or right to supervise, rather than power to make decision. Thus, in exercising the consent right, the party giving out the contract should firstly respect willingness of the owner of land contractual management right. The definition of consent right should follow the principle of allowing transfer, instead of restricting transfer [4]. Except following cases, it should approve the contractor' requirement for transferring his land contractual management right: (i) the contractor does not have stable non-agricultural occupation or stable income source, and transfer of agricultural land will lead to difficulty in living; (ii) if the contract of transfer is signed by force; (iii) the purpose of agricultural land use is changed; (iv) the transferee does not have agricultural production capacity; (v) the period of transfer exceeds remaining term of land contractual period.

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# Chapter 65
# A New Integrated Index for Urban Quality of Life Based on Estimated WTP from Housing Market

**Yingjie Zhang, Yuan Zhang, and Antoine Nguy**

**Abstract** The spatial distribution of public service facilities directly affects the efficiency of urban space and residents' quality of life. This paper has constructed a new *Integrated Quality of Life Index*, combining single indices for different kinds of public services using estimated *willingness to pay* (WTP) from housing market as weight, and then apply this new index to supply and demand matching analysis. Our case study is conducted in Beijing, where subway stations, primary schools and parks are selected as three typical kinds of public services. Firstly, we construct single supply index for each kind of public services using potential models. Secondly, we quantify residents' preferences of these different services, deriving their estimated WTP from hedonic models of housing price. Finally, we create the integrated quality of life index by combining three single indices weighted by the estimated WTPs, and then apply this index to supply and demand matching analysis across 129 *jiedao*s for different household income levels. This study provides a new attempt to build an integrated index of public services and matching analysis, and the research findings will help to improve the degree of consideration of demand-oriented factors in the supply of public services as well as urban residents' quality of life.

**Keywords** Quality of life • Public services • Willingness to pay • Supply-demand matching

Y. Zhang (✉) • Y. Zhang • A. Nguy
Institute of Real Estate Studies, Department of Construction Management,
Hang Lung Center for Real Estate, Tsinghua University, Beijing, China
e-mail: zhang-yj06@mails.tsinghua.edu.cn

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## 65.1 Introduction

### *65.1.1 Research Background*

In Chinese cities, public service facilities present a rather serious spatial mismatch issue. It severely impacts the efficiency of cities and residents' quality of life, which in turn hinders the sustainable development of cities. When it comes to urban development, the supply and spatial distribution of public social facilities directly affects the efficiency of urban space and residents' quality of life. In today's Chinese cities, many local public service facilities are excessively concentrated in the inner city. That results in a lack of coordination with the process of population and industrial suburbanization, which in turn hinders the "job-live" spatial match, generates additional traffic flows and reduces spatial efficiency.

Taking Beijing as an example, the proportion of "key primary schools" and best hospitals located within the 3rd ring road exceeds 60 %, though they account for less than 10 % of all primary schools and hospitals respectively. Consequently, residents living in the urban periphery have to bear high transport costs in order to access to these public services, thereby increasing traffic congestion in Beijing and seriously reducing quality of life and the efficiency of urban operations.

Thus, there is an urgent need for more scientific methods and indicators to systematically measure the quality of public services within the city, in order to promote scientific site selection and matching of supply and demand for public service facilities. Current studies often ignore residents' objective preferences, as they only focus on a few types of services or combine them using subjective assignment.

### *65.1.2 Motivation and Approach of This Paper*

This paper aims at constructing a new integrated Quality of Life Index for measurement of urban quality of life, which means to combine single indices for different kinds of public services using estimated *willingness to pay* (**WTP**) from housing market as weight, and then apply this new index to supply and demand matching analysis for urban public services.

Our case study is conducted in Beijing, where subway stations, primary schools and parks are selected as three typical kinds of public services. More specifically, we will first consider the supply side, and construct single supply index for each kind of public services using potential models. Secondly, from the demand side, we analyze residents' preferences for different services, deriving their estimated WTP from hedonic models of housing price. Finally, we create the integrated quality of life index by combining three single indices weighted by the estimated WTP, and compare this integrated quality of life index and population density in each *jiedao* as an attempt to conduct supply and demand matching analysis for local public services.

## 65.2 Related Literature Review

### *65.2.1 The Spatial Analysis of Urban Public Services*

In the international related researches, the meaning of urban public services and urban public facilities is basically the same, and refers to shared services or facilities that the government provides—directly or indirectly—to the public. In practice, scholars' object of research mainly focuses on all types of facilities that residents have to go there in order to enjoy the service, including schools, libraries, hospitals, parks, stadiums, bus and subway stations, and so forth [1, 8, 13, 14, 17, 18].

In respect to the analysis and evaluation of the spatial distribution of public services and its reasonable level, academics focus on spatial equity. Research evolved from a mere measure of the mean number of facilities to a precise calculation of the public service quality. In addition, previous researches that only focused on supply are giving way to studies that also consider demand. This transformation comes together with a change from an objective analysis of the situation to the consideration of a subjective evaluation of the evolution process. Chinese scholars have published good review papers in this field [5, 10, 12, 19].

### *65.2.2 The Development of Key Measurement and Analysis Techniques*

"Accessibility" is a key concept that measures the ability to reach a given public service. The original meaning simply is to characterize whether it is easy—spatially speaking—to go from a location to another one. But the exact definition of this indicator has never been unified, and the most appropriate method has not been determined yet [2]. In general, there are different calculation methods for different situations. The choice of the method eventually has an important impact on the evaluation of the public services' spatial distribution [16, 17]. That is why scholars generally determine the accessibility calculation method according to the available data and the accuracy required for their empirical analysis [7].

In the meantime, Chinese scholars also published rather comprehensive reviews about accessibility measures [11, 15, 20]. Among empirical studies in Chinese cities, the accessibility and equity of the spatial distribution of green spaces, parks and hospitals received much attention [3–6]. However, there are few research results about systematic comprehensive indicators in Chinese studies, and in one of the rare studies that investigate that [9], single indices are simply summed, not accounting for residents' preferences.

## 65.3 Analysis Framework and Data

### *65.3.1 Analysis Framework*

This paper aims at providing a new method to build an integrated index of public service quality across different locations within the city, which is named integrated quality of life index. The spatial extent of this research is the urban built-up area in Beijing. Three kinds of typical public services are selected, namely subway stations to account for public transit, primary schools for educational services and parks for environmental public services.

Firstly, from the supply side, we measure the quality of public service facilities and spatial distribution within the study area, and construct single supply index for each kind of public services using potential model, as shown in Eq. (65.1).

$$S_k = \Sigma_i \frac{n_i}{d_{ik}^2} \tag{65.1}$$

where $n$ represents the weight of the public service facility $i$ (a given park, school, or subway station), $d$ is the distance from one location $k$ to public service $i$. After calculating for each $I$ of one group, we sum them and get $S_k$, the 'accessibility' of one kind of public service for location $k$. Larger value of the accessibility means higher supply level of a given public service at location $k$.

Secondly, from the demand side, we analyze the difference in preferences for different kinds of public services among households using hedonic models of housing price, which have been commonly used by scholars to estimate the marginal prices of different features of a house, such as location features and physical features. Equation (65.2) is a standard hedonic price model, and the estimated WTP can reflect households' preferences. A higher WTP for a public service indicates that people value it more when they consider where to live.

$$logP_i = \beta_0 + \boldsymbol{\beta_1} * \boldsymbol{S_k} + \boldsymbol{\beta_2} * \boldsymbol{X_i} + \varepsilon_i \tag{65.2}$$

$\boldsymbol{X_i}$ is a vector of control variables, including housing unit size, housing age, neighborhood quality, and the location measured by the distance to CBD. $S_k$ refers to the three single supply indices we have calculated in the first stage, namely *park* for the index of accessibility to parks, *school* for index of the accessibility to primary schools, and *subway* for the index of accessibility to subway stations. $\boldsymbol{\beta_1}$ are residents' WTP for each public service and $\boldsymbol{\beta_2}$ estimates the WTPs for other features of the house.

Finally, we build the integrated quality of life index by combining three single indices weighted by the estimated WTP in second stage using Eq. (65.3), and compare this integrated index and population density at the level of *jiedao* in Beijing as an attempt to conduct supply and demand matching analysis for local public services.

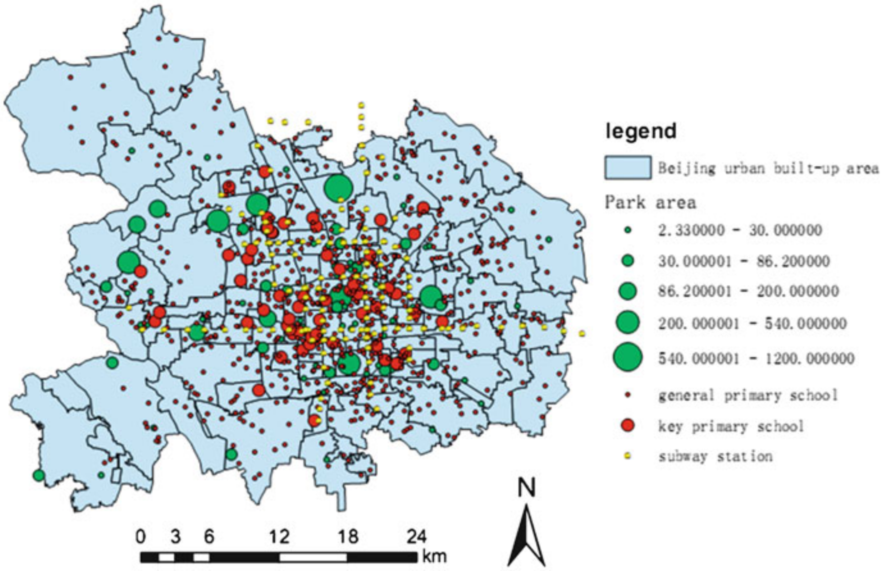


**Fig. 65.1** The spatial distribution of three typical public services in Beijing built-up area

$$S^I = \frac{\beta_{park} \times park + \beta_{school} \times school + \beta_{subway} \times subway}{\beta_{park} + \beta_{school} + \beta_{subway}} \tag{65.3}$$

After estimating those integrated indices for the supply side, we measure the demand index using each *jiedao*'s population density on the basis of the 2010 Beijing Census Data. A higher density of a *jiedao* implies a higher demand for public services.

We investigate whether a high level of demand brings about a high supply level. If an area has a high demand index but a low integrated supply index, public services should be enhanced in this area.

## *65.3.2 Data*

### 65.3.2.1 Three Kinds of Typical Public Services and Their Spatial Distribution

We select three kinds of typical public services, namely primary schools, subway stations and parks. There are a total of 713 primary schools in Beijing urban built-up area, among which 57 schools are key primary schools and 656 schools are ordinary. The number of subway stations and parks are 147 and 80 respectively. The spatial distribution of these public services in Beijing urban built-up area is shown in Fig. 65.1.

**Table 65.1** Descriptive statistics

| Variable | Definition | Obs. | Mean | Std. dev. |
|---|---|---|---|---|
| **1. Basic** | | | | |
| *Log(HP)* | Log price of a residential housing unit (Yuan per square meter) | 15,787 | 0.8055414 | 0.6951648 |
| **2. Location** | | | | |
| *D_CBD* | A residential unit's distance to CBD, in km | 15,787 | 8.653773 | 5.478146 |
| **3. Amenity** | | | | |
| *Park* | A community's accessibility to parks, in one per square meter | 15,787 | 158.5002 | 149.3324 |
| *School* | A community's accessibility to schools, in one per square meter | 15,787 | 76.88611 | 134.4095 |
| *Subway* | A community's accessibility to subways, in one per square meter | 15,787 | 5.939676 | 6.818073 |
| *Edu_jwh* | A community's average education year of all house owners, in year | 15,787 | 5.543662 | 0.5279078 |
| **4. Housing physical features** | | | | |
| *Area* | A residential unit's size, in square meter | 15,787 | 74.03218 | 37.01668 |
| *Year* | A residential unit's age, in year | 15,787 | 21.95547 | 13.64553 |

#### 65.3.2.2 Households in Communities and Their Housing Value

To account for households' characteristics and their housing values, we have access to micro data from the 2010 Beijing Urban Household Survey, which was conducted by the National Bureau of Statistics. This unique micro survey data provides us key information about housing value, family income, location and housing physical features of residents. Surveyed families were chosen at random in every community in the urban built-up area. There are altogether 323 communities and 15,787 households in our dataset. Table 65.1 provides descriptive statistics.

