Liyin Shen · Kunhui Ye
Chao Mao *Editors*

Proceedings of the 19th International Symposium on Advancement of Construction Management and Real Estate

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Contents

Part I
Sustainable Urbanization

Chapter 1
SWOT Analysis for In Situ Urbanization in the Southeast of Chongqing

Yajun Cai, Yilong Zhang and Huanhuan Wu

Abstract In recent years, our country's urbanization rate has been increasing by about 1 % annually, and it has been into a period of rapid development of urbanization in China. In nowadays, the in situ urbanization becomes one of the main path of the new type of urbanization in China. Base on reading a large number of new urbanization related literature and do some on-the-spot investigation in the southeast of Chongqing. This paper takes the southeast of Chongqing as an example, do the SWOT analysis on the whole of the Chongqing southeast. At last, the author takes up some suggestions on its path of in situ urbanization: constructing the small cities and towns with national characteristics; developing tourism vigorously; lengthening the agricultural industrial chain and increasing the proportion of tertiary industry; breaking the county independent state and strengthening regional joint.

Keywords The southeast of Chongqing · The in situ urbanization · SWOT analysis

1.1 Introduction

Since the reform and opening in China, the urban population has increased by 500 million. According to the development of statistical bulletin that issued by the provinces, autonomous regions and municipalities directly under the central government in 2013, China's urbanization rate reached 53.7 %, already more than the world average urbanization rate. The eastern region urbanization level has reached 66.03 %, the central region reached 47.93 %, the North-East region reached 58.75 %, however the western region was only 44.30 %. The urbanization rate of Eastern developed regions is higher close to 12 % than the western underdeveloped regions. Prime Minister Li Keqiang stressed that human is the core of the new type

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of urbanization in the national annual 2013, the new type of urbanization must have employment support, service guarantee and can't stand pie. The large, medium and small urban should develop coordinated; the eastern, central and western regions should advance through suit measures to local conditions. Most importantly, the new urbanization and agricultural modernization must supplement each other to protect the interests of the farmers.[1] In December 2013, at the central working conference of urbanization, it putted forward the slogan of "hope to see the mountain, see the water and remember homesickness", to emphasize that the development of the new urbanization should base on the original village, aim to improve people's life, and realize the in situ urbanization finally.

New type of urbanization is determined as a major national strategy in the 18th CPC National Congress. The new type of urbanization has greatest potential for steady growth, expanding domestic demand, transferring mode and adjusting structure. The urban and rural areas as a whole, the urban-rural integration, production city interaction, economical and intensive, ecological livable and harmonious development is the basic characteristics of the new type of urbanization. The new type of urbanization requires the medium cities, the small cities and towns and the new rural communities to develop coordinated and promote mutually. Compared the traditional urbanization and the new urbanization, we can see that in the aspect of dynamic mechanism, the traditional industrialization is replaced by the service industry, and new industries; in the aspect of main relationship between urban and rural areas, the binary partition is replaced by integration; in the aspect of propulsion means, "from top to bottom" replaced by "from bottom to top"; the resources and environment, unsustainable development is replaced by sustainable development. In a nutshell, the new type of urbanization is the solution of the traditional urbanization, it attaches great importance to the economic society and the balance of urban and rural regions. At present the research on in situ urbanization is insufficient, it is worth studying to realize better and faster development of in situ urbanization. In this paper, the author takes the southeast of Chongqing as an example to discuss the path of in situ urbanization.

1.2 The Research Status

1.2.1 The Foreign Research

Foreign studies on in situ urbanization began with the studies of mixed geographical space between urban and rural areas, its main work focused on urban geographical concept and the related indicators research. They analyzed the phenomenon of urbanization and discussed the dynamic mechanism through empirical research. Many scholars dissolved the urbanization path of research into the

[1] http://news.xinhuanet.com/2013lh/2013-03/17/c_115053973.htm.

urbanization mode, dynamic mechanism and development policy research from their own research expertise.

The research on the in situ urbanization path had certain results through foreign scholars' efforts. Since the Leif Edvinsson putted forward that we should encourage to foster knowledge purposefully in 2003, Margaret Haines pointed out that knowledge city also should encourage the technology innovation, scientific research and increase creativity as the strategic in 2004. Then also in 2004 the "E100 table BBS" published the declaration of knowledge city, that marked the knowledge city was accepted by the world as a new kind of city development strategy (Haines 2004). The knowledge city as new path of urban development, that is a new standard of city civilization progress (Zhizhang 2007).

For studies of the impact mechanism of the in situ urbanization path selection, six characteristics of the in situ urbanization phenomenon are summed up by McGee through his long-term research on developing countries and regions, such as dense population, convenient transportation, non-agricultural increase, etc. He also proposes that the in situ urbanization arises from the interaction between urban and rural areas, rather than the single city in his further research about the extended metropolitan regions, which goes beyond the traditional duality theory of urban and rural areas. McGee analyses the factors which may influence this phenomenon from different aspects, such as location condition, the guiding role of urban area, population density and so on (McGee 1989). The influence of population density and traffic conditions on the path of the in situ urbanization are also stressed in the studies of Canadian scholar Qadeer. Other scholars in related studies have also pointed out that the impact mechanism of the path of the in situ urbanization include the increase of non-agricultural labor force in rural areas, dense population, increase of urban facilities and so on. Synthesizing the researches of the foreign scholars, we can find that studies of the dynamic mechanism of this urbanization phenomenon focus on urban population density, traffic condition, the social economic ties of urban and rural areas and so on. When the effect of these factors reaches a certain intensity, rural settlements will face a corresponding in situ transition, which is different from the traditional mode of urbanization that appears to rely on rural-urban migration (Qadeer 2000).

1.2.2 The Domestic Research

The concept in situ urbanization was proposed by Yu (2007) he made the research on the related phenomena in Quanzhou, Jinjiang. And it was defined as a process that rural population and settlements have achieved to change into town without massive space migration. Shengzu Gu (2000) also mentioned this concept from his own point of view and called it county countryside depending on its spatial scales.

Since the reform and opening, the urbanization in China mainly has focused on migration to big cities, which has brought much pressure for their development. By the definition of in situ urbanization we can see that in situ urbanization can reduce the pressure and solve the problem of rural surplus labor. The research on the path of achieving in situ urbanization is scattered and lacks theoretical framework in some districts in China. The research to Putian in 2008 by Min (2008) found that the population density and the degree of non-agriculture were high outside the built zone; the proportion of construction places increased and the infrastructure improved. The investigation to northwest by Rong Zhao said that the northwest develops by making use of its unique natural condition. The research to Fujian coastal areas points out the differences of the countryside-city ability between coastal and inland area.

Groups of small town with population of 50,000–200,000 exist in Yangtze River Delta, Zhujiang Delta and southern Fujian. The typical ‘Yangtze Mode’, ‘Sunan Mode’, ‘Wenzhou Mode’, ‘Jinjiang Mode’ can provide other districts with reference. Currently many scholars summarized the path of urbanization based on the more mature experience of the Yangtze River Delta, Pearl River Delta, southern Fujian and other areas as follows: Taking local or nearby agricultural products as raw materials, the formation of the processing industry as a leader, driven by agriculture and integrated development of tertiary industry in small towns; Relying on local produce and resources play technology, the establishment of industrial economic base, developing professional wholesale and commodity markets to form trade market small towns; The use of local minerals and other natural resource development and mineral processing industry extractive industries, forming mining small towns; Relying near medium-sized cities, receiving radiation of medium-sized cities, bear part of the city’s functions, forming suburbs satellite small town.

1.3 The Current Situation of the Studied Area

1.3.1 The General Situation in Chongqing

Chongqing is the largest and most populous one in China’s four municipalities directly under the central government, so there are many impressive differences between its urban and rural areas in the aspects of natural conditions, resource reserves, development status and potential. Since 2003, relying on trunk transportation lines, dots shaft development, network layout, the rapid progress of the new urbanization of Chongqing has gradually convert into a big, medium and small urban system under the pattern of “lap wings”. The third plenary meeting of the fourth CPC Chongqing Municipal Committee was held on September 13–14, 2013. During the meeting, the concept of the five functional areas of Chongqing was proposed on the basis of “lap wings” regional development strategy. These five functional areas can further divide functional regions scientifically, give a clear functional position of the counties, and can conduct coordinated development of urban and rural regions at a higher level. It is a comprehensive, fundamental, and strategic work, bringing Chongqing into 4.0 era (Fig. 1.1; Table 1.1).

Fig. 1.1 The distribution of the five functional areas in Chongqing

Chongqing Mayor Huang Qifan proposed four paths on September 24, 2013 to explain the strategy of urbanization in "Chongqing Mayor's International Economic Advisory Group Eighth Annual Conference", the first is the layout of the five functional areas to promote the development of "Chengdu-Chongqing economic Belt"; Second, Chongqing must attach great importance to the construction of infrastructure; The third path is the coordinated development of urbanization and industrialization; The last path is urban and rural areas development as a whole. These four paths are regarded as Chongqing new urbanization development strategy and policy.[2]

1.3.2 *SWOT Analysis of the Status in the Southeast of Chongqing*

Southeast Chongqing is one of the regions with good ecological environment, including "*one district and five counties*", respectively Qianjiang District, Shizhu

[2] http://cq.ifeng.com/cqnews/detail-1_2013_09/24/1254937_0.shtml.

Table 1.1 The general situation of the five functional areas in Chongqing

Five functional areas	Scale (km^2)	Orientation	Path
Urban function core area	294	To build a metropolitan center with agglomerate elements, strong radiation drive effect, and national impact	Improve the urban functions, optimize the industrial structure, enhance the image of the modern city, refine urban management, protect the ecological environment
Urban function expansion area	5179	Epitomizes economic radiation power and service influence of national center city	Expand urban space orderly, plan and layout in group mode, integrate and develop production and the city
New urban development area	23,200	The main field of future industrialization and urbanization, key areas gathering new industries and population	Adhere to the "four modernizations", develop urban and rural areas simultaneously first, construct the large industrial parks and modern pastoral urban cluster
Development area of ecological conservation in northeast of Chongqing	33,900	National key ecological function areas and the main agricultural areas. International Tourism Zone of the Yangtze River Three Gorges and processing base of characteristic resources	Put the construction of ecological civilization in a more prominent position Make efforts to conserve and protect the green mountains and clean water in Three Gorges area, improve the level of public service
Development area of ecological protection in southeastern of Chongqing	19,800	National key ecological function areas, ecological folk culture tourism zone, the minority area of the whole city	Highlight the primary task of ecological protection. Synchronize economic and social growth and environmental protection

county, XiuShan county, Youyang County, Wulong County and PengShui county, the area of this region is about 19,800 square kilometers.

1.3.2.1 Analysis of Strengths

The regional advantages: Southeast Chongqing is located in the basin edge mountain in southeast Sichuan Basin where Dalou Shan mountains meet Wuling mountains, it's near northern Guizhou, western Hunan, and western Hubei Province, and it is an important wing of Chongqing's "*lap wings*" development pattern. The transportation facilities there have been improved steadily. Now it takes three hours to go to Chongqing, and about four hours to Changsha. That means this area has become suburb of these two metropolitan circles.

The tourism resources advantages: According to the survey, there are a total of 1780 tourism resources monomers in Southeast of Chongqing, wherein the natural resources monomers mainly with "physiographic landscape" account for 56.9 %, and the human resources ones with "buildings and facilities" account for 43.1 %. There are many national geological parks and national nature reserves.

The resources advantages: This area has relatively abundant hydropower resources, varieties of mineral resources (45 types have been found), rich biological resources. This can create the preconditions for the cultivation of special industries.

The policy advantages: This area is supported by many policies, such as western development policy, ethnic policy and specific policies given by the city. The goal of these policies is to create southeast Chongqing as a "Economic highland in Wuling mountainous area, Folk eco-tourism zone, poverty alleviation and development demonstration zone".

1.3.2.2 Analysis of Weakness

The natural environment disadvantages: carrying capacity of the land and the environment is limited. There are many mountains, less flat and the land conditions are poor, ecological environment is fragile. What's more, there have frequent natural disasters, the soil erosion is serious. So that, the economic and social development are great constrained.

The infrastructure disadvantages: Poor transportation, low road grade, poor quality road, irrational network structure, electric power construction lag, water conservancy project construction lag and severe water shortages in some areas are serious.

Talent disadvantage: The labor quality is low, the talent is short, the science-education-culture-health career development is slow and the social security is not perfect. Primary school education accounted for more than 40 % of the total rural labor force, but high school and higher education accounted for only about 5 %.

The low urbanization rate: Southeast Areas of Chongqing is low level of urbanization in the five functional areas. Its urbanization rate is the lowest, only about 25 %. The level of urbanization is far behind the level of industrialization. This imbalance is largely restricted the development of the process of urbanization.

1.3.2.3 Analysis of Opportunity

Economic development opportunities: Today, the geographic conditions in southeast of Chongqing become increasingly improved and it becomes the gateway to Southeast coast. The "one hour economic circle" makes the contact more convenient. So that it has the potential to further expand the market conditions and the development of large circulation.

Policy opportunities: "314" overall deployment, southeast of Chongqing should focus on these two tasks: poverty alleviation and development, national unity and progress. Southeast of Chongqing should adjust measures to local conditions and common struggle to promote continuous poverty alleviation and promote the prosperity and development in national regions. Southeast of Chongqing should take all of those measures to speed up the pace of getting rid of poverty to get rich in Chongqing southeast areas.

1.3.2.4 Analysis of Threat

Competitive threat: Zhangjiajie is close to Chongqing southeast, and its south is Phoenix town. So it has the threat of marginalization.

1.4 Suggestion on Sustainable Development of the In Situ Urbanization in the Southeast of Chongqing

By the above SWOT analysis of the southeast of Chongqing, it should make full use of external opportunities, and combine with its own internal advantages to develop in situ urbanization. In this paper, the author put foreword the following path for the in situ urbanization in southeast of Chongqing.

1.4.1 In Situ Construct the Small Cities and Towns with National Characteristics

The Chongqing southeast can build small towns with national characteristics base on their own multi-ethnic advantages to achieve in situ urbanization. The six counties of Chongqing southeast have their own natural geographical environment, and their industry development is very different, too. Each regional forms a regional economic pillar industries with local characteristics and according to their strengths to advance the development of in situ urbanization. For example, Qianjiang District features flue-cured tobacco industry. XiuShan County is given priority to manganese ore processing. PengShui county focus on the development of hydropower industry. Medicinal industry is Shizhu county's pillar industry.

1.4.2 Developing Tourism Vigorously

The six counties of Chongqing Southeastern have rich tourism resources. Qianjiang District can rely on rural pastoral scenery and the ancient town to develop the rural agricultural tourism. For example, establishing the comprehensive development of agriculture demonstration garden and "rural tourism"; The development models of Xiushan, Youyang, Pengshui those three counties are close. On the one hand, we can establish agricultural sightseeing garden, orchard base form, and farmers can carry out "rural tourism". On the other hand, we can rely on the natural beauty of Minority community and human resources to develop rural cultural tourism. The Huangshui Town of Shizhu county relied on the rich forest resources and folk culture to create Shizhu's Hunagshui national forest park and develop the forest ecological tourism. Wulong County, relying on Dragon Gorge water seam, Sanqiao natural bridges, Fairy Mountain National Forest Park, Hibiscus and other tourist attractions to develop the forest ecological tourism, folk Village development, rural tourism, etc.

1.4.3 Lengthen the Agricultural Industrial Chain and Increase the Proportion of Tertiary Industry

Chongqing Southeastern relies on ecological landscape and folk culture of ethnic minorities to develop its tourism. The tourism combine the food, housing, transportation, travel, shopping, entertainment and other related industries and agriculture, forestry, animal husbandry, fisheries together; form the first, second and third industry association, and achieve the common development of agricultural processing, commerce, services and other tertiary industries. Through that way to promote the in situ urbanization. The tourism increases the value of agricultural products, establish their own brand, lengthen the agricultural industry chain, and promote agricultural industrialization. Consequently result to raise the proportion of tertiary industry.

1.4.4 Breaking the County Independent State, Strengthen Regional Joint

The development of the six counties of Chongqing Southeastern has been always in a relatively independent status. Even the phenomenon of competition awareness exceeding the cooperation was appeared in advancing the process of urbanization, that hampered the development of local economy seriously. The six country of Chongqing Southeastern should develop together to strengthen the competitiveness of the tourism brand, establish benign competition and cooperation. At the same time, we should plan the travel routes with target, achieve large-scale production, ensure maximum of market value to accelerate the in situ urbanization process.

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Chapter 2
Urban Management Mode and the Choice Under the Trend of New Urbanization

Ling Zhou and Yuzhe Wu

Abstract Urbanization has brought high population density and urban expansion, as well as put forward higher requirements for urban social management and economic development. Firstly, representative urban management modes in domestic and overseas will be reviewed. Secondly, as it is pointed out that the theory and practice research of urban management modes require further study according to the goals of new urbanization. It's important to clarify the roles of the government, market, community and culture and take different combinations of social orders in terms of different types of cities. Finally, research on new urban management mode under the trend of the new urbanization should be carried on from the perspective of ideology-order-governance.

Keywords Urban management mode · New urbanization · Urban resource marketization mode · Humanistic mode of urban management · Urban grid management mode

2.1 Introduction

Before 1978, China's urbanization progress was very slow [Fig. 2.1 Urbanization rate of China (1949–2013)] and was in the low period (Yao 1998) due to the lack of experience on economic development and urban construction. However, since 2000, China has entered in the first half of S-curve of Urbanization process (King and Golledge 1978) and the urbanization rate has exceeded to 50 % in 2011. Moreover, according to the forecast of United Nations, there will be 13–15 million people moving into towns and cities during the next twenty decades (United

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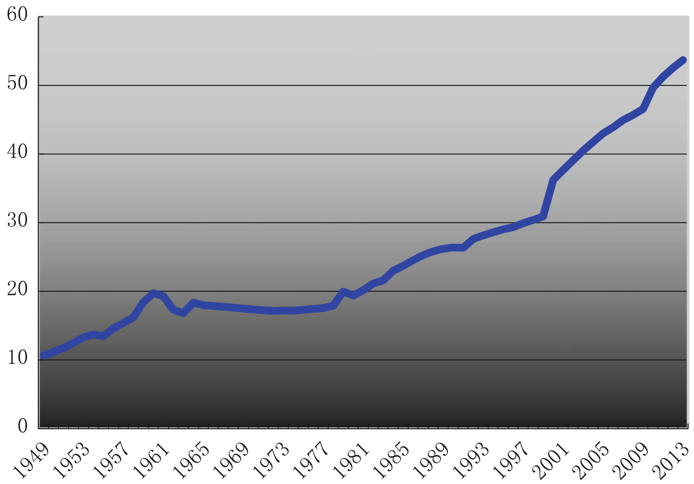

Fig. 2.1 Urbanization rate of China (1949–2013)

Nations 2010). Urbanization are proceeding rapidly. In this context, cities are improving in quantity and quality. The development circumstances are changing dramatically and the complexity of cities is rising substantially. Therefore, the traditional urban management mode is no longer suitable for cities in China while there is a gap of research on the concept, operation mechanism and method of modern urban management. Under the trend of new urbanization, research on urban management is extremely urgent.

Research on urban management mode is necessary. City, defined as the political, economic and cultural centre of a certain area, plays a vital role in national and regional economic and social development. Furthermore, higher requirements for urban construction, environment and service industry are put forward because of the increase in population in the process of urbanization. In addition, the regional competition of economy noticeably evolves into the competition between cities, especially in the context of economic globalization. Improving competitiveness is the main task of the cities in China now. Urban management is the foundation of function optimization. Only when cities' function are optimized and given full play, can urban inner quality and comprehensive competitiveness be enhanced.

In this paper, urban management modes internal and external will be reviewed firstly. Then it is pointed out that the existing modes are not always applicable under the trend of new urbanization. Although some studies about new management mode have been conducted on, they are not systematic. To make a further study on management mode, it is significant to clarify the roles of the government, market, community and culture and take different combinations of social orders in terms of various types of cities. At last, it is proposed that research on new urban management mode should be carried on from the perspective of ideology-order-governance.

2.2 Urban Management Mode

2.2.1 Overseas Research on Urban Management Mode

Cities are always in the process of enriching the connotation and extension. The management modes of cities have obvious differences because they have different development goals and in different development phases. Williams and Adrian (1963) carried out a comparative study about different cities and classified them into four types, which have their own management characteristics. The first one focused more on economic growth, which was driven by expectation of speculation and growth in population and wealth. The second one was defined by extension of amenities, which paid more attention to home environment instead of working conditions and the main objective of governments was guaranteeing the living of residents. The third one was oriented by conservative caretaker governments, which laid emphasis on traditional services. Local governments provided only basic services and the residents preferred to a low tax rates and limiting the government's use of private property. The last one was neutral arbitration among discrete interests and aimed at the balance of the various aspects in the urban management.

Researches on urban management modes abroad usually focus more on the balance of powers. Rivlin (1971) classified urban management modes into decentralization, community control and market mode. Decentralization is a very prevalent mode in the USA while community control mode is more common in the centralised states. Market mode could be considered as the extreme form of decentralization. Since the late 1970s, a governmental reform movement named new public management has arisen in the western developed countries, which influenced the urban management directly. Ferlie (1996) not only proposed the mode of downsizing and decentralization from the perspective of a balance of powers, but also presented efficiency driving, in search of excellence and public service orientation in view of utility. From the late 1980s onward, massive changes have taken place in cities' politics, economy and society, which impacted greatly on the original systems of cities. Urban governance emerged as the times required. According to Peters (1996), urban management modes are divided into market government model, participation government model, flexible government model and deregulating government model by governance structure. Pierre (1999) assorted governance modes into managerial model, corporatist model, progrowth model and welfare model based on the characteristics of governments.

In the 21st century, urban management modes abroad are diversified. But basically continue the trends of decentralization (Pierre 2011), community participation (Abbott 2013) and public administration marketization (Walker et al. 2011), etc.

2.2.2 Domestic Research on Urban Management Mode

There are a lot of researches on urban management mode in China, but they are not very systematic. Urban resource marketization mode is generally considered as the main mode in China since the 1990s (Qiu 2004). Since the new millennium, social crisis had occurred frequently in our country. Academic circles and the government began to explore a new mode of city management and advocated a transformation from economy-oriented mode to society-oriented mode (Cai and Li 2005). Then in 2006, with the popularization of digital technology, urban grid management mode arose at the historic moment (Chen 2006). Therefore, urban resource marketization mode, humanistic mode of urban management and urban grid management mode are representative modes of urban management in China.

2.2.2.1 Urban Resource Marketization Mode

Some researchers named this mode urban management. However, according to Zhou and Hong (2003), this mode is related to the principles of urban resource utilization. Therefore, term of urban resource marketization is more appropriate, which emphasizes more on urban resource allocation.

Since the 1994 tax-sharing reform, local governments suffered a decline in fiscal revenue, while affairs were more onerous because of urbanization. Hence, urban resource marketization mode became the main management of many cities in China (Zhao 2002). This mode contributed a lot to the breakthrough of fund bottleneck, urban construction and improved the competitiveness sequentially. Besides, the establishment of a land market system and the tax-sharing reform laid the foundation of urban resource marketization mode and urban competition provided the impetus. Thus, the practice of this mode carried out prior to theory study in China (Ye 2004).

Zhang and Zhu (2002) thought that urban resource marketization managed the city by managing public goods and resources and was closely linked to urban planning, urban governance and urban competitiveness, which formed the whole urban management. Hong and Zhou (2003) and Qiu (2004) expressed a similar opinion. They believed that urban resource marketization mode could not only maintain or increase the value of urban resource through business mode, but also give full play to the government's function of providing social service, such as the public goods.

However, currently, urban managers are likely to regard resource marketization as land finance and rely too much on land transfer fee, related revenue and mortgaging land for urban construction financing (Liu and Jiang 2006; Zhou 2010).

2.2.2.2 Humanistic Mode of Urban Management

The mass migration brought by urbanization resulted in greater difficulties in population management, public security management and community management. Wang (1997), the director of National Academy for Mayors of China, proposed that people was the main body of cities, so the management and construction of cities should always be human oriented. Humanistic mode of urban management matches this opinion.

In his book, *From Functional City to Cultural City*, Shan (2007) points out that, to be livable is cities' most important goal. As a result, only when the center of development has been changed from matter to human, can we build a harmonious city. Sun (2009) thought that human oriented management should always focus on meeting people's needs, improving the quality of life and realizing people's over-all development. With the organization of communities, ensure people's right of existence and development and create a stable society.

Another perspective of humanistic is public participation in urban management. You and Chen (2004) put forward an urban management mode oriented by satisfaction of the public, whose essence was humanistic management as well. In fact, a management mode with public participation makes the government face people that have diverse demands. Therefore, managers have to change their management idea and transfer their mode to urban governance (Zhao and Liu 2010).

2.2.2.3 Urban Grid Management Mode

With the reform of urban management system, the growing city scale and rapid development of information technology, demands have been made on innovation of urban management. Urban management mode supported by technology becomes the trend of urban management (Qiu 2006).

Gridding urban management model (Chen 2006) is one of the most representative works about gridding management mode in domestic. The characteristics of this mode is combining technology with management. This mode is characterized by ten thousand meter unit grid, components management, events management and two axis mechanism. To be specific, divide the city into seamless polygons, which are monitored by supervisors. Two institutions, Supervision Center of Urban Management and Committee of Urban Management, are set up and work together with the coordination of information system.

Though this mode has been in favor of by the government, it still has some defects and limitations. Tian (2012) argued that this mode had the problems of high cost and was often introduced as supporting mechanism of big events, which meant it was not a daily activity. Moreover, gridding management is likely to weaken the capacity of self-government of communities.

2.3 The Choice Under the Trend of New Urbanization

With the development of urbanization, urban system will be more complex. As indicated above, urban management modes in our country, such as urban resource marketization mode, humanistic mode of urban management and urban grid management mode may not be suitable any more. Therefore, the urban management mode under the trend of new urbanization needs further study and practice.

2.3.1 Research on New Urbanization

Urbanization in China is not only different from those in Europe or America, but also different from those in Latin America and other developing countries (Qiu 2010). In terms of time, British's urbanization took 200 years under the background of the first industrial revolution and American took 100 years under the background of the second industrial revolution. Latin America spent 50 years due to the concentration of jobs. As for China, if we take 30 % as a start, only 15 years was spent to exceed 50 %. Lu et al. (2007), a member of the Chinese Academy of Sciences, thought that China's urbanization process is too rash and out of control in terms of space. *National New urbanization Planning 2014–2020* points out that lots of problems occurred in such a highly compressed process, mainly reflected in (following areas): a large number of peasant workers having difficulty in merging into cities; land urbanization developing faster than the population urbanization; unreasonable distribution and scale of cities; low level of urban management services; increasingly serious urban disease; inadequate protection of historical and cultural heritages. New urbanization is introduced to solve these problems.

Ideas such as interaction of household registration and land, urban-rural integrated development, compact city development, ecological civilization have integrated into new urbanization. Referring to the problems of citizenization of migrant workers, Cai (2013) proposed that household registration reform was badly needed in urbanization. Firstly, absorb peasant workers as census registered people. Secondly, provide basic public services for peasant workers who are not qualified as citizens. Thirdly, build a social security system that covers both urban and rural areas. Duan (2011) pointed out that China's urbanization must make sure the adaption to the resources and ecology. It's important to pay attention to the coordination of urban-rural areas and urban system, so as to realize the benign interaction of urbanization pattern and macro pattern. Wu (2013) introduced agglomeration index from the 2009 world development report and indicated that the construction of small towns should be focused on the agglomeration effects and city groups needed further development for their radiant effects. Gu (2011) emphasized the importance of science and technology and thought that spatial restructure and global-local links caused by communication technology had great impacts on urban management model. In new urbanization, post-Fordist city, edge city, network city, tourism, leisure and cultural city, creative city, eco-city, low-carbon city, tech-city, smart city and so on, are worthy of attention.

However, the existing researches generally focus on one aspect of urban management and there is no systematic research on urban management in the process of new urbanization. Therefore, further studies should be conducted on urban management mode.

2.3.2 Urban Management Mode Under the Trend of New Urbanization

By what means will peasant workers move into cities in the future? How should urban system be in terms of space? What criteria should cities possess? To solve these problems, *National New urbanization Planning 2014–2020* set the goals of citizenization of transferred agricultural population, optimization of urban form and layout and the improvement of urban sustainability. In brief, new urbanization should be characterized by humanism, dynamic and ecological features (Li 2012; Qiu 2012). In this context, urban management mode in the future should be adapted to the new characteristics and objectives of new urbanization.

Davey (1993) argued that the core of urban management in the process of urbanization is the matching of the growing population and urban development, such as infrastructure, housing and employment. There are lots of urban management modes in overseas for China to use for reference. However, because of the differences of natural resources and environment, social and economic development, and political system and so on, if we copy their modes totally, it may well cause chaos in urban management. In his book, *The Great Disruption*, Fukuyama classified the social orders into two dimensions, including reason and irrationality, spontaneous order and hierarchy. These four factors could be combined into four orders. Reason and spontaneous order could be combined to form the market. Reason and hierarchical authority could be combined to form the government. Irrationality and hierarchy could be combined to form the community. Irrationality and spontaneous order could be combined to form the culture (Fukuyama 1999). Urban management in China has a long history. During the early period after the foundation of China, the government was the dominator of urban management. Then after the reform and opening up, especially after 1990, the market gradually became a counterbalance to the government. Because of many factors, such as the government controls, communities had little influence on urban management. But with the emergence of new media, the power of communities was higher because of virtual community. However, when it comes to culture in China, things are different. Traditional culture is based on agricultural civilization and western culture couldn't adapt to china's national conditions, which means culture is not incompatible with urban management.