## 65.4 Single Supply Index of Three Typical Public Services

From the supply side, we establish a grid pattern (as shown in Fig. 65.2a), composed of 1,000 m by 1,000 m cells in order to improve the accuracy of supply index, and calculate single supply indices for the three key public services in every cell. First of all, we need to elaborate on the weights and space scope in the calculation.

**The Supply Index for Schools.** We weight every key primary school 10, and every ordinary primary school 1, with such obvious difference because of the large difference in education quality and the opportunities of their students to attend key middle schools, and eventually the best universities. In the potential model, $d$ is the distance of the center of each cell to primary schools that are located less than 2,000 m away from the center.

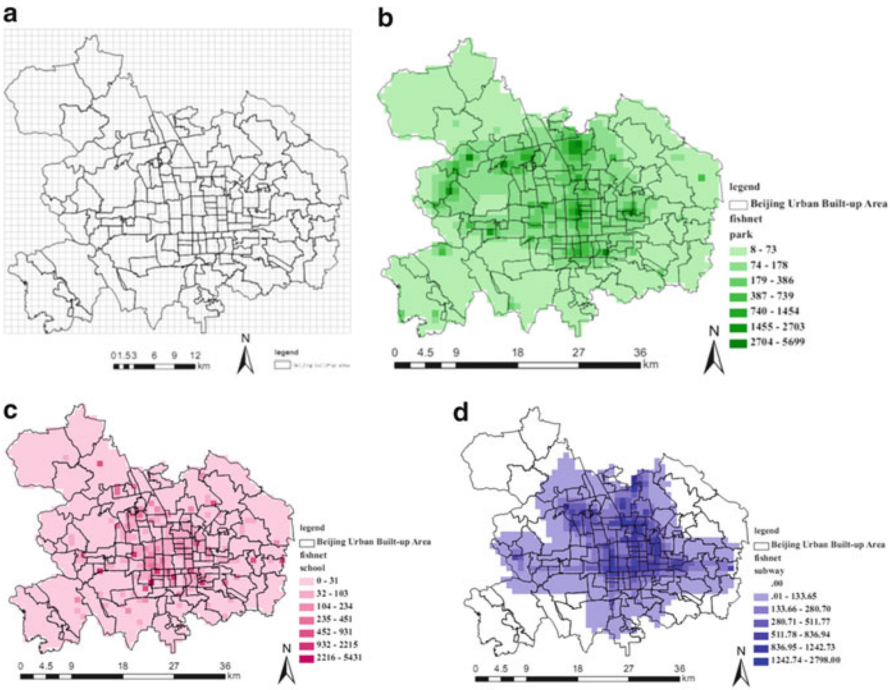


**Fig. 65.2** (**a**) The fishnet. (**b**) The supply index of parks. (**c**) The supply index of schools. (**d**) The supply index of subway

**The Supply Index for Subways.** Subway stations are treated as homogeneous and *d* is the distance of the center of each cell to subway stations located less than 4,700 m away from the center, which is the largest distance between two consecutive stations in Beijing, the distance between *Wu Daokou* station to *Shang Di* station on the subway line 13.

**The Supply Index for Parks.** Parks are weighted by their areas. For each location, we sum up its accessibilities to every park in the built-up area without any spatial limitations, because residents may choose to enjoy larger green spaces, though they are further away from their house.

Our results of single supply indices are shown in Fig. 65.2b–d.

There are 1,347 cells in Beijing urban built-up area. The smallest supply index for parks is 8.08 and the largest one for parks is 5,699.05. The largest supply index for primary schools is 5,431.25 and there are 152 cells whose supply indices are 0. As for subway stations, the largest supply index is 1,080.11 and there are 571 cells whose supply indices for subway stations are 0.

## 65.5 Estimating WTP Using Hedonic Housing Price Analysis

The results of our estimated WTP using hedonic housing price model are provided in Table 65.2 with t-statistics in parentheses. The $R^2$ indicates that our model can explain almost 50 % of the variation in housing price. All of the coefficients have expected signs and are statistically significant. Column (1) shows the regression results using full samples, and sub-samples of poor households and rich households are presented in column (2) and column (3) respectively.

### 65.5.1 *Basic Results of Our Control Variables*

In column (1), we estimate a significant negative price gradient of −0.010 with respect to the distance from CBD. This means that a 1 km increase in the distance to the city center would result in about 1 % decrease in housing price.

**Table 65.2** The estimated WTPs in housing price regressions

| Equation | (65.1) | (65.2) | (65.3) |
|---|---|---|---|
| | Total sample | Poor sample | Rich sample |
| Variables | Log(HP) | Log(HP) | Log(HP) |
| D_cbd | −0.01032*** | −0.01279*** | −0.00629*** |
| | (−11.452) | (−9.923) | (−5.232) |
| Area | −0.02131*** | −0.02946*** | −0.01814*** |
| | (−57.812) | (−41.849) | (−36.543) |
| area2 | 0.00005*** | 0.00009*** | 0.00003*** |
| | (31.408) | (23.065) | (18.363) |
| Year | −0.00434*** | −0.00453*** | 0.00329* |
| | (−4.036) | (−3.020) | (1.815) |
| year2 | 0.00008*** | 0.00007*** | −0.00003 |
| | (4.770) | (3.402) | (−0.891) |
| edu_jwh | −3.60849*** | −3.89131*** | −3.34389*** |
| | (−33.990) | (−24.790) | (−22.192) |
| edu_2 | 0.35674*** | 0.38002*** | 0.32851*** |
| | (36.774) | (25.900) | (24.389) |
| Park | 0.00011*** | 0.00011*** | 0.00014*** |
| | (3.960) | (2.736) | (3.433) |
| school | 0.00018*** | 0.00017*** | 0.00018*** |
| | (5.858) | (3.953) | (4.334) |
| subway | 0.00384*** | 0.00352*** | 0.00532*** |
| | (5.710) | (3.899) | (5.534) |
| Constant | 11.08706*** | 12.19516*** | 10.29795*** |
| | (37.924) | (28.835) | (24.308) |
| Observations | 15,787 | 7,894 | 7,893 |
| R-squared | 0.481 | 0.489 | 0.522 |

t-statistics in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

As for the housing unit size, the turning point is 213.1 square meters, and because most houses are smaller than this threshold value, we consider that the house price decreases when the unit size increases, indicating that people prefer smaller houses. In addition, the turning point of the housing age is 27.13 years, so the house price is lower when the house is older but built less than 27.13 years ago. However, when the house has been built for more than 27.13 years, an increase in housing age will result in an increase in the house price because old houses are always located near the city center. As for the average education level of a community, the turning point is about 5, which represents 12 years of education, so an increase in the community's average education level will result in an increase in the house price.

### 65.5.2 The Estimated WTP for Different Single Supply Indices

When it comes to people's preferences for public services, we include our three single supply indices in the hedonic model. First, we estimate a significant negative price gradient of 0.00011 with respect to the accessibility to parks. It means that a unit increase in the accessibility to parks will increase the house price by 0.011 %. Secondly, a unit increase in the accessibility to schools will result in 0.018 % increase in the house price. Thirdly, a unit increase in the accessibility to subway stations will lead to 0.384 % increase in house price.

We divided people into two groups, the poor sample, whose income is less than the median, and the rich sample. As expected, rich people's WTP for each public facility is higher than poor people's, especially for the subway. WTP for a unit increase in accessibility to subway stations is 0.532 % of the house price for the rich sample, compared with only 0.352 % of the house price for the poor sample.

## 65.6 The Construction and Application of the Integrated Index

Based on estimated WTPs and single supply indices, we derive the integrated index using Eq. (65.3). From the supply side, we calculate the integrated index of every *jiedao* by averaging the integrated indices of the cells overlapping it, as shown in Fig. 65.3a, which presents the supply index in *jiedao* level for the whole sample.

For the demand side, we calculate the population density to represent the intensity of residents' demand. Figure 65.3b shows the demand index for the whole sample. As we can see, the spatial distribution of the population is much wider than the integrated supply level of public services, indicating spatial mismatch.

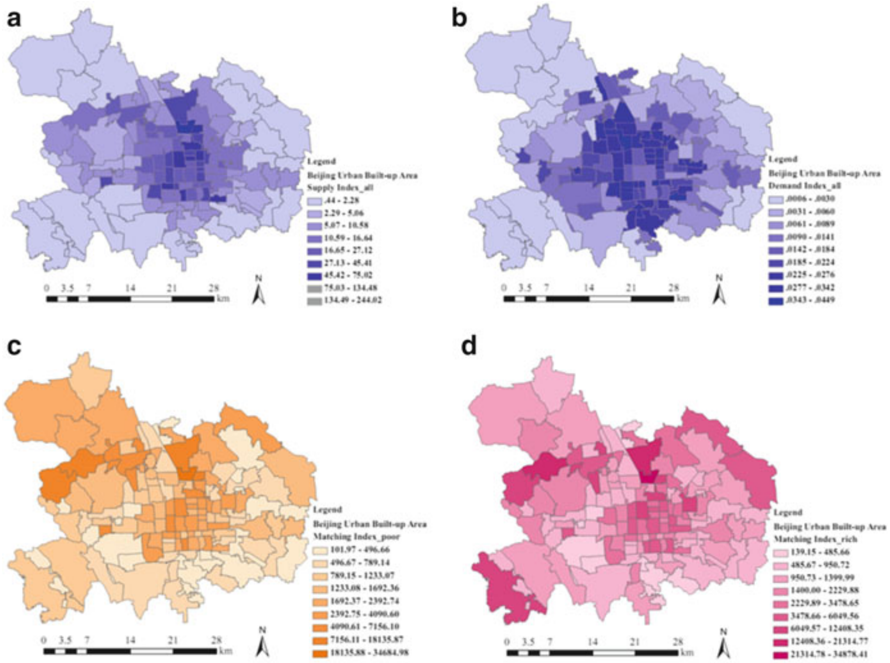


**Fig. 65.3** (**a**) Integrated QoL index of all people. (**b**) The demand index of all people. (**c**) Matching index of the poor. (**d**) Matching index of the rich

In order to make results of the extent of the matching of supply and demand more intuitive, we calculate the matching index (the supply index divided by the demand index) for both the poor and the rich samples. Our micro survey data indicate that they have different WTPs for public services and different proportion in each *jiedao*. Figure 65.3c, d show the distributions of the two matching index in each *jiedaos* for the poor and the rich respectively. Overall, the matching index is higher in the north of the built-up area, implying that the supply is relatively more adequate to the demand in the north, while the problem of insufficient supply is worse in the south. In most *jiedao*s, the matching indices of the rich are much larger than the poor's. The three typical *jiedao*s are *Wang Zuozhen, Chao Wai,* and *Cui Gezhuang*. For example, in *Wang Zuozhen jiedao*, the matching index of the rich sample is seven times higher than that of the poor sample. On the contrary, the three representative *jiedaos* where the poor's matching indices are larger are *Shang Zhuang*, *Xi Beiwang*, and *Su Jiatuo*. The matching index of the poor sample in *Shang Zhuang jiedao* is twice as much as that of the rich sample. These significant differences in matching indices between the two groups prove that it is very necessary to consider residents' characteristics.