According to the goals of new urbanization and Fukuyama's analysis of social orders, new urbanization should be characterized by humanism, dynamic and ecological features. The urban management emphases of cities should be investigated from the dimensions of reason-irrationality and spontaneous order-hierarchy. Then roles of the market, government, community and culture in different types of urban management modes should be explored. According to the emphases and roles, seek a suitable urban management mode for a city with certain priority of four orders.

Specifically, in terms of urban management ideology, cities should be guided by the goal of new urbanization planning, so as to realize social fairness, full employment, and sustainable development. In terms of urban management orders, social orders should be combined with urban management system and carry out the reform of land, household registration system and fiscal system, including derived aspects, such as housing, education, health care and other social security system. In terms of urban governance, governments, markets, communities and culture should work together. Thus, it is necessary to manage cities with appropriate social orders combination. New urban management mode under the trend of the new urbanization should be carried out from the perspective of ideology-order-governance.

2.4 Conclusion

This paper reviews kinds of urban management modes in different countries and different periods. Then the development of urban management in China is discussed. Because of the differences of development, nature conditions, resources, history and culture, cities with different development goals in different periods have different emphasis on urban management. So there is no universal mode for urban management. Cities should suit their management modes to local conditions and get the balance of the government, market, community and culture.

Therefore, there is no specific mode being proposed. Urban management modes are always different for different cities. The roles of the government, market, community and culture in various cities are different subsequently. Despite of that, urban management of various cities still have some similarities. Under the trend of new urbanization, urbanization management has the same management concepts, including humanism, dynamic and ecological features, which are the development directions of urban management. The goals of new urbanization could be achieved with the cooperation of the government, market, community and culture.

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Chapter 3
Impact on the Scale Efficiency of Urban Land Caused by Floating Population: Based on DEA Framework

Jiaojiao Luo and Yuzhe Wu

Abstract Due to the rapid urbanization, a large number of floating populations, who will prompt city land-use spatial scales to grow broader, rush into cities. This article is based on production factors and designs two data envelopment analysis models for evaluating urban land efficiency with population index and choose 69 counties of Zhejiang Province as decision making units to do some researches on scale efficiency in different cities. The result shows that the urban land scale efficiency level in Zhejiang Province is general high when referred to the whole situation, but regional difference is very clear. County which wants to adjust its floating population ratio to an optimal level must consider local practical situation. That is to say, local floating population offset does not have an obvious linear relationship with per capita GDP. So the government's policy should be oriented to local conditions in making "land-population" linkage policy so as to balance city population and urban land expansion.

Keywords Urban land use scale efficiency · Migration population · Data envelopment analysis · Zhejiang Province

3.1 Foreword

Cities in China have achieved rapid development such as high urbanization rates and good economic indexes since they seized the opportunity from reform and opening up. However, high speed development also causes some problems. For example, China's urban population in 2000 is 460 million and in 2012 the number increases to 710 million, which means annual growth rate of urban population is

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3.7 % during 2000–2012. In the next place, urban construction area in China in 2000 is 22,114 km^2 and then the number change into 45,751 km^2. If we take a numeration based on this two data, we can easily figure out annual growth rate of urban construction area is 6.25 % far outclass annual urban population growth rate. In the rapid urbanization progress, lots of population come to the city absolutely will produce a shock to the urban land as is the medium of urban function. Specifically, city occupies the periphery agricultural land, forest land or other non-construction land for the sake of meeting floating population's production and living needs. Whereas, taking fundamental realities of the country about land shortage, should city go on expanse land scale? Does city do well in urban land efficiency? Will it possible to achieve intensive use in urban land resources?

The paper tries to adopt DEA (development envelopment analysis) to answer above questions. Of course, researches on land efficiency by utilizing DEA are a lot in academia which can be divided into four types according to research scope: national, inter-regional, provincial and municipal (Liang et al. 2008; Liao and Dong 2011; Wang and Yan 2005). For instance, Mangmang and Minjuan (2011) choose 11 cities in Shanxi Province to be samples and establish a single input factor for building urban land productivity measure model. He finds out the key of easing land contradiction between supply and demand is carrying out land resource optimal configuration system. Da et al. (2007) first announces land, capital and labor as input indexes, GDP and fiscal revenue as output indexes in DEA, then runs the Matlab software to calculate city DEA relative efficiency values for cluster analysis. Finally, conclusion comes out that land use efficiency is not necessarily correlated with the level of city.

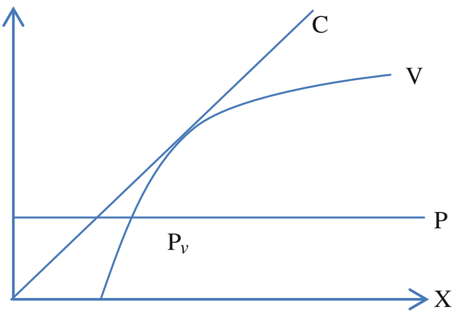
3.2 Introduction of DEA Method

Data envelopment analysis is a non-parametric statistical method proposed in 1978 by the renowned operational research experts Charnes et al. (1978) based on relative efficiency and applied to judge whether a multi-input, multi-output unit is technology, scale effectively. The earliest prototypes can be traced back to 1957, Farrell (1957) proposed envelopment ideas while analyzed the UK agricultural productivity.

DEA has strong advantage because it takes weight of inputs and outputs from all decision units as variants and becomes relative effectiveness evaluate method. Meanwhile, DEA admits intrinsic relationship between input and output, but does not need to list each expression to explain specific relation. There derives quite a number of sub-class model since DEA came out. This research will choose variable return to scale model (VRS) evolved from constant returns to scale model (CRS). With the premise of variable return to scale, VRS evaluate subjects' efficiency through linear combination equation.

Suppose there are n decision-making units (DMU), each DMU has k inputs, m outputs, the maximum efficiency is 1. Find out the corresponding u, v which can

Fig. 3.1 VRS analytical



maximize the value uy_i/vx_i. For convenience of calculation, we take in S representing difference value between actual value and optimal value and λ representing a sort of weight combination among u,v. Given scale variability, add additional constraints $\sum_{i=1}^{n} \lambda_i = 1$ to VRS linear equations. Then VRS model can describe as the following:

$$\begin{cases} \quad \min\theta = V_D \\ \text{s.t.} \quad \sum_{i=1}^{n} \lambda_i X_i + S^- = \theta X_{i_o} \\ \quad \sum_{i=1}^{n} \lambda_i Y_i + S^+ = Y_{i_o} \\ \quad \sum_{i=1}^{n} \lambda_i = 1 \\ \quad \lambda_i \geq 0, i = 1, 2, \ldots, n \\ \quad S^+ \geq 0, S^- \geq 0 \end{cases}$$

X_{i_o}, Y_{i_o} stand for DMU i_0's input and output vector respectively. In the context variable scale, VRS attempts to find some kind of input-output combinations from DMU n so that they can cut down factor input but don't reduce output. This research refers to indicators such as scale efficiency and technical efficiency whose relationship is shown in Fig. 3.1.

OC stands for production frontier when scale returns are constant. On the contrary, BV represents the production frontier of variable returns of scale. P is production factor actual input, P_C is the intersection of OC and AP, P_V is the intersection of BV and AP. Assuming DMU j is analyze subject, if take no account of scale returns, DMU j technical efficiency equals $TE = AP_C/AP$. As a matter of fact, scale returns are variable, thus efficiency value $SE = AP_C/AP_V$ can be influenced by the distance between P_C and P_V. Since PP_V is jumble caused by pure technical efficiency defining as $PE = AP_V/AP$, we can conclude an equation $TE = PE \times SE$ among TE, SE, PE. This equation adds up to technical efficiency is equivalent to the product of pure technical efficiency and scale efficiency.

3.3 Applied Research

3.3.1 Study Area Overview

Zhejiang Province is one of the economic active provinces in China where GDP in 2010 has reached to 2.27 trillion with 11.9 % growth rate. According to related statistics, urban construction land in 2006 is 2163.93 km^2, per construction land fixed assets investment is 0.351 billion/km^2 and output value 0.685 billion/km^2. In 2010, construction land area in Zhejiang Province rise to 2801.37 km^2, per construction land fixed assets investment is 0.438 and output is 0.916 billion/km^2. Those entire data illustrate Zhejiang urban land-use expansion is in high speed as well as it still exists room for urban land-use efficiency improvement.

3.3.2 Index Selection

Western modern economics believe production factors are generally composed of four elements, namely labor, land, capital and entrepreneurs. Given the fact that paper considers region efficiency, so we abandon entrepreneurs production factor and transform labor, land and capital factors into measurable data (see Table 3.1) for conducting two analyze models named reference model and comparison model respectively whose vital difference are population index for the sake of discovering the impact of floating population on urban land-use scale efficiency. Specific indexes are as follows:

1. Labor. Reference system choose permanent population (PP) to measure labor factor with the acquiesce PP are local total labor input when refers to production. Comparison system separates PP index to floating population (FP) and permanent population-floating population (PP-FP) so as to explore floating population impact on urban land-use efficiency. Specific data come from the "Sixth Nationwide Population Census" in Zhejiang Province and relevant counties.
2. Land. Urban construction land area that indicates land input including industrial land, commercial land, residential land and so on about social activities conducted in city is chosen to describe land factor both in reference system and

Table 3.1 Input and output indicators in urban land-use efficiency evaluation

Model	Input indicator	Output indicator
Reference system	PP (permanent population), urban construction land area, social fixed assets investment	The second and tertiary industries value
Comparison system	FP (floating population), PP-FP (permanent population-floating population), urban construction land area, social fixed assets investment	The second and tertiary industries value

comparison system. Taking consistency of input indexes into account, data of urban construction land area are from the 2011s "Zhejiang Urban Construction Statistical Yearbook".

3. Capital. Social fixed assets investment whose specific data is from "2011 Zhejiang Statistical Yearbook" is selected to picture capital input factor both in reference system and comparison system for it has direct influence on the local economic value.
4. Output. Reference system and comparison system both determine the second and tertiary industries value which directly reflects construction output and land-use level throng presenting all production outcomes upon construction land on the form of currency as production output index. The data needed are from "2011 Zhejiang Statistical Yearbook".

3.3.3 Scale Efficiency Measurement and Analysis

1. Scale efficiency measurement and analysis in reference system

If a DMU's scale efficiency reaches 1, we call this DMU achieves efficient scale and its scale configuration stay at the best situation from the point of production scale. According to the DEAP operation results, in reference system, average values of scale efficiencies in Hangzhou, Jiaxing, Shaoxing, Huzhou, Taizhou are all above 0.9, followed by Ningbo, Wenzhou, Jinhua and Quzhou where the average value are over 0.8. Nevertheless, such value in Lishui district is low with the value of 0.6. In reference system, the average value of urban scale efficiency in Zhejiang Province is 0.878 with 49 counties greater than and 20 counties less than. There are 10 DMUs in Zhejiang meet optimum scale. That is to say already 10 DMUs' scale efficiency values are 1 covering Hangzhou Downtown, Ningbo Downtown, Cixi City and et al. Cities where value surpass 0.9 are Yuyao City, Huzhou Downtown, Linan City and so on 46 DMUs. Cities scale efficiency values over 0.5 include 20 districts such as Wenzhou Downtown, Chunan Downtown, Dongtou Downtown as well as 3 districts under 0.5 like Yunhe County, Qingyuan County and Jingning County (Fig. 3.2).

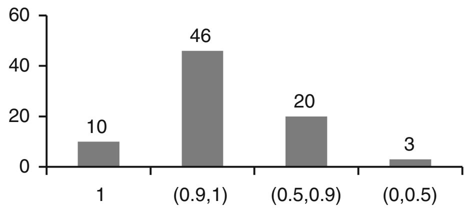


Fig. 3.2 DMU scale efficiency distribution in reference system

Table 3.2 Statistics of DMU scale efficiency in reference system

Returns to scale	Constant returns to scale	Increasing returns to scale	Decreasing returns to scale
Number of counties	10	52	7

In addition to some in constant returns to scale DMU accompanying with efficiency value 1, reference system also indicates 52 counties including Quzhou Downtown, Zhoushan Downtown, Lishui Downtown, Shaoxing Downtown, Tonglu County exist a phenomenon increasing returns to scale and 7 counties including Wenzhou downtown, Ruian City, Haiyan City, Zhuji City appear a trend decreasing returns to scale (Table 3.2).

2. Scale efficiency measurement and analysis in comparison system

In the light of comparison system model computational results, Zhejiang average scale efficiency increases slightly and the exact value is 0.931. Hangzhou, Ningbo, Jiaxing hold the value over 0.95; Jinhua and Wenzhou hold the value over 0.9; Lishui only get 0.74 value. Similar to reference system, number of counties with efficiency value above average is much more than the amount of cities with sub-average value. There are 16 DMUs where scale efficiency values are 1 like Hangzhou Downtown, Ningbo downtown, Wenzhou downtown and et al.; 33 DMUs where scale efficiency values are over 0.95; other 13 DMUs where scale efficiency values are under 0.9 covering two DMU-Qingyuan county and Shening County where the scale efficiency values are less than 0.5 (see Fig. 3.3).

In addition to some in constant returns to scale DMU accompanying with efficiency value 1, comparison system also indicates 38 counties including Jiaxing Downtown, Shaoxing Downtown, Zhoushan Downtown exist a phenomenon increasing returns to scale and 15 counties including Ruian City, Huzhou Downtown, Jinhua Downtown appear a trend decreasing returns to scale (Table 3.3).

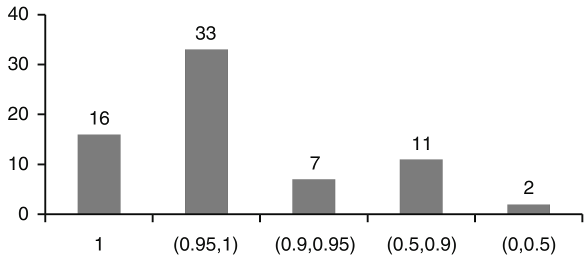


Fig. 3.3 DMU scale efficiency distribution in comparison system

Table 3.3 Statistics of DMU scale efficiency in comparison system

Returns to scale	Constant returns to scale	Increasing returns to scale	Decreasing returns to scale
Number of counties	16	38	15

3. Impact on urban land-use scale efficiency caused by floating population

Floating Population certainly will flow to economically developed city to pursuit higher quality life incurred by economic gap among regions. Thus, for developed city, people influx could well lead to even greater frustration for city needs to expand commercial land, residential land and infrastructure construction land by occupying certain urban land surface space. The more people flow into city, the bigger urban land scale will be. It may be possible that the circulation “population influx → land expansion → urbanization → population influx” always exists there. However, the fact is out of question.

The paper hopes to find the definite relationship between floating population and urban land-use efficiency through comparing data among reference system and comparison system. Define x as FP/(PP-FP), namely on behalf of floating population ratio. Define y as difference value of urban land-use efficiency in reference system and comparison system, namely comparison system scale efficiency value-reference system scale efficiency value (CSSEV-RSSEV). It is apparent that figuring up x is simple via basic data. Whereas, due to variable returns of scale, how to calculate index y can be divided into three situations: (1) One city’s scale efficiencies both belong to same trend in returns to scale in reference system and comparison system. Take Tonglu County for example, Tonglu County gets 0.943 irs scale efficiency in reference system and 0.968 irs scale efficiency in comparison system. Thus y is equals to $0.968 - 0.943$. (2) One city’s scale efficiency is 1 either in reference system or comparison system. For instance, Jiande City gets 0.936 irs scale efficiency in reference system and 1 scale efficiency in comparison system. Thus y is equal to $1 - 0.936$. (3) One city’s scale efficiency trends are adverse in two systems. Take only one instance, Ninghai County gets 0.967 irs scale efficiency in reference system and 0.992 drs in comparison efficiency, in that way, $y = 2 - 0.967 - 0.992$.

Draw a scatter diagram of x and y (see Fig. 3.4). Observing diagram we can find that linear relationship is not very strong between x and y and the trend line are more likely inverse function line. Whereupon replace x and draw another scatter diagram of –ln x and y (see Fig. 3.4). Apparently, figure demonstrates positive correlation. Eventually, paper makes use of SPSS software to do regression analysis and obtains a new regression equation—$y = -0.105 \ln x - 0.047$. Although in this regression operation, R^2 value is 0.626 not high enough, regression effect is significant and can confirm the existence relationship between floating population and urban land-use scale efficiency.

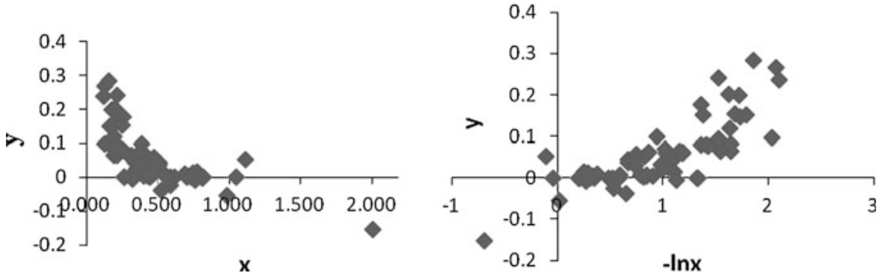
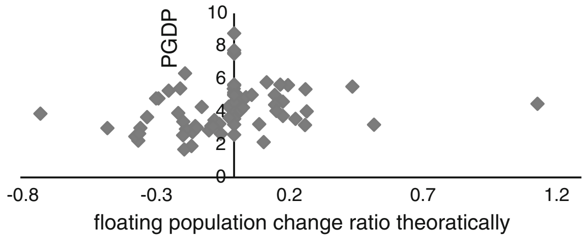


Fig. 3.4 Scatter diagram

Fig. 3.5 Scatter diagram



Now, paper puts up an assumption that all DMU scale efficiency values in comparison system are 1 and then calculate values equaling to scale efficiency in comparison system minus one in reference system for the sake of gaining a sort of new difference value to be drawn with 2010 per GDP of all counties in Zhejiang Province at a scatter diagram (see Fig. 3.5). In order to be more detailed, changing scatter diagram to table is important (Table 3.4).

Table 3.4 reveals following regular phenomena:

1. To achieve urban land-use optimum efficiency, rules that should be obeyed vary from counties to counties in Zhejiang Province. For instance, some counties located in Hangzhou may need to cut down floating population ratio, others in there may be unnecessary.
2. Counties where PGDP is less than 30,000 yuan at research point all call for reducing floating population ratio due to the backward economy and lack of the ability to digest intra-regional floating population labor.
3. Counties where PGDP is between 30,000–40,000 yuan at research point should take different adjustment policy. First of all, counties such as Chunan, Dongtou haven't fully absorbed local labor and it is unwise for them to continue rising floating population ratio. In the next place, Wenzhou city reaches best floating population ratio together with Tonglu County and Fuyang Ciy are prepare to welcome more floating population.
4. Counties where PGDP is between 40,000–60,000 yuan at research point should take different adjustment policy. On the one hand, Taizhou Downtown and

Table 3.4 Summary sheet of floating population change ratio theoretically and local PGDP

PGDP (10,000 yuan)	Reduce floating population rate	Increase floating population rate	Maintain floating population rate
<3	Yongjia County, Pingyang County, Cangnan County, Wencheng County, Taishun County, Panan County, Kaihua County, Xianju County, Songyang County, Qingyuan County, Jingning County, Longquan City		
3–4	Chunan County, Dongtou County, Wuyi County, Pujiang County, Changshan County, Longyou County, Jiangshan City, Tiantai County, Lishui Downtown, Qingtian County, Jinyun County, Suichang County, Yunhe County	Ruian City, Jinhua Downtown, Dongyang City, Sanmen County, Linhai City	Wenzhou City, Yueqing City, Lanxi City
4–6	Xiangshan County, Ninghai County, Jiaxing Downtown, Jiashang County, Shaoxing Downtown, Yongkang City, Zhoushan Downtown	Tonglu County, Fuyang City, Yuyao City, Haiyan County, Haining City, Tongxiang City, Huzhou Downtown, Deqing County, Changixng County, Anji County, Zhuji City, Shengzhou City, Yiwu Citi, Quzhou Downtown, Taizhou Downtown, Wenling City	Jiande City, Linan City, Cixi City, Fenghua City, Pinghu City, Xinchang County, Shangyu City, Yuhuan County
>6	Daishan Couty		Hanghzou Downtown, Ningbo Downtown, Shaoxing County, Shengsi County

Yiwu City are able to increase floating population rates at the aim of quick economic development. On the other hand, Jiande City, Linan City and all that are supposed to maintain floating rates contrary to Shaoxing Downtown, Zhoushan Downtown and et al. need to cut down floating proportion.

5. Counties where PGDP is over 60,000 yuan at research point can be divided into two types. One ought to maintain present floating population ratio such as

Hangzhou Downtown, Ningbo Downtown and the like. Another type only refers to Daishan County where floating population rate is too high to optimize land-use efficiency.

3.4 Conclusions

3.4.1 Main Analysis Conclusions

Urban land-use efficiency is a vital indicator in describing land-use rational and efficient use. Given the contradiction between rapid economic development needs and land scarcity restriction in expanding urban construction land randomly, improving urban land-use efficiency for further urbanization is absolutely necessary. In this paper, 69 counties in Zhejiang Province are chosen to be objects for empirical studies and therefore, come up some main conclusions while compare reference system and comparison system as follows:

1. The urban land scale efficiency level in Zhejiang Province is rather high as whole, but regional difference is very clear. Average values of scale efficiencies in Hangzhou, Ningbo, Jiaxing, Huzhou, Shaoxing are all above 0.95, followed by Wenzhou, Jinhua and Quzhou where the average value are over 0.9. Nevertheless, as for Lishui city, such value only reaches 0.7.
2. Correlation analysis proves negative correlation between scale efficiency difference value (CSSEV-RSSEV) and floating population rate, namely the larger floating population rate is, the smaller difference value will be.
3. According to the model analysis, counties which want to adjust its floating population ratio to an optimal level must consider local practical situation. In other words, analysis result denies single rule that present in adjust ratio and PGDP. In spite of that, some counties like Lishui district where economic development may not very well all need to cut down floating population ratio. Furthermore, the most developed areas like Hangzhou Downtown already get best value.

3.4.2 Policy Suggestions

Ganged management is sure to produce a breakthrough value from resource than normal market economy conditions so as to help decision makers or market benefits from annexation worth. Therefore, population migration and urban land development should drive on the same line. For one thing, government is responsible for guiding floating population migration along the counties with the principle of nearest population settlement and preventing population from flowing into big city blindly. For another, clear actual situation of urban land supply and demand to

Table 3.5 Summary sheet of linkage variation in "population-land"

	Expand land-use scale	Balanced development between land-use and population	Conduct population influx
Increase floating population rate	Tonglu County, Fuyang City, Cangnan County, Haining City, Deqing County, Anji County, Sanmen County, Wenling City		Yuyao City, Ruian City, Haiyan County, Tongxiang City, Huzhou Downtown, Changxing County, Zhuji City, Shenghzou City, Jinhua Downtown, Yiwu City, Dongyang City, Quzhou Downtown, Taizhou Downtown, Linhai City
Maintain floating population rate		Hangzhou Downtown, Jiande City, Linan City, Ningbo Downtown, Cixi City, Fenghua City, Wenzhou Downtown, Yongjia County, Yueqing City, Pinghu City, Shaoxing County, Xinchang County, Shangyu City, Lanxi City, Shengsi County, Yuhuan County	
Reduce floating population rate	Chunan County, Xiangshan County, Dongtou County, Pingyang County, Wencheng County, Taishun County, Jiaxing Downtown, Jiashan County, Shaoxing Downtown, Wuyi County, Pujiang County, Panan County, Yongkang City, Changshan County, Kaihua County, Longyou County, Jiangshan City, Zhoushan Downtown Daishan County, Tiantai County, Xianju County, Lishui Downtown, Qingtian County, Jinyun County, Suichang County, Songyang County, Yunhe County, Qingyuan County, Jingniang County, Longquan City		Ninghai County

improve urban land-use efficiency by innovative technique and scientific farmland, woodland expropriation. Current poor impact on urban land-use scale efficiency caused by floating population mainly because blind movement. It can be seen from the research that many big cities like Hangzhou Downtown, Ningbo Downtown, Wenzhou Downtown and so on where economically developed are close to the optimal scale efficiency thanks to fully shared information through which people can gain enough awareness on local population carrying capacity. As for some small cities, they most suffer the unbalanced floating proportion pressure as well as irrational urban construction land amount. Furthermore, these cities should do certain adjustment in population and land management due to limitation of population and land-use information flow.

In that way, what is the correct adjustment guidance? How to achieve optimal land-use efficiency by changing floating population and urban land-use scale? Combining the results from reference system and comparison system, the following table summarizes 69 counties' policy orientation to achieve optimal scale efficiency of urban land-use.

Take Tonglu County for example, in accordance with reference system and comparison system analysis result, Tonglu is supposed to increase floating population proportion for its scale value is 0.968 irs. If wants to reaches best scale, it must expand urban land-use scale and permanent population. Moreover, Table 3.5 tells us Tonglu County now has already absorbed its local labor and prepares to welcome floating population coming from other regions. In short, with the aim of improving urban land scale efficiency, Tonglu ought to input population and land factors as well as adopt new floating population. As is known to all, government masters control right in population influx and land expansion throng rigid policy. Hence, it's achievable for governor to attract surrounding population into the cities and improve overall region benefit level, even gain ganged development in "population- land" through increasing infrastructure or other economic measures. But for Chunan County, Xiangshan County or cities alike, due to social economic level constraint, continue to adopt new floating population may not be a good thing. In consequence, these cities should find another way such as implementing new urbanization development strategy, creating disposable income through creating employment opportunities, developing secondary and tertiary industries and most important, promoting "citizen" work for floating population. It is unwise if government ignores completing "citizen" system. In other words, based on coordination development among regions, helping floating population "settle down" in cities under land-use high efficiency condition can realize generally highest benefits in districts.

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Chapter 4
In-Situ Urbanization in Tourism-Oriented Towns in China's Southwest Mountainous Area: A Case Study of Yongxin Town

Qi Sun

Abstract As a key driver of urbanization, in-situ urbanization regards small towns as basic nodes and each town is guided to form characteristic industries suitable to local development, which will contribute to relieving urban pressure and promoting rural prosperity. The process of urbanization in mountainous regions of southwest China is limited by rough terrain. By contrast, abundant tourism resources and dotted villages promote it. Therefore, an urbanization pattern which suits measures to local conditions is necessary. By using Yongxin Town which is a typical tourism-oriented town in mountainous regions of southwest China in Chongqing as a case study, the author analyzed the approach of in-situ urbanization in Yongxin Town. Effective measures of local in-situ urbanization were summarized as follows: (1) Development orientation based on local landscape; (2) Developing facilities to extend the travelers' residence time; (3) Improving the traffic situation; (4) Exploring and expanding the space for consumption of tourism; (5) The highly educated personnel. The study also suggested extending the tourist season and increasing the incomes of local labor should get more attention. Moreover, this study provides reference on in-situ urbanization in other tourism-oriented towns.

Keywords Mountainous regions of southwest china · In-situ urbanization · Tourism-oriented towns · Chongqing

4.1 Introduction

The in-situ urbanization plays an increasingly important role in China's population urbanization. During the process of in-situ urbanization, local community construction achieves development relying on the rural infrastructure and economy

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conditions, during which the rural population become into urban population directly and the local industries get development through making full use of the local resources (Pan and Wang 2012). The existing in-situ urbanization phenomenon appears more frequently in the eastern region, where the industrial development is regarded as the foundation of in-situ urbanization. Considering that small town development in China's southwest mountainous area is limited by traffic inconvenience, development lagging, resources absence, low accumulative effect and other mal-conditions, the in-situ urbanization based on industrial pattern may not apply to the practical situation in this area. The industrial pollution can also damage the environment and tourism resources in the southwest mountainous area, which is conflicted with the concept of people-oriented and sustainable development which is the core thought of China's new-type urbanization. There is another strategy of rural development which is driven fundamentally by the development of tourism and it can also be regarded as a pattern of in-situ urbanization. This special urbanization pattern is based on the tourism, characteristic agriculture and other relevant industries, which is very different from the classical industrial pattern. It is more suitable for the mountainous southwest tourist towns and villages by contrast. The author chooses Yongxin Town which is a typical tourism-oriented town in China's southwest mountainous area and makes a case study. Through the in-depth analysis of the case, this paper tries to provide some effective methods to other small tourism-oriented towns in the area for reference.