## 65.7 Conclusion

This paper has proposed a new approach for constructing a new Integrated Quality of Life Index, combining single indices for different kinds of public services using estimated willingness to pay (WTP) from housing market as weight. The application of this integrated index to supply and demand matching analysis across 129 *jiedaos* for different household income levels shows that our research framework is valid.

We find a mismatch between supply and demand of public services in Beijing. The supply of public services within the city is relatively sufficient compared to the peri-urban area, while the relative supply of public services in southern Beijing is clearly insufficient as compared to the north. Against that background, on the one hand, when it comes to areas with a relatively abundant supply of public services, old low-density residential land should be redeveloped and floor area ratio of new residential land should be raised, in order to accommodate more residents and to improve the efficiency of public services use. On the other hand, for areas where supply shortage issues are more serious, new public service facilities should be built timely, especially in current densely populated areas. In a word, the integrated index defined in this research will help to analyze and evaluate the current spatial distribution of urban public services and support the site selection decision of future public services.

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# Chapter 66
# The Evolution of Chinese Commercial Property Market

**Qiulin Ke**

**Abstract** With the adoption of an open door policy and economic reform, China began to integrate into the global economy. Marketisation and rapid economic growth in the 1980s at first created a market of user demand for land and buildings from overseas investments and local businesses, subsequently, the development market and investment market have emerged and been formed. After over three decades, the China's real estate market has gone through the stages of experiment, evolution, transformation and maturing. Beijing and Shanghai, the two largest commercial property markets have attracted international investors' interest. Thus, it is becoming increasingly important for investors to develop a better understanding of this largest emerging real estate market. This paper aims to explore perceptions of market maturity and issues of importance for investment in this property markets. In this research, we apply the key determinants based on previous work undertaken by Keogh and D'Arcy (Market maturity and property market behaviour: a European comparison of mature and emerging market. J Prop Res 11:215–235, 1994) in mature market to the analysis of Chinese real estate market, particularly focusing on Beijing and Shanghai. The questionnaire is designed to obtain fair and objective views from property consultancy firms active in Beijing and Shanghai market.

**Keywords** China • Beijing • Shanghai • Commercial property market • Evolution • Maturity

## 66.1 Introduction

As Chinese economy has been transformed into dynamic private sector-led economy and integrated into the global economy, its property market has experienced dramatic changes. Starting from a closed, centrally planned economy in the early 1980s, the

Q. Ke (✉)
The Bartlett School of Built Environment, University College London, London, UK

Dr Karen Sieracki, KASPAR Associates Ltd., Tonbridge, UK
e-mail: q.ke@ucl.ac.uk

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commercial property market emerged first of in the cities of Beijing, Shanghai and Guangzhou, driven by the demand for international standard office space by multinational companies coming to China to set up regional headquarters or/and offices, which created a user market of demand for land and buildings from overseas companies and local businesses. A property development industry was needed to meet the market demand for premises. The property market emerged. Over the past three decades, the property market in China has evolved through the ups and downs and developed into the second largest property market behind Japan in Asia.

Market structures are the products of idiosyncratic, historical, political, legal, economic and cultural forces within any country. In emerging markets buyers and sellers are not easily or efficiently able to come together. Ideally, every economy would provide a range of institutions to facilitate the functioning of markets, but developing countries fall short in a number of ways. These institutional voids make a market "emerging" and are a prime source of the higher transaction costs and operating challenges in these markets.

Changes in property markets have also been analysed from the perspective of their evolution towards 'maturity' [2, 6, 14]. Market maturity is only a starting point to understanding market behaviour and trends. Keogh and D'Arcy [14] define that market 'maturity' is a function of the degree of diversification of user and investor opportunities, flexibility of adjustment of property interests, market openness, the existence of information and research systems, professionalization, and standardization of property rights and market practices. The underlying assumption is that property markets evolve in complexity as they are integrated into more sophisticated global economic and financial flows. Moreover, this evolution follows a roughly common direction, i.e. towards the development of market structures and practices more akin to those prevailing in the fully mature property markets of the world's financial centres [14]. Clearly, institutional characteristics vary from one national property market to another and from one time period to another. These differences are important to the analysis of market outcomes and behaviour. The evolution of property markets to its maturity has been observed in Southern European countries [8, 13, 14] and the countries in Central and Eastern Europe [1, 19]. More recently, Chin and Dent [4] and Chin et al. [5] investigate the evolution of property markets in Southeast Asian cities. These prior research indicates there is significant difference between these markets and would reinforce that an institutional approach to market maturity as the place-specific outcome of a complex interplay of global economic forces and the social, economic, institutional and cultural structures framing each market, rather than a linear and universal evolutionary process [9].

The themes of research about Chinese property market mirror the evolution and development stage of its property market. In 1990s, the research about China property market focuses on land use right reform, its related issues and recommendation, the privatization of land market and urban development (e.g. [3, 16, 20, 22, 23, 25]). Most of the studies are qualitative, due to the unavailability of historical data. Since 2000, the studies focus on housing market reform, house pricing and the factors affecting the housing prices (e.g. [10, 17, 18, 24]). Most of the research is quantitative, benefitting from the availability of data in housing sector. Due to the relatively short history of Chinese commercial property market and lack of quality market data, the studies of Chinese commercial property markets are scant. So far there are only a few papers (e.g. [11, 12, 21]) investigating the office rental pricing and adjustment, submarkets substitute in Shanghai and Beijing. There is few qualitative study of Chinese commercial property market structure.

This paper focuses on evolution of market process and its influence on property market activities with the focus on its two largest commercial property markets: Beijing and Shanghai. The paper is structured as follows. Section 66.2 discusses the evolution of Chinese commercial property market. Section 66.3 analyses the survey findings and conclusions are drawn in Sect. 66.4.

## 66.2 The Evolution of Chinese Commercial Property Market

Until the 1980s, there was no market mechanism for the transfer of real property in China. Land was either owned by the state or held in collective ownership by village communities. Since the 1980s many cities in China have expanded rapidly and collectively owned land has been absorbed into urban development. The commercial property market, especially the office markets emerged, first in large and significant cities such as Beijing, Shanghai and Guangzhou, with the arrival of foreign companies which stimulated the demand for commercial office space since the beginning of 1980s and created the user market of demand for office space. Beijing and Shanghai are most popular destinations of foreign companies.

China's free market reforms date back to the early 1990s, China had capital account restrictions that limit overseas investment opportunities. The broader and more general opening up of the economy, in 1992, when the Communist Party formally embraced Deng Xiaoping's view that the market system was not incompatible with the ideals of socialism and called for the establishment of a socialist market economy. This provided essential political support for major decisions to restructure the role and function of government, as well as the development of plans to speed up enterprise, financial, and social reforms and set the stage for a more fundamental "globalization" of the Chinese economy. In 2001 it was admitted to the World Trade Organisation (WTO), giving it greater access to world markets. Within china, economic growth is driving a massive rural-to-urban migration, with new cities being created within the space of a decade. The need to provide homes, offices, factories, social infrastructure and shopping malls is creating a huge property development boom. However, many of the new buildings have not been built to Western safety, leaving a legacy of risk for user and investors.

The second period, between 1993 and 1996, was one of transformation when there was a sharp rise in rent as a result of severe shortage of office space supply and increasing demand for space by the massive influx of foreign companies establishing offices, first of all. According to DTZ, by the end of 1993, the total prime office stock was 0.15 million sqm in Beijing and 0.12 million sqm in Shanghai, with low vacancy rates. There were few property transactions during this period. Office property was owned by state owned enterprises. To meet the rising demand of multi-national companies, large scale of office construction commenced prior to 1993. This period was volatile. The investment in real estate rose dramatically, first, property prices rocketed, huge amount capital flew into property sector; the property market became overheated. Many speculative projects commenced during this period. The pace of economic growth was slower than that of property investment and could not absorb the space supplied onto the market. The property market was out of control. Chinese government took tight credit control and banks stopping lending. At the same time, the economic growth slowed down and demand for space was reduced. Many building became void. The property price fell; many projects commenced in the beginning of 1990s were left uncompleted. The real estate market entered into the winter.

The third period (1997–2000) was marked by substantial increases in supply of office property. During the Asian Financial Crisis, China's economic growth slowed down and the office take-up rate was low. The overinvestment in real estate in the previous time period resulted in an oversupply of office space in the markets. Consequently, office rents fell.

The fourth period starting from 2001 has been characterized by some improvement in market transparency. Sustained economic growth and increases in FDI have stimulated office space demand. Rents had risen and the investment in office buildings was increasing before the global financial crisis began in 2007. This period witnesses the massive inflow of global funds into the Chinese real estate market. At present, Chinese real estate market is still in the sustainable development phase and different from the mature period of the property markets in the developed countries, such as America and UK. China is in the boost phase of the urbanization and industrialization.

Foreign investment is deemed as a central force promoting urban restructuring and the emergence and transformation of global cities in China. The important role of the state and local conditions in constructing development zones and in the channelling of foreign investment are identified. For instance, FDI is the major force behind Shanghai's development. Built on geographical and historical advantages, the inflow of foreign investment has led to significant spatial and economic transformation of Shanghai, which is becoming the most important location for regional headquarters of multinational corporations, and one of the most important financial centres in China. Shanghai's property market has attracted the attention of institutional investors for years, such as Morgan Stanley and Goldman Sachs making purchases. These institutional investors were mainly searching for value-added and opportunistic investments. Ke and White [11, 12] find that the FDI is one of the significant factors influencing Shanghai office rent.

Beijing plays a dual role as a political centre as well as an international financial centre. The state-owned enterprises are one of the major occupants of office buildings, alongside multinational companies. These Chinese corporates have often preferred owning to renting which reflects the history of state-owned enterprises owning their own premises. These two markets are different in certain aspects. For example, Ke and White [12] fail to find FDI has significant impact on office rent, whilst it is one of the significant factors influencing Shanghai Puxi office rent [11, 12]. Lecomte [15] finds that Beijing office market is a national played and is significantly influenced by national GDP, whilst Shanghai, a local player, is significantly influenced by local GDP and employment.

Mainland China is one of the emerging markets around the world that has been increasingly targeted for investment opportunities. However, the emerging markets are different from the developed markets. For example, Deloitte [7] has identified several major issues confronting international real estate investors in China, including lack of transparency, the legal system, complexity and inconsistency of transaction processes, mismatched valuation criteria used by vendors and investors, tedious procedures for bringing in and repatriating capital, and limited liquidity. These issues affect foreign investors' perception and evaluation of the real estate market, and may directly influence market opportunities.

## 66.3 Survey Findings and Analysis

In order to gauge attitudinal opinions and the significance of various factors influencing market maturity, the survey utilized a scaling techniques, containing descriptive terms based on a gradual progression in magnitude with 1 represents "very well developed" or "very mature" and 5 represent "very limited development" or "very immature".

The questionnaire design is based on those characteristics identified from previous studies such as Keogh and D'Arcy's work and Chin et al. The target group for this survey is researchers working in the research departments of international property consultancy firms in Beijing and Shanghai. These firms operate on the front line of Chinese property markets, providing professional consultancy for their clients and investors, they are important stakeholders in investment decision-making process; at the same time, they are familiar with the international standard practice. So they are able to judge the level of market maturity of local property market with reference of other mature markets.

The questionnaires were sent to 18 renowned international property consultancy firms in Beijing and Shanghai. Eleven of them responded. The respondents are the head of research department or the senior researchers with more than 5 years' experience about China's property market. Among them Five are from Beijing and six from Shanghai. Their views about the factors that constitute market maturity are similar; therefore, we don't make further breakdown in our analysis due to the small sample.