4.2 In-Situ Urbanization and Tourism-Oriented Urbanization

The phenomenon of in-situ urbanization, including "the urbanization from below" (Cui 1999), "rural urbanization" (Xue and Zheng 2001) and "new country community" (Zhu 2006), has been recognized for a long time. Based on comparative analysis of relevant concepts, the four main patterns of China's in-situ urbanization are summarized as: SuNan model oriented by township enterprises, Pearl River Delta model oriented by export-orientated economy development, Wenzhou model oriented by family management and JinJiang model oriented by agglomeration of township enterprises (Zhu 2012). The urbanization process existing in a considerable number of small towns can be categorized by these four patterns, during which there is a significant transformation from agricultural-based economic structure to gradual accumulation of industrial products, business and services, while in the meantime the surplus agricultural labor force begins to transfer into industrial sector and tertiary sector. However, a high proportion of the population is still classified as agricultural population within the current household registration system which is called hukou system in China (Shen 2006). Therefore, the identity transformation from farmer to citizen should be a focus of most concern in the process of China's new-type urbanization, which is also the core problem that can be solved by in-situ urbanization.

Obviously, tourism-oriented in-situ urbanization has not been considered as a main pattern by contrast. Nonetheless, considering that adjusting measures to local conditions and making full advantages of distinguishing properties are required in the choice of urbanization pattern, town development has achieved progress in some tourism towns. So this paper tries to examine this strategy of rural development which is fundamentally oriented by local development of tourism instead of the industry. It is true that there is some certain similarity between tourism-oriented urbanization and classical types of in-situ urbanization, but there still exist some significant differences, as tourism-oriented town urbanization is based on the production of spaces of consumption, which will create new demands for the land use pattern and transformation of local employment structure (Mullins 1999). As Mullins (1991) defined, tourism urbanization is a process during which cities and towns are built or regenerated almost exclusively for the purpose of leisure and pleasure, and thus urban growth is closely tied to tourism-related industries (Mullins 1991). This concept can effectively examine the process of China's in-situ urbanization oriented by tourism and relevant industries. In this sense, the process of town expansion and growth is primarily attributed by the development of tourism sector which produces spaces for consumption, while the town construction, including infrastructure, manufactured landscapes, and accommodations, also devoted into exploiting the space of consumption for tourism in the meantime, during which local labor force begins to enter into the tourism-related sectors. Therefore, the conception of tourism urbanization and in-situ urbanization oriented by tourism will not be distinguished in this paper.

In recent years, tourism urbanization has received more attention gradually in the urban study area. Gladstone (1998) argues Mullins' (1991) view that tourism urbanization gets success only through the exploitation and consumption of nature, and he puts forward two types of urban growth generate from tourism development: one type corresponds more with the demand for "sun, sand and sea" vacationers and is heavily dependent on the consumption of nature (e.g. the Sunshine Coast); the other type specializes large, artificial, capital-intensive tourists attractions such as theme parks (e.g. Orlando) and casinos (e.g. Las Vegas) (Gladstone 1998). It should be noted that the city or town construction must benefit the expansion of consumption for tourism in either type, during which the means of production and labor force will gather into this area, which can promote the process of urban construction. Although the phenomenon mainly appears in urban area, there are also a large number of cases of rural district can support the view. Li (2012) refers the phenomenon of transformation from peasant communities into tourist attraction in the case study of Guizhou, during which the space of residence is also the space for tourism consumption (Li 2012). Qian et al. (2012) regards the town development based on the consumption of both natural landscape and manufactured landscapes as the category of tourism-driven urbanization (Qian et al. 2012), which is very similar with Mullins' opinion (Mullins 2003).

This paper combines perspectives of in-situ urbanization, tourism urbanization and other urban development from plenty of research in order to explore a detailed strategy of in-situ urbanization in small oriented towns and find out the interrelation between local resource basis, tourism related industry, town development and the household registration.

The empirical data in this paper were mainly collected from the fieldwork in 2013. The statistical data and the information of local population, town construction and some policies were provided by local government. Interviews with local government officials offer the main information about local urbanization process and tourism development. Besides, the questionnaires for local residents will support the analysis of local population and the urbanization of population. Based all the information and data above, this paper tries to explore the path of in-situ urbanization in Yongxin Town and the conclusion can be instructive.

4.3 Tourism and Spatial Situ-Urbanization

4.3.1 Study Area Overview

Yongxin Town is located in the northwestern district of Chongqing Qijiang, which is 63.6 km from the downtown area of Chongqing. Yongxin Town is the town of agricultural industrialization demonstration in Qijiang, which has 231 km^2 area and includes 32 administrative villages and a community. The town belongs to the subtropical moist climate region, which has abundant rainfall as well as great regional differences between temperature, light and water. Owing to the highest elevation of 1182 m and the lowest altitude of 188 m, Yongxin Town has obvious stereo climate. Yongxin Town is rich in natural resources, which is famous of millions Mu of orchard in Mountain Fenghuang. In addition, the red plum in “Ping Tan Gully” won the World Exposition. All kinds of landscape are distributed in many places in this town, the natural landscape such as Qingxi River, the mountains which is covered by the primeval forest and Mountain Fenghuang which owns the millions Mu of orchard. Yongxin Town, otherwise, has Ming streets, reproductive totem and eight wonders of ancient and modern human landscape. Suitable climatic conditions, rich products characteristics and vast Landscape distribution made the favorable travel foundation of Yongxin Zhen, therefore also promoted the local development of urbanization.

4.3.2 Tourism Promoting In-Situ Urbanization

4.3.2.1 Tourism and Industrial Diversification

During the process of urbanization, the industrial development can offer employment opportunities for the population moved from rural district. As a type of diversified industry, the development of tourism industry will promote the evaluation of service industry, construction, agricultural product processing industry,

Table 4.1 Annual tourism revenue of Yongxin Town

Year	Number of tourist visits (in thousands)	Tourism revenue (Chinese yuan, in thousands)	Annual growth rate of tourism revenue (%)
2007	–	–	–
2008	138	2927	–
2009	402	7200	145.76
2010	408	8310	15.42
2011	341	16,000	92.54
2012	400	40,000	150.00

Source Government Work Reports from 2007–2012

pension industry and a series of related industries. Since 2007, local government has put the focus on the tourism and carried out a series of policies, during which sightseeing tourism, mountain entertainment, commercial exhibition industry and other characteristic tourism industries are gradually formed. It can be obviously figured out that tourism has played an increasingly role in fostering local economic vitality and its contribution degree to local economy has been continuous growing (Table 4.1).

4.3.2.2 Tourism and Town Construction

As mentioned above, the town construction should contribute to the expansion of consumption for tourism, which mainly depends on the attraction to tourists. With the development of tourism, rural construction is not only to meet the demand of tourist accommodation, but to fulfill the local residential demand. For one thing, rural communities need to strengthen the infrastructure modernization upgrade in order to promote the service ability of tourism; for another, the increasingly growth of the number of local residents who will engage in tourism and related works requires more living space near the scenic areas. Since 2007, local government has completed 16 residential communities which cover more than 200,000 m^2 and 3 large squares. A series of strategies stimulated the local residents' enthusiasm of migrating to the new residential area and promoted the tourists reception capacity as well. While in the meantime, the local government focused more on infrastructure construction. Up to 2011, not less than 150 million Yuan has been invested into highway construction and a road through the whole tourism circuit has been formed initially. Both tourists and local residents get benefit from the town construction.

4.3.2.3 Tourism-Oriented Urbanization and Industrial Structure

Since 2007, the local government takes a train of measures aimed at promoting tourism and related industries so as to driving local economic development. The reasonable tourism localization based on respective tourism in every village prompt

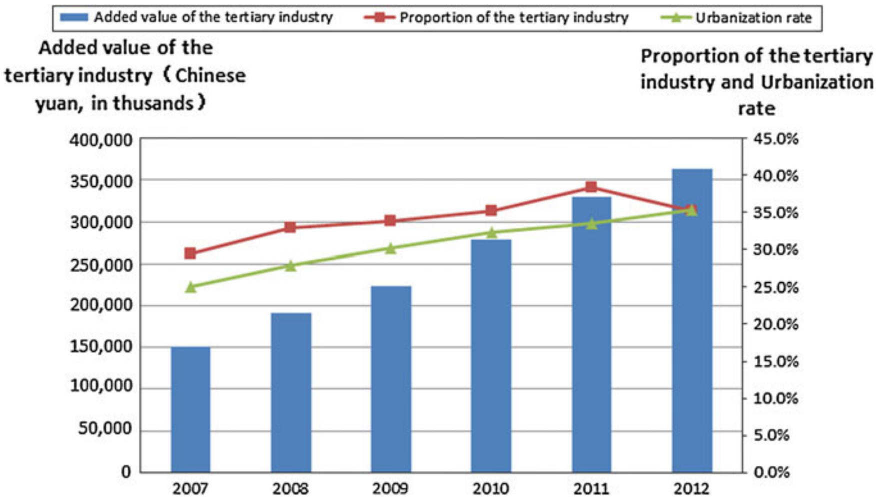

Fig. 4.1 Urbanization rate, proportion of the tertiary and added value of the tertiary industry from 2007 to 2012. *Source* Yongxin Town statistical yearbooks from 2007 to 2012

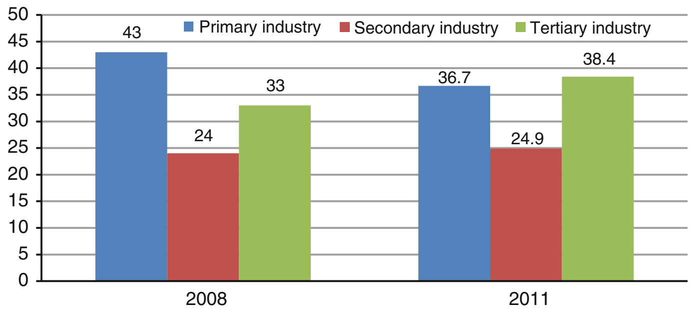

Fig. 4.2 The proportion between local three industries in 2008 and 2011. *Source* Yongxin Town statistical yearbooks from 2007 to 2012

many creative tourism projects, during which the town construction and tourism got rapidly developed. The added value of the tertiary industry increased with years and the ratio of local GDP rose consistently. Moreover, the urbanization rate has increased at nearly 10 % from 2007–2012 (Fig. 4.1).

Another significant effect is that the local industrial structure has been improving constantly and tertiary industry has been growing as the dominant industry. In 2008, the proportion between local three industries was 43:24:33 and the ratio in 2011 changed into 36.7:24.9:38.4. It is the first time that the tertiary industry ratio becomes the highest among the three industrial structures, which means the in-situ urbanization oriented by tourism has gained certain effect (Fig. 4.2).

4.4 Tourism and Urbanization of Population

After explaining the relationship between tourism and special in-situ urbanization, the human factor, which is far more important during the process of urbanization, must be considered, since new type of urbanization emphasizes the person's urbanization should get more attention. Generally speaking, local residents are both the builder and designer of the town and the beneficiaries of construction achievements. It is essential to identify the migratory preference and related influence factors. Based on these thinking, the questionnaire survey and interviews specific to local presidents were conducted and 168 valid samples were collected.

4.4.1 Essential Characteristic of Respondents

Among the 168 respondents, there are 120 people belong to agricultural registered permanent residence, accounted for 71.4 % and 48 people belong to urban registered permanent residence, accounted for only 28.6 %. However, the number of people who engaged in non-agricultural works is very large according to the field observation. Rural non-agricultural labor force is not completely in the sense of urban population, but it has a certain town features and this part of population is referred as the "expectant urban population" by Zhu (2012) in the research on the phenomenon of in situ urbanization (Zhu 2012), which means urbanization of population has enormous potential.

In terms of age structure, 168 respondents mainly distributed in the middle age section and the people aged 31–50 accounted for 63.7 %. The aging trend remains clearly age and the proportion of young people under the age of 30 is small (Fig. 4.3). This is because peasant-household tourism, small workshops production and commodity retail often require certain original capital while middle-aged people have a certain amount of deposits, thus become the main force engaged in the industries above. In addition, the income of related service industry is not very considerable so that the youth groups often choose a migrant youth groups.

Among the 168 respondents, the people received primary school education accounted for 28.6 %, the people received junior high education accounted for 45.2 %, the individuals who has high school diploma accounted for 23.2 % and the group who has college degree and above accounted for only 3 % (Fig. 4.4). The lack of highly educated personnel will hinder the development of tourism, especially for the tourism innovation and tourism management whose development depend more on the human resource.

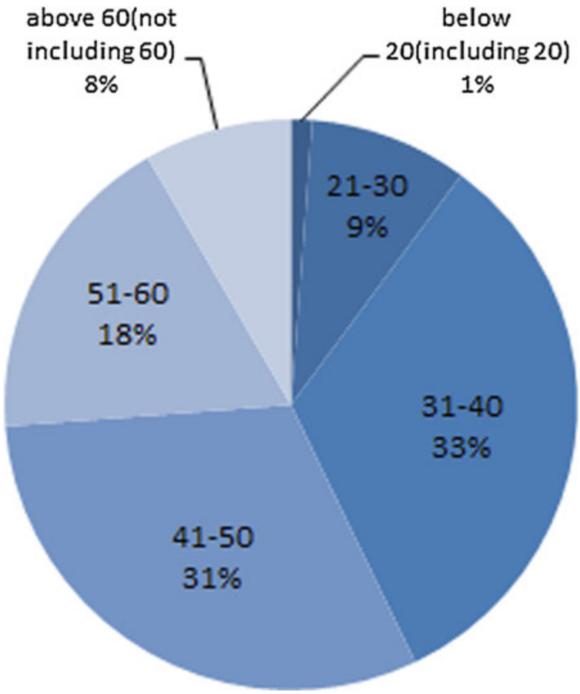

Fig. 4.3 Age structure. *Source* Analysis based on the questionnaires and interviews

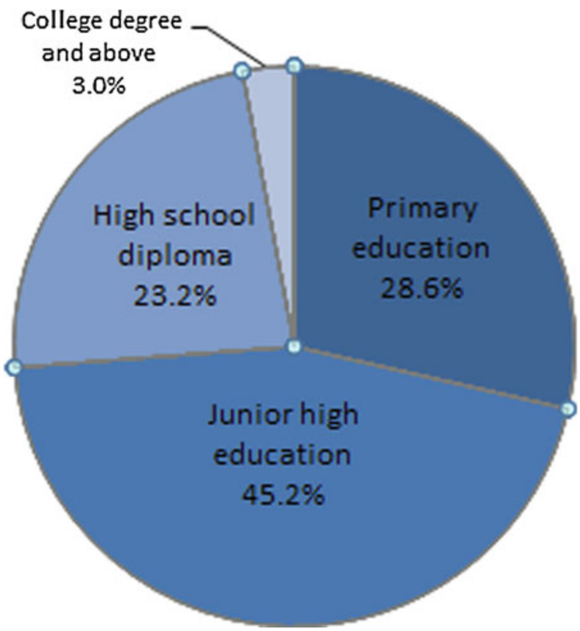

Fig. 4.4 Educational background structure. *Source* Analysis based on the questionnaires and interviews

4.4.2 Migration Intention and Evaluation for the Town Construction of Respondents

4.4.2.1 The Obstacles of Migration for Respondents

62.5 % of the respondent considered that the migration cost was the main factor restricting their migration. The migration process tends to cost more than in other district due to the poor traffic condition. Moreover, the high house prices and the cost of living are not affordable for the existing income level of local residents. But from another angle, it provides opportunities for in-situ urbanization. In addition, 50 % of respondents referred they were unwilling to leave their hometown to the city, and 22.6 % expressed that they didn't want to abandon the land and housing they own. All these views reflected local people's everlasting local mood and the homeland complex, which can also boost the process of in-situ urbanization as an affective factor.

4.4.2.2 The Recognition of Deficiency of Town Construction

Although the local government has invested a large amount of money for fundamental facility construction and road construction, yet the large number of villages and most of their locations are scattered, which is a key restriction factor of town expansion. It can also be verified by the questionnaires, which shows 62.5 % of considered the road construction needs to strengthen. Meanwhile, 47.6 % of respondents thought that local medical and health conditions required improved, which is closely related to people's living and reflects the coping ability to deal with emergency of tourists to some extent. Furthermore, 35.1 % of people choose the "street cleaning", 37.5 % of people choose the "sports facilities construction" and the "waste disposal" was chosen by 45.2 % of respondents. These three factors are mainly about town scape that has effect on tourism environment. A graceful town scape can extend the time in which tourists stay so as to expand the consumption space. As for other options, most respondents considered that the conditions of living, shopping and public security are excellent and it is convenient for both the tourists and local residents.

4.5 Conclusions

The recent tourism-oriented urbanization process in Yongxin town has represented a unique approach of China's in-situ urbanization. According to the present research on in-situ urbanization, the case study generally fits into the basic features of the classical model. Tourism urbanization in Yongxin has led to a rapid population growth and labor growth as well as significantly expansion of urban space.

Meanwhile, the tourism development in Yongxin has also resulted in a dramatic transformation of local employment structure while the increasingly provision of tourism-related services is also dependent on the non-agricultural labor force. Furthermore, as the number of tourists and residents in the tourism space grows increasingly, the requirement for the local infrastructure construction gets more and more intense which will lead to the urban elements gathering, during which the in-situ urbanization will be realized gradually.

There still exists some limitation that lies in the lack of some other cases as comparison with Yongxin. However, combine with the basic theory with the case study, this paper still demonstrates that tourism-oriented urbanization can also be a typical pattern of in-situ urbanization and offers some useful and referable advise for other small tourism towns in China's southwest mountainous area. Firstly, the tourism orientation and the developing direction should be based on the local tourism resource and landscape. Secondly, in order to extend the resident time of tourists, the government should invests more on the infrastructure construction so as to build comfortable environment. Thirdly, the traffic situation has a direct influence on the cost and thus it should be improved more conveniently. Fourthly, exploring and expanding the space for tourism consumption has important effect on the process of tourism urbanization. Last but not least, introducing the highly educated personnel actively will strongly promote the future development, which is an immutable truth in modern society.

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Chapter 5
Types, Settlements and Spatial Distribution of Chinese Senior Caring Institutions—A Case Study of Beijing

Xiaolu Dou and Changchun Feng

Abstract Based on the global aging background and increasing older population in big cities, this study focused on the basic social service settlement—senior caring institutions. This paper described the general types and patterns of American and Chinese elderly caring institutions. Using Beijing as a case, it generated the number, price and distribution of government/private organized institutions by districts. Result suggested there was a significant imbalances between districts. Center districts had larger older patio but less beds, while country districts had less institutions but more beds. There are also price and facility differences between government and private organized institutions. The government organized institutions generally have less scale and beds, and more affordable. Several changes should be applied to serve more demands and suggestion for future older policy also was discussed.

Keywords Beijing · Senior population · Senior caring institutions · Spatial distribution

5.1 Introduction

As population aging has become a global trend, although decades later than developed countries, China is stepping in the "senior society" gradually. The proportion of older adults keeps increasing, especially in metropolitan areas. Beijing, the capital and the biggest city in China, has been facing aging problems for years. Indicated by the 2011 senior population and senior career development report, till 2011, there were 1278 million people living in Beijing. Among them, 248 million aged 60 and above, taken a proportion of 19.4 %. The old-age

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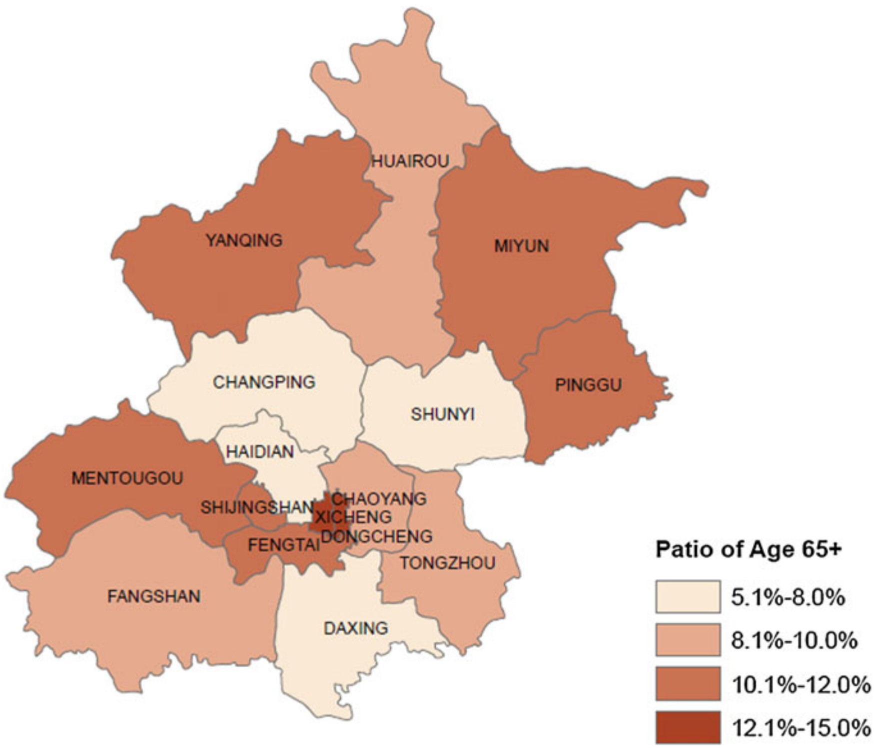

Fig. 5.1 Proportion of people ages 65 and above. *Data source* 2012 Beijing census yearbook and personal data collection

dependency rate (ODR) was 27.6. The degrees of aging also differs from districts. While the core-central districts (Dongcheng and Xicheng) had the largest proportion of older people, the functional development districts, which were suburbs before, did not contain that much seniors. Their senior proportion even lower than satellite cities (See Fig. 5.1).

The increasing senior population called a strong demand of housing and caring institutions supply. Influenced by one-child policy and resultant changing family structure, the traditional family caring model is becoming more and more difficult (Tang 1987). Seniors have to rely more on government subsidies and society services. While most of older people tend to age-in-place, there are still a considerable number of seniors need to be taken care in professional institutions. However, the number and quality of caring institutions have not met the demands. Their spatial distribution also could not fit for the districts' population, either (Cheng et al. 2011).

This paper addressed the typical kinds of senior caring institutions. In case study, it discussed the services, costs, and spatial distribution of institutions in Beijing. The data was gathered from 2012 Beijing Census Yearbook and multiple sources from internet, and analyzed by GIS. The study tried to draw an overview about the facility conditions and arrangements in Chinese metropolitan areas.

5.2 Types of Senior Caring Institutions in U.S.

Senior caring institutions usually sort to several types, depend on the different services they offered. In the U.S., there are five typical types of senior caring institutions, which are Retirement Community (RC), Senior Apartment, Assistant Living (including Boarding Home), Nursing Home, and Day Care Center. They are sorted to satisfied different health stage of seniors. Traditionally, these institutions are often scattered in a city/community, but some Continuing Caring Retirement Communities (CCRC) and Senior Apartments could contain several kinds of services. Older people could move to other part of the building, depend on their function conditions, without changing institutions.

Retirement Communities (RC) and Assistant Living (AL), which target middle to high income seniors, need to be paid out of pocket. For RC, they are basically real estate project. Usually they are located in sun-belt areas such as Florida and California, with different house layouts, including acceptable medical institutions, public spaces, cafes, golf, tennis, and so on. People should buy them as normal house and usually should have a full down-payment since they could hardly get mortgage. AL is a kind of private-owned senior apartment, offering caring services like meal and cleaning for those elders who have limited capacity. Most of them have various entertainment and education programs, libraries, and transportation service, too. They also have social workers and occupational therapists offering support and consulting. The cost varies on room size and location, generally charged \$3000–\$5000 or more. Some small ALs, also called Boarding Homes, which located in community and organized by community agencies, could also offer services as ALs but charge less.

Senior Apartment has different organize models. Some of them are government subsided, targeting on low-income seniors. If one's income lower than a certain line, which differs from states but usually evaluated by poverty line, he/she could be eligible to apply for a senior apartment with 1/4–1/2 of their total income. This kind of housing also can be taken as part of affordable housing, but have limitation to peoples ages 57 and above. Other apartments are market-price, offering independent living choices for the seniors who cannot afford single-family house or RCs. As they are independent living, they do not offer any support of daily life or medical cares.

Nursing Homes, which were always compared to Chinese elderly caring institutions, are scattered in almost every community. Different from China, they are professional caring institutions for the very ill seniors, usually be paid by people's insurance (Medicare or Medicaid). Most of the elders who live in nursing homes are completely incapable to take care of themselves. They need help in eating, bathing, clothing or something essential for daily life. Basically the seniors living in Nursing Homes could be regarded as patients, to some extent. Nursing Homes were very popular in 1950s–1970s, however, as the appearance of ALs and the increasing demands of independency and dignity, more and more people choose to age-in-place instead of living in nursing homes. That called the needs of Day Care Centers, another kinds of caring institutions. Seniors who have minor functional or emotional disorders could stay in Day Care during daytime, and get back to their homes when they have caregivers accompany. Some community institutions in China also act as that way.

5.3 Facility Conditions in China

Aging society, although a global challenge, just began to gain general attention for less than 10 years in China. Two decades later than the western world, the "baby boomers" in China were generally born in 1950s–1960s. The group started getting old till 21 century. Before that, aging population were not really a problem. As a matter of fact, communities in China always have senior caring institutions, both in urban and in rural areas. The urban planning law demands every community should have a senior facility and have a standard system called "Index of Thousands". The principle of village construction also has a provision that village committee should set a special sector for the lonely, older adults. However, there were not many older adults when the laws were been implemented, so the standards and provisions were set by a vague and inadequate way of description (Liu and Tinker 2001). Further, as it is a moral tradition that children should take care of their old parents, little people are willing to send their parents to caring institutions, even day care. Community institutions usually only take in people who have no children alive or have serious mental impairments.

The types and services of senior caring institutions also show unique patterns in China. Community institutions-always regarded as nursing homes, are not really "nursing homes" since they have no professional team to deal with caring things. Basically, the staff just put an eye on older adults in case they hurt themselves. Many of the community caring institutions do not accept fully dependent people, they suggest them go to hospital instead. The common settlement they could offer is a small room/apartment with kitchen, chairs and a few beds. Seniors could stay there without or tiny payment, but not have that many activities as the Day Care Center. There are some private caring institutions in big cities, targeting dependent seniors. However, they are not that popular since they charge much more, and usually cannot take insurance (Chu and Chi 2008; Dong and Wu 2001).

In recent years, under the effect of western and the aging policy, larger senior apartments were built in China. They typically were located in the suburb, organized by government or government-private cooperation, and had different options of single, double and multiple sharing rooms. Comparing to private organizations, they cost less, have relatively better location, which makes them more popular. Some senior apartments with high reputation have a 3–5 years waiting list (Xincui 2007).

Many private sectors-real estate developers, insurance and medical companies have noticed the huge future demands of senior caring institutions. They began to build retirement communities, senior apartments and vacation resorts, targeting young-olds with higher personal assets. These institutions are managed in different ways. Some of them have memberships, while others sell houses. They are

Table 5.1 Older populations and beds supplies by districts

Name	Population (k)	65+	Proportion (%)	Government	Private	Total
Dongcheng	908	117	12.89	19	5	24
Xicheng	1287	182	14.14	42	7	49
Chaoyang	3745	340	9.08	37	6	43
Fengtai	2214	231	10.43	50	5	55
Shijingshan	639	64	10.02	20	6	26
Haidian	3484	261	7.49	9	6	15
Fangshan	986	92	9.33	34	10	44
Tongzhou	1291	109	8.44	28	6	34
Shunyi	953	72	7.56	18	2	20
Changping	1830	137	7.49	15	15	30
Daxing	1470	102	6.94	29	6	35
Mentougou	298	34	11.41	11	1	12
Huairou	377	36	9.55	15	3	18
Pinggu	420	43	10.24	17	5	22
Miyun	474	51	10.76	23	1	24
Yanqing	317	33	10.41	23	4	27
Total	20,693	1904	/	390	88	478

Data Source 2012 Beijing Census Yearbook, Personal data collection

becoming a significant component of market supply. Yet so far, government owned institutions still take a larger proportion in market. In Beijing, government owned/cooperated institutions are almost four times bigger than private sectors. Table 5.1 indicated the numbers by districts.

5.4 Spatial Distribution of Institutions in Beijing

Although several types of institutions exists, the supply of service are still in a great shortfall. According to the census, till 2012, there were only 74,000 beds for elderly caring in Beijing, only 2.97 beds per thousand people (Beijing statistics yearbook 2014). Given the large, increasing number of older population, this number seems far from enough. Besides, there is a huge difference between districts. As mentioned before, the center districts has higher older ratio, and they do not have much potential to build more institutions because of limited lands. For the edge counties/districts, as their population are much less, their beds supply are more optimistic, almost all of which are beyond average except Changping. The worst region is suburbs. Given the high population density, some developed districts, such as Haidian and Chaoyang even have less than 1bed/per thousand people. (See Fig. 5.2.)