Following the studies of Chin and Dent [4] and Chin et al. [5]; the survey focuses on the institutional environment of China's commercial property market.

**Table 66.1** Relative perceptions of institution environment in Beijing and Shanghai

| | | |
|---|---|---|
| Political stability | 2.67 | (0.75) |
| Currency exchange stability | 2.57 | (0.49) |
| Restriction & regulation on foreign investors | 2 | (0.53) |
| Legal framework | 3.14 | (0.99) |
| Transparency of legislative system | 3.43 | (0.73) |
| Legal regulation | 3.33 | (0.47) |
| Sound financial/economic structure | 3 | (0.82) |
| Liberalization of financial markets | 3.67 | (0.47) |
| Strength & stability of economy | 2.5 | (0.76) |
| Level of transparency of market | 3.67 | (0.75) |
| Profession level | 3 | (0) |
| Perceived corruption level | 2.5 | (0) |
| Government intervention | 1.67 | (0.75) |
| Tax | 1.67 | (0.47) |
| Urban form (planning) | 3 | (0.58) |
| Public infrastructure level | 2.17 | (0.690) |
| Sound financial/economic structure | 4 | (0.71) |
| Strength & stability of economy | 3.75 | (0.43) |
| Restriction & regulations on foreign investors | 4.25 | (0.43) |

Note: 1 represents "very well developed" or "very mature" etc. and 5 represents "very limited development" or "very immature, etc.

The perceptions of institution environment are reported in Table 66.1. Comparing the survey findings with the ones by Chin et al. [5], we find that most of the factors of institution environment perceptions are higher than other four cities, but lower than Bangkok, suggesting that the institution environment in China is less developed than these Southeast Asian cities. For instance, the legal framework (3.14), transparency of legislative system (3.43) and legal regulation (3.33) are less developed than Hong Kong (the means are 1.56, 1.72 and 1.72), Kuala Lumpur (the means are 2.37, 2.57 and 2.57), Singapore (the means are 1.43, 1.43 and 1.43) and Taipei (the means are 2.73, 2.83 and 283), but slightly better than Bangkok with the means of 3.22, 3.5 and 3.5 respectively for these factors. Property tax is high and at the same level of Hong Kong (1.61), higher than other cities. In China tax rates applied to real estate investment have crept steadily high in recent years. There are so many taxes at every level: income tax, business tax, deed tax, land appreciation tax. The high tax decreases the internal rate of return on investment.

Government intervention in China is higher (1.67) than all five Southeast Asian cities. It is widely known that China's property market is government policy market. Politics dominates economics. Since 2009, Chinese government has introduced a battery of measures to cool the real estate market such as increasing the mandatory down payment for mortgages, restricting the number of homes people could buy, reducing financing to real estate developers by raising the interest rate and increases of reserve requirement ratio. Though these measures are to curb the housing price and have more effect on housing sector, but as the policy gets tougher and tougher, the perceived increase policy risks will certainly weigh on sentiments.

Starting from a closed, centrally planned economy in the early 1980s, China has capital account restrictions that limit overseas capital flowing in and out of China.

Interestingly, most of the respondents think the currency, i.e. RMB is more stable (2.57) than Bangkok (the mean is 3.13) and Kuala Lumpur (the mean is 2.6), though not convertible at the moment.

## 66.4 Conclusion

With the adoption of an open door policy and economic reform, China began to integrate into the global economy. The commercial property market emerged and formed since the beginning of 1980s to meet the demand of foreign companies to set up regional office in Beijing and Shanghai. After over three decades, the China's real estate market has gone through the stages of experiment, evolution, transformation and maturing. Beijing and Shanghai, the two largest commercial property markets have attracted international investors' interest. Thus, it is becoming increasingly important for investors to develop a better understanding of this largest emerging real estate market. This paper investigate the market evolution and maturity of China's two largest commercial property markets, Beijing and Shanghai with the framework of Keogh and D'Arcy [14] and cross compare with the survey findings of five Southeast Asian cities (Bangkok, Hong Kong, Kuala Lumpur, Singapore and Taipei) by Chin et al. [5].

To sum up, the respondents feel property market in Shanghai and Beijing are considered to be moderately mature, but still a emergent market. This survey suggests that these two markets are more mature than Bangkok and Taipei in most aspects. Shanghai and Beijing have lower level of market information standard and development stability than all the five cities. Shanghai and Beijing have the highest tax, at the same level of Hong Kong and the highest government invention. The results should be treated cautiously. The survey of Chin et al. was conducted in 2006; things could be improved during these 7 years period in these markets, especially the three emergent markets.

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# Chapter 67
# The Empirical Analysis to the Improvement of Local Finance System by the Full-Scale Taxation of the Real Property

**Weidong Qu, Wei Yang, Shuo Yang, and Jiajia Wang**

**Abstract** First, this paper intends to analyses the status and the problems existed in the local finance system of China by comparing with the system of developed countries. Then, we discuss how the reform of real property tax can improve the finance system of the local government by studying the essence and the destination of the real property tax. Next, we choose Beijing, Shanghai, Wuhan and Qingdao to conduct an empirical analysis of how the real property tax can improve the local finance system via studying the size of the local fiscal revenue and expenditure structure. Also, we demonstrate the effect of the full-scale taxation of the real property on local finance system by simulating the taxation in the four cities above. And at last, we get the conclusion of the empirical analysis.

**Keywords** Property tax • Local fiscal revenue • Mass appraisal • China

## 67.1 Introduction

The market mechanism can't achieve all the economic functions alone. It needs guidance, revision and supplement from the public policy in some aspects. And the effective implementation of the public policy needs the support of the public finance. The achievement of a government is in relationship with the finance policy [22]. The article 17 of the decision of the CPC Central Committee on a number of major issues to improving the socialist market economic system says that the main basis to formulate the fiscal policy and the monetary policy is the macro-control goals and general requirements of the government. And the fiscal policy should

W. Qu • J. Wang (✉)
Renmin University of China, No. 59 Zhongguancun Street, Haidian District, Beijing, China
e-mail: quweidong@mparuc.edu.cn; wangjiajia_0519@163.com

W. Yang • S. Yang
Zhejiang Topcheer Information Technology Co., Ltd., Huanchengxilu 33, Hangzhou, China
e-mail: yw@topcheer.cn; ys@topcheer.cn

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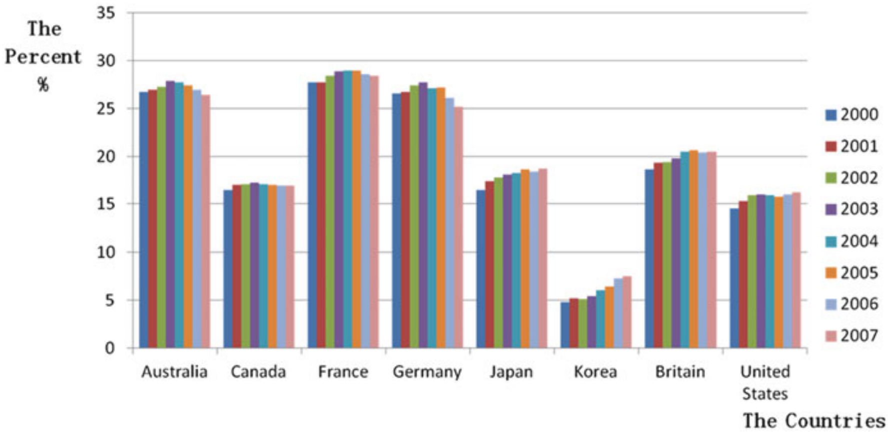


**Fig. 67.1** Part of the developed countries' government social spending accounted for a proportion of GDP in the year (%) (Date source: The OECD official website database)

carry out its function to insure the economic growth, optimize the economic and the social structure and adjust the income distribution.

The Fig. 67.1 shows the ration of the government social spending and the GDP of some developed countries. Though the ration is different according to the countries, the numerical number is all around 20 % and is sustainable with the time. The government action is a standard to measure the social ethics and civilized life and the fiscal policy has a profound impact on the level of social welfare, investment and financing and residents' savings [12]. Many countries has implemented their tax reform because of the demand of the social and the economic [30].

Generally, the function of tax system of the developing countries should include some planning functions besides the function of tax in industrialized countries. The aim of the economic policy is the aim of the finance policy in developing countries, including economic growth, the international balance of payments and stability, and the appropriate distribution between income and wealth [2]. So, we can see that the tax reform is a must for China to become a developed country.

The distribution of the revenue between the central and local government is about half to half since the tax system reform in 1994, but the expenditure of the central government has dropped down from 30 % in 1994 to 17 % in 2010. Figure 67.2 shows the ration of general expenditures affairs in central and local government of China in 2010. We can conclude that the revenue and the expenditure are seriously asymmetry of the local government. Although the vertical fiscal gap could be filled by fiscal transfers, the effect isn't notable because of the imperfect of the system [8]. So, there is still defect in the tax system [14], and make the local government treat the revenue as their major goal [7].

With the promotion of the marketization and urbanization of China and coupled with our unique dual-track system of land ownership, it is inevitable for the local government to choose the land finance as the way to expand their revenue [32].

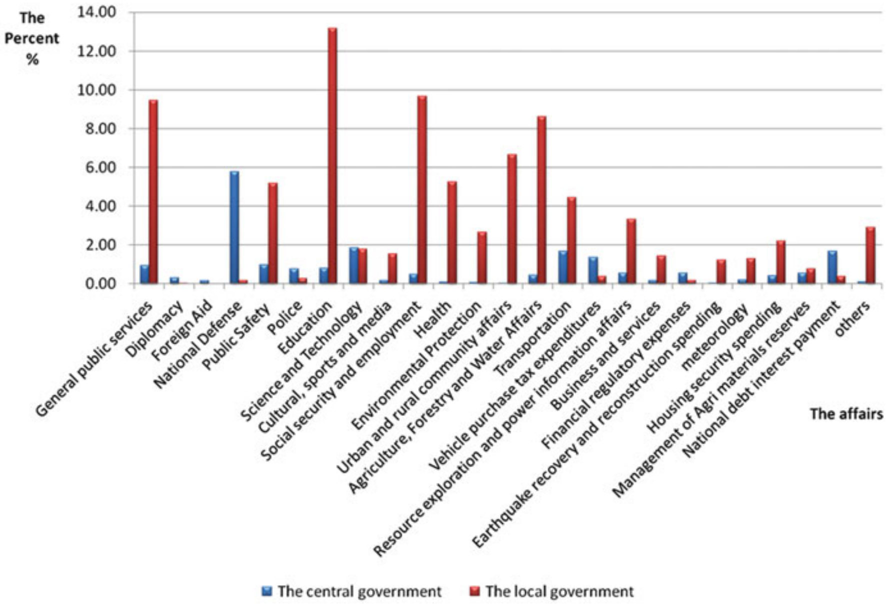


**Fig. 67.2** 2010 general expenditures affairs in the proportion of China's central and local governments (%) (Data source: Final statement of local public finance expenditure in 2011, Final statement of the central public finance expenditure in 2011)

The state council approved the Land Management Law in 1998, and set that the government could levy or expropriate the land in accordance with the law and give the land owner compensation for the public interest. So, the local government finally found a way to solve the problem of lacking of revenue and the land finance comes to the earth [9, 10].

Integrating various definitions and combining the fact of land revenue, the paper definite that the land finance is only the revenue the government gets from selling land. Figure 67.3 is the land premium income accounted for the proportion of the local fiscal revenue of China from 1991 to 2010. We can see that after 2003, the proportion is expanded.