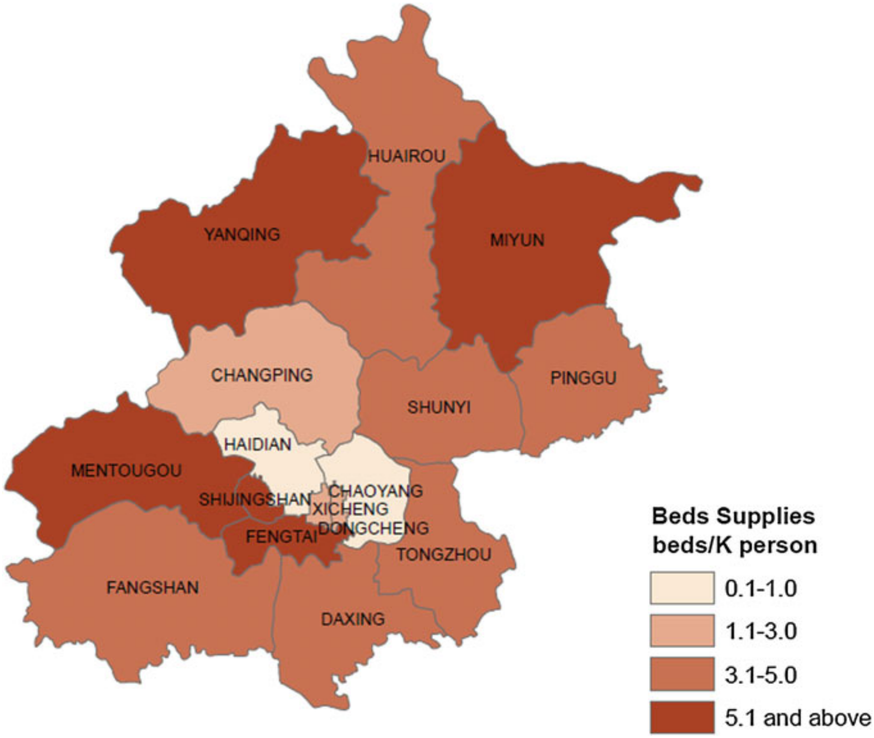

Fig. 5.2 Beds supplies by districts. *Data Source* 2012 Beijing census yearbook and personal data collection

The beds supplies and prices also differ in government and private sectors. Generally, government organized institutions have less beds, and charge less, too. The average beds offered by government sectors are 125/per facility, while private sectors have 242. That means, though the private sector is not dominate in number, they deed provide more beds. Since the regulations, government sectors have a relatively fixed range of price, while private sectors could more market-oriented. The average monthly cost of government sectors range from RMB 904 to 1548. For private sectors this number is RMB 1383–2996. Price also varies by districts. The highest government price occurred in Fengtai, which had a range from 1370 to 2495, while the highest private price occurred in Chaoyang, which could be 6408. The lowest government price in Yanqing was 662, and the private was 625 in Pinggu. Tables 5.2 and 5.3 showed the differentiations (Senior career development report 2014).

The reason for the differences between government and private sectors could be explained as following aspects. First, most of the government organized institutions are based on communities. They were set as a mandatory supplemental institutions,

Table 5.2 Monthly cost of institutions by district

Name	Lowest monthly cost/gov	Highest monthly cost/gov	Lowest monthly cost/pri	Highest monthly cost/pri
Dongcheng	814	1403	1504	2072
Xicheng	1105	1623	2003	3525
Chaoyang	1162	1998	2000	6408
Fengtai	1370	2495	3270	6210
Shijingshan	1079	2020	1238	1835
Haidian	860	1482	1146	3540
Fangshan	743	1174	1128	1628
Tongzhou	923	923	1407	1907
Shunyi	790	1617	1510	2885
Changping	866	1836	1219	3090
Daxing	817	1894	1005	1848
Mentougou	869	1392	1100	1900
Huairou	845	1403	967	1367
Pinggu	741	1289	625	1735
Miyun	820	1064	1000	6000
Yanqing	662	1150	998	1990
Average	904	1548	1383	2996

Data Source 2012 Beijing Census Yearbook, Personal data collection

Table 5.3 Beds distributions by sectors and districts

Name	Total beds	Total beds/gov	Total beds/pri		Average beds/gov	Average beds/pri	Beds/k person
Dongcheng	1468	935	533		49	104	1.03
Xicheng	3089	2100	989		50	141	1.63
Chaoyang	8865	1389	7476		202	232	0.37
Fengtai	11,824	9254	2570		238	514	4.18
Shijingshan	4311	3322	989		166	165	5.20
Haidian	3760	1790	1970		199	328	0.51
Fangshan	5452	2954	2498		87	250	3.00
Tongzhou	4818	3008	1810		107	302	2.33
Shunyi	2480	2080	400		116	200	2.18
Changping	11,823	2070	9753		148	650	1.13
Daxing	4941	3694	1247		127	208	2.51
Mentougou	1727	1607	120		146	120	5.39
Huairou	1677	1357	320		90	107	3.60
Pinggu	2389	1609	780		95	156	3.83
Miyun	2521	2301	220		100	220	4.85
Yanqing	2504	1810	694		79	174	5.71
Total	73,649	41,280	32,369	Average	125	242	2.97

Data Source 2012 Beijing Census Yearbook, Personal data collection designated according to the number and proportion of older people in community. Since the size of community, especially the old ones, are not very big, the caring institutions only have certain number of beds for a few people. But private institutions should consider the operating cost and scale benefit. They must serve a wider area for more people to keep their profit. Second, as government institutions could get land without payment, they usually get good location but relatively small area. In contrast, private ones should buy (or rent) lands in suburban areas, as they neither could find that much land nor could afford the high price in city center. Third, with government as back-ups, the government institutions barely have any debt or profit pressure, which make them lack motivation to expand services or upgrade facilities. Also, they need not to charge people more since the operation revenue has nothing to do with staff earning. For private institutions, they have to make money from their costumers, even if they could get some government subsidies. But the higher price also become an obstacle, preventing some price-sensitive people from moving in.

5.5 Discussion and Conclusion

There is a huge gap between the increasing older population and the caring facilities. As the "baby boomers" getting old, their demands for caring will became more emergency. Under the effect of the "One Child Policy", it is getting harder to rely on children when people old. In big cities, this circumstance is more serious since people there have more working and life pressure. In addition, older people, especially those who have functional or mental impairs, need more specific caring services and skills. All of them have called a large demand of caring institutions with professional staffs and management. However, the traditional facilities settlement seems not fit for the increasing demands anymore. The group of seniors, either independent or dependent, need more specific market segregated and targeting designed institutions.

The differences between districts should also be noticed. While older people living in city center facing a serious shortage of caring facilities, suburban area with more residents should not be ignored, either. Although their older patio is not that high now, the demand may become impressive in the future. Another problem is the price. The government organized institutions with less cost are much more popular than private ones. However, there are limited space for them to expand, and the government can hardly afford more. Private companies should become a major component of the older caring market in the future, whose main challenge is get an equivalence between service quality and organizing cost, so to share the burden with government sectors. Public and tax policies should be carried out to offer some deduction and subsidies for private sectors, too. Moreover, non-profit organizations should be introduced and invited to play an important role in the future.

As the relatively less population and more affordable land supply, elder caring facilities in country districts seems sufficient so far. However, with better nature environment and lower housing price, those area are becoming popular destinations of recreation. Many companies have been built resort facilities there, while several retirement communities are under construction, too. Considering the future trend, those countryside areas should make strategy plans to prepare enough houses and institutions for the elderly migrants.

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Chapter 6
Application of Modified Statistical Triangle of Accident Causation in Construction Health and Safety

Z. Mustapha, C.O. Aigbavboa and W.D. Thwala

Abstract The purpose of the paper is to presents a review of literature on safety hazard identification and possible preventive measures in the construction industry. Unidentified hazards in the construction industry are likely to present the most unavoidable risks. Therefore, hazard identification is paramount to construction safety management since risk assessment is the practical means by which hazardous events are managed. Safety hazard identification in the construction industry towards the improvement of employee's health and safety (H&S). Unidentified hazards in the construction industry are likely to present the most unavoidable risks. Therefore, hazard identification is paramount to construction safety management since risk assessment is the practical means by which hazardous events are managed. The study is mainly literature review with reference to existing theoretical literature, published and unpublished research. The paper presents an overview of hazards and accident causation. The findings from the study have shown that falls at construction sites are the leading cause of death and most of these deaths were attributed to falls from roofs, scaffolds, and ladders. Construction accidents lead to delay in project completion, increase the expenses and ruin the reputation and reliability of constructors. The following were identified as some of the barriers to H&S improvement: lack of information sharing across projects, full-time safety department, subjective nature of hazard identification and risk assessment. The study explores safety hazard identification in the construction industry towards the improvement of employee's H&S. The study presents a strong background on hazard identification in the construction safety management.

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6.1 Introduction

Construction projects, especially large ones, are complex and dynamic and the workers might work an average of only 1500 h in a year while workers in manufacturing, for example, are more likely to work regular 40 h weeks and 2000 h per year (Weeks 2011). The construction industry has always been blamed for the high rates of accidents and fatalities despite its contributions to economic growth. The construction industry has been placed among the industries with unreasonable rates of accidents, permanent and non-permanent disabilities and even fatalities (Abdul Hamid et al. 2003). The construction industry plays an important role in improvement of any countries' economic growth. The proportion of gross domestic product (GDP) in industrialized countries varies widely and construction is about 4 % of GDP in the United States, 6.5 % in Germany and 17 % in Japan (Weeks 2011). According to report by National Safety Council (NSC) 1000 construction workers died at work and 350,000 suffered disabilities in 1996. Construction workers constitute only 5 % of the United States' workforce, an out of proportion rate of 20 % of all occupational fatalities and 9 % of all disabling occupational injuries relate to construction industry (Abdelhamid and Everett 2000).

High rates of accidents and fatalities in this industry have placed it among hazardous industries (Hosseinian and Torghabeh 2012). The costs of injuries, which are direct and indirect, workers' compensation insurance, legal liability as well as legal prosecutions have pushed parties involved to seek ways of mitigating these hazards. The world rates of occupational injuries, illnesses and fatalities are still alarming (Weeks 2011). Construction workers are exposed to a wide variety of health hazards on the job. Exposure differs from trade to trade, from job to job, by the day, even by the hour. Exposure to any one hazard is typically intermittent and of short duration, but is likely to reoccur (Weeks 2011). Construction accidents lead to delay in project completion, increase the expenses and ruin the reputation and reliability of constructors (Wang et al. 2006). In 2009, falls accounted for more than one third of fatal occupational injuries in construction (34 %). Nearly half (48 %) of all fatal falls in private industry involved construction workers (OSHA 2011). In the period 1992–2005, about one-third of the fatal falls in construction were from roofs, 18 % were from scaffolding or staging, 16 % were from ladders, and 8 % were from girders or structural steel. The other 25 % of fatal falls includes falls through existing floor openings, from nonmoving vehicles, from aerial lifts, etc. (OSHA 2011). According to Gambatese and Hinze (as quoted by Hosseinian and Torghabeh 2012) high rates of accidents and fatalities have placed the construction industry among hazardous industries. Hazard has been defined by FOCUS 4 (nd) as a condition that is likely to cause injury, illness or death to a worker. Wang et al.

(2006) asserted that the world rates of occupational injuries, illnesses and fatalities are still alarming. Construction accidents can be prevented by identifying the root causes of accident. Since research has shown that fall hazards is the leading cause of accident in construction industry. This paper presents a review of literature on safety hazard identification and possible preventive measures in the construction industry. It began with a discussion of major types of falls in the construction industry, barriers to improving hazard identification. This is followed by the preventive measures for fall hazards, OSHA's fall protection standards and control and management of hazards in construction based on modified statistical triangle of accident causation within the context of how hazards leads to accidents.

6.2 Literature Review

According to the construction chart book (CPWR 2007), more iron workers are killed from falls than workers in any other construction occupation. The rate of work-related deaths among ironworkers is 10 times higher than the construction average. Falls remain the leading cause of death for workers engaged in residential construction, with an average of 40 workers suffering a fatal fall from a residential structure each year (Firl 2012). According to data from the U.S. Bureau of Labor Statistics an average of two construction workers die each day in the United States. Deaths and injuries from falls represent a major, persistent. In 2010, the 9.1 million construction workers (including self-employed workers) in the United States accounted for 7 % of the national workforce, yet experienced 17.1 % of fatal work-related injuries. In 2011, the rate of fatal injuries in construction was the second highest of any U.S. industry. Within the industry, falls at construction sites are the leading cause of death, accounting for 35 % of deaths among private sector construction workers (not including government or self-employed workers) in 2011; most of these deaths were attributed to falls from roofs, scaffolds, and ladders. Deaths and injuries from falls represent a major, persistent, yet preventable public health problem (CDC 2013). According to Finneran and Gibb (2013) construction is one of the most hazardous industry sectors with many thousands of workers being killed and seriously injured each year all over the world. Even though there has been progress over the years but there is still a long way to go to reach the vision of an industry where people return home at the end of a shift healthier than when they arrived. Good H&S management leads to project wide benefits. Finneran and Gibb (2013) further asserted that H&S in construction is about using appropriate means to ensure workers are both safe and healthy. Occupational fatalities caused by falls are a serious concern which will help employers to identify fall hazards at construction sites to enable them protect their employees (OSHA 2011). Accident prevention has been defined by Heinrich as 'an integrated programme, a series of coordinated activities, directed to the control of unsafe personal performance and unsafe mechanical conditions based on certain knowledge, attitudes, and abilities' (Abdelhamid and Everett 2000).

Some other synonyms for accident prevention have been emerged later such as loss prevention, loss control, total loss control, safety management, incidence loss control (Abdelhamid and Everett 2000). Since all hazards in construction workplaces are not always possible to be identified and eliminated therefore, effective accident investigation programmes are essential to get the required data (Hosseinian and Torghabeh 2012; Cliff 2012). However, unidentified hazards negate the risk assessment process; risks cannot be assessed and control measures developed and implemented if those involved are not aware of the hazard in the first place. Hosseinian and Torghabeh (2012) in their research on major theories of construction accident causation models concluded that accidents and incidents in construction workplaces are unplanned and unwanted occurrences which involves movement of persons, objects or materials which may result in injury, damage or loss to property or people. They further asserted that not all accidents are preventable since risk is beyond the human intervention. Therefore, manner workers need to be watchful, and strategies are required to manage risk and improve upon it. They concluded by saying that majority of accidents happen when employees disregard safety rules (unsafe acts) and management ignore the presence of unsafe conditions.

6.3 Major Types of Falls in the Construction Industry

Unprotected roof edges, roof and floor openings, structural steel and leading edges have identified as the major types of falls in the construction industry. Since almost all sites have unprotected sides and edges, wall openings, or floor holes at some point during construction. If these are not protected, injuries from falls or falling objects may result, ranging from sprains and concussions to death (OSHA 2011). Factors such as improperly covered or protected floor holes and openings are a common fall hazard because it is easy for an employee step into a hole or opening when carrying something that blocks his view. This implies that falls to a lower level are a major cause of fatalities in construction.

6.3.1 Roofing, Siding and Sheet Metal

Roofing, siding and sheet metal work have the highest rate of occupational injuries and illnesses for a non-manufacturing industry. Roofing and fall protection and unprotected sides and edges is one of the most frequently cited serious violations of OSHA. Fall protection, fall hazard training and fall protection for connectors have been cited as the most frequently serious OSHA violations (OSHA 2011).

6.3.2 Improper Scaffold Construction

Without fall protection or safe access, it becomes hazardous for employees working with heavy equipment and building materials on the limited space of a scaffold. Falls from improperly constructed scaffolds can result in injuries ranging from sprains to death (OSHA 2011). Majority of the employees are injured in scaffold accidents and it is in connection with planking or support giving way, or to lack of guardrails or other fall protection. OSHA's most frequently cited serious scaffold violations include lack of fall protection; scaffold access; use of aerial lifts without body belts and lanyards, platform construction and no worker training (OSHA 2011).

6.3.3 Unsafe Portable Ladders

There is risk in falling if a portable ladder is not safely positioned each time an employee uses it. This may lead to slippery from its supports and an employee may lose balance while getting on or off an unsteady ladder. This incident may cause injuries ranging from sprains to death. According to OSHA (2011) BLS data show that falls from ladders account for over 100 fatalities each year. Factors that contribute to falls from ladders are ladder slip (top or bottom), overreaching, slipping on rungs/steps, defective equipment and improper ladder selection for a given task. Frequently cited OSHA ladder violations include not having a portable ladder extend 3 ft above the landing, no worker training, and improper use of the top of stepladders.

6.4 Barriers to Improving Hazard Identification

Carter and Smith (2006) in their research on Safety Hazard Identification on Construction Projects identified the following as barriers to H&S improvement.

1. Knowledge and information barriers:
   - Lack of information sharing across projects;
   - Lack of resources on smaller projects, e.g., industry publications, full-time safety department, etc.
   - Subjective nature of hazard identification and risk assessment
   - Reliance upon tacit knowledge.
2. Process and procedures barriers:
   - Lack of standardized approach;
   - Undefined structure for tasks and hazards (Carter and Smith 2006).

6.5 Preventive Measures for Fall Hazards: Use Fall Protection Equipment

The three generally acceptable methods of protection for workers on a construction site who are exposed to vertical drops of 6 ft or more are guardrails, safety net systems and personal fall arrest systems. Guardrails are considered prevention systems, as they stop an employee from having a fall in the first place.

Safety net systems are designed to catch an employee and break his fall. They must be placed as close as practicable under an employees working surface, but never more than 30 ft below. A personal fall arrest system consists of an anchorage, connectors, and a full-body harness that work together to break any fall (OSHA 2011). It is advisable to use fall prevention systems, such as guardrails, than fall protection systems, such as safety nets/fall arrest devices, because prevention systems provide more positive safety means. Scaffold work requires guardrails or a personal fall arrest system on any platform 10 ft or higher. Safe access must be provided by employers for employees to prevent them from climbing cross-bracing as a means of access (OSHA 2011).

6.6 Training

Employees should be trained on how to protect themselves whenever they are exposed to fall hazards. Employees must be able to recognize the hazards of falling and explain the procedures to be followed in order to minimize fall hazards. The training should include the use of scaffolds (OSHA 2011).

6.6.1 OSHA's Fall Protection Standards

OSHA's fall protection standards require employers to provide fall protection for employees when they are exposed to a fall hazard. The standards cover hazard assessment, fall protection and safety monitoring systems. Controlled access zones, safety nets, and guardrail, personal fall arrest, warning line and positioning device systems are also addressed (OSHA 2011). Employers are required to assess the workplace to determine if the walking/working surfaces on which they are to work have the strength and structural integrity to safely support workers. Employees are not permitted to work on those surfaces until it has been determined that the surfaces have the strength and structural integrity to support all workers. Once employees have determined that the surface is safe for workers, the employer must select one of the permitted types of fall protection for the work operation if a fall hazard is present. Works at a falling height of 6 ft or more from an unprotected side or edge requires a guardrail system, safety net system, or personal fall arrest system to protect the employee (OSHA 2011).

6.6.2 Proper Scaffold Construction

Employers must construct all scaffolds according to the manufacturer's instructions. A "competent person" must supervise as scaffolds are erected, moved, taken apart or changed, and must inspect the scaffolding. A guardrail system or a personal fall arrest system is required for scaffolds more than 10 ft above a lower level. In addition, employers must provide safe access to scaffold platforms (OSHA 2011).

6.6.3 Worksite Maintenance

Poor worksite maintenance can lead to clutter and debris on a construction site, creating additional slip, trip and fall hazards. Poor maintenance of ladders, scaffolds and fall protection equipment can also lead to serious injuries. Employers are required to keep worksites free of form and scrap lumber with protruding nails and other waste and trash, including combustible debris (OSHA 2011).

6.6.4 Control and Management of Hazards in Construction

Control and management of hazards in construction are in two main forms namely: avoidance of occurring of hazardous event and restricting the severity potential of hazards when the hazard happens. The first step is preventive control measures which include practices to restrict the entrance of hazardous event into the triangle by lessening the probability of happening of the hazard. Precautionary control measures are at the second step which is designed to restrict the movement of hazardous event through the upper part of the triangle; this step lessens the risk via lessening the severity of the hazard if it happens (Carter and Smith 2006).

The location where hazard will be placed when hazard happens is known as 'hazardous event' which is the base of the triangle as shown in (Fig. 6.1). The severity of the hazard will 'determinism' the term used for the lower base of the triangle. This means that a hazardous event with no physical injury for instance zero severity (Carter and Smith 2006). The intermediate part of the triangle represents the area of severity greater than zero. This implies that the hazardous event causes an accident with physical injuries. The highest point of the triangle represents the most hazardous event. This on the other hand implies the accident occurs and the result is fatality and loss of human life in the movement of the hazard up the triangle (Carter and Smith 2006).

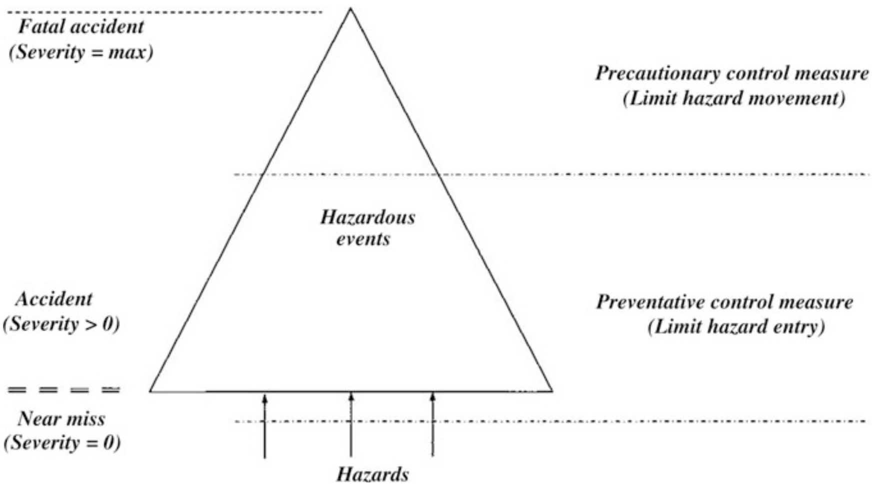

Fig. 6.1 Modified statistical triangle of accident causation. Adapted from Hosseinian and Torghabeh (2012), Carter and Smith (2006)

Carter and Smith (2006) asserted that to obtain the general rationale for performing all safety risk assessments the hazards should be considered in terms of their probability of occurrence and severity of consequence as shown below:

1. Estimate the probability of a hazard's occurrence, i.e., its frequency, and its probable severity if it does occur;
2. Evaluate the risk associated with the hazard based upon the frequency and severity estimations
3. Respond to the hazard by implementing suitable control measures

The discussed accident causation and risk control scenario shown in (Fig. 6.1) has one major assumption. That is the hazard is identified in the first place. If a hazard is not identified it will have the following:

1. Complete freedom of entry into the triangle, i.e., the hazard will have an uncontrolled probability of occurrence
2. Complete freedom of movement within the triangle, i.e., the hazard will have an uncontrolled severity if it does occur (Carter and Smith 2006).

6.7 Findings and Conclusion

The study shows that construction is one of the most hazardous industry sectors with many thousands of workers being killed and seriously injured each year all over the world. Construction accidents lead to delay in project completion, increase the expenses and ruin the reputation and reliability of constructors. These incidents have placed it among the industries with unreasonable rates of accidents both permanent and non-permanent disabilities and even fatalities. Falls at construction sites are the leading cause of death and most of these deaths were attributed to falls from roofs, scaffolds, and ladders. Deaths and injuries from falls represent a major, persistent, yet preventable public health problem. The following were identified as barriers to H&S improvement: lack of information sharing across projects, lack of resources on smaller projects such as industry publications, full-time safety department, subjective nature of hazard identification and risk assessment, reliance upon tacit knowledge, lack of standardized approach and undefined structure for tasks and hazards. Not all accidents are preventable since risk is beyond the human intervention and majority of accidents happen when employees disregard safety rules (unsafe acts) and management ignore the presence of unsafe conditions. However, unidentified hazards negate the risk assessment process; risks cannot be assessed and control measures developed and implemented if those involved are not aware of the hazard in the first place.

It can be concluded from the findings that construction accidents lead to delay in project completion, increase the expenses and ruin the reputation and reliability of constructors. Falls at construction sites have been identified as the leading cause of death and most of these deaths were attributed to falls from roofs, scaffolds, and ladders. The findings has also shown that not all accidents are preventable since risk is beyond the human intervention and majority of accidents happen when employees disregard safety rules (unsafe acts) and management ignore the presence of unsafe conditions. However, unidentified hazards negate the risk assessment process; risks cannot be assessed and control measures developed and implemented if those involved are not aware of the hazard in the first place. These accidents can be prevented by identifying the root causes through accident investigation techniques such as modified statistical triangle of accident causation.

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Chapter 7
Research on New-Style Urbanization Model in Hainan Province Under the Background of International Tourism Island

Qiaolin Luan and Shichuan Wei

Abstract Research purpose: This paper discusses on the connotation and basic model of the tourism-oriented new-style urbanization, as well as the selection of urbanization model in Hainan province under the background of international tourism island construction. Research methods: literature method, comparative analysis method, comprehensive analysis method. Research results: The tourism-oriented new-style urbanization is the comprehensive integration of tourism exploitation and regional development and urbanization, which tends to merge in industry and further forms a comprehensive development model of the regional economy and urbanization. The advantages of this model are as follows: to solve the problem of farmer's identity, having no pollution, beautification of the city, in situ urbanization, being conducive to the realization of coordinating urban-rural development. The paper expounds the functional characteristics and development direction and the operation model of "the large and medium-sized urbanization model", "tourism town construction model", "tourism complex model" and " new rural communities tourism model". Conclusion: Tourism-oriented new-type urbanization model had been fully reflected in the processes of urbanization in Hainan Province. It takes on typical characteristics, coinciding with the idea of civilized and ecological city in the 21th Century.

Keywords New-style urbanization · Tourism · Comprehensive development model · Hainan province

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7.1 Introduction

Since first established as a special economic zone 22 years ago, Hainan province has now developed from a backward island in the border area into a prosperous economic zone and has made great achievements in urban development. When the construction of Hainan International Tourism Island was listed as a national strategy in December 2009, Hainan province ushered in new, major historical opportunities and gradually formed the special economic structure dominated by tourism industry and modern service industry. Tourism development was fully integrated with regional development and urbanization and tended to form an industrial unity with the latter two, shaping an integrated development model for urbanization and tourism-led regional economy based on the convergence of pan-tourism industries. In December 2012, the Central Economic Work Conference put forward the important concept of new-type urbanization and emphasized that to achieve the goal of urban development we should first realize the harmony among population, economy, resources and environment; the coordinated development among large, mid and small towns and cities; and the harmonious relations among population aggregation, citizenization and public services. The urban development of Hainan province coincided with new-type urbanization, presenting a paradigm for tourism-led urban development. By studying the relations between tourism and urbanization, the author analyzes the tourism-led model for urbanization and explores a spatial layout for new-type urbanization in Hainan province.

7.2 Connotations of New-Type Urbanization

Urbanization is a comprehensive concept. It includes not only the change in urban and rural population but also the improvement of population quality; not only the change in the ratio of urban population to rural population but also the resulting change in national economic structure; not only the process of labor gathering in cities but also the flow of capital and other production factors into cities; not only the urbanization of villages but also the self-development of towns and cities (The Research Group of Beijing New Dimension Planning Institute 2013). Since the reform and opening-up, we have made remarkable achievements in urbanization whose rapid process has become an important symbol of China's progress. In 2012, the urbanization rate in China reached 52.57 %. However, during the process of urbanization in the past, we single-mindedly sought development speed and scale expansion and ignored many problems. Resource waste, environmental pollution, insufficient public facilities, lack of supporting services, the failure in turning farmers into "citizens" and many other problems were looming large. They not only hindered the further development of China's urbanization but also caused the blowout of social problems. Under such a background, the central government proposed the new-type urbanization strategy to combine the process of urbanization with the remedies to problems left over by past urbanization, so as to put forward more equitable and efficient high-quality urbanization (Hu 2012). The following problems need to be addressed for new-type urbanization.

Citizenization. In recent years, China has witnessed a relatively rapid process of urbanization but a relatively slow speed of “citizenization”. Among the group counted as urban population, there are still 250 million farmer workers who cannot enjoy equal treatment in public services as urban citizens. In addition, there are 70 million flowing population in between towns and cities who are also treated differently in public services. The new-type urbanization must well address the issue of changing “farmers” into “citizens”.

Overall Urban-rural Development. Due to the rapid development of urbanization, much attention is paid to cities while villages are to some extent neglected; besides, city and countryside are usually governed under two different sets of regulations. How to address these problems and promote the scientific development of rural economy and society is a major task faced by the overall urban-rural development. The new-type urbanization should focus on cracking the problem of dual structure within cities, boosting domestic demand, and increasing job opportunities.

Urbanization Problems under Ecological Civilization. Since the reform and opening-up, there have emerged many problems such as serious environmental pollution and ecosystem degradation in industry-based urbanization. Since the Sixteenth National Congress of the Communist Party of China, ecological civilization has become a government priority under the guidance of scientific outlook on development. The Eighteenth National Congress of the Communist Party of China discussed ecological civilization in an independent chapter for the first time and stressed the prominent position of ecological civilization.

Problem of In Situ Urbanization. Different from unordered sprawling, urbanization is an active and steady process that promotes a more reasonable urban system of large cities, small towns and new rural communities. To promote new-type urbanization we need to promote agricultural industry and rural economy, increase farmers’ income, improve rural infrastructure, develop rural social undertakings and deal with other problems related to “agriculture, farmer, and rural area”.