According to the figure, we can know that the fluctuation of the proportion is acute and as it is a total rent for the land for 70 years. Also, in consideration with the nature of government, it's the tax that supports it, not the other. So the action of government that makes their fiscal depend on the land finance largely threatens the stability of the local financial and its sustainable development. We need to change the situation.

Based on the international experience, the real estate tax existed in the form of property taxes is one of the main revenue of local government and it play a very important role in the local public administration [26]. Shanghai and Chongqing has begun the tax reform in the beginning 2011 and want to explore the road of reform for the country. And this paper will try to simulate the collection of real estate tax to study the improvement of local finance system by the full-scale taxation of the real property.

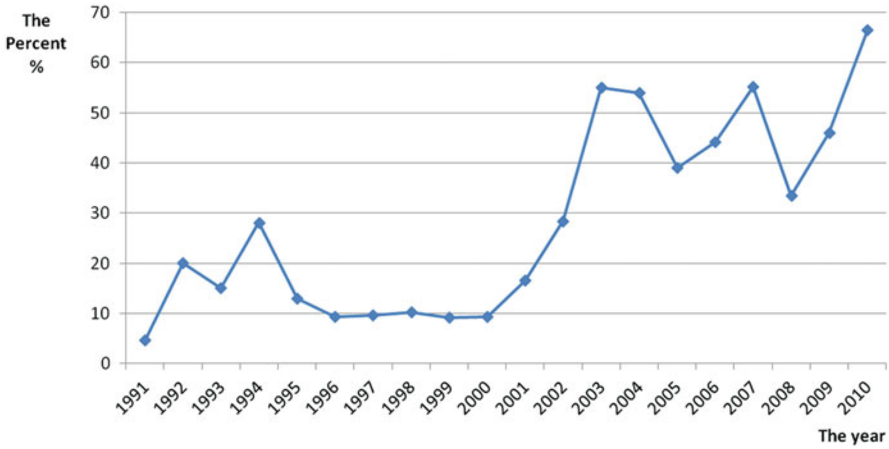


**Fig. 67.3** China's land transfer revenue accounted for the proportion of the local fiscal revenue from 1991 to 2010 (%) (Data source: Final statement of local public revenue)

## 67.2 Literature Review

Most of the current tax system of China is formulated in 1980s. And the taxes and fees related to the land are various, mot standardized and very different in different areas [35]. The decision of the CPC Central Committee on a number of major issues to improving the socialist market economic system indicates that we should implement the urban construction tax reform, and collect the property tax when conditions are ripe, and cancel the related taxes at the same time. Currently, the real property tax reform has been on the date. The real property tax here means the tax based on the value of real property.

Because of the yawning gap of local revenue brought up by the reform of the tax system and the development of the urbanization and industrialization, it has been an indisputable fact that our local finance is bound by the land finance [19]. The fundamental reason to land finance is the current taxation system [31], and the way to solve the problem is to establish a taxation system that matches the scientific property rights, financial resources and powers [38]. The property tax is the best revenue source for the local government [33].

Harry Karcher [15] thinks that the property tax should contain seven qualities as a stable tax base, the benefit is stable and predictable, the revenue is not easy to output, fair, easy to manage, obvious and should not lead to a unhealthy competition between the department. An ideal property tax system should be an system that the value of all the taxable property been identified, described and recorded. The real property tax is the main part of the property tax.

The Advisory Commission on Intergovernmental Relations found that most people think that the real property tax is one of the most terrible and unfair tax after their survey to the attitude people has on the government efficiency and real property tax from 1972 to 1975. And Neufeld [23], Layfield [18] thought that the main reason why people don't satisfy with the real property tax is because of the bad service based on the tax. Larry et al. [17] study the inequality which brought up by the real property tax using the non-equilibrium model that made by Paglin and Fogarty that based on the difference between the simulated value and the market value of a property and find that there is a low effective tax rate of the high-value real estate as well as assess the value does not meet the market value. Jeffrey [13] finds that institutional factors are the determinants of the views of the real estate tax by studying three communities under the situation of the people who is against the property tax. It's the citizens living in the community who has the ultimate impact on the enacting of property tax, not the chosen policy maker.

The property tax is based on the assessed price, not the market price, and each local government would have their own measures for the administration of real estate tax to fit for their area. And that's the obvious difference between the property tax and the other taxes [24]. And the assessed value based on the market could ensure the fairness and balance of the property taxes. So we can conclude the property tax must be developed combined with specific local circumstances to meet the needs of local citizens as a local tax.

The property tax is an important safeguard for the effective implementation of the fiscal policy of the local government [37]. Wu Yonghong uses the data of 351 companies from 2001 to 2006 of Massachusetts to make a panel economic and technical analysis and finds that though the property tax based on the commercial property is higher than that based on the residential property, it's not stable. So the local government finance should mainly rely on the residential real estate tax in the long term. And the collection of property tax doesn't influence the surviving of companies and their location choice [21]. Besides, the government could provide more public services using the property tax. So, it's both favorable for local governments and for businesses to levy property tax. Moreover, the more clear the relationship between the "tax and service" and the "cost and benefit", the more endorsement the government would get from the citizens because of their public service [25]. So we can know the way how governments use the property tax has a strong impact on the rationality and the degree of support of the property tax. The property tax reform of China should make clear of its application.

As a traditional view, consumers would burden the capital-based property tax and land-owners would burden the land value-based property tax in the long term [5]. The property tax is emerged for people for their ownership of a property and having the ability to pay for it [11]. Seth [28] thinks that many studies on the tax merely based on the annual data and that can not reflect the long-term nature of the property tax burden. Seth uses the expected income to reflect the housing needs of the people and finds that the progressivity of the tax burden considered from the perspective of lifelong income is not as strongly as from the annual data. So the disproportion is not as serious as many economists and policy makers have thought. Gavin [6] thinks property tax can be seen as a tax burden levied on personal wealth, not on the income. After further analyses, he thinks that in terms of a life cycle, property taxes based on wealth tax burden is significantly regressive compared with property taxes based on the income tax burden. So it is heavier for young people.

According to the above, the regressivity of property tax is strong considering with a short time and it is not equal for low-income people. And whether reduce the tax burden on property taxes or not still has a big controversy because of the function of adjusting income distribution of the property tax [29]. Thomas [29] finds that the change of tax rate has a big influence on people to buy or rent a house according to his research on the redistribution effect of the measures to reduce the tax burden on property conducted by New Jersey in 1976. The redistribution of property taxes in the high and low income populations, and different ages is also very clear and to the high-income population, the effect is more significant [27]. Also, many of the American municipal government treat TIF (tax increasing finance) as a tool to develop the economic, mainly for the government investment. The collection of property tax would push up the price of residential class and business class [3, 20].

Although there are a lot of controversies on the implementation of the real estate tax, there is no doubt that it is the pillar of local finance for most countries. Real estate taxes and other property taxes accounted for more than 70 % of the local finance in Canada and the United States, and is the only source of tax revenue for local finance in Australia. p And its ability to provide income for local governments to promote the rational use of land, to be able to create more equality characteristics, but also China's need for real estate tax [1]. China should build a real estate tax system in line with the national conditions of China's land to push forward the reform of the financial system.

## 67.3 The Reference of the World's Public Finance System to China

### *67.3.1 The Tax System Reform Should Continue to Improve in Accordance of a Combination of Our Political System, and Should Make Clear of the Local Finance Function*

The United States, Germany and Australia are all the implementation of the tax-sharing system. But there are differences existed in them: the shared taxes are less in the USA, and government at all levels has pillars tax. Shared tax of Germany accounts for about 74 % of all taxes, governments at all levels enjoy less tax. Australian tax system is hierarchical management and government at all levels has its unique sources of revenue, property tax is the only sources of revenue for local government.

The financial authority and powers of the central government and local governments should be relatively balanced corresponding to the fiscal revenue allocated among all levels of government. On the whole, the federal government general expenditure for national defense, international relations, and other state-to-state relations, social security, resources, energy, etc., state and local government for the area administration, education, health, transport, police, etc.

Although China has provides the central and local fiscal revenue and expenditure matters in the 1994 tax reform, the results are unsatisfactory. China's local government finances are involved in almost all state affairs.

So we know, the revenue-sharing is common, but each country has its own characteristic. China adopted the five administrative system, below the provincial government is the local government. And the system is different from other countries. Below the provincial level, the financial system has yet to truly enter the tax-sharing track [14], and should be improved. Meanwhile, the local finance should be clear responsibility.

### 67.3.2 Improving Inter-governmental Transfer Payment and Promoting the Establishment of Financial Balance System

Transfer payment made by the US federal government to state government's accounts for more than 20 % of the fiscal revenue; while transfer payment made by state governments to local governments accounts for approximately 30 % of the fiscal revenue. In order to keep the uniformity of all public service levels and realize coordinated development of regional economy and strengthening of macro-control, Germany stipulates that governments of all levels should adopt longitudinal balance and horizontal balance for adjustment. In Australia, the equalization-oriented transfer payment is an important means to relief the differences of regional financial ability; it is also an important way to make sure that backward areas' public services achieve a basic level.

So we can see that transfer payment means a lot in these countries when it comes to balancing regional differences and ensuring local governments to provide effective public service. Although the central government's tax rebates and transfer payments account for nearly 45 % of the local finance, China's inter-governmental transfer payment still lacks of fairness and efficiency due to following reasons: political factors, regional discrimination of tax rebate, big financial differences between regions, and the absence of scientific calculation methods.

Therefore, China's local financial reform should focus on improvement of inter-governmental transfer payment and promotion of the establishment of financial balance system.

### 67.3.3 Strengthen the Levy of the Real Estate Tax and Play Its Pivotal Role in the Local Financial

Based on the analysis on the majority of countries in the international community, real estate taxes (land tax, property tax) is the main source of revenue for local governments as one kind of property taxes: The real estate taxes is nearly 70 % of the U.S. government tax and it is the only sources of government revenue in Australia. From the aspect of tax base, most of the U.S. real estate taxes should be exempted except for religious, charitable and other institutions to guarantee the stability of the sources of revenue; Germany government exempts higher tax for the sale or rental of real estate. In terms of functionality, real estate taxes in the United States and Australia mainly plays financial income function, to support the payment of the uses for local education, police, fire, free medical care, as well as local infrastructure construction, etc.; In Germany, it plays the income distribution role.

Whether based on the analysis of the empirical or the theoretical analysis, real estate taxes are the best choice for local fiscal revenue. Even though our nation uses real estate tax, it is not the main part of the financial income. And the real estate taxes for the financial income first come out in the early 2011 in Shanghai and Chongqing for experiments. Meanwhile, the state-owned land use right transfer income is becoming the main support for local government financial income, which is against the government property.

To sum up, on the one hand, China's local fiscal system structure itself flawed, pillar income dislocation, hard to distinguish taxes and fees; On the other hand, the absence of central financial makes the financial burden too heavy, imperfect tax policy cause the workless of the local financial department. Therefore, three aspects should be reformed; the tax system, the central finance and local financial system. Strengthen the levy of the real estate tax and play its pivotal role in the local financial. Meanwhile, reducing local governments' reliance on land finance by reforming the tax system is the main solution.

## 67.4 China's Real Estate Tax Reform Solutions

### *67.4.1 Focusing on the Financial Functions of the Real Estate Tax, Taking the Residential Real Estate Taxes as Tax Base*

Tax has basic functions, financial income, income distribution and resource allocation [4] Different countries keep taxing on real estate is to finish the implementation of the national land policy objectives or to meet local fiscal revenue [35]. For our country, as one kind of property tax (USA, Australia), the financial function of the real estate tax can ease the current local government over-reliance on the financial plight of land; As income tax (Germany) or property rates (Hong Kong, Singapore), the revenue allocation function of real estate tax can suppress the real estate marketing acts, and to ease the dilemma of the high real estate price.