7.3 The Internal Relationship Between Tourism Development and Urbanization

With the steady progress in constructing international tourism island, the tourism industry has now become a pillar industry in Hainan province, accompanied by booming pan-tourism industry clusters, thus directly contributing to the process of urbanization. Of the three industrial structures in Hainan province in 2012, tertiary industry took up 47 %; tourism industry had been fully integrated with the process of regional development and urbanization and tended to form an industrial unity with the latter two, shaping the integrated development mode for the urbanization process and the tourism-led regional economy based on the convergence of the pan-tourism industry (Dai 2013). Tourism displays prominent advantages in boosting consumption, promoting industrial development, enhancing values and increasing ecological effect and happiness value effect. These advantages determine the important role of tourism in providing efficient solutions to the overall urban-rural development, ecological environment problems, employment issues and other social problems. Its "new" and "efficient" solutions are mainly manifested in the following aspects.

Firstly, farmers' identity problem is solved (Dai 2013). The tourism-led urbanization is premised on tourism transport, tourist gatherings, and tourist consumption. Leisure consumption centers formed by tourist gatherings promote farmers in tourist areas to change their identities from pure farmers to service workers, processers, or service workers coupled with farmers, processers coupled with farmers, or other multiple industrial identities, and meanwhile increase their incomes.

Secondly, pollution-free urbanization beautifies cities to some extent. With the acceleration of industry-based urbanization, energy and mineral resource consumption speeds up, bringing about serious environmental pollution. The industry-based urbanization that entails environmental pollution and high resource consumption is unfit for the direction of future development. On the contrary, tourism industry is a low-pollution and low-energy industry whose development will inevitably improve and beautify the environment. Therefore, the new tourism-led urbanization satisfies the state's requirements for ecological civilization.

Thirdly, in situ urbanization. Tourist attractions, generally located in suburbs or remote areas, do not necessarily rely on the downtowns for gathering. Some rely on central towns, some on small towns and some on villages. Therefore, where there are people gathering and leaving, there are hubs for crowd gathering, consumption concentration, service aggregation and the identity conversion from farmers to high-income non-agricultural workers. The elements of the tourism industry extend to drive the development of the pan-tourism industry, forming the industry convergence and industrial clustering. The industrial clustering brings people together, making the industrial area home to native urban residents, farmer-turned residents, industrial workers, incoming tourists, residents coming for leisure living (the second home) and residents coming for vacation, and thus building an industry-backed foundation for urbanization. In addition, the demand for tourist service facilities and the concentration of consumption propel the construction of tourist supporting infrastructure and a complete social system and promote the development of in situ urbanization.

Fourthly, conducive to the overall urban-rural development. Tourism is closely associated with "transport". By transporting tourists and their spending power, the tourism industry forms consumption gathering, people crowding, industrial clustering and thus land concentration. As a result, farmers get liberated from the primary industry and become able to engage in the production of second or tertiary industry to raise their income and change their identity. The development of tourism industry greatly boosts the construction of basic infrastructure and public service facilities, which synchronizes with the development of urbanization, reduces costs, beautifies cities and improves the livelihood of residents (Wu 2008). On this basis, cities and villages achieve an overall development by relying on the tourism industry.

7.4 New Urbanization Model Led by Tourism

The new tourism-led urbanization model is, on the basis of the bearing capacity of regional resources and environment, to make overall planning, protect and utilize the unique advantageous resources of urban-rural space (Wei 2001), to achieve an integrated development for the tourism-led regional economy based on the convergence of the pan-tourism industry and the urbanization process, to promote the distinctive, networked, multi-node, and penetrable "regional complex" in region, and to form the spatial pattern for the tourism-led coordinated urban-rural development. The new tourism-led urbanization consists of four main aspects, namely, the expansion and upgrading of modern large cities, the characteristic development of small and medium-sized towns, the tourism complex model, and the construction of new village communities. These four aspects have different models and mechanisms.

7.4.1 The Urbanization Model of Large and Medium-Sized Cities and Towns

The so-called large and medium-sized cities and towns mentioned in this paper refer to super-large, large and medium-sized cities with a population of 500,000 people or more, which themselves enjoy a large group of tourists and most of which are tourism destinations. The construction of tourist attractions will greatly enhance the city's brand and increase the development space for the urban service industry. The development of large and medium-sized cities driven by tourism mainly include five man approaches, namely, the development of urban tourist attractions, the development of new-style recreational business districts, the transformation of old towns into recreational streets, the construction of different leisure satellite towns, and the overall planning and development of ring-road touring belts.

The development of urban tourist attractions is to build core attractions of large cities as tourist destinations by relying on the unique tourism resources of these cities, focusing on constructing tourist attractions and increasing the appeal of urban scenic spots (Zhang et al. 2011). The development of urban tourist attractions is always the basis of urban tourism. Whether the scenic spots are located inside or outside towns, the more appealing they are, the more driving force the tourism industry will provide for urban development.

Recreational business district (RBD), is an indispensable hub for recreation and gathering in large and medium-sized cities and the core of city brand and urban charm. There are a variety of recreational centers in cities. Some are more about recreation and shopping, some more about recreation and business, some more about recreation and entertainment. Some have developed into a comprehensive leisure district that integrates shopping, business, recreation, entertainment and catering. Recreational centers and districts in Sanya and Haikou have seen some initial success. In the construction of new towns, the best mode for the large-scale development of new towns and cities is to build recreational business districts on large centralized land.

The construction of different recreational satellite towns is an important approach for the tourism-led development of large cities. Unique leisure satellite towns, be they based on large recreational satellite complex, large theme parks, large-scale sports facilities, large exhibitions venues, institutions and facilities for health keeping and elderly enjoyment, etc., can always promote the satellite towns' development through unique clustering. For example, the Central Shopping District (CSD), planned and built in Beijing Liangxiang Satellite Town located in the Changyang county of Fangshan District, is a newly-build clustering center for recreation and entertainment, including a high-end business district, fashion and leisure district, CSD district, and cultural and creative district.

The ring-road touring belt is a development model for the overall urban-rural planning. Within a one-hour drive's radius of the city, there can form a leisure belt whose development are supported by satellite towns, small towns, tourist areas, or villages. This belt will turn into an integral part of garden cities in the future, the most distinctive part of new-type urbanization and the highlights of tourist cities.

Judging from the overall architecture of urban development, the tourist development of large and medium-sized cities has formed a systematic development structure consisting of urban recreational center, urban recreational street, recreational satellite town, and ring-road touring belt, on the basis of old town transformation, new town construction, overall urban-rural planning, and city-industry integrated development. Old towns are transformed into recreational districts, new towns are built with recreational districts, and the sprawling cities have turned into garden cities with high green coverage rate and many recreational districts (Liu 2013). Among them, the development of recreational satellite towns and ring-road touring belts propels the migration of residents out from the downtown, which coincides with the transformation of old towns and the formation of new districts. Then through urban greening and environmental preservation, garden cities and towns take shape. This is not only an approach to achieve the internal enhancement and external expansion of large and medium-sized cities, but also the best path to upgrading large cities.

7.4.2 The Construction Model of Tourist Cities and Towns

Small prefecture-level cities, county towns, and designated towns, show less driving force than large and medium-sized cities but are more likely to form distinct theme features, suitable to take the road of characteristic tourism-led urbanization. This is the most important model of tourism-led urbanization in China.

For medium-sized and small towns with rich tourist resources, we can rely on the natural resources to realize characteristic tourism development and develop coastal towns, riverside towns, lakeside towns, winter resort towns, summer resort towns, spa towns, ski towns and other characteristic towns; we can rely on the cultural resources to build famous cultural towns and cities, leisure old towns and cities, ethnic customs towns, art towns, craft towns, creative cultural towns, trading and shopping towns and movie towns etc.; we can rely on the tourist attractions to create all kinds of reception towns and take advantage of the pan-tourism extension of scenic spots to build exhibition towns, sports towns, and leisure agriculture towns (tropical botanical gardens, tropical agricultural sightseeing) etc.; we can also depend on special resources, unique industries, characteristic wholesale markets and other features to build wine towns, jade towns, and furniture towns. The clustering development of the pan-tourism industry increases the possibility of forging characteristic tourist towns and opens up an all-new path to urbanization through the integration of characteristic tourism and characteristic industries. All can become the core of attraction. Coupled with tourism development, any place that has special resources or advantageous industries can become a pan-tourism town.

For some small towns with less appealing qualities, we should tap potential resources to develop tourism products, seek opportunities for the development of the pan-tourism industry, and promote the tourism-oriented urbanization (Peng and Yang 2010). Not all urbanization needs to be carried out with tourism development, but to some extent all urbanization should make good use of tourism-oriented approaches to achieve better results of urbanization.

7.4.3 The Tourism Complex Model

As a special form of new-type urbanization, a tourism complex is neither a traditional tourist attraction nor a pure residential community. Moreover, it doesn't fall into the categories of designated town and new-type rural community as well. Rather, it is a land parcel (a suburb area, a rural area, or the surrounding area of a large scenic spot) with certain tourism resources and land space in between a city and a village. This land relies on good transportation conditions and avails of the "transport effect" of tourism to move urban spending power to the land parcel, thus giving impetus to the integrated development of this land. In this way, this land parcel will realize the clustering of the pan-tourism industry, the gathering of tourist population, and the development of relevant supporting facilities and thus form new tourism-oriented settlements.

Tourism complex, which is fundamentally supported by the integration of the pan-tourism industry and primarily driven by the gathering of recreational consumption, can't work properly without amenities and supporting facilities as well as innovative services and management. Now it has already become the mainstream model for "in situ urbanization" in feasible areas.

7.4.4 The Model of New Tourism Rural Community

This is one of the most popular models for tourism-led in situ urbanization. The main path of this model, based on the bigger context of urban-rural integration, centering on forging agriculture-tourism industry chain, oriented towards rural tourism and leisure vacation, featured by countryside sightseeing and relaxation, supported by rural commercial and recreational real estate, and aimed at rural garden lifestyle, is to transform and upgrade independent villages into integrated tourism communities through land integration, introduction of city infrastructure, presentation of cultural features and settlement of the employed farmers.

For the construction of new rural villages, the tourism industry plays a very good role in promoting industrial value. While helping farmers to find resources for industrial transformation, the tourism industry transfers resources for livelihood into resources for production, promote industrial development locally and help form the new rural community model for the integrated development of tourism, agriculture and residence.

7.4.5 Comparative Analysis of the Four Development Modes

Through the analysis above, it can be found there are distinctions among the four new urbanization models led by tourism, which makes models be chosen and enforced according to certain circumstances. The development of large and medium-sized cities driven by tourism mainly includes five main approaches, namely, the development of urban tourist attractions, the development of new-style recreational business districts, the transformation of old towns into recreational streets, the construction of different leisure satellite towns, and the overall planning and development of ring-road touring belts. Small prefecture-level cities, county towns, and designated towns, are more likely to form distinct theme features, suitable to take the road of characteristic tourism-led urbanization. The tourism complex model, relies on good transportation conditions and avails of the "transport effect" of tourism to move urban spending power to the land parcel, thus gives impetus to the integrated development of this land. In this way, this land parcel will realize the clustering of the pan-tourism industry, the gathering of tourist population, and the development of relevant supporting facilities and thus form new tourism-oriented settlements. The model of new tourism rural community, helps farmers to find resources for industrial transformation, transferring resources for livelihood into resources for production, and therefore promotes industrial development locally and help form the new rural community model for the integrated development of tourism, agriculture and residence.

7.5 The New Tourism-Led Urbanization Model in Hainan Province

Along with the advancement of international tourism island, Hainan province has gradually developed the new four-tiered urban pattern consisting of provincial central cities, regional central cities, county towns and central towns; promoted the construction of tourist resorts, fostered the central residential areas of small towns and villages; established the "quad-core, multi-center and networked" urban-rural spatial pattern; and formed the modern urban-rural system with "unique features, collective development, integrated functions and ecological civilization".

7.5.1 Large and Medium-Sized Tourist Cities and Tourist Central Cities

Haikou, Sanya, Danzhou-Yangpu and Qionghai-Boao—the four major central cities and tourist centers, have gradually taken shape with prominent scale effect, showing the functions of "core competitiveness" in the North, South, East and West of the province (Fig. 7.1). These central cities show relatively high bearing capability and versatility, have relatively high demand for travelling and recreation and stimulate the development of neighboring regions. These cities not only send out but also receive tourists and consumers and by virtue of its demand for recreation, entertainment, vacation and living have developed the pan-tourism industry as the backup and driven the development of nearby small towns, thus promoting the overall urban-rural planning and development.

Haikou will be constructed into one of the major regional central cities in southern China and a central city of Beibu Gulf Rim and Hainan International Tourism Island. The recreational business district, exhibition district, and recreational shopping street, as the main carriers of urban culture, embrace ecological, landscape and recreational features and can increase the appeal of the city as a tourist destination. Sanya will be developed into a world famous and Asia's leading international tropical seaside landscape tourist city and the south service hub of Hainan International Tourism Island. Danzhou and Yangpu District will be developed together into a complex center that gives impetus to the development of

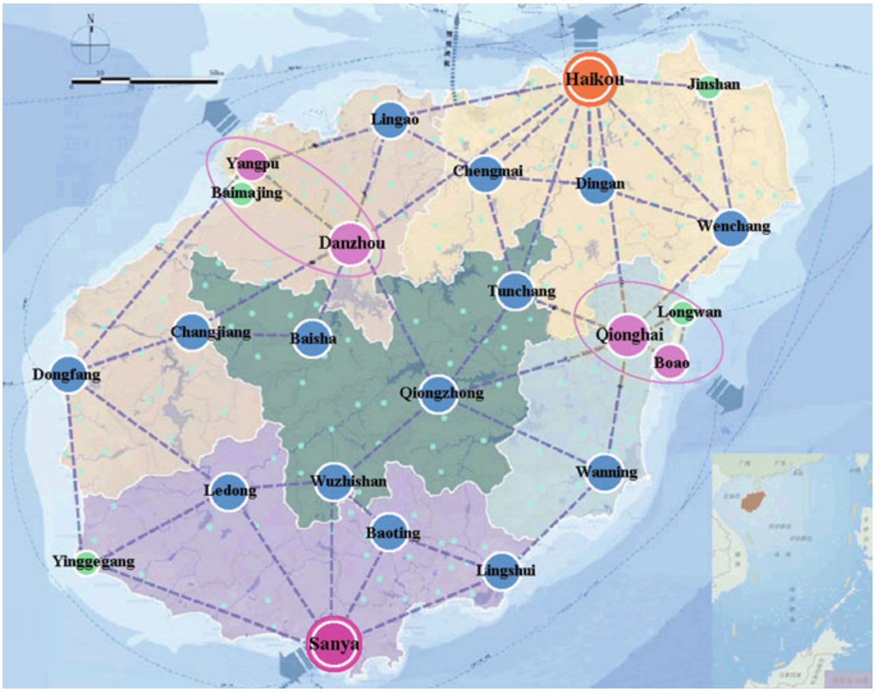

Fig. 7.1 “North-south-east-west” model of large and medium-sized tourism Hub City

western Hainan and functions as Hainan’s new industrial center, resource and energy base, foreign trade hub, western trading center, and modern manufacturing center, etc. Qionghai-Boao will be developed together to construct the complex center that gives impetus to the development of eastern Hainan and functions as Hainan international conference and exhibition center, high-end commercial business center, leisure tourism center in eastern Hainan, forming the tourist central city of eastern Hainan.

7.5.2 Characteristic Leisure Tourist Town

Satellite towns and central towns, at the same level in urban system, are peripheral independent cities closely associated with large cities. The rapid process of urbanization in China has brought about great development opportunities for satellite towns and central towns in the urban system. Due to their advantages in geography, market and resources, satellite towns and central towns close to large cities have become the prime choice for weekend recreation or holiday vacation of urban residents who enjoy a higher rate of travelling.

To build characteristic tourist towns, we need to Accelerate the development of Wencang, Wanning, Wuzhishan, Dongfang District and other 13 towns to make them important nodes and tourist service centers of modern Hainan urban-rural system; build 183 designated towns and construct central towns with distinct features and strong industrial support, promote the development of special industries and absorb local surplus rural labor force; and focus on building 55 tourist towns with rich ethnic customs, beautiful environment and prominent features.

7.5.3 *New Rural Tourist Community (an Integrated Community for Agriculture, Living and Tourism)*

The tourism development of new rural communities and suburbs of large cities is an effective way to the in situ urbanization of villages. The tourism-based villages, especially tourist reception villages, can turn means of livelihood to means of production, for villagers can use their own houses to engage in tourism industry and hence change their identity from farmers to citizens, shift their occupation from agricultural industry to service industry, and eventually change villages into town communities. Through tourism-oriented land integration, introduction of urban infrastructure, presentation of cultural features, and settlement of the unemployed, we can transform and upgrade in-city villages, suburbs of large cities and independent villages, encourage the concentrated layout and construction of villages, build high-quality modern central village communities and special villages, intensively develop 600 central village communities, implement the "Village for Tourism" plan, and build 1000 special tourist villages, so as to make them the basic support for the integration of ecology, civilization, village and city in Hainan.

7.6 Conclusion

The tourism-oriented new-style urbanization is the comprehensive integration of tourism exploitation and regional development and urbanization, which tends to merge in industry and further forms a comprehensive development model of the regional economy and urbanization. The tourism-oriented urbanization is one of the major means of urbanization, according with the concept of ecological and sustainable development. Its contributions are reflected in four aspects: having no pollution and beautifying the city, leading to in situ urbanization, being conducive to the realization of coordinating urban-rural development, and solving the problem of farmer's identity. There are four main tourism-oriented urbanization models: the expansion and upgrading of modern large cities, the characteristic development of small and medium-sized towns, the tourism complex model, and the construction of new village communities. Generally speaking, analyzing the applicable conditions of the four tourism-oriented urbanization, based on the actual situation of cities in Hainan province, this paper proposed the basic conception of Hainan tourism-oriented urbanization. Hainan province has gradually developed the new four-tiered urban pattern consisting of provincial central cities, regional central cities, county towns and central towns; promoted the construction of tourist resorts, fostered the central residential areas of small towns and villages; established the "quad-core, multi-center and networked" urban-rural spatial pattern; and formed the modern urban-rural system with "unique features, collective development, integrated functions and ecological civilization".

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Chapter 8
Review and Prospects of Research on Tourism Urbanization

Shichuan Wei and Dan Cui

Abstract Through a general survey of the urbanization development in the world, it can be seen that urbanization dominated by industrial advance has now developed to a stage where it is promoted in multiple ways, in which tourism urbanization has attracted great attention. In this paper, methods of documentation and induction are adopted to make a systemic analysis and an in-depth summary of relevant research on tourism urbanization, finding that the existing researches involve the definition and categorization, the dynamic mechanism, the development mode and strategic countermeasures of tourism urbanization. Deficiencies include: study on dynamic mechanism has been limited to qualitative research, lacking quantitative research, especially measuring models corresponding with various development modes; the existing research mainly focuses on a single city, with few from the aspect of regional coordinated development. Finally, it is presented how the research on tourism urbanization will develop in the aspects of regional coordinative development, tourist village and town construction and quantitative study and so on.

Keywords Urbanization · Tourism urbanization · New urbanization · Regional coordinative development

8.1 Introduction

The industrial revolution triggered the industry driven urbanization in human society. After World War II, industrialization and urbanization began to develop in the whole world, and global urbanization was driven forward at an unprecedented rate. There have been mountains of research results on industrial urbanization, and

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it is widely believed that industrialization is the impetus for urbanization development (Qiu 2003; Jiang 2004; Sun 2008; Zhu and Gong 2010), which is the engine and accelerator of urbanization. With the coming of post-industrialization era and the emergence of postmodern views on consumption and cities, people have an increasing need for high quality life and urban recreation, and tourism gradually becomes a driving force of great importance in economy, the development of which plays a vital role in promoting the progress of urbanization. The studies and practices of tourism urbanization are just unfolding and on the rising, and have drawn wide attention from international academic circles and urban construction authorities (Gladstone 1998; Gu and Chai 1999; Lu 2005; Wang and Song 2009; Lin 2013). Among these, the most remarkable event shall be the "Tourism Driven Urbanization Forum" held at China National Convention Center in Beijing in July 2013, during which wide-ranging and in-depth discussion has been made on how the tourism driven urbanization in China shall develop, facing the strategic opportunity of "new urbanization" carried out in China in this new period.

Tourism urbanization has become one of the important patterns of urbanization (Huang and Ke 2001; Wu 2013), and is a low-carbon, ecological and sustainable path adoptable in urbanization. This paper uses the methods of documentation and induction, to make a systemic analysis and in-depth summary of relevant research on tourism urbanization, so as to enrich the theoretical studies of tourism urbanization development and to provide a reference for the practice of new urbanization.

8.2 The Concept of Tourism Urbanization

With regard to the concept of tourism urbanization, there is a viewpoint that it refers to an urbanization phenomenon triggered by the expansion of tourism to cities (urban tourism). The Australian scholar Mullins (1991) holds that tourism urbanization is a new and unique urbanization emerging during the second half of the 20th century, formed from a single consumption function (tourism consumption function), which is a pattern of urbanization based on the sale and consumption of goods and services for pleasure. Zhu and Jia (2006) argue that tourism urbanization is not just a result of urban development driven by tourism, but more of a dynamic development tendency and evolution process. It includes (1) tourism urbanization is a dynamic development process, during which tourism is centralized in urban areas, the tourist function of urban areas is intensifying and the scale of urban tourism is expanding; (2) tourism urbanization is the change of urban areas' role in tourism, and a process during which urban areas transform from a pure tourist destination to a complex of the tourist source place and destination; (3) tourism urbanization is also a dynamic process of the improvement of the urbanization level driven by tourism. Wu (2001) holds that a tourist flow counter to the ecological tourist flow to escape from urban areas has been formed, as tourists prefer the diversified opportunities to travel and relax in urban areas, and this trend of tourism is called "urbanized tourism".

The second viewpoint is that tourist urbanization is a process of tourism development promoting the development of cities and towns. Lu (2005) holds that from the perspective of urbanization, tourism urbanization refers to the process of population concentration towards urban areas, which is led by tourism as a driving force. From the perspective of consumption, tourism urbanization refers to the process of improving urban functions to meet the transition of people's consumption from traditional living consumption to modern recreational consumption. The urbanization process triggered by tourism as an important component of modern tourism consumption is a new pattern of urbanization. Huang et al. (2000) argue that tourism urbanization is the phenomenon that as rural population gravitates towards urban areas, the tourist cities are constantly increased in number, enlarged in scale and improved in the level of modernization, and thus cities gradually play a bigger role in tourist activities. Wang and Yan (2003) hold that the development of tourism drives the factors of productivity such as population, capital and material to flow and gather in tourist areas, thus promoting the constant progress and expansion of urban areas. This process is tourism urbanization, and it consists of two parts, which are the increase of city scale and the improvement of city quality. Qiu (2005) points out that based on the consumption of cultural difference, tourism resources (tourist destination) as the gravity field attract tourists to form a temporary tourist flow. In this way, urban elements related to tourist destinations are driven to gather and accumulate in circulation. This phenomenon is regarded as tourism urbanization, or we can say that tourism is the major impetus for this urbanization. Lin (2013) holds that tourism urbanization is the urbanization process directly driven by the consumption concentration resulting from tourism, with generalized tourism industry clusters driven by tourism as its industrial foundation.

The third viewpoint integrates the two mentioned above. Wang and Song (2009) holds that tourism urbanization is a type of urbanization, a process in which promoted by the development of tourism as a driving force, population and industries gather in tourist destinations and cities and towns are expanded and restructured in space. Wu (2013) considers tourism urbanization is one of the many paths to the development of new urbanization. It is a process during which driven by the development of tourism, the factors of productivity such as production, capital and material flow towards and concentrate in tourist areas, thus stimulating continuous progress and expansion of urban areas. It will enlarge the scale of urban areas and improve the quality of the urban areas, while gradually enhancing the role that urban areas play in tourism activities.

8.3 The Promotion Mechanism Between Tourism Industry Development and Urbanization

There are an emerging number of research findings on the promotion mechanism between the development of the tourism industry and urbanization. (Wei 2001; Wu 2008; Wang and Song 2009) Xu (2005) argues that urban areas and tourism are in a dynamic process of development, not only to promote but also to constrain each other, and this is manifested as the non-linear features and multiple modes in behavior. The role of the tourism industry in the development of new urbanization mainly shows in[1]: (1) leading the featured development of urban areas, activating urban culture and manifesting urban features; (2) guiding the human oriented development of urban areas, improving the urban functions and services; (3) leading the urban areas to develop in a differentiated way, enhancing their attraction and grade; (4) leading the ecological development of urban areas, building ecological civilization and beautiful cities; (5) leading the international development of urban areas, keeping in line with international criteria and cultivating international brands. The effect of tourism on urbanization mainly lies in 5 aspects: (Beijing New Dimension Planning and Design Institute Project Team 2013; Gu 2013) (see Footnote : First, it boosts employment. As a labor intensive industry, tourism is featured by rather high employment elasticity, and its development can promote the development of many relevant industries, create a great number of jobs and provide an effective solution to the problem of employment in urban areas. Second, it promotes local urbanization. Tourism can provide jobs for farmers, to enable them to work in their hometown; promote the change of agricultural production mode from pure production of agricultural products to the integration of production and processing; change the farmers' standing at work; increase farmers' income and promote the change of farmers' living styles, to make them gradually urbanized. Third, it has an industrial promoting effect. Tourism industry is highly comprehensive and of great relevance to other industries, with a long industrial chain. It has made a significant breakthrough out of the range of traditional tourism, involving extensively many relevant trades and industries, intermingled with them and penetrating into them to form a generalized tourist industry cluster. Fourth, it has an effect on investment and consumption. Last, it is a green and low-carbon industry. The tourist resources can be used repeatedly once developed, and the tourism industry has the advantages of "low consumption of resources, causing less pollution to the environment". As a typical Smokeless Industry, it will reduce the resource consumption and environmental pollution of urban areas.

[1]Seize the opportunity of New Ubanization and explore the way of Tourism Urbanization—summary of views presented by guests at Tourism Driven Urbanization Forum. China Tourism News, Issue 2013, 7, 31:017.

8.4 The Development Mode, Countermeasures and Cases of Tourism Urbanization

There have also been an increasing number of research findings on the development mode, strategic countermeasures and cases of tourism urbanization in recent years. Sheng (see Footnote 1) proposes the 8 models of tourism urbanization based on specific industries, including the urbanization models through the development of leisure agriculture, cultural and creative industries, tourist attractions, theme resorts, historical, cultural and ethnic customs, festival, special events and conferences and theme commerce. Beijing New Dimension Planning and Design Institute Project Team (2013) makes a segmentation in terms of the hierarchical improvement and construction of urban architecture, and presents that the tourism-driven new urbanization model consists of the expansion and upgrade of the existing large cities, the characteristics development of small cities and towns, the development of the project for the integration of industrial, urban and ecological functions, and unincorporated tourism urbanization and new rural community construction. In the aspect of strategic countermeasures for tourism urbanization development, Gu (2013) suggests improving policy system for the development of tourism and strengthening the cohesion with urbanization development planning; enhancing industrial integration, striving to develop new formats of tourism and promoting the green and low-carbon development of urbanization; vigorously stimulating tourism consumption and letting urbanization play its strategic role in expanding domestic demand; strengthening the construction of tourism infrastructure and enhancing the population aggregation function of urban areas; improving the cultivation of talents in tourism, properly guiding labor force to flow towards the tourist industry to provide an effective solution to the problem of employment in the process of urbanization; studying and implementing the Tourist Law of the People's Republic of China to further standardize the market order. Bao (2012) argues that the strategy for medium-sized cities is to vigorously develop the core elements of tourism and some leading-edge and distinctive city functions, on basis of certain themes and features, so as to promote the transformation and upgrading of urban tourism as a whole. Wu (2013) points out that in the process of tourism-driven urbanization, the government should strengthen the reform of the planning system; in planning legislation, improve the existing laws for resources by making supplements; in the meantime, fulfill its responsibilities in the functional planning for tourism. Few case studies have been made on tourism-driven urbanization. Huang et al. (2003) have taken Jiangsu province as a subject to analyze the multi-coupling relationship between the tourism destination system and regional urban system in terms of element, structure and function. Moreover, through the analysis of the spatial structure of urban system and functional structure of urban tourism, in combination with the characteristics of tourism industry, they classified cities into three grades: central tourist cities, tourist cities, featured tourist towns or tourism resorts; Wu (2008) has taken the Yangtze River Delta for example, to analyze the tendency of regional tourism development, including regional tourism urbanization, urban tourism regionalization and the interactive development of tourism in the core cities within a region and so on; Yuan et al. (2013) have made a case study of Chongqing, to investigate the layout of urban and rural leisure space by using the core-radiation method. Beijing New Dimension Planning and Design Institute Project Team (2013) have carried out research and practical work on the tourism urbanization in Kunyu and Pu'er of Yunnan and Yiwu of Zhejiang, in terms of distinctive regional cultures, building of leisure cities and the integration and development of urban tourism.

8.5 Research Commentary

To sum up, the research on tourism urbanization at home and abroad is mainly concentrated in the following three aspects:

1. The definition and categorization of tourism urbanization. There are three major viewpoints with regard to the concept of tourism urbanization: it refers to an urbanization phenomenon triggered by the expansion of tourism to cities (urban tourism); it is a process of tourism development promoting the development of cities and towns; it is a type of urbanization, a process in which promoted by the development of tourism as a driving force, population and industries gather in tourist destinations and cities and towns are expanded and restructured in space.
2. Research on the dynamic mechanism of tourism urbanization. It is argued that urban areas and tourism are in a dynamic process of development, not only to promote but also to constrain each other, and this is manifested as the non-linear features and multiple modes in behavior. Moreover, the unique tourism resources, cultural charm, and modern transportation network has significantly promoted the development of Tourism, which has in turn boosted the city expansion, city quality improvement and city grade sublimation.
3. Development mode and strategic countermeasures of tourism urbanization. Development mode of tourism urbanization mainly focused on two aspect: development supported by specific industries; development based on reconstruction and expansion of the existing urban, including the expansion and upgrade of the existing large cities, the characteristic development of small cities and towns, the development of the project for the integration of industrial, urban and ecological functions, and unincorporated tourism urbanization and new rural community construction. Furthermore, strengthening the reform of the planning system, perfecting Tourism policy system, and intensifying the tourism infrastructure are there chief development strategies.

However, there are weak aspects of the existing research: study on dynamic mechanism of development has been limited to qualitative research, lacking quantitative research; the existing research mainly focuses on the planning, design and dynamic mechanism of tourist development in a single city, with few from the aspect of regional coordinated development. Considering such insufficiency, further research will be carried out in the following two aspects:

1. Quantitative and empirical research on dynamic mechanism of tourism urbanization. Future research should be based on qualitative study and focus on carrying out quantitative study on the dynamic mechanism, development scale and radiation range of tourism urbanization in terms of tourist resource types, tourist resource quantity and grade, tourist resource spatial distribution, spatial distance, traffic condition, the number and preference of tourists and so on.
2. Research on regional coordinative development of tourism urbanization. It is an important subject of the research on regional tourism urbanization how tourist cities and towns highlight their characteristics and develop their Uniqueness, while complementing each other with advantages and realizing joint development, to form an organic whole with their own features.

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Chapter 9
Gap Analysis of Pune City's Urban Infrastructure—Issues in Sustaining the Sprawl

Mona N. Shah and Shekhar Nagargoje

Abstract In 2008, Pune became the seventh metro (mega) city of India, based on a study carried out on eight parameters namely social infrastructure, infrastructure availability, real estate cost and availability, transportation facility (connectivity), presence of quality educational institutes, employment opportunity, facility of financial services and business environment (Assocham, Report: the 7th emerging metro city in India, 2008). Pune has high literacy rates of 80.73 %, skilled population, seven universities, huge clusters of automobile and manufacturing, IT, biotechnology, and establishments. Prominent industrial bases and corporate headquarters are located in Pune. The most critical and important public and governmental establishments, factories, defence, research and development etc. are present in this city. Problems of Pune city are numerous in providing for social and physical infrastructure. Using the Gap Analysis technique, the paper looks at the existing gaps in the provision of key urban services in the peripheral areas of the sprawl.

Keywords Sustainable · Urbanisation · Urban infrastructure · Gap analysis

9.1 Rationale and Growth of Cities

Following the 1800s, cities began, being viewed with predominantly two perspectives. The first, the systems' view, of cities as aggregators of optimisation, (man, capital, entrepreneurship), and another as open-ended processes, subject to gradual evolution (Bettencourt and Luis 2008). As early as 1915, Geddes spoke of

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world cities like London, Tokyo and New York and Paris that could be faced with great social inequalities that would threaten their existence but avoid the predicament by improved “civic efficiency” (Geddes 1915). World cities had political power, were places of national and international government; epicentres of trade, finance and communication; and attracted talents in education, research, arts and culture (Clark 1996). Cities are the central attraction for human, economic and environmental capital, therefore sustainability and urban resilience tend to centre upon issues of round spatial uses, civic amenities, technology, demographic growth and the force that arbitrates and guides all the rest, namely governance.

The boundaries of governance can be expanded by the presence of a vibrant civil society, which acts as a ‘checks and balance mechanism’ and at the same time, contributes in innovation and commitment to the city’s future. Ng and Hills (2003) described this as a three-way partnership among public, private and civil society. Cities gain from the spatial economies of scale with their growth as productivity gains accrue to the city. Larger cities in a comparable system are denser and volume of per capita infrastructure networks is smaller. Cities are wealthier, more expensive but productive culturally and technologically in terms of creative endeavours and concentrated pools of innovation. Bettencourt and Luis (2008), views cities as (a) measurable entities in which social networks mix, based on cost of transportation of information, goods and people (b) decentralised infrastructure networks that are built gradually over a period of time, (c) become dense due to institutions and people in closer contact.

The physical components in a city comprise of physical resources and planned processes that are within the city’s bounds and control with the outside interactive elements (Pickett et al. 2001). The above are manmade elements. Other elements refer to the social elements comprising of people, institutions and activities. Urbanization has played an important role in the development and modernization of underdeveloped and developing countries, and increasing attention has been paid to cities and urbanization by scientists and policy makers over the last several decades (Hope 1986; Zhang and Song 2003; Siciliano 2012). Rapid urbanization has greatly accelerated economic and social development (De Sherbinin et al. 2007). Many cities in developing countries are experiencing horizontal growth due to factors like in-migration, leading to an outward spread from the traditional city centre. There is great difficulty to keep pace with the ‘sprawled’ expansion and resulted in growing energy costs and overall paucity of urban infrastructure felt by constituents of cities (Edwards 1999). A key characteristic of cities among other things is that of providing cost-effective transportation infrastructure to connect nationally and internationally along with a sound information network (Ciumasu 2013). Moreover, sustainable cities harmonize human growth with natural habitat. This is done by (1) business-friendly and efficient governance systems (2) development of resource management systems and (3) carrying out human accelerator strategy.

9.2 Urban Sprawl

Urban sprawl is a phenomenon mainly driven by population growth and large scale migration. In developing countries like India, where the population exceeds one billion, urban sprawl is taking its toll on the natural resources at an alarming pace. Traditional top-down approach in planning has come under scrutiny on the backdrop of dwindling urban finances (Ogu 2005). In the case of Nigeria, technocratic systems to improve infrastructure do not include the poor and marginalised and cannot build sustainability if addressed only to the middle and high income housing estates and government reservations. Urban planners require information related to the rate of population growth and pattern and extent of sprawl to provide basic amenities such as water, sanitation, electricity, etc. In the absence of such information, most of the new sprawl areas lack basic infrastructure facilities. In case of India, urban management issues have been influenced by India's commitment to liberalisation and globalisation that have dictated spatial changes, review of prevailing zoning, building bye laws (floor area ratio and density), development control regulations, urban housing and transport (Chadchan and Shankar 2012).

In Asia in a study on urban mobility it was found that the per capita values for sustainability were the highest amongst all the regions in the world. This was attributed to the very high densities of cities in Asia and mixed use spatial patterns. Mixed use development allows easy access to goods and services. Due to this, road infrastructure provision decreases due to reduction in duplication. However, the corresponding indicators on air quality and noise are not as encouraging (Isabel 2008). A study carried out to determine the service provision for water in four large urban cities in the country revealed that service levels in all the cities experienced wide gaps in the demand for and actual supply provided by the local governments. The primary reason was growing demand and poor infrastructure leading to water losses (Shah and Gottipatti 2011). Cities in developing countries grow at the cost of the peripheral agricultural lands being acquired for different uses. Like China, India is experiencing rapid urbanisation with projected urbanisation reaching close to 60 % by 2030 from its current 32 % (Report, Census 2011). This presents doubts about the sustainability of these rapidly growing cities. The speed and the quality of urbanisation are equally important (Shen 2014).

9.3 Spatial Uses of Land and Planning Aspects in Indian Cities

The sustenance of cities greatly hinge upon the interplay of land and its use. Given the scarcity of this resource in urban contexts city managers, planners and architects must scrupulously consider all aspects of effective land use, and the built environment that would be adequate to address the current and future needs of a city's population. Horizontal city growth entails expanding into peripheral land parcels that may be mostly agrarian or forest lands. In developing countries especially in stage two of development (Report 2012) where rapid urbanisation is taking place and agricultural exports are high, rapid deforestation takes place at higher rates. To create sustainable and resilient cities it is necessary to operationalise many elements that include all geo-spatial planning, ICT, mainstreaming public and private infrastructure, limiting urban sprawl by creating mid-size cities (Colliers et al. 2013). The newly acquired land requires establishing civic infrastructure systems to support settlements in this augmented area which are susceptible to deficit of infrastructure. Lack of funds in developing countries results in severe shortages of provision of technical networks (Ling and Phua 2007) or also termed as physical infrastructure services. A 'malleable design and planning framework that is symbiotic in nature with respect to the urban and non-urban elements and readdress land use, infrastructure, energy, health and food supply are needed (Knight and Riggs 2010). Planners recommend a cellular design of urbanism that is based on reduction in parking and commuting for almost all purposes (Haahs 2011). In India, city development plans do not get passed diligently resulting in ad hoc land use changes by city managers. Consequently short term priorities take precedence over planned long term development of the urban area. Scarce urban land tends to get allocated exclusively for certain projects, leaving less space for public infrastructure such as gardens, parks, eco-habitat preserves within the cities. Such a system is also vulnerable to other malpractices leading to increasing the social inequalities and marginalisation of the less resourced.

9.4 Urban Infrastructure (Technical Networks/Urban Services)

Technical networks and urban services that support urban development viz. drinking water supply, waste management, energy and power, telecom, public transportation, need effective integration and collaboration (Toubin 2014). Interdependencies amongst these enable urban areas to develop sustainability and resilience. Judged on the parameters of resilience like (a) Number of impacted clients; (b) Surface of the impacted area; (c) Number of days of service interruption; (d) Cost of damages; (e) uninterrupted supply of services, very few cities in India would qualify. Modern technical networks need to be robust to combat vulnerability of any kind, natural or manmade (Agarwal et al. 2014).

As Pune expands in an outwardly direction, underlying villages are incorporated into the municipal limits through prescribed political processes. The actual inclusion takes decades to ratify, while the 'centrifugal' forces of development overtake constitutional processes. Construction of housing precedes infrastructural services in these areas. There is a resulting huge burden on existing city infrastructure. In reality though, the high degree of pressure of affordable housing units, drives the private players to negotiate directly with the farmers and acquire land parcels for development. The land use change formalities are subsequently executed by city managements (Shah 2012).

9.5 Background of Pune City

Pune has been a historically significant city, but since the 1950s has transformed into an industrial and defence establishment, education and software hub, and has consequently witnessed a significant in-migration from rural hinterlands as well as other parts of the country. Rapid urban growth and increasing population from a mere 0.48 million in 1951 to 3.1 million in 2011, this growth has resulted in environmental degradation of the city and resulted in considerable strain on the city's infrastructure.

9.6 Regional Setting and Demographic Profile of Pune City

In 1987, the urban area of Pune was 138.36 km^2, with an addition of 23 peripheral villages in 2001; the area has increased to 243.84 km^2. The revised City Development Plan addresses the urban area of Pune as a whole (Voyants 2012). The population of Pune city as per Census 2011 is more than 3 million which has grown by more than six times in the last 60 years. Migration per annum, has increased from 3.7 Lakhs in 2001 to 6.6 Lakhs in 2011 (Voyants 2012). The population density has increased from 10405.28 person per sq.km in 2001 to 12,770.25 person per sq.km. Population density especially in the core areas is very high. Pune's rapid socio-economic development has had a significant impact on the urbanization in the city; future growth will be determined to a large extent by the development patterns in the city and Pune Metropolitan Region (PMR). Population projections indicate that the projected population of Pune City to be approximately 5 million in 2030 and grow up to 8.59 million by the 2041 (Voyants 2012).

9.7 Socio Economic Profile

The workforce participation rate of Pune is approximately 34 % and the non-workers comprise 66 %, indicating the dependency rate. The city is a leading business centre in Maharashtra. It is one of the main investment hubs of the state and falls within the DMIC Project (Delhi Mumbai Industrial Corridor) influence area. It has had a long standing base for various large and small industrial units operating in sectors like auto components, engineering, IT/ITES, BPO, pharmaceuticals and food processing. It also serves as the regional wholesale market, market centre and a distribution centre for agricultural produce.

9.8 Land Use and Urban Growth

The Pune Municipal Corporation (PMC) is a statutory body, responsible for managing planned development in Pune city. It is also the sole agency mandated to develop and dispose of land in the city. Pune city's pattern of growth has been based on a ring and radial pattern, with reliance on road based transport. The Development Plan of Pune 2001 envisaged the huge demand for housing; hence the newly added 23 villages are mostly utilized for residential use, thus increasing the land use for residential (housing) purposes from 37 % in 1987 to 50 % in 2001. A considerable shortage exists for housing, commercial and industrial space. Large scale unauthorized development, and areas with nonconforming land uses are also witnessed. The high rate of in-migration and lack of formal access to appropriate housing and urban infrastructure has led to the genesis of unregulated sprawl development in and around Pune.

It has been observed in the case of Pune that acquiring and merging fringe villages into the urban sprawl has not worked effectively. The demand and supply of urban services is grossly mismatched as the provision of urban services to the 23 villages of the sprawl, is unequal and ad hoc. The PMC has deficient resources to extend its urban infrastructure services into these villages, while housing development by private developers continues rapidly. Thus it is observed that there exist severe shortage of water supply, sewerage, developed land, housing, transportation and other facilities (PMC 2011). Moreover the level, quality and distribution of services too are inadequate. Several studies have indicated that large segments of urban population do not have access to drinking water, sanitation, basic health services and education (Data for Development and Mindful of Gaps 2014).

9.9 Growth Pattern of Pune City 1857–2014

In 1997, 38 villages were included in Pune, but following the opposition from several villages, 15 complete and five partial villages were dropped from the civic limits in 2001. The Development Plan (DP) for remaining 23 villages merged with the city has experienced haphazard development and a huge infrastructural strain. Refer Table 9.1 and Fig. 9.1.

9.10 Methodology

The objective of the study was to compute the extent of the existing gap between demand for and supply of municipal urban services in the acquired villages in Pune's periphery. A study of the existing literature revealed that most reports are limited in describing the services provided and tend to fall short in quantifying the exact extent of shortfall in units of the provision (Voyants 2012). A select few

Table 9.1 Growth of Pune city limits

S. No	Year of inclusion	Name of villages included in Pune
1	1857	South Shankarsheth Road to Ambil Nullah Road, Northeast right bank of the Mutha river, East Wellesly Road to New Modikhana near Nagzari
2	1958	Bopodi, Dhanori (partial), Yerawada, Lohegaon (partial), Wadgaon Sheri (partial), Ghorpadi (partial), Mundhwa (partial), Hadapsar (partial), Hingne (Budruk), Dhankawdi, Pashan (partial), Aundh, Wanowrie, Bhosari, Dapodi, Kalas (partial)
3	1997	Ambegaon(Bk), Kothrud, Warje, Baner, Ambegaon(kh)(P), Mohmadwadi, Wadgaon(Bk), Bavdhan(Kh), Balewadi, Shiwane(p), Hadapsar(P), Kondhwa(Kh), Dhankawadi, Hingane(Kh), Pachgaon (Kuran), Wadgaon(Kh), Undri(P) Dhayari(P)and, Kondhwa(BK) and Kharadi Dhanori, Wadagaon Sheri, Kalas

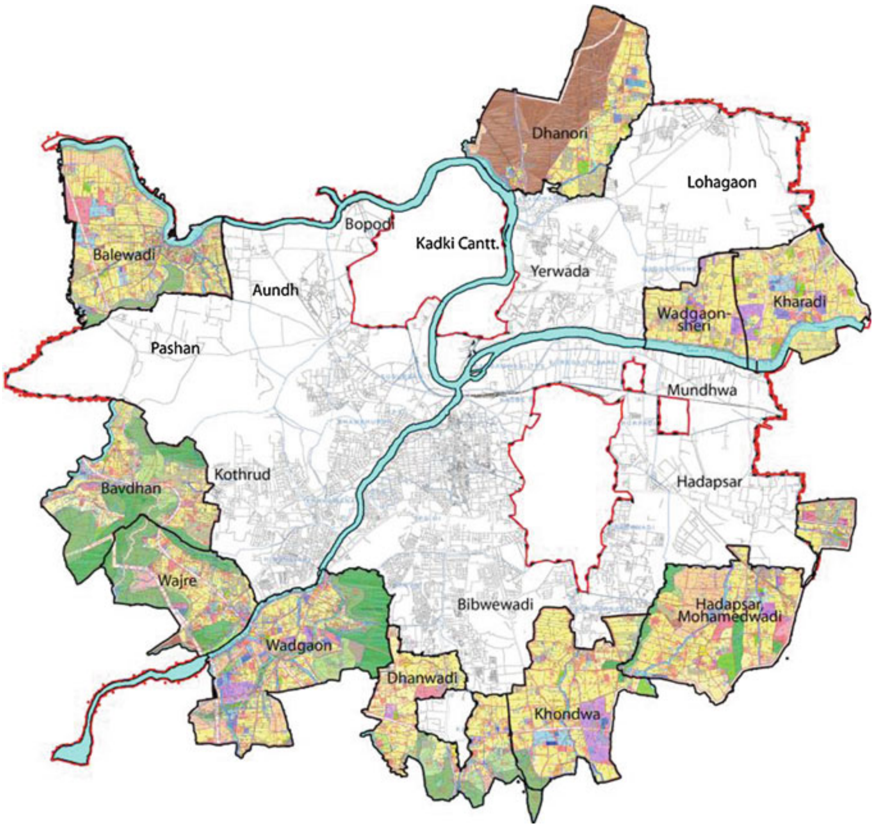

Fig. 9.1 Map showing 23 Villages acquired and merged into Pune city limits—1997. Darker areas indicate the 23 sprawl villages included in Pune Municipal Corporation limits after 1997. *Source* Pune Municipal Corporation

parameters covering physical infrastructure attributes of growing urban sprawl have been considered in this study of Pune City.

Thus the paper attempts to determine the 'actual' gaps in a few key services with respect to the requirement and the provision of services to these areas. Numerous field visits to government offices to collect and collate data from various data sources were made in the period between January 2014 and March 2014. Data was collected at two points, the wards in which the village is situated and the PMC's main office. Data gathering has been difficult as it is not maintained in a standardised manner at the village level and PMC head office. Access and quality of records is a challenge in India as is the case in most developing countries (Ling and Phua 2007; Data for Development and Mindful of Gaps 2014).

Urban services chosen wherein data has been recorded with greater consistency were chosen viz. water supply, urban roads, sewerage, street lighting, and storm water drainage. In the next step, data collected from the PMC was compared with the nation-wide standard of Urban Development Plan Formulation & Implementation Guidelines (UDPFI). The UDPFI Guidelines provide standardised guidelines to urban planners and city managements for the provision of infrastructure services to urban areas of varied population sizes in India. These guidelines are referred to compute the gaps in existing and desired levels of infrastructure for the population segments under study. Based on the standards, unit wise gaps were calculated for each of the earlier mentioned services. Thereafter, using the statistical software tool SPSS, the maximum likelihood estimate,[1] separate ranking was carried out using weighted average score technique to identify top five villages among the 23 sprawl villages with the least gaps in demand and supply of urban infrastructure services. Gap estimation is mainly determined by the accuracy of the gap. It is difficult to measure gaps directly in the field. There have been numerous studies and techniques developed for estimating the gap. Among these methods, the maximum likelihood technique proves to be the most accurate and reliable (Troutbeck 1992). In general, for a fixed set of data and underlying statistical model, the method of maximum likelihood estimate selects the set of values of the model parameters that maximizes the likelihood function. Intuitively, this maximizes the "agreement" of the selected model with the observed data, and for discrete random variables it maximizes the probability of the observed data under the resulting distribution. Thereafter, the upper and lower range of probability for confidence interval for mean was calculated for 95 % confidence interval for all five parameters identified for evaluation. Finally the MLE output analysis was used to ascribe ranks to the 23 sprawl villages based on a Gap Index, refer Table 9.2

[1]Maximum Likelihood estimate of parameter θ is the value of θ which maximizes the likelihood $L(\theta)$ http://www.stat.washington.edu/thompson/S341_10/Notes/week6.pdf.

Table 9.2 Maximum likelihood estimate

Descriptive statistics						95 % confidence interval for mean	
	Minimum	Maximum	Mean	Std. deviation	Variance	Lower bound	Upper bound
Water	10	35	18.26087	6.503267649	42.29	15.44864575	21.07309338
Sewage	30	37.5	35.02174	1.950980295	3.8	34.17807199	35.86540628
Roads	0	4	2.043478	1.870300435	3.49	1.234699704	2.852256818
Storm water drainage	2	15	9.347826	2.932710438	8.6	8.079626993	10.61602518
Street lights	5	18	10.86957	3.324213479	11.05	9.432067513	12.30706292

Source PMC records, Output of SPSS Tool

9.11 Analysis and Findings

Refer Table 9.2 showing the descriptive statistics and 95 % confidence interval for mean for 5 measurable parameters of urban infrastructure, i.e. water, sewage, roads, storm water drainage and street lights to evaluate mean, standard deviation, variance and MLE. Table 9.2 contains the gap estimates of all the services under study viz. water, sewage, urban roads, storm water drainage and street lighting. It is observed that water services experience the maximum deviation. Majority of the villages fall within the gap range of 15.44[2]–21.07 lpcd. However some of the villages have a sizeable gap in provision ranging from 10 lpcd up to 35 lpcd. Housing development provided by private parties ensures water provision to the projects albeit insufficiently, in these villages. Private water supply is the main source of household water provision. PMC outreach in ensuring water supply falls short in the 23 sprawl villages under study. In the case of sewage service, it shows that the majority of the villages fall under the gap range of 34.17–35.86 lpcd with a low variance of 3.8, this indicates that the majority of the villages have fairly adequate level of service. In case of roads services, it shows that most of the villages fall within the gap range of 1.23–2.85 km with a low variance of 3.49 indicating that 95 % of the villages falling in this range have manageable road deficits. For storm water drainage service, it shows that most of the villages fall in the gap range of 8.07–10.61 km with a variance of 8.6, indicating that the majority of the villages have very poor levels of storm water drainage services. Finally, in the case of street lighting most of the villages fall in the gap range of 9.43–12.30 km with a high variance of 11.05, indicating that 95 % of the villages have poor degree of street lighting.

In case of sewage and road services low variance indicates that the private parties provide these services as an integral element of ensuring project attractiveness and sale.

9.12 Ranking of Villages

The output of the MLE analysis was used to arrive at the ranking of villages to identify which among the 23 sprawl villages fare better in terms of provision in existing levels of urban infrastructure. For that, rating weights were obtained using expert opinion method based on ranks given by experts to the importance of each service. The experts were drawn from senior urban planners practising in India in the range of 08–10 years experience. Refer Table 9.4. Further the ranks were converted into factored weights by dividing the highest ranked parameter with the total weight of all other parameters. Refer Table 9.5 Further the factored weights were applied to all the services under consideration, refer Table 9.3. A gap index was developed by multiplying the existing gap by the factored weight for each

[2]Lpcd—UDPFI unit of measure described as litres per capita per day.

Table 9.3 Ranking analysis

Village name	Population	Water	0.33	Sewage	0.20	Roads	0.27	SWD	0.13	St. lighting	0.07	Gap index	Rank
Balewadi	24,332	15	5.0	36	7.2	4	1.07	7	0.93	11	0.73	14.93	9
Baner	24,433	15	5.0	36	7.2	0	0.00	7	0.93	6	0.40	13.53	4
Bavdhan (Kh)	14,447	15	5.0	36	7.2	0	0.00	15	2.00	8	0.53	14.73	8
Kothrud	19,153	15	5.0	36	7.2	0	0.00	2	0.27	5	0.33	12.80	2
Warje	24,574	10	3.3	37.5	7.5	0	0.00	8	1.07	15	1.00	12.90	3
Shiwane (p)	15,205	15	5.0	36	7.2	4	1.07	9	1.20	8.5	0.57	15.03	10
Hingane (Kh)	15,228	15	5.0	36	7.2	4	1.07	15	2.00	10	0.67	15.93	14
Wadgaon (Bk)	14,614	15	5.0	36	7.2	0	0.00	12	1.60	12	0.80	14.60	7
Wadgaon (Kh)	18,064	25	8.3	33	6.6	0	0.00	7	0.93	15	1.00	16.87	16
Dhayari (P)	16,690	25	8.3	33	6.6	3	0.80	7	0.93	8	0.53	17.20	18
Pachgaon (Kuran)	20,244	15	5.0	36	7.2	4	1.07	12	1.60	18	1.20	16.07	15
Dhankawadi	17,270	15	5.0	36	7.2	4	1.07	12	1.60	12	0.80	15.67	13
Ambegaon (Bk)	17,454	10	3.3	37.5	7.5	0	0.00	9	1.20	5	0.33	12.37	1
Ambegaon (kh) (P)	15,272	10	3.3	37.5	7.5	3	0.80	10	1.33	10	0.67	13.63	5
Kondhwa (Kh)	33,045	15	5.0	36	7.2	4	1.07	10	1.33	15	1.00	15.60	12
Kondhwa (BK)	18,796	25	8.3	33	6.6	4	1.07	7	0.93	12	0.80	17.73	19
Undri (P)	27,453	25	8.3	33	6.6	0	0.00	7	0.93	15	1.00	16.87	17
Mohmadwadi	30,023	15	5.0	36	7.2	0	0.00	12	1.60	10	0.67	14.47	6
Hadapsar (P)	88,297	15	5.0	36	7.2	3	0.80	10	1.33	12	0.80	15.13	11
Wadagaon Sheri	20,244	25	8.3	33	6.6	4	1.07	10	1.33	11	0.73	18.07	22
Kharadi	25,430	25	8.3	33	6.6	3	0.80	10	1.33	10	0.67	17.73	20
Dhanori	14,736	25	8.3	33	6.6	3	0.80	10	1.33	11.5	0.77	17.83	21
Kalas	18,490	35	11.7	30	6	0	0.00	7	0.93	10	0.67	19.27	23

Table 9.4 Expert opinion survey results

Respondents	Ranks				
	Road	Sewage	Street lighting	Storm water drainage	Water
Respondent 1	5	2	4	3	1
Respondent 2	2	4	3	5	1
Respondent 3	2	3	5	4	1
Respondent 4	2	4	5	3	1
Respondent 5	2	3	5	4	1
Respondent 6	5	2	4	3	1
Respondent 7	2	3	5	4	1
Respondent 8	2	4	5	3	1
Respondent 9	2	3	5	4	1
Respondent 10	2	3	4	5	1
Respondent 11	2	4	5	3	1
Respondent 12	2	3	5	4	1
Respondent 13	2	4	5	3	1
Respondent 14	2	3	4	5	1
Respondent 15	2	3	5	4	1
Mean	2.4	3.2	4.6	3.8	1
Derived ranks	2	3	5	4	1

Table 9.5 Ranks and respective weights

Rank	Parameters	Weightage	Factored Wt.
1	Water	5	0.33
2	Road	4	0.27
3	Sewage	3	0.20
4	SWD	2	0.13
5	Street lighting	1	0.07
Total		15	1.00

Source 15 urban planners surveyed using expert opinion method or judgement method

village and summation of gap index specific parameter (viz. urban roads, water, sewage, street, and lighting) to obtain the cumulative gap index. Ranks were assigned on the basis of lower to higher gap index. Lower the gap index the better the urban infrastructure. The villages are arranged in descending gap index order and ranks in ascending order as presented in Table 9.6

Table 9.6 Final ranking of villages based on least gaps in infrastructure provision

Village name	Population	Gap Index	Village rank
Ambegaon (Bk)	17,454	12.367	1
Kothrud	19,153	12.800	2
Warje	24,574	12.900	3
Baner	24,433	13.533	4
Ambegaon (kh) (P)	15,272	13.633	5
Mohmadwadi	30,023	14.467	6
Wadgaon (Bk)	14,614	14.600	7
Bavdhan (Kh)	14,447	14.733	8
Balewadi	24,332	14.933	9
Shiwane (p)	15,205	15.033	10
Hadapsar (P)	88,297	15.133	11
Kondhwa (Kh)	33,045	15.600	12
Dhankawadi	17,270	15.667	13
Hingane (Kh)	15,228	15.933	14
Pachgaon (Kuran)	20,244	16.067	15
Wadgaon (Kh)	18,064	16.867	16
Undri (P)	27,453	16.867	17
Dhayari (P)	16,690	17.200	18
Kondhwa (BK)	18,796	17.733	19
Kharadi	25,430	17.733	20
Dhanori	14,736	17.833	21
Wadagaon Sheri	20,244	18.067	22
Kalas	18,490	19.267	23

Ranked on basis of weighted importance

9.13 Conclusion

The study points to the fact that Pune city faces huge gaps in the provision of infrastructural services for the newly acquired villages in the growing urban sprawl. MLE method helped to determine the range of the existing gap and to understand the upper and lower limits of the existing gap in 23 villages. The gap index helped to determine the ranking and subsequently reveal that most of the villages in Pune city's sprawl are not performing well inadequate infrastructure provision. This indicates that lower index values translate into better demand and provision of the urban services. As it stands currently, sustainability of Pune city is under threat, prolonged delays in effecting measures in the installation of augmented capacity and quality of services will severely affect the city's ability to progress in the future. The role of city management, civil society, planning and technology cannot be undermined to avoid this situation.