In our country, the land price is an important part of the house prices; the revolution of the real estate tax can ease the financial predicament of land finance, then alleviate the problem of high prices and play the real estate tax revenue allocation function. Therefore, China's real estate tax reform should be defined as a property tax, and focus on playing its fiscal revenue.

As the real estate tax mainly used for local services expenditure, in order to make the real estate tax to play its fiscal revenue, combined with its fair and equitable quality, the first important thing is that all residential real estate should be taken as the tax base, such as the United States, Australia, the Netherlands and other countries. Secondly, tax exemption, tax cuts as well as differentiated tax rates should be considered based on the foundation of tax levy, such as the protection of housing allowance, low tax rates for the first set of housing family, more housing progressive rates and high-end housing high tax rates and other measures.

### 67.4.2 Integrating All the Taxes and Charges Related to the Real Estate, Depending on the Price of the Real Property Rather than the Quantity

Under the premise of comprehensive taxation on residential real estate, we must pay attention to prevent double taxes happening after collecting the real estate tax. Moreover, our active taxes don't achieve their expectant function goals, such as plough protection function from the farmland conversion tax, income distribution function from the land increasing tax and so on. As a result, reform of real estate taxes should integrate all the taxes and charges related, achieve their maximum function goals in order to relieve citizen's burden and make taxes legal at the same time.

This paper holds the view that reform of real estate taxes in China should be revenue function-based, their main purpose is local output as the basic local taxes, so we should guarantee the balance between tax collection and budget outlays. America determines tax rate of the real estate taxes as follows, local government determine the total quantity of budget and other incomes except the property tax for next year, and the differential section is property tax. Then local government would determine rate of the property tax as ratio of the total quantity and total value of the property tax.

We should follow the method when determine the real estate taxes to residential real estate as well. We should make the number of houses in different types, the value of houses and the budget outlays at first, and then announce the budget of real estate taxes and tax rate of different house types. Make decision on revenue position depends on the budget outlays; determining rate depends on the estimated value of real estate finally.

### 67.4.3 Making the Use of the Tax Clear

As a dominant part of local taxes, housing property taxes financially guarantee that local governments administrate and provide public services successfully. What's more, since housing property taxes levy inhabitants' housing property as

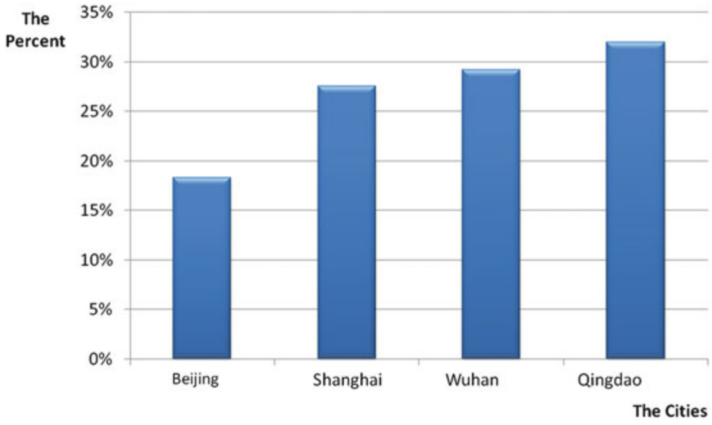


**Fig. 67.4** The proportion of state-owned land use right transfer income accounted to the local fiscal revenue of Beijing, Shanghai, Wuhan and Qingdao (Data resource: Beijing 2011 municipal financial public budget revenue and expenditure accounts, Shanghai 2011 municipal financial public budget revenue and expenditure accounts, Wuhan 2011 municipal financial public budget revenue and expenditure accounts, Qingdao 2011 municipal financial public budget revenue and expenditure accounts)

their tax bases, their usage should be crystal clear. In other countries, the income of house property taxes are paid for the expenses of local affairs, for instance, local education, police, social security, employment and public infrastructures, etc. People who benefit from these investments are individuals who have paid property taxes in the districts. In Shanghai's and Chongqing's pilot projects of housing property reformation, the practice of investing the housing property taxing in low income rental houses is inconsistent with the general usage of housing property taxes.

According to what has been mentioned above, the local governments' current practice of excessive dependence on income from lands is widely denounced. Image five shows the share of revenue from state-owned land use right granting in local finance revenue in Beijing, Shanghai, Wuhan and Qingdao, which is far higher than the share of housing property taxes revenue, but lower than that of other countries (Fig. 67.4).

The role of land transferring fees played in local finance was kind of overstated. Land transferring fees are government funds, which have special usages. The reformation of housing property should not aim at balancing the land transferring fees. Housing property taxes revenue should be the financial backbone of local public administration and services, and their usages should be clarified. The paper maintains that the usage of housing property taxes revenue should be invested in local education, police, health care, social security, employment and public infrastructures, etc.

## 67.5 The Empirical Analysis to the Improvement of Local Finance System by the Real Property Tax Reform

### 67.5.1 Research Methods

In accordance with the classification to the tax system of the country of the world [36], the paper chooses the tax system of America, Germany and Australia to analyze. According to the analysis of other countries and regions in the international real estate taxes, we explore the improvements to China's real estate tax reform of local finance by the study of the nature of the real estate tax and destination. Then, we propose the empirical analysis approach to study the improvement of the local finance system by the collection of the real property tax according to the method proposed by Kerry Konya [16].

This section is to verify the effect of the real estate tax reform ideas of local finance improvements above through the simulation of different scale urban real estate tax. In order to compare the scale of urban real estate tax demand, we select two first-tier cities Beijing and Shanghai, Wuhan, Qingdao, two second-tier cities to compare. First, the simulation of the real estate tax as a precondition to the following four-point assumption:

1. All the residential real estate is levied;
2. Housing type is not considered;
3. The tax base is the price (Including land and housing price);
4. The standard to judge whether the tax is heavy is the difference between per capita tax burden and the difference between the per capita consumption expenditure and the per capita disposable income.

As the collection of property tax is according to the expenditure, we have determined three criteria according to the function of real property tax to use.

1. The real property tax is mainly used for location education, policy, health care, social security and employment and public facilities construction. We determine this expenditure as the first standard.
2. The state-owned land use right transfer income of the city as the second standard.
3. As the pillars of real estate tax revenue, the proportion of their share of local taxes should be higher than 50 %, so we decide 50 % of the total tax as the third standard.

We define real property tax as RT, the expenditure of location education as E, the expenditure policy as P, the expenditure healthy care as H, the expenditure social security and the expenditure employment as S, the expenditure public facilities construction as CP, the land transfer income as L, local tax as LT. So the equity could be expressed as below:

$$\mathrm{RT}_1 = \mathrm{E} + P + H + \mathrm{S} + \mathrm{CP}$$

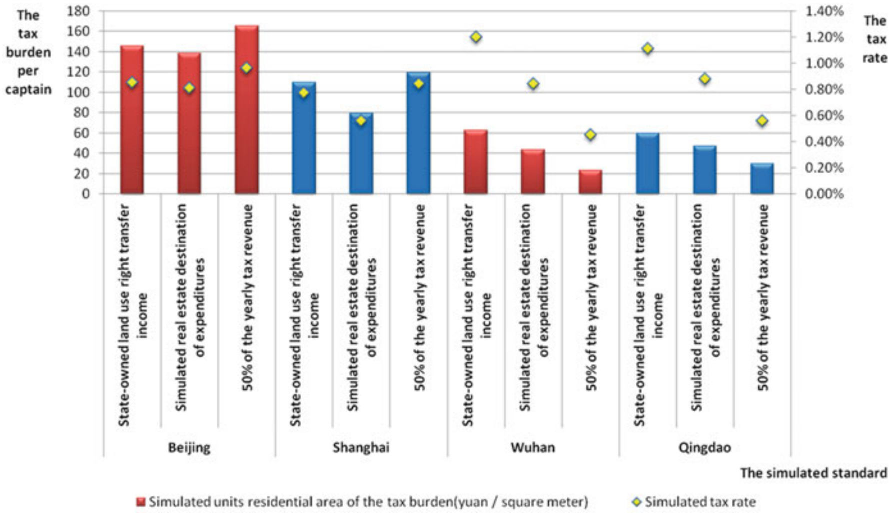


**Fig. 67.5** The simulated real property tax rates and the tax burden of units residential of the four cities

$$\mathrm{RT}_2 = \mathrm{L}$$

$$\mathrm{RT}_3 = 0.5 * \mathrm{LT}$$

According to the calculation of [34], if the new levy property tax burden of more than 3.6 % of annual household income, the tax burden is heavy. We assume every family has three people, so the tax burden should not exceed 1.2 % of the per capita disposable income. But Wu's calculation is too narrow to consider the use of the real estate tax, underestimated the amount of real estate taxes and did not take into account the relationship between household spending and tax credits.

In this paper, we consider the overall tax reform. To measure the proportion of total household income in real estate taxes based on Wu Liqun's idea of the real estate tax burden, we assume that if the real estate tax burden per capita of more than 30 % of the average per capita balance of payments, the tax burden is heavy.

This article mainly makes horizontal contrast by four cities analog data and longitudinal comparison of analog data over the years in Beijing. The equity is:

$$\mathrm{PT} = \mathrm{URA} * \mathrm{URAP} * \mathrm{TR}$$

### *67.5.2 The Analysis to the Simulated Results*

The data of Beijing and Shanghai is of 2010, and the data of Wuhan and Qingdao is of 2009. The data is from the Statistical Yearbook and Financial Yearbook of each city. Figures 67.5 and 67.6 show the simulated results of four cities. And Figs. 67.7 and 67.8 show the simulated results of Beijing from 2008 to 2010.

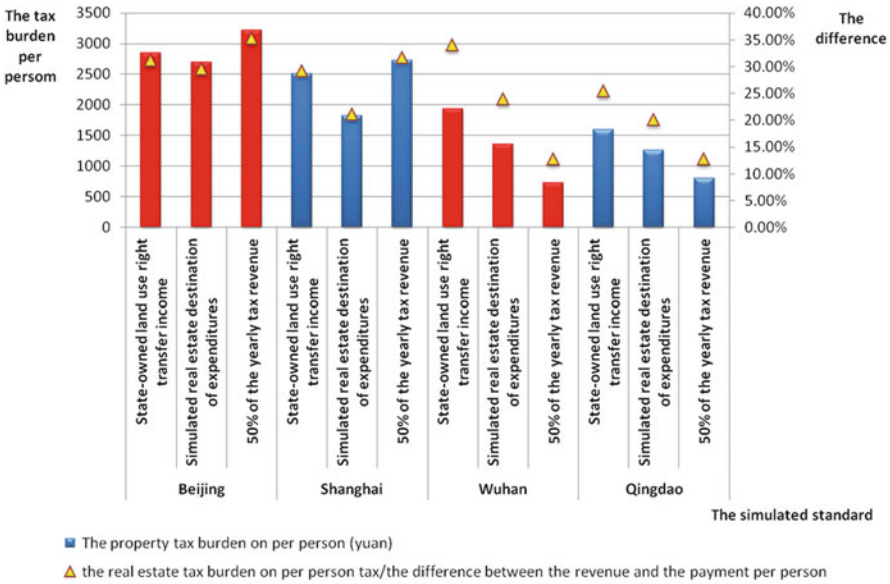


**Fig. 67.6** The simulated real estate tax burden and the ration of the tax and the difference between the revenue and the payment on per person of the four cities