Appendix

Names of the respondents

S. No	Name of the respondents
1	Mr. Alange B.
2	Mr. Raikar P.
3	Mr. Dudhe V.
4	Mr. Shah D.
5	Mr. Singh K.
6	Mrs. Mitra S.
7	Mr. Singhal P.
8	Mr. Bodke S.
9	Mr. Rai N.
10	Mr. Jha R.R
11	Mr. Bhutani V.
12	Mr. Shah Z.
13	Mrs. Saini A.
14	Mr. Diwan R.
15	Mr. Sonpatki P.

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Part II
Sustainable Construction

Chapter 10
Photovoltaic Solar Systems for Residential Dwellings

Vivian W.Y. Tam

Abstract Usage of fossil fuels over the century has led to global air pollution and the production of SO_2, CO_2 and NO_x with the issue linked to global warming. These problems are directly from the results of burning finite fossil fuels such as coal, oil and natural gas in satisfying human energy consumptions. Development of renewable clean energy source is thus the key to success in overcoming such issues. Solar electricity produced from photovoltaic solar systems has the potential to deliver clean sustainable energy. This paper examines life cycle cost effectiveness in using photovoltaic solar systems with capacities ranging from 1.5 to 5 kW in relation to the number of occupants and consumption for residential dwellings over a 15-year period for eight major Australian cities. Life cycle cost comparisons among different types of electricity grid connected systems, including a gross-feed-in-tariff (GFIT) scheme, a net-feed-in-tariff (NFIT) scheme and a buy-back scheme, are also explored. It is found that all major cities can receive life cycle cost saving in installing photovoltaic solar systems in their residential dwellings. The life cycle cost saving is between \$273 and \$53 021 and the percentage of cost saving is between 0.35 and 123.83 % in a 15-year period. It is appeared that the GFIT and NFIT schemes offer better benefits than the buy-back scheme in installing photovoltaic solar systems. It is also found that the higher the capacity of the photovoltaic solar systems, the higher the life cycle cost saving can be received. This paper contributes to prove the cost effectiveness of using photovoltaic solar systems with the example from Australian residential dwellings.

Keywords Photovoltaic solar system · Sustainable renewable energy · Cost effectiveness · Residential dwelling · Australia

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10.1 Introduction

Global warming is a result of products from burning fossil fuels for human consumption such as energy requirement for coal power stations, and petroleum use for cars which is now evident to affect the current temperature changes and has occurred in Earth's climate. Burning fossil fuels such as coal, petroleum and wood can increase $SO_{2,}$ CO_2 and NO_x in our atmosphere. Human beings have been using fossil fuels for the past few hundred years, which took around 400 years to develop and store underground. Nonetheless by utilising fossil fuels have given opportunities for humanity to setup civilisations in cold climates (Krauter 2006). Even though such activities are essential for the viability of the human race and fulfilling the energy requirement, fossil energy is a finite resource. Global warming is on everyone's agenda since the scientific evidence being apparent that greenhouse gas emissions caused by human activities are related to the Earth's climate (Beggs 2009).

About two thirds of Australia's greenhouse gas emissions are from fossil fuel electricity generation (Beggs 2009). Coal is the predominant source of fossil fuel, which is widely used in Australia for producing electricity. Preponderance of 13 % greenhouse gas emissions was contributed by residential building sector (Wang et al. 2011). An average household produces about 14 tons of greenhouse gas each year (Australian Bureau of statistics 2010).

In residential building sector, one of the main focuses has been on reducing energy consumption of dwellings and increasing energy performance by introducing sustainable building designs. Mwasha et al. (2011) developed an approach for determining the most appropriate sustainable energy performance indicators from the newly developed model for sustainable performance of residential building envelops. Zhu and Lin (2004) also developed a similar approach for the Chinese environment in recommending series of technical approaches along with different phases of sustainable design and construction based on the analysis of the requirements, characteristics, standards for sustainable housing and urban construction.

Development of renewable clean energy source is one of the key success factors in overcoming issues on global warming. Humans are now directing extra effort technologically and politically into developing energy systems that can directly utilise sun energy (Lynn 2010). Solar electricity produced from photovoltaic solar systems has the potential to deliver clean sustainable energy effectively and efficiently (Zhao et al. 2001). Dincer reviewed the photovoltaic electricity generation status, potential and policies of the leading counties in solar energy and highlighted that some European countries are in leading positions in generating electricity from solar energy using photovoltaic systems (Dincer 2011). Spain is implementing new energy-related technologies with special emphasis on solar energy and reviewing the European and Spanish legislation regarding construction and renewable energy in order to center the world attention on the implementation of policies geared towards an optimal energy performance and the use of renewable energy (García et al. 2007). Ordonez et al. (2010) analysed the solar energy potential for grid-connected photovoltaic systems installed on residential rooftops in Spain. Evans et al. (1998) presented the concepts, system development and integration, construction process and measured performance of a developed solar powered incubator which integrates low impact renewable energy systems and support the conservation of endangered species. Valderrama et al. (2011) developed and constructed an experimental solar pond for solar energy storage by controlling salinity and thermal gradient.

Positive steps are being undertaken to minimise greenhouse gas emissions in Australia and photovoltaic solar systems are contributing towards sustainability. The current amount of photovoltaic solar systems installed cannot address the global warming issues in whole but renewable energy production is contributing towards minimising carbon emissions (Steinfeld and Meier 2004). One of the main concerns for the residential householders is the economic issue on the use of photovoltaic solar systems. Therefore, this paper examines and compares the life cycle costing effectiveness of using photovoltaic solar systems with capacities ranging from 1.5 to 5 kW in relation to the number of occupants and consumption for residential dwellings over a 15-year period. Eight major cities in Australia, including Sydney, Canberra, Melbourne, Brisbane, Hobart, Adelaide, Darwin and Perth, are investigated. Life cycle costing comparisons among different types of electricity grid connected systems, including a gross-feed-in-tariff scheme, a net-feed-in-tariff scheme and a buy-back scheme, and are also explored.

10.2 Life Cycle Costing for Using Photovoltaic Solar Systems

Figure 10.1 illustrates the process required for measuring life cycle costing in using photovoltaic solar systems.

10.2.1 Determination of Annual Mean Daily Global Solar Exposure

The global solar exposure to the photovoltaic solar systems is subjected to locations and elevations. Table 10.1 summarises the mean, lowest and highest annual mean daily solar exposure in the Australian major cities and is measured in kilowatt-hour per square meter (kWh/m^2). Kilowatt-hour per square meter is the measurement used by the Australian Bureau of Metrology in measuring the total daily solar irradiance, which falls on Earth's surface. Darwin receives the highest annual daily global solar exposure of about 6.53 kWh/m^2 while Hobart receives the lowest annual daily global solar exposure of about 3.64 Wh/m^2 in Australia.

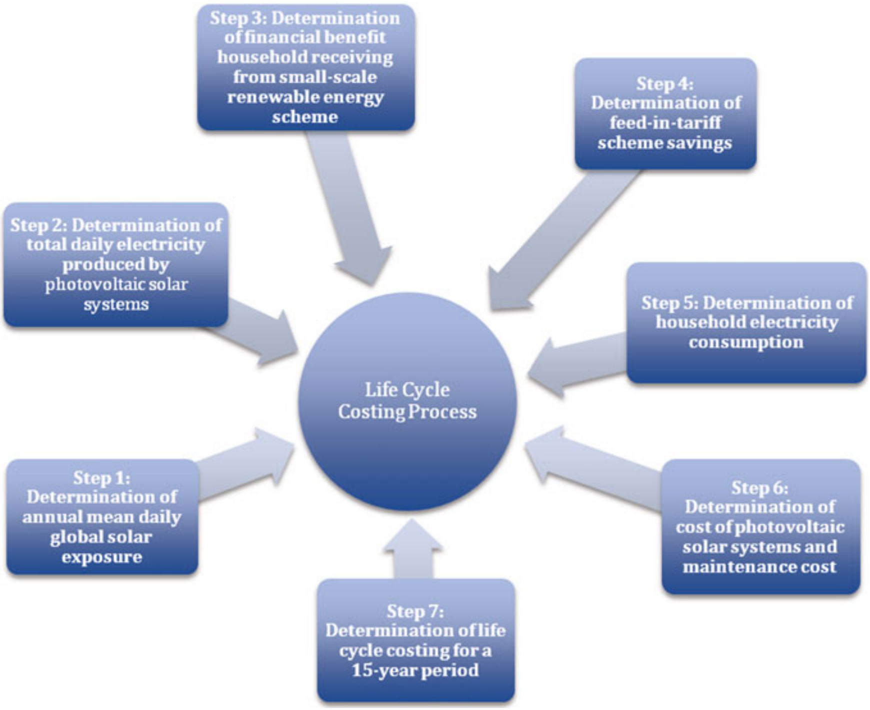

Fig. 10.1 Research methodologies for measuring life cycle costing in using photovoltaic solar systems

Table 10.1 Annual mean daily global solar exposure in the Australian major cities (Australian Bureau of Meteorology 2011b)

Cities	Station number	Station name	Elevation (m)	Annual daily global solar exposure		
				Mean (kWh/m^2)	Lowest (kWh/m^2)	Highest (kWh/m^2)
Sydney	66062	Observatory Hill	39	4.69	4.33	5.25
Canberra	070247	Australian National Botanic GA	585	4.94	4.50	5.56
Melbourne	086232	Melbourne Botanical Gardens	29	4.33	3.92	5.11
Brisbane	040690	Brisbane City	Unknown	5.33	5.03	5.75
Hobart	094145	Hobart (Knock lofty)	232	3.97	3.64	4.69
Adelaide	023011	North Adelaide	48	4.94	4.22	5.72
Darwin	014163	Darwin Botanic Gardens	15	6.00	5.64	6.53
Perth	009225	Perth Metro	25	5.47	5.06	6.06

Table 10.2 Daily electricity produced by the photovoltaic solar systems (in kWh/m^2) (Australian Bureau of Meteorology 2011a)

Solar system capacities (kW)	Sydney	Canberra	Melbourne	Brisbane	Hobart	Adelaide	Darwin	Perth
1.5	7.05	7.35	6.45	7.95	6.00	7.35	9.00	8.25
2	9.40	9.80	8.60	10.60	8.00	9.80	12.00	11.00
3	14.10	14.70	12.90	15.90	12.00	14.70	18.00	16.50
4	18.80	19.60	17.20	21.20	16.00	19.60	24.00	22.00
5	23.50	24.50	21.50	26.50	20.00	24.50	30.00	27.50

10.2.2 Determination of Total Daily Electricity Produced by Photovoltaic Solar Systems

The daily electricity produced by the photovoltaic solar systems is calculated by multiplying the capacities of the system and the mean annual mean daily global solar exposure collected (from Table 10.1). Table 10.2 summarises the daily electricity produced by the systems with capacities from 1.5 to 5 kW. Regardless of the capacity of the photovoltaic solar systems, Darwin will generate about 33.3 % more than Hobart, about 28.3 % more than Melbourne, about 21.6 % more electricity than Sydney, about 18.3 % more than Canberra and Adelaide, about 11.6 % more than Brisbane, and about 8.3 % more than Perth.

10.2.3 Determination of Financial Benefit Household Receiving from Small-Scale Renewable Energy Scheme

Over the past few years, Australian government and state governments have introduced various types of solar rebates for assisting households with renewable energy options and maximising renewable electricity generation sources in term of selling and creating certificates from their renewable energy power stations. The certificates are based on the total amount of renewable electricity generated or displaced by the systems (Department of Climate Change and Energy Efficiency 2011; Office of the Renewable Energy Regulator 2011). The renewable energy target is divided into two parts: (1) small-scale renewable energy scheme; and (2) large scale renewable energy scheme. In this study, photovoltaic solar systems are related to the small-scale renewable energy scheme.

Solar credit scheme is initiated by the Australian government to provide support for household owners in receiving additional financial benefits for installing renewable energy systems. The level of subsidy that household owners receive is depended on: (1) the zone which the photovoltaic solar systems will be installed, in which zone 1 has rating of 1.622, zone 2 has rating of 1.536, zone 3 has rating of 1.382 and zone 4 has rating of 1.185 (ComLaw 2001); (2) capacity of the

Table 10.3 Small-scale technology certificates available for the photovoltaic solar systems without multipliers (Office of the Renewable Energy Regulator 2011)

City	Photovoltaic solar system capacity				
	1.5 kW	2 kW	3 kW	4 kW	5 kW
Sydney	31	41	62	82	103
Brisbane	31	41	62	82	103
Canberra	31	41	62	82	103
Melbourne	26	35	53	71	88
Hobart	26	35	53	71	88
Adelaide	31	41	62	82	103
Perth	31	41	62	82	103
Darwin	34	46	69	92	115

photovoltaic solar systems; (3) market price for the certificate; (4) the total deeming period of the certificates is going to be created for; (5) multiplier in relations to the installation period, in which multipliers of 5, 4, 3, 2, and 1 are for installation periods at June 2009/June 2010, July 2010/June 2012, July 2012/June 2013, July 2013/June 2014, and from 1 July 2014 onwards respectively (Office of the Renewable Energy Regulator 2011). One small-scale technology certificate is equivalent to 1000 kWh (or 1 MWh) electricity generated by the photovoltaic solar systems. Australian household owners have two options with the certificates that are created. They can either receive financial benefits by assigning the certificates to registered agents in exchange for discount on the good or delayed cash payment, or to sell the certificates to the government with a fixed price of $40 per certificate (ORER 2011a, b). Deeming period of 15 years has been selected for this research due to household owners can only receive all small-scale technology certificates they are eligible for their photovoltaic solar systems for a total period of 15 years. Table 10.3 summarises the available certificates for different capacities of photovoltaic solar systems without multipliers in the Australian major cities. When the multiplier is more than 1, the certificates available is determined by the certificates available for a 1.5 kW photovoltaic solar system with multiplier plus the different between the capacities of the systems without multiplier.

10.2.4 Determination of Feed-in-Tariff Scheme Savings

Many countries have introduced solar bonus/feed in tariff (FIT) scheme in order to introduce incentives for the photovoltaic solar system owners. In Australia, the state governments regulate the FIT scheme in ensuring that household owners do not get disadvantaged by the electricity retailers. There are two type of FIT schemes introduced in most Australian states/territories: (i) gross-feed-in-tariff (GFIT) scheme; and (ii) net-feed-in-tariff (NFIT) scheme. Some states/territories did not have any feed-in-tariff scheme regulated by state/territory government; electricity retailers have thus introduced buy-back scheme where they will pay certain rate for

Table 10.4 Feed-in-tariff schemes and their rates in the Australian major cities (Australian Capital Territory 2009; Tackling Climate Change 2009; Aurora Energy 2011; Department of Primary Industries 2011; Living Greener 2011; NSW Government 2011; Office of Energy 2011; Power Water 2011; Queensland Government 2011)

City	Scheme	Cents/kWh	Commencement date
Sydney	GFIT	20.00	27 October 2010
Canberra	GFIT	45.70	1 July 2010 until 30 June 2011
Melbourne	NFIT	60.00	1 November 2009
Brisbane	NFIT	44.00	1 July 2008
Hobart	Buy-back	22.65	Depends on Aurora Energy
Adelaide	NFIT	44.00	1 July 2008 until 30 June 2028
Darwin	Buy-back	19.23	Depended on Power Water Corp NT
Perth	NFIT	40.00	1 August 2010

every kWh the photovoltaic solar system generates, which is similar as the GFIT scheme. Table 10.4 summarises the scheme used and their rates with their commencement dates in the Australian major cities.

Under the GFIT scheme, the photovoltaic solar systems must be connected to the grid. Homeowners must sell all renewable energy generated by their photovoltaic solar systems to electricity retailers; hence all electricity the household consumes must still be bought from the electricity retailers. The households under states/territories with the GFIT and buy-back schemes, the total daily savings can be calculated by multiplying the total daily electricity produced by the systems (see Table 10.2) and the FIT discount rates (see Table 10.4).

Under the NFIT scheme, the photovoltaic solar systems must also be grid connected. The main difference from the GFIT scheme is that the NFIT scheme allows homeowners with the photovoltaic solar systems to consume the electricity produced by their systems and any surplus electricity produced can be sold back to their electricity retailers or the household needs to buy the electricity from the electricity retainers if they did not generate enough from their systems. Therefore, the households with this scheme do not need to buy electricity from electricity retainers when their systems are generating enough electricity for their daily use.

10.2.5 Determination of Household Electricity Consumption

Households will vary in electricity consumption, which depends on their size of the dwellings, number of occupants, number and types of life-style appliances, and any equipment on standby-mode. To enable consistent calculation and comparison of the life cycle costing for the photovoltaic solar systems, electricity retail prices and electricity consumption figures from Sydney have been selected for this study (Energy Australia 2010).

Based on the recent survey (IPART 2010), the average consumption of electricity for households in 2010 was about 4 % lower than the consumption in 2006. The average annual household electricity consumption is about 7200 kWh. Household consumers were getting charged 17.35 cents per kWh of electricity for the first 1750 kWh per quarter (or 7000 kWh per year) and any kWh thereafter was charged at 25.50 cents per kWh in 2010. Service availability charges were 43.00 cents quarterly. The electricity price has been proposed and increased by 17.9 % in 2011 (IPART 2011). Table 10.5 summarises the electricity consumption and its cost in relations to the number of occupants in a dwelling.

For the households under the NFIT scheme, it needs to calculate the surplus electricity produced by the photovoltaic solar systems (if any) by the yearly electricity consumption in relations to number of occupants (see Table 10.5), the yearly electricity generated by the photovoltaic solar systems (see Table 10.2) and the electricity rates to sell back to the electricity retainers (from Table 10.4). Table 10.6 summarises the cost/savings of electricity under the NFIT scheme in relations to number of occupants and locations. The biggest savings of about $1791.90 can be achieved when the household is with 1–2 occupants and installed a 5 kW system in Brisbane. It should also be highlighted that the photovoltaic solar system capacity of 1.5 and 2 kW cannot generate enough electricity and provide any savings for any size of the household occupants in any Australian major cities. The households need to buy the extra electricity required from the electricity retainers.

10.2.6 Determination of Cost of Photovoltaic Solar Systems and Maintenance Cost

Cost of photovoltaic solar systems has decreased dramatically over the last decade due to increase in production, competition in market, technology improvements and government incentive schemes. When buying the photovoltaic solar systems, consideration should be made on the type of silicon used in manufacturing the panels and product lifespan. Most photovoltaic solar systems come with a 25-year warranty and it must be Australian standard approved products. Clean energy council provides a list of approved panels and invertors including list of Australian-wide registered installers. Household consumers must verify the products and service in meeting the Clean Energy Council's requirements (Clean Energy Council 2011).

The price of the photovoltaic solar systems can be affected by variables including (Clean Energy Council 2011): (1) locations; (2) number of panels required; (3) orientation of panels; (4) type of panels and invertors; (5) system design and configuration; (6) government rebates and support schemes; (7) shipping cost for equipment and parts; (8) contractor installation cost; (9) removal of trees or other shadings; (10) type of roofing; (11) height of roof; and (12) site preparation needs. Table 10.7 summarises the highest, lowest and average price of the various

Table 10.5 Electricity consumption and its cost in relations to the number of occupants

Number of occupants	Electricity consumption yearly (kWh)	Electricity consumption quarterly (kWh)	Cost for the first 1750 kWh per quarter (AUD)	Cost for the remainder (AUD)	Service availability quarterly charge (AUD)	Total quarterly usage charge (AUD)	Total yearly usage charge (AUD)
1–2	5600	1400	$242.90	0	$39.24	$282.14	$1128.55
3–4	8800	2200	$303.63	78.08	$39.24	$420.94	$1683.75
5–more	11,300	2825	$303.63	274.13	$39.24	$616.99	$2467.95
Average household	7200	1800	$303.63	12.75	$39.24	$355.61	$1422.45

Table 10.6 Cost (negative)/savings (positive) of electricity under the NFIT scheme

City and system capacity (kW)	Consumption by number of occupants			
	1–2	3–4	5+	Average
Melbourne				
1.5	−$720.09	−$1275.29	−$1867.62	−$997.69
2.0	−$583.93	−$1139.13	−$1667.51	−$861.53
3.0	−$311.63	−$866.83	−$1300.58	−$589.23
4.0	$406.80	−$594.52	−$1028.27	−$316.92
5.0	$1348.50	−$322.21	−$755.96	$388.50
Brisbane				
1.5	−$625.10	−$1180.30	−$1728.00	−$902.70
2.0	−$457.28	−$1012.48	−$1481.36	−$734.88
3.0	$89.54	−$676.84	−$1110.59	−$399.24
4.0	$940.72	−$341.21	−$774.96	$236.72
5.0	$1791.90	$383.90	−$439.32	$1087.90
Adelaide				
1.5	−$663.09	−$1218.29	−$1783.85	−$940.69
2.0	−$507.94	−$1063.14	−$1555.82	−$785.54
3.0	−$197.64	−$752.84	−$1186.59	−$475.24
4.0	$683.76	−$442.53	−$876.28	−$164.93
5.0	$1470.70	$62.70	$565.98	$766.70
Perth				
1.5	−$606.10	−$1161.30	−$1700.08	−$883.70
2.0	−$431.95	−$987.15	−$1444.13	−$709.55
3.0	$169.00	−$638.85	−$1072.60	−$361.25
4.0	$972.00	−$290.55	−$724.30	$332.00
5.0	$1775.00	$495.00	−$375.99	$1135.00

Table 10.7 Cost of photovoltaic solar systems (in AUD)

Solar system capacity (kW)	Highest price	Lowest price	Average price
1.5	$11,000	$12,250	$11,625
2	$14,250	$15,800	$15,025
3	$20,455	$23,182	$21,818
4	$24,091	$27,273	$25,682
5	$27,273	$28,182	$27,727

capacities of the photovoltaic solar systems from the retainers (Clean Energy Council 2011).

The photovoltaic solar systems do not require major servicing as the system do not have any moveable parts; however, the system does require a qualified registered electrician or a solar panel installation specialist to perform testing and cleaning every five-years depending on the system capacities, locations and local environment factors. In this paper, 3 % inflation has been assumed and \$200 is allowed for maintenance cost every five-years. This cost consists of a 2-h labour (with \$75/h) and equipment hire/use (for about \$50).

10.2.7 Determination of Life Cycle Costing for a 15-Year Period

The life cycle cost calculation for households under the GFIT and NFIT schemes require different calculation approaches, as the households will use their own generated electricity first from their photovoltaic solar systems and sell the surplus electricity or buy the extra required electricity to the electricity retainers under the NFIT scheme.

Examples of the life cycle cost calculation and comparison for not using any photovoltaic solar system and using a 5 kW photovoltaic solar system for five or more occupants under the GFIT scheme in Sydney are shown in Table 10.8.

Life cycle costing for not using any photovoltaic solar system for five or more occupants under the GFIT scheme in Sydney at Year n
= −Electricity consumption by the household (from Table 10.5) × electricity rate (which is 17.35 cents per kWh for the first 7000 kWh and 25.50 cents per kWh thereafter)] × (1 + inflation rate)$^{n-1}$
Life cycle costing for using a 5 kW photovoltaic solar system for five or more occupants under the GFIT scheme in Sydney at Year 1
= −Cost of photovoltaic solar system (from Table 10.7) − electricity cost − maintenance cost) + small-scale renewable energy scheme benefit + feed-in-tariff scheme savings
= −Cost of photovoltaic solar system (from Table 10.7)
− electricity consumption by the household (from Table 10.5) × electricity rate (which is 17.35 cents per kWh for the first 7000 kWh and 25.50 cents per kWh thereafter)
− maintenance cost (\$200 for every five-years)
+ {[small-scale technology certificates available for a 1.5 kW system (from Table 10.3) × multiplier (which is 5 in this study based on the installation period) + different of the small-scale certificates available between 5 and 1.5 kW systems] × \$40 (set by the Australian government)}
+ [daily electricity produced by the system (from Table 10.2) × feed-in-tariff scheme rate (from Table 10.4) × 365 days]
= −\$27,727 − \$2468 − \$0 + [31 × 5 + (103 − 31) × \$40] + (23.5 × \$0.20 × 365)
= −\$27,727 − \$2468 + (\$9080) + (\$1716)
= −\$19,400

Table 10.8 Life cycle cost for not using any systems and using a 5 kW photovoltaic solar system for five or more occupants under the GFIT scheme in Sydney

Year	Not using any system		Using the system						Life cycle cost saving (B − A)
	Electricity cost	Total accumulative cost (A)	Cost of the photovoltaic solar system	Electricity cost	Maintenance cost	Small-scale renewable energy scheme benefit	Feed-in-tariff scheme savings	Total accumulative cost (B)	
1	−$2468	−$2468	−$27,727	−$2468	–	$9080	$1716	−$19,400	−$16,932
2	−$2715	−$5183	–	−$2715	–	–	$1716	−$20,399	−$15,216
3	−$2986	−$8169	–	−$2986	–	–	$1716	−$21,670	−$13,501
4	−$3285	−$11,454	–	−$3285	–	–	$1716	−$23,239	−$11,785
5	−$3613	−$15,067	–	−$3613	−$225	–	$1716	−$25,362	−$10,295
6	−$3975	−$19,042	–	−$3975	–	–	$1716	−$27,621	−$8579
7	−$4372	−$23,414	–	−$4372	–	–	$1716	−$30,278	−$6864
8	−$4809	−$28,223	–	−$4809	–	–	$1716	−$33,371	−$5148
9	−$5290	−$33,513	–	−$5290	–	–	$1716	−$36,946	−$3433
10	−$5819	−$39,333	–	−$5819	−$261	–	$1716	−$41,310	−$1978
11	−$6401	−$45,734	–	−$6401	–	–	$1716	−$45,996	−$263
12	−$7041	−$52,775	–	−$7041	–	–	$1716	−$51,321	$1453
13	−$7745	−$60,521	–	−$7745	–	–	$1716	−$57,351	$3168
14	−$8520	−$69,041	–	−$8520	–	–	$1716	−$64,155	$4884
15	−$9372	−$78,413	–	−$9372	−$302	–	$1716	−$72,114	$6297

Life cycle costing for using a 5 kW photovoltaic solar system for five or more occupants under the GFIT scheme in Sydney at Year n
= −Cost at Year (n − 1) − electricity cost (from Table 10.5) × (1 + inflation rate)$^{n-1}$ − maintenance cost × (1 + inflation rate)$^{n-1}$ + feed-in-tariff scheme savings

Based on the above analysis, by using a 5 kW photovoltaic solar system for five or more occupants in Sydney can save about $6297 over a 15-year period.

The life cycle cost calculations for the households under the NFIT scheme is a bit more complicated than the households using the GFIT scheme. Examples for not using any photovoltaic solar system and using a 5 kW photovoltaic solar system for five or more occupants under the NFIT scheme in Brisbane are shown in Table 10.9. The life cycle cost calculation for not using any photovoltaic solar systems under the NFIT scheme is the same as the life cycle cost calculation under the GFIT scheme.