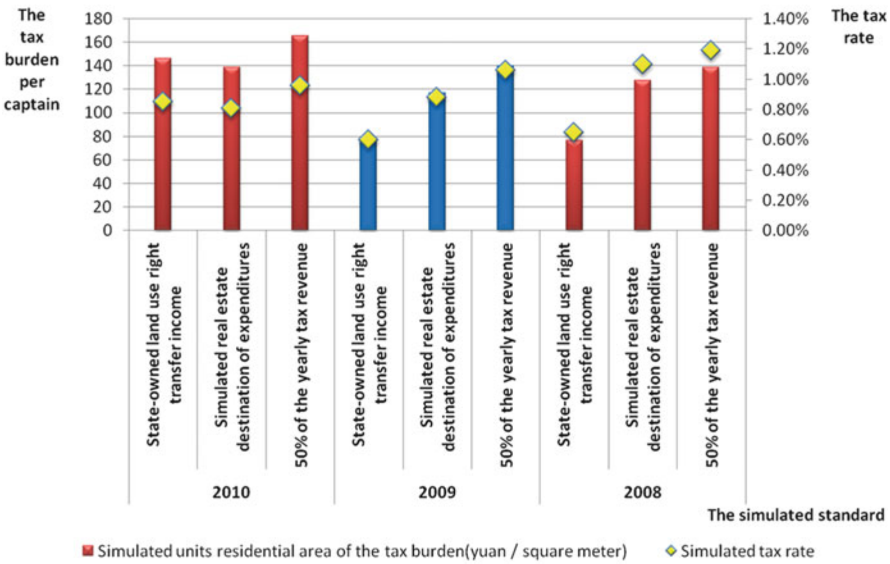


**Fig. 67.7** The simulated real property tax rates and the tax burden of units residential of Beijing from 2008 to 2010

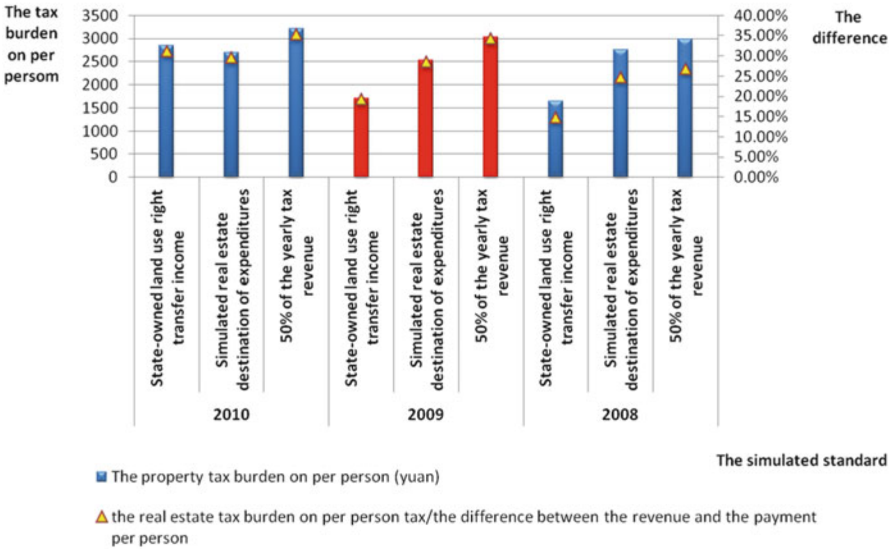


**Fig. 67.8** The simulated real estate tax burden and the ration of the tax and the difference between the revenue and the payment on per person of Beijing from 2008 to 2010

Simulating formula:

$$PT = URA * URAP * TR$$

$$URAT = AT * RP$$

$$SPTP = URAT * PHA$$

PT = property tax, URA = Urban residential area, URAP = Urban residential average price, TR = Tax rate, URAT = Units residential area of the tax burden, AT = Analog tax rate, RP = Residential average price, SPTP = The simulated property taxes per person, PHA = Per capita housing area.

According to the comparison of simulations of transverse results, the four-simulation-standard real estate tax burden of Beijing and Shanghai reach 30 %, which is the critical value of imbalance percentage between per capita real estate tax burden and the payment balance. While the data of Wuhan and Qingdao is less than 30 %. Different simulation standards leads to different ranking of the tax revenue: taking real estate tax incidence expenditure as a simulation standard, Beijing has lightest burden while the rests are in mid-range; taking the revenue of state-owned land usage right transfer revenue as a simulation standard, Wuhan and Qingdao have the heaviest burden, taking the 30 % of financial revenue (excluding land usage right transfer revenue) as a simulation standard, Beijing has the heaviest burden while the other three does not.

Volatility of four simulation standard of Beijing is the lowest, so we take Beijing as a case for longitudinal comparison. From chart 2, the simulation standards shows a large volatility and the simulation standards as the 30 % of financial revenue (excluding land usage right transfer revenue) shows high tax burden, so both of them are inappropriate as a standard. We can come to the same conclusion as the comparison of transverse simulations, that is, Expenditure of the real estate tax "Expenditure and Revenues" should take 50 % of the tax revenue of the year and real estate tax incidence expenditure as standards. The real estate tax incidence expenditure of Beijing and Shanghai are less than 50 % of the tax revenue, but the real estate tax incidence expenditure Wuhan and Qingdao are more than 50 % of the tax revenue. It shows that the tax revenue of the second-tier cities is lower.

Through the Positive Analysis, this article based on comprehensive outcomes of four standards suggests that the levy of real estate tax should be between two simulation values, one of which is based on the use of real estate tax and the other is with 50 % of taxes that year as standard. The collection of real estate tax will not increase taxation burden on residents. This paper take the average real estate tax as simulation value and owing to the real estate tax directly relate to the value of residential house, these taxes can be distributed among the people of distinguishing income according to different value of residential house, then play a role well in distribution of income role.

Now, the new collection of real estate tax can meet either the local tax needs up 50 % or the government expenditure demands for education, medical treatment, social security, employment and public security. It contributes to reducing the financial pressure of local government and to promoting the reform of local government about financial system. Full collection of real estate tax is built upon the common consideration about the land and housing value; consequently, in order to avoid the rent forms of income binding the local government, the revenue from transferring the use right to the State-owned land needs to be reformed.

## 67.6 Conclusion

The principle of fair and just of the real property should be embodied in the people who enjoy the benefits. That is, as a local tax, the beneficiary group should be the people in the local government area who pay the tax. According to international real estate tax purposes, the use of this type of tax should be local education, police, social security and employment, public facilities construction. So, we can get the conclusion that the tax could ease the pressure of the entire financial system of the local government.

The collection amount of real property tax each year should be made a budget in accordance of the expenditure next year according to the tax and real estate tax burden affairs this year and shouldn't take the land revenue and total finical revenue into consideration. The role of the real estate tax is reflected in a more solid financial base for local governments to provide, making convenient local government public administration activities. And to alleviate the financial problems of the current land finance, it is important to regulate the intergovernmental transfer payments and avoid local budget deficit increasingly serious phenomenon.

The relationship between the real property tax, the finance system and the land finance should be “the real property tax → he finance system → the land finance”. We should promote the reform of the financial system by the real estate tax reform, and through the reform of the financial system gradually ease the dependence of local governments on land finance.

Real estate tax on local fiscal improvement is mainly reflected in the following seven areas:

1. As one part of the property taxes, real estate tax could meet the demand for local fiscal revenue.
2. The real estate tax reform should be integrated with other parts of fiscal reform.
3. Different type of real estate should take different tax rates, so it can play its revenue allocation function.
4. “Expending according to revenues” real estate tax will not increase the tax burden on people.
5. The clear purpose real estate taxes can contribute to raising the level of the local public administration and public services.
6. Real estate taxes could solve the problem that the local fiscal revenue largely relied on land finance.
7. The levy of real estate tax next year should be rely on the standard of tax budget and the burden of government affairs expenditure budget of this year.

So, we can say that the real property tax is a must for the government to promote the perfection of the entire tax structure adjustment and intergovernmental transfer payments, and to make China’s financial system more balanced between the central and local government, to relieve local financial pressure. The effect of the reform is obvious and can lead to a more optimized local financial institutional structure and a more comprehensive functionality.

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# Chapter 68
# An Evaluation of Students' Satisfaction with University Hall of Residence

**C.O. Aigbavboa, W.D. Thwala, and C.C. Eke**

**Abstract** This paper present the findings of post occupancy survey of Sophiatown residence; one of the residence and presently the largest residence in University of Johannesburg Auckland pack campus in Johannesburg, South Africa. The purpose of the paper is to evaluate the extent to which the building is satisfactory to the students. The data were collected during October and November 2012. The primary data for the study was collected through a structured questionnaire survey. A total of 150 questionnaires were distributed and 135 were received back from the occupants of the residence. The survey results revealed that a majority of the occupants (students) of the residence were satisfied with most qualities in the residence which makes the residence satisfactory to the students.

**Keywords** Residential satisfaction • Student residents' • Post occupancy evaluation • University building • South Africa

## 68.1 Introduction

According to Khalil and Husin [10], people are concerned about an environment which is suitable and which is comfortable to work in; and occupants demand to have priority in terms of the comfort ability to utilize the facilities and services as they were intended to be used by the users.

In the proposed study 'student's residential satisfaction' means that the users (Students) of the residence are receiving a good quality service and the services rendered meet there expectations. When expectations are unrealistic, disappointment cannot be avoided. Ojasalo [19] states that if the unrealistic expectations can be made realistic, then it is possible to provide a service which satisfies the

C.O. Aigbavboa (✉) • W.D. Thwala • C.C. Eke
Department of Construction Management and Quantity Surveying,
University of Johannesburg, Johannesburg, South Africa
e-mail: caigbavboa@uj.ac.za

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expectations. Abdulla [1] defines satisfaction as an experience of fulfilment of an expected outcome. That is, if the performance matches the expectation; the students will be satisfied.

According to Pinder et al. [21], acquiring and maintaining student housing facility in a suitable state is an important function for any organization or institution. Failure to do so may have an adverse effect on building users. The satisfaction of the residence are not only for the occupants (students) but also for their visitors, including members of the public, who have business in the building. Correct student housing conditions are important factors for health and performance in every way. This is because the way a building functions when it is used is essential for both whether or not it is regarded as a success and constitutes an asset for its owners and occupants [15]. A systematic evaluation of buildings in use is an effective way to produce this knowledge in relation to the planning of new buildings and not least for the development and change of existing buildings that are not satisfactory to the occupants [5]. However, there are many concepts, definitions and methods that are relevant to a building's quality, standard and condition. Most of these are associated primarily with a building as a physical object and not with its usability. An important approach to usability of building is that a building in itself has no value, but has value only when it is used and satisfies the occupants.

Therefore, the problem statement for the study is to uncover the extent to which the University of Johannesburg newly constructed residence (Sophiatown residence) is satisfactory to its occupants/users (the students). The problem to be investigated is if the residence is satisfactory to the students. Since POE is the process that assesses how well buildings match user's needs and also identifies ways to improve building design, the objective of the study is to evaluate the extent to which the building is satisfactory to the (occupants) students. The main purpose of study will be to assess the building functional suitability and fitness for its intended purposes from the building occupants' perspective. The papers with a general overview of the concept of residential satisfaction, followed the presentation of the methodology used in undertaking the research. Next the paper presents the findings from the questionnaire survey before conclusion and recommendations are made.

## 68.2 Residential Satisfaction Overview

Numerous studies on housing satisfaction have evaluated housing provisions by dealing with problems of occupant satisfaction. Theoretically, the concept of housing satisfaction has been utilized in at least four different ways:

- as a key predictor of an individual's perception of general quality of life [6];
- as an indicator of incipient residential mobility, and hence altered housing demands and effected neighbourhood change (Speare 1974; [22]);

- as an ad hoc evaluative measure for judging the success of housing developments constructed by the private sector [14];
- to assess residents' perceptions of inadequacies in their current housing environment so as to direct forthcoming private or public efforts to improve the status quo [9, 16].

Onibokun [20] informs that the habitability of a house is influenced not only by the engineering elements, but also by social, behavioural, cultural, and other elements in the entire socio-environmental system. Hence, a dwelling that is adequate from the engineering or from the design point of view may not necessarily be adequate or satisfactory from the inhabitants' point of view. Onibokun [20] concluded that the house is only one link in a chain of factors, which determine people's relative satisfaction with their accommodation. Varady [22] further argued that housing satisfaction acts as an intermediary variable between background characteristics and mobility behaviour. In the work of Lane and Kinsey [13] they reported that housing characteristics were more crucial determinants of housing satisfaction than demographic characteristics of housing occupants.

Residential satisfaction is influenced by the occupants' perception of the various aspects of the house, the aspects of the community and how the house and the community are managed. Occupants tend to make an immediate comparison between their previous dwelling and their present housing and that also influences residential satisfaction. In the evaluation of residential satisfaction, certain characteristics, services and amenities in the residential environment may be identified that plays a role in housing satisfaction. Residential satisfaction or housing satisfaction gives an indication of how people respond to the environment in which they live [8]. A completed residential building should be able to function in such a way that it satisfies the occupant's needs. Once the building has been completed and it is occupied, maintenance commences to ensure that the elements or facilities in the building function to their maximum capacity. Occupants of the building will then evaluate the facility to determine whether the building is functioning in accordance with its intended purpose [18].

Residential satisfaction is under the umbrella of post occupancy evaluation (POE) because the occupants' satisfaction of any building (residence) is determined by the building's evaluation. Kirk and Stirret [11] define POE "as part of value engineering that continuously improves the facilities in the building". By that time, the POE was being used based on the occupants' needs, as the building performance is judged on the based on the user satisfaction needs. The intention of the POE is to improve the quality of the building and to identify the problems that can be used as benchmarks so that previous mistakes and unwanted features are not included or repeated in future projects. Occupant satisfaction with the building is associated with the efficiency of building performance. For POE to be more effective, management must ensure that they create a working environment that is conducive to the safety and well-being of their occupants (students). The managerial style of managers must be structured in such a way that they will attend to and embrace occupants' grievances timeously. The resident's managers must empower their students so that they will be more accountable and responsible for whatever they are doing in the residents [7].

Measuring residential satisfaction is there important because it broaden one's understanding of how and why occupants respond to certain factors in the environment in which the live as well as to certain housing types and living conditions. It provides information that can be used to improve residential living conditions of those people whose preferences and requirements are not known through the normal housing channels and markets as the relate to the more affluent segment of the population [8]. Residential satisfaction is based on entirely on the occupant's individual definition of residential quality. For instance, one occupant's idea of good residential quality might be to have a toilet and bathroom inside the room whilst for another, it might not be. Residential satisfaction also depends on culture and, in some cases, different socio-economic levels. Occupants usually compare what they consider to be high or good residential quality to the current residential environment in which they reside. When the gap between what they expect and what they have decreases, residential satisfaction increases [3].

As population of student increases, more and more people invariably have to reside in the residence. This trend then increases the need for more student residence and also providing conducive environment for easy movements and recreational activities for residential satisfaction [4]. The process of the post occupancy review evaluates and identifies any remedial work required, provides information to support continuous improvement for future project and can be an important part of the communication process for change management. Furthermore, it focuses on the occupants' needs and measures the extent to which the building's outcome meets the occupants' expectations in relation to the safety qualities and importance of the residential environment and the functionality of the design; and the effectiveness of the design, construction, communication and occupancy process [12].

## 68.3 Methodology

The data used in this paper were derived from both primary and secondary sources. The primary data was obtained through the survey method, while the secondary data was derived from the review of literature and archival records. The primary data was obtained through the use of a structured questionnaire survey. This was distributed to a total of 150 occupants (students) who are residing in Sophiatown residence. Out of the 150 questionnaires sent out, 135 were received back representing a 90 % response rate. This was considered adequate for the analysis based on the assertion by Moser and Kalton [17] that the result of a survey could be considered as biased and of little value if the return rate was lower than 30–40 %. The data presentation and analysis made use of frequency distributions and percentages of all the respondents. The research was conducted between the months of October and November 2012.

The questionnaire was in two sections (A & B). The designs of the questionnaire envisage a maximum of 20 min for its completion.

Section A gathered the demographic information of each member of the residence that participated in the survey. This included questions on their gender, their age, their ethnicity or population group, student status, their present level of study, their highest education qualification and how long they have been living in Sophiatown residence. Section B collects information on the satisfaction of the building. This section of the questionnaire was structured in a way respondents had to answer the overall quality rating of the residence, their satisfied or dissatisfied with the building, the quality and importance of the building factors and how easy to move around the residence.

### *68.3.1 Mean Item Score (MIS)*

A five point Likert scale was used to determine the environmental performance of the residence. The adopted scale was as follows:

1 = Very negative
2 = Negative
3 = Neutral
4 = Positive
5 = Very positive

The five-point scale was transformed to mean item score (MIS). The indices were then used to determine the rank of each item. The ranking made it possible to cross compare the relative importance of the items as perceived by the respondents. This method was used to analyse the data collected from the questionnaires survey. The mean item score (MIS) was calculated for each item as follows;

$$\mathbf{MIS} = \frac{\mathbf{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}}{\Sigma N} \tag{68.1}$$

Where;

$n_1$ = Number of respondents for very negative;
$n_2$ = Number of respondents for negative;
$n_3$ = Number of respondents for neutral;
$n_4$ = Number of respondents for positive;
$n_5$ = Number of respondents for very positive;
$N$ = Total number of respondents

After mathematical computations, the criteria are then ranked in descending order of their mean item score (from the highest to the lowest).

## 68.4 Findings and Discussion

Findings from the 135 usable questionnaire revealed that 33 % were female, while 67 % were male. The majority of the respondents (76 %) were within the age group of 20–29, followed by (24 %) of the respondents who belong to the age group below 20. The ethnicity that comprises the majority of the respondents were blacks (97 %), followed by (3 %) whites. Majority of the respondent status (97 %) were full time students and 3 % were part time. Majority of respondents were in the first year of their study at the university representing 34.1 %; followed by 30.4 % - second year and only 2.2 % were in their final year of study. Majority of the respondents highest education qualification were grade 12 (76 %) which agrees with the initial findings on the students' level of study; while 11 % were post graduate students and 2 % were enrolled for either a diploma or certificate programme. The respondents were asked how long they have been living in the Sophiatown residence; the results of the study indicated that the majority of the respondents (44.8 %) have been living in the residence for less than a year, while a cumulative percentage of 55.2 % have lived in the residence for more than a year.

When the respondents were asked to rate the overall quality of the building facilities (Table 68.1), findings revealed that respondents had high rating in some facilities in the building. Respondents showed high level of satisfaction with access to public transport (MIS = 4.56; R = 1) which was ranked first, followed by the building safety (MIS = 4.32; R = 2), Parking lot (MIS = 4.30; R = 3), Community hall (MIS = 4.29; R = 4), Laundry (MIS = 4.22; R = 5), Computer (MIS = 4.21; R = 6), Bedroom (MIS = 4.01; R = 7), Student hall (MIS = 3.89; R = 8), Toilet and bathroom (MIS = 3.76; R = 9), Internet services (MIS = 3.56; R = 10), Kitchen (MIS = 3.47; R = 11), Parking spaces (MIS = 2.79; R = 12), and TV room (MIS = 2.41; R = 13) was ranked last.

Literature reviewed indicated that the intention of post occupancy evaluation study is to improve the quality of the building and to identify the problems that can

**Table 68.1** Building features satisfaction level

| Level of satisfaction | MIS | Rank (R) |
|---|---|---|
| Access to public transport | 4.56 | 1 |
| Building safety | 4.32 | 2 |
| Parking lot | 4.30 | 3 |
| Community hall | 4.29 | 4 |
| Laundry | 4.22 | 5 |
| Computer | 4.21 | 6 |
| Bedroom | 4.01 | 7 |
| Study hall | 3.89 | 8 |
| Toilet and bathroom | 3.76 | 9 |
| Internet services | 3.56 | 10 |
| Kitchen | 3.47 | 11 |
| Parking spaces | 2.79 | 12 |
| TV room | 2.41 | 13 |

**Table 68.2** Level of satisfaction with safety features (human and non-human)

| Safety features and facilities | MIS | Rank(R) |
|---|---|---|
| Lighting | 4.44 | 1 |
| Accessible fire escape route | 4.20 | 2 |
| Visibility of the security personnel | 4.18 | 3 |
| Access control to building | 3.96 | 4 |
| Accessible firefighting equipment | 3.90 | 5 |
| Access to transportation | 3.49 | 6 |

be used as benchmarks so that previous mistakes and unwanted features are not included or repeated in future projects. The findings of the study correlates with previous work as carried out in South Africa by Aigbavboa and Thwala [2], where it was found that the students were satisfaction with the parking lots, computer lab and laundry rooms. From the physical observation of the satisfied building features, the research observed that the hall of residence has more than enough parking lots for students who were vehicle owners, while the computer lab was were equipped to support the student learning, likewise the laundry rooms that had state of the art facilities for student usage. Also, the students were satisfied with the access to public transport as the hall of residence is directly situated very close to a major road in the university suburb. Hence, the findings support the statement as posit by Nawawi and Khalil [18] that a completed residential building should be able to function in such a way that it satisfies the occupant's need, which is what the developed residence has rightly done.

Furthermore, when the students were asked to rate the level of the safety features (human and non-human) in the residence, as shown in Table 68.2; it was revealed that the students showed a high level of satisfaction with all the safety facilities and features as provided by the university in the hall of residence. For instance the Lighting level was ranked first (MIS = 4.62; R = 1), access to transportation (MIS = 4.59; R = 2), access control to building (MIS = 4.51; R = 3), accessible fire-fighting equipment (MIS = 4.47; R = 4), accessible fire escape route (MIS = 4.45; R = 5), while the visibility of the day and night security personnel (MIS = 4.29; R = 6) was ranked least. The findings concurs with the general POE literatures which indicated that for a building to perform to its optimal level, the building management must ensure that they create an environment that is conducive to the safety and well-being of their occupants or students.

## 68.5 Conclusion

This paper examined residential satisfaction in the context of students' housing in South Africa. Findings from the study revealed that the students' housing provided performed above average from the students' evaluations; implying that the residences matched the needs of the students in some aspects.

In conclusion, the findings from the study revealed that majority of the occupants were satisfied with the building overall quality rating except for few qualities.

However, the result showed that the occupants were not satisfaction with the residence study hall, toilet and bath room, kitchen and TV room, as these were the common areas where the resident students had contact, as most students act the way they like without respect to other students. Hence, it is recommended that the university through the residence management should set ground rules on the behaviour of students' when in these common areas (facilities) of the residence.

With regards to the safety features in the building, the research findings revealed that the students had high level of satisfaction with the provided lighting, accessible to fire escape route and the visibility of the day and night security personal around the residence. In essence, based on the comprehensive evaluation of the building satisfaction, majority of the students were satisfied with most qualities in the residence which makes the residence satisfactory to the students.

This study has shown that the outcomes of satisfaction studies in other housing settings cannot simply be generalised to students' housing in South Africa. Hence differences arise from the students' characteristics as well as from the measured features of the housing. However, the characteristics of the students which predicted satisfaction were almost similar to those of adults in previous studies; the measurements of the housing they were satisfied with or not satisfied with were likely to be related to the transitory nature of the housing and their age. There were also certain aspects of the students' housing which differed significantly from the family house. Therefore, the results revealed in this study gives valuable insights for the student housing departments in South Africa universities towards the improvement of much better student housing in the near future because of the rising student numbers in South Africa University.

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