Life cycle costing for using a 5 kW photovoltaic solar system for five or more occupants under the NFIT scheme in Brisbane at Year 1
= −Cost of photovoltaic solar system (from Table 10.7) − electricity cost − maintenance cost + small-scale renewable energy scheme benefit
= −Cost of photovoltaic solar system (from Table 10.7)
− [(electricity consumption by the household (from Table 10.5) − daily electricity produced by the system (from Table 10.2) × 365 days) × electricity rate (which is 17.35 cents per kWh for the first 7000 kWh and 25.50 cents per kWh thereafter plus the service charge if the consumption is positive or feed-in-tariff scheme rate from Table 10.4 if the consumption is negative]
− maintenance cost ($200 for every five-years)
+ {[small-scale technology certificates available for a 1.5 kW system (from Table 10.3) × multiplier (which is 5 in this study based on the installation period) + different of the small-scale certificates available between 5 and 1.5 kW systems] × $40 (set by the Australian government)}
= −$27,727 − [(11,300 − 26.5 kWh × 365) × $0.1735 + $39.24 × 4] − $0 + [31 × 5 + (103 − 31) × $40]
= −$27,727 − $439 − $0 + $9080
= −$19,086

Life cycle costing for using a 5 kW photovoltaic solar system for five or more occupants under the NFIT scheme in Brisbane at Year n
= −Cost at Year (n − 1) − electricity cost × (1 + inflation rate)$^{n-1}$ − maintenance cost × (1 + inflation rate)$^{n-1}$

Tables 10.10 and 10.11 summarise the life cycle cost saving and the percentage of cost saving respectively of using photovoltaic solar systems with different numbers of occupants and different capacities of the photovoltaic solar systems in the major Australian cities over a 15-year period. It is found that the life cycle cost saving is between $273 and $53,021 and the percentage of cost saving is between 0.35 and 123.83 % in a 15-year period. The most cost effective photovoltaic solar systems are the 5 kW installed in Canberra for 1–2 household occupants with the

Table 10.9 Life cycle cost for not using any systems and using a 5 kW photovoltaic solar system for five or more occupants under the NFIT scheme in Brisbane

Year	Not using any system		Using the system					Life cycle cost saving (B − A)
	Electricity cost	Total accumulative cost (A)	Cost of the photovoltaic solar system	Electricity cost	Maintenance cost	Small-scale renewable energy scheme benefit	Total accumulative cost (B)	
1	−$2468	−$2468	−$27,727	−$439	–	$9080	−$19,086	−$16,618
2	−$2715	−$5183	–	−$483	–	–	−$19,570	−$14,387
3	−$2986	−$8169	–	−$532	–	–	−$20,101	−$11,932
4	−$3285	−$11,454	–	−$585	–	–	−$20,686	−$9232
5	−$3613	−$15,067	–	−$643	−$225	–	−$21,554	−$6487
6	−$3975	−$19,042	–	−$708	–	–	−$22,262	−$3220
7	−$4372	−$23,414	–	−$778	–	–	−$23,040	$374
8	−$4809	−$28,223	–	−$856	–	–	−$23,896	$4327
9	−$5290	−$33,513	–	−$942	–	–	−$24,838	$8676
10	−$5819	−$39,333	–	−$1036	−$261	–	−$26,135	$13,198
11	−$6401	−$45,734	–	−$1139	–	–	−$27,274	$18,460
12	−$7041	−$52,775	–	−$1253	–	–	−$28,528	$24,248
13	−$7745	−$60,521	–	−$1379	–	–	−$29,906	$30,614
14	−$8520	−$69,041	–	−$1517	–	–	−$31,423	$37,618
15	−$9372	−$78,413	–	−$1668	−$302	–	−$33,394	$45,019

Table 10.10 Life cycle cost saving of using photovoltaic solar systems in a 15-year period

City and system capacity (kW)	Consumption by number of occupants			
	1–2	3–4	5+	Average
Sydney				
1.5	$1506	$1506	$1506	$1506
2.0	$1079	$1079	$1079	$1079
3.0	$273	$273	$273	$273
4.0	$2356	$2356	$2356	$2356
5.0	$6297	$6297	$6297	$6297
Canberra				
1.5	$12,177	$12,177	$12,177	$12,177
2.0	$16,322	$16,322	$16,322	$16,322
3.0	$23,136	$23,136	$23,136	$23,136
4.0	$32,840	$32,840	$32,840	$32,840
5.0	$44,403	$44,403	$44,403	$44,403
Melbourne				
1.5	$5764	$5764	$11,861	$6282
2.0	$7050	$7050	$15,179	$7568
3.0	$9629	$9629	$20,764	$10,147
4.0	$22,488	$15,137	$26,272	$15,655
5.0	$35,249	$22,424	$33,559	$30,187
Brisbane				
1.5	$9782	$9782	$17,296	$10,300
2.0	$12,114	$12,114	$22,133	$12,632
3.0	$22,033	$16,825	$27,960	$17,343
4.0	$31,737	$24,425	$35,560	$30,515
5.0	$43,300	$39,820	$45,019	$42,078
Hobart				
1.5	$4859	$4859	$15,993	$5376
2.0	$5843	$5843	$16,977	$6361
3.0	$7818	$7818	$18,952	$8336
4.0	$17,079	$12,722	$23,857	$13,240
5.0	$19,925	$19,405	$30,540	$24,647
Adelaide				
1.5	$8575	$8575	$15,522	$9093
2.0	$10,505	$10,505	$19,767	$11,023
3.0	$14,411	$14,411	$25,546	$14,929
4.0	$27,883	$21,206	$32,341	$21,724
5.0	$38,482	$35,002	$40,995	$37,260
Darwin				
1.5	$12,495	$12,495	$23,629	$13,013
2.0	$15,611	$15,611	$26,746	$16,129

(continued)

Table 10.10 (continued)

City and system capacity (kW)	Consumption by number of occupants			
	1–2	3–4	5+	Average
3.0	$24,248	$21,810	$32,945	$22,328
4.0	$27,621	$30,939	$42,074	$32,344
5.0	$32,813	$41,223	$53,021	$31,219
Perth				
1.5	$10,386	$10,386	$18,184	$10,904
2.0	$12,919	$12,919	$23,316	$13,437
3.0	$23,225	$18,033	$29,167	$18,551
4.0	$32,206	$26,035	$37,170	$31,944
5.0	$43,046	$41,486	$47,031	$42,784

Table 10.11 Percentage of cost saving of using photovoltaic solar systems in a 15-year period

City and system capacity (kW)	Consumption by number of occupants			
	1–2 (%)	3–4 (%)	5+ (%)	Average (%)
Sydney				
1.5	4.20	2.82	1.92	3.33
2.0	3.01	2.02	1.38	2.39
3.0	0.76	0.51	0.35	0.60
4.0	6.57	4.40	3.00	5.21
5.0	17.56	11.77	8.03	13.93
Canberra				
1.5	33.96	22.76	15.53	26.94
2.0	45.52	30.51	20.82	36.11
3.0	64.52	43.25	29.51	51.19
4.0	91.59	61.39	41.88	72.66
5.0	123.83	83.00	56.63	98.25
Melbourne				
1.5	16.08	10.77	15.13	13.90
2.0	19.66	13.18	19.36	16.75
3.0	26.85	18.00	26.48	22.45
4.0	62.72	28.30	33.50	34.64
5.0	98.30	41.92	42.80	66.79
Brisbane				
1.5	27.28	18.29	22.06	22.79
2.0	33.78	22.64	28.23	27.95
3.0	61.45	31.45	35.66	38.37
4.0	88.51	45.66	45.35	67.52
5.0	120.76	74.43	57.41	93.10

(continued)

Table 10.11 (continued)

City and system capacity (kW)	Consumption by number of occupants			
	1–2 (%)	3–4 (%)	5+ (%)	Average (%)
Hobart				
1.5	13.55	9.08	20.40	11.90
2.0	16.30	10.92	21.65	14.07
3.0	21.80	14.61	24.17	18.44
4.0	47.63	23.78	30.42	29.30
5.0	55.57	36.27	38.95	54.54
Adelaide				
1.5	23.91	16.03	19.80	20.12
2.0	29.30	19.64	25.21	24.39
3.0	40.19	26.94	32.58	33.03
4.0	77.76	39.64	41.24	48.07
5.0	107.32	65.43	52.28	82.44
Darwin				
1.5	34.85	23.36	30.13	28.79
2.0	43.54	29.18	34.11	35.69
3.0	67.62	40.77	42.01	49.40
4.0	77.03	57.83	53.66	71.57
5.0	91.51	77.06	67.62	69.08
Perth				
1.5	28.97	19.41	23.19	24.13
2.0	36.03	24.15	29.73	29.73
3.0	64.77	33.71	37.20	41.05
4.0	89.82	48.67	47.40	70.68
5.0	120.05	77.55	59.98	94.67

total cost saving of 123.83 % with about $44,403 for the GFIT scheme, the 5 kW installed in Brisbane for 1–2 household occupants with the total cost saving of 120.76 % with about $43,300 for the NFIT scheme, and the 5 kW installed in Darwin for 1–2 household occupants with the total cost saving of 91.51 % with about $32,813 for the buy-back scheme.

The life cycle cost saving and percentage of cost saving are highly depended on the daily electricity produced by the photovoltaic solar systems and rates of their feed-in-tariff scheme saving. Darwin receives the highest daily electricity produced based on its geographical location but with the lowest rate in the feed-in-tariff scheme saving, while Melbourne receives the highest rate in the feed-in-tariff scheme saving but with the second lowest daily electricity produced.

It is found that the GFIT and NFIT schemes offer great benefits for life cycle cost saving in installing photovoltaic solar systems, as the rates in the feed-in-tariff scheme saving are good. However, the buy-back scheme in Perth and Darwin in general receives the lowest life cycle cost saving and percentage of cost saving in the 15-year period. It appears that the rates of the feed-in-tariff scheme saving from the buy-back scheme are the lowest since it offers from their electricity retailers, in which it affects the life cycle cost saving.

It is also found that the higher the capacity of the photovoltaic solar systems, the higher the life cycle cost saving you can receive.

10.3 Conclusions

This paper examined the life cycle cost effectiveness of using photovoltaic solar systems ranging from 1.5 to 5 kW in relation to the number of occupants and consumption for residential dwellings over a 15-year period. Eight major Australian cities including Sydney, Canberra, Melbourne, Brisbane, Hobart, Adelaide, Darwin and Perth were investigated. It was found that all major cities can receive life cycle cost saving in installing photovoltaic solar systems in their residential dwellings. The life cycle cost saving is between $273 and $53,021 and the percentage of cost saving is between 0.35 and 123.83 % in a 15-year period. It was appeared that the GFIT and NFIT schemes offer better benefits than the buy-back scheme in installing photovoltaic solar systems. It was also found that the higher the capacity of the photovoltaic solar systems, the higher the life cycle cost saving you could receive. This paper contributed to prove the cost effectiveness of using photovoltaic solar systems with the example from Australian residential dwellings.

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Chapter 11
Defining Green Road Infrastructure Projects—A Critical Review

Peng Wu, Bo Xia, Xianbo Zhao and Josua Pienaar

Abstract Green infrastructure is considered as a strategic approach to address the ecological and social impacts of urban sprawl. The main elements of green infrastructure have been well established and include a series of multifunctional ecological systems, such as green urban space, green road infrastructure and the links between these systems. However, it should be noted that the elements of green road infrastructure have only been briefly mentioned in isolated life cycle stages, e.g. design, procurement, construction, maintenance and operation. The definition of green road infrastructure and the elements in green road infrastructure projects remain largely unknown. To explore the elements in green road infrastructure, a critical review was adopted. As the development of green road infrastructure projects is guided by rating systems, a comparison of three major green roads rating systems, including Greenroads™, Envision™ and Infrastructure Sustainability Rating Tool—IS, was conducted. The comparison reveals that green roads can be defined as road projects that have superior performance in economic, social and environmental sustainability. The sustainability features in green roads mainly include environmental sustainability, social sustainability, economic sustainability, quality, pavement technology and innovation. The results will contribute to an increased understanding of green roads and will be useful to improve the performance of road projects on these sustainability features.

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Keywords Green roads · Sustainable development · Sustainability features · Rating systems

11.1 Introduction

"Green infrastructure" is used to describe the abundance and distribution of natural features in the landscape like forests, wetlands, and streams (Weber et al. 2006). The concept is based on increasing global recognition of sustainable development, which is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 43). The terms "green" and "sustainable" are often used interchangeably. Similar to the definition of green building, green projects or sustainable projects refer to projects that can enhance the environment and benefits human well being, community, environmental health and life-cycle cots (Adler et al. 2006). In the past few decades, green projects, notably green buildings, have been through a flourishing development due to a growing market demand for environment-friendly solutions and products (Wu and Low 2010; Xia et al. 2013).

The transportation sector has a large impact on the sustainable development of the human society. The sector is one of the largest sources of greenhouse gas (GHG) emissions. For example, according to U.S. Environmental Protection Agency (2013), transportation represented approximately 27 % of total U.S. GHG emissions. The sector also accounted for overall half of the net increase in total U.S. GHG emissions from 1990–2011 (U.S. Environmental Protection Agency 2013). Road transport also has other significant impacts on a variety of environmental issues, such as biodiversity, wildlife, urban stormwater and urban environment (Australian Bureau of Statistics 2013). Given the importance of the transportation sector for the society to achieve sustainable development, many green initiatives have been taken. Of particular interest is the development of green road infrastructure projects (hereinafter referred to as green roads) in recent years. Mulmi (2009) argued that the triple bottom line of sustainable development can be applied to road construction and green roads should fulfill the requirements of environment sustainability, sustainable communities and sustainable economy. The European Commission (2012) stated that green roads fit into its surroundings and contribute, by means of design and composition, to minimizing the impact of traffic (noise, air pollution and vibrations) and energy consumption of the transport system. Mandalozis et al. (2013) provided some good practices, which were drawn from a series of case studies, in green roads.

However, it should be noted that these studies focus on isolated life cycle stages or issues in the development of green road infrastructure. A holistic approach should be used when examining the concept and requirements in green roads to assist future development. This paper therefore aims to examine the concept and requirements in green roads through a comprehensive literature review, based on which further analysis on the development of green road infrastructure projects can be conducted.

11.2 What Are Green Roads?

Green projects refer to projects that can meet the requirements of the triple bottom line of sustainable development, including environmental, economical and social aspects. One notable example in the history of green projects is green building, which emerged during the late 19th and early 20th centuries (Cassidy 2003). The concept refers to tailoring a building and its placement on the site to the local climate, site conditions, culture, and community to reduce resource consumption, augment resource supply, and enhance the quality and diversity of life (Adler et al. 2006).

The whole green concept is a division under the umbrella of sustainable development, which is characterized by Sara Parkin of the British environmental initiative forum for the future as "a process that enables all people to realize their potential and improve their quality of life in ways that protect and enhance the Earth's life support system" (Forum for the Future 2008). The concept has gained rapid recognition in the building industry through "green building", which is a holistic solution to achieve sustainable development in the project life cycle. However, the concept has only been applied similarly to the transportation sector recently. According to Muench et al. (2010), a green road is defined as roadway project that has been designed and constructed to a level of sustainability that is substantially higher than current common practice. These may include the implementation of new techniques and tools to promote reuse and recycling, the use of low energy consuming construction and maintenance technology, the use of environmentally-friendly materials, etc.

In order to systematically assess the development of green road infrastructure and more importantly, to guide the development, similar to the practices that are adopted in green buildings, various rating systems have been developed. In order to assess and certify green building, many rating systems, including the most commonly used the Leadership in Energy and Environment Design (LEED) and the Green Globes, were developed. Similarly, the most commonly used rating systems for green roads include: Greenroads™, Envision™ and Infrastructure sustainability rating tool (IS).

11.3 Green Road Rating Systems

11.3.1 Greenroads™

Greenroads™ is a comprehensive rating system that is designed for the certification of green road projects by the University of Washington in 2007. The aim of the rating system is to:

- Define what sustainable features should be assessed in green road projects;
- Provide accountability for the assessment of these sustainable features;

Table 11.1 Compulsory requirements in Greenroads^{TM}

PR-1 Environmental review process	A comprehensive environmental review must be completed
PR-2 Life cycle cost analysis	A life cycle cost analysis for pavement section must be performed
PR-3 Life cycle inventory	A life cycle inventory analysis for pavement section must be performed
PR-4 Quality control plan	A quality control plan should be established to assess the contractor
PR-5 Noise mitigation plan	A noise mitigation plan should be established
PR-6 Waste management plan	A waste management plan should be established
PR-7 Pollution prevention plan	Stormwater pollution prevention plan should be established
PR-8 Low impact development	A low impact development feasibility study should be conducted
PR-9 Pavement management plan	Have a pavement management system
PR-10 Site maintenance plan	Have a roadside maintenance plan
PR-11 Educational outreach	Publicize sustainability information of the project

Source Anderson et al. 2011

- Encourage the use of innovative designs and technologies; and
- Communicate the sustainable features of the projects to various stakeholders.

In order to be certified by Greenroads^{TM}, the project needs to comply with 11 compulsory requirements. These requirements are shown in Table 11.1. As can be seen from Table 11.1, the focus of Greenroads^{TM} covers the three aspects of sustainability. The economic sustainability of the project is assured using life cycle cost analysis. The environmental sustainability of the project is assured using life cycle inventory and other waste or pollution management plans. The social sustainability of the project can be achieved by publicizing sustainability information of the project.

Other than the compulsory requirements, Greenroads^{TM} also has a total of 118 voluntary credits that are allocated to environment and water (EW), access and equity (AE), construction activities (CA), materials and resources (MR), pavement technologies (PT) and custom credits (CC). Depending on the voluntary credits obtained, the projects can be awarded as certified (32–42 voluntary credits), silver (43–53 voluntary credits), gold (54–63 voluntary credits) and evergreen (64+ voluntary credits).

Greenroads^{TM} focuses on some design issues (e.g. the use of recycled and regional materials), construction issues (e.g. the construction activities) and operational issues (e.g. pavement management). However, if assessed using the life cycle concept, there are two major issues in Greenroads^{TM}. The rating system does not cover demolition or the end-of-life phase of the project which may have a significant impact on the environmental performance of the project. For example, Wu et al. (2014) found that the end-of-life phase of concrete can have a significant impact on the life cycle greenhouse gas emissions and the impact should be appropriately included in the life cycle analysis. Similarly, the impact of end-of-life treatment of pavement or other green road components should be appropriately addressed. In addition, the main target of Greenroads™ is pavement. As pavement is the core structural component of road infrastructure, this strategic focus can accurately assess the contractor's ability to design or construct the green project. However, road projects are designed to facilitate the use of transportation vehicles and as a holistic approach to facilitate such use, the impact of the projects on transportation vehicles should not be overlooked. For example, Loijos (2011) found that in adequate design of the pavements can increase the fuel consumption of transportation vehicles, thus increasing energy consumption and emissions. The maintenance of roads (i.e. roadworks) should also be conducted in such a way to cause minimum interruptions to the traffic to avoid an increase in energy consumption and emissions. The impacts caused by components other than pavements should also be investigated.

11.3.2 Envision™—Sustainable Infrastructure Rating System

The sustainable infrastructure rating system—Envision™ was launched by the Institute of Sustainable Infrastructure (ISI) in 2012. According to the Institute for Sustainable Infrastructure (2014), Envisions™ evaluates grades and gives recognition to infrastructure projects, including road projects, that provide progress for and contributions to a sustainable future. The purpose of the rating system is to foster a necessary and dramatic improvement in the performance and resiliency of physical infrastructure across the full dimensions of sustainability, i.e. the triple bottom line including economic, social and environmental sustainability.

A major difference between Envision™ and Greenroads™ is that the former rating system adopts a life cycle view of the project. As can be seen in Fig. 11.1, Envision™ adopts a four stage evaluation process. In the most important stage, i.e.

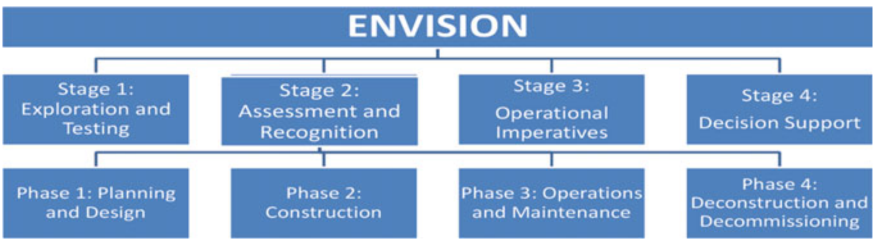

Fig. 11.1 The evaluation procedure in Envision™ (*Source* Institute for Sustainable Infrastructure 2014)

assessment and recognition, the rating system adopts a life cycle point of view that includes planning and design, construction, operations and maintenance, as well as deconstruction and decommissioning.

In total, Envision^{TM} has five main categories, including quality of life, leadership, resource allocation, natural world and climate. Under each of the category, there are a total of 60 subcategories against which a project should be evaluated. Depending on the scores achieved, the project can be certified as improved, enhanced, superior, conserving and restorative. Projects that are awarded as conserving usually have zero negative impact. If a regenerative effect can be identified in the infrastructure project, the project can then be awarded as restorative.

11.3.3 Infrastructure Sustainability Rating Tool—IS

The IS rating tool was developed by the Infrastructure Sustainability Council of Australia. The rating tool is a comprehensive system to evaluate sustainability in three major areas in infrastructure system, including design, construction and operation. One major difference between IS and other rating systems is that IS can offer interim certification as the project progresses. For example, a certification for design can be sought after by the developer at the end of planning and design. Such certification will be replaced by the certification for construction and operation as the project progresses.

There are five major categories in the IS, including management and governance, using resources, emissions, pollution and waste, ecology, as well as people and place. There are 51 subcategories consisting of 100 scores to be allocated. An additional 5 scores can be allocated to innovation. Depending on the scores achieved, the project can be awarded as commended, excellent or leading.

11.4 Discussions

Green road projects are road projects that have superior performance on sustainability features than other common road projects. The central issue in defining green road projects is therefore the identification of sustainability features. Table 11.2 presents a comparison of the three major rating systems on green roads to identify the sustainability features in green roads. As can be seen from Table 11.2, although different rating systems have different focus, there are some common practices adopted.

It is not surprising that environmental sustainability is one of the main focuses of green road projects. Given that environmental issue is one of the most challenging issues at the moment, focusing on environmental sustainability may help infrastructure projects to address environmental issues.

Table 11.2 Sustainability features in green road rating systems

Sustainability features	Greenroads™	Envision™	IS
Economic sustainability	Project requirements		
	Environment and water		
Environmental sustainability	Environment and water	Wellbeing	Procurement and purchasing
	Construction activities	Materials	Climate change adaption
	Materials and resources	Energy	Energy and carbon
		Water	Water
		Siting	Materials
		Land + water	Discharges to air, land and water
		Biodiversity	Land
		Emissions	Waste
		Resilience	Ecology
			Urban and landscape design
Social sustainability	Project requirements	Purpose	Community health, well-being and safety
	Access and equity	Wellbeing	Heritage
		Community	Stakeholder participation
		Collaboration	
Pavement	Pavement technology		
Quality	Project requirements	Management	Management system
	Environment and water	Planning	
	Construction activities		
Innovation	Custom credits	Innovation	Innovation

As can be seen from Table 11.2, environmental sustainability in green roads includes:

- the selection of appropriate site for development;
- the use of appropriate urban and landscape design;
- addressing environmental impacts, especially emissions, land, waste and water;
- preserving ecology; and
- reducing the use of energy and materials by using low energy consumption materials or regionally manufactured materials.

The focus on environmental sustainability is in accordance with the development of the rating systems in green buildings, such as LEED, the Green Globes and the Green Mark (Wu and Low 2010). According to Wu and Low (2010), the assessment of environmental impacts is one of the core areas in green building rating systems and environment-friendly features have always been the best representative features of green buildings.

Similarly, social sustainability accounts for a large portion of the credits in these rating systems. Social sustainability in green roads includes:

- the provision of improved access to community;
- improving the wellbeing and safety of the community;
- collaborating with various stakeholders to encourage engagement; and
- knowledge sharing with the public.

In social sustainability, all rating systems highlight the importance of engagement, either by educational and cultural outreach (in Greenroads™), fostering collaboration and teamwork (Envision™), or knowledge sharing and stakeholder engagement (IS). It seems that the rating systems for green projects have evolved to include more than just environmental aspects of the projects. Although addressing environmental impacts is important, initiating a transition in decision making process to include the triple bottom line of sustainability by education and engagement is now a common practice.

It is surprising to see that only Greenroads™ has listed economic sustainability explicitly in the rating systems. A life cycle cost analysis of the overall project should be conducted and separate life cycle cost analysis of the project components, e.g. stormwater, may be needed. The issue with incorporating economic sustainability is that the strategies taken to address environmental impacts may harm the economic performance of the project and the costs associated with green projects may be higher than traditional projects (Yudelson 2008). For example, According to Hwang and Tan (2012), compressed wheat board, which is a green substitute for plywood, costs about 10 times more than ordinary plywood. Searching for green alternatives and the certification of buildings will also lead to high cost premium of green projects (Yudelson 2008). Therefore, the rating systems do not list a certain level of rate of return as the economic indicator. Conducting a life cycle cost analysis of the project will be sufficient to gain relevant credits.

Another sustainability feature of green road projects is quality control. Quality control plan, site maintenance plan, quality management system, risk management system and other quality control issues should all be established to ensure that the projects can have a superior long-term performance. One significant difference in Greenroads™, compared with other rating system, is that it has a separate section on pavement, one core component of road infrastructure projects. The performance of pavement is therefore separately listed in Greenroads™.

11.5 Conclusion

Due to the global recognition of sustainable development, the development of green projects has been expanded to infrastructure projects, including road projects. While some initiatives in assessing green roads have been established, the education about the definition and sustainability features of green roads may have been left behind.

Similar to the development of green buildings, green roads incorporate the triple bottom line of sustainable development and have superior performance than other traditional road projects on environmental sustainability, social sustainability, pavement technology, quality control and innovation. The economic sustainability may not be superior due to the high premium costs of green roads. The life cycle costing of green roads should therefore be a future research focus because achieving economic sustainability remains as one of the core areas in sustainable development and should not be overlooked.

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Chapter 12
Measuring Sustainability Performance Within the Australian Energy Industry

Nayana Dissanayake, Bo Xia and Peng Wu

Abstract Sustainability has become crucial for the energy industry as projects in this industry are extensively large and complex and have significant impacts on the environment, community and economy. It demands the energy industry to proactively incorporate sustainability ideas and commit to sustainable project development. This study aims to investigate how the Australian energy industry responds to sustainability requirements and in particular what indicators used to measure sustainability performance. To achieve this, content analysis of sustainability reports, vision statements and policy statements of Australian energy companies listed in the 2013 PLATTS Top 250 Global Energy Company Rankings and government reports relating to sustainability has been conducted. The findings show that the energy companies extensively discuss sustainability aspects within three dimensions, i.e. community, environment, and economy. Their primary goals in sustainability are supplying cleaner energy for future, and doing business in a way that improves outcomes for shareholders, employees, business partners and the communities. In particular, energy companies have valued the employees of the business as a one of the key area that needs to be considered. Furthermore, the energy industry has become increasingly aware of the importance of measuring sustainability performance to achieve sustainability goals. A number of sustainability indicators have been developed on the basis of the key themes beyond economic measures. It is envisaged that findings from this research will help stakeholders in the energy industry to adopt different indicators to evaluate and ultimately achieve sustainability performance.

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12.1 Introduction

The global population growth and the rising living standards place massive pressure on energy and continue to drive the energy demand. It has become crucial for the energy industry to embrace sustainable development as energy projects are extensively large and complex and have significant impacts on the environment, community and economy (Zuo et al. 2013). If not appropriately managed, energy projects can have significant negative impacts over the projects' life cycle (Wu and Low 2009, 2012; Wu et al. 2013). In addition, the community at large expects a reliable and competitively priced energy supply and increasingly expects that the energy is produced and consumed on a more sustainable basis. On the other hand, businesses that integrate sustainability in their planning and performance are likely to improve productivity, avoid unnecessary business costs and build reputation from the community where they operate, which eventually open up new opportunities and the market (Beheiry et al. 2006). Sustainable project practices address the capital project risk factors which can negatively influence the project performance-delaying projects, incurring contingencies on unforeseen conditions, high occurrence of injury incidents, reduced labor satisfaction (Beheiry et al. 2006). It demands the energy industry to proactively incorporate sustainability ideas and commit to sustainable project development. In doing so, the energy industry can assess the importance of these activities to the business, and stakeholders are keen to identify, and report them within global reporting guidelines.

The present awareness clearly represents that all stakeholders are concerned about establishing an indicative system which reports, measures, and assess sustainability performance (Ghosh et al. 2006). 'Sustainable Australia Report 2013' highlights that there are a number of trends and drivers of sustainable development in Australia and around the world that impact the future generations, and consequently suggests that measuring sustainable performance with suitably designed indicators is inevitable (National Sustainability Council Australia 2013).

Energy companies in Australia have extensively implemented sustainability practices within three dimensions, i.e. community, environment, and economy. Their primary goal in sustainability is supplying cleaner energy for future, and doing business in a way that improves outcomes for shareholders, employees, business partners and the communities. In particular, the energy companies have valued the employees of the business as a one of the key areas. Most energy companies aim at avoiding and minimizing the impacts on the environment and community with the use of tailored techniques and management strategies. Notably, the energy companies increasingly do monitoring, auditing and inspections to improve the practices and procedures in achieving sustainability. These actions include but not limited to measuring and reporting sustainability performance.

Furthermore, the energy industry has become increasingly aware of the importance of measuring sustainability performance to conduct the business sustainably. To do so, they have developed the sustainability indicators on the basis of the social, environment and economic aspect beyond economic measures which assess the impact of business activities for better performance.

This study aims to investigate how the Australian energy industry responds to sustainability requirements and in particular explores existing indicators that are used to measure sustainability performance. The Australian companies which are in the 'PLATTS TOP 250 Global Energy Industry Rankings 2013' list were selected for a comprehensive investigation. It is envisaged that findings from this research will allow stakeholders in the energy industry to evaluate and achieve sustainable performance, and ultimately set the path for building a sustainable Australian society.

12.2 Measuring Sustainability Performance

Sustainability requires that the wellbeing of society, community livability, environmental sustainability and economic prosperity over the time. Sustainability aspects are extensively discussed within three dimensions, i.e. community, environment, and economy. These three dimensions cannot be measured alone but should look at collectively (Beheiry et al. 2006). Measuring sustainability is about monitoring how each of these three dimensions is tracking over the time. This means that the resources inherited by future generations allow for the same or greater levels of wellbeing as enjoyed by us today. Accurate measurement of sustainability within three dimensions is therefore essential and various industries and companies have concluded that the sustainable development approach brings value to the company and there is need for the industries to develop set of indicators against which the sustainability performance can be benchmarked (Beheiry et al. 2006).

'Indicator' is defined as an operational representation of an attribute of a system, while data is the actual measurements or observations of the values of the indicator (Beheiry et al. 2006). Indicators are the bases for quantitative and qualitative assessment of sustainability performance, indicate possible new and valuable correlations and also provide a basis for future planning actions (Ghosh et al. 2006). Indicators can be in various forms such as a variable, a function of a variable, qualitative variable, ranking variable or a quantitative variable.

As reported in Ghosh et al. (2006), many countries have developed various sets of indicators. In particular, the United Nations division of sustainable development developed a comprehensive set of 134 indicators for categories of society, economics, environment and institutions where these categories were divided into subthemes vertically, and each theme was further sub-divided horizontally into driving force (the cause), state (the present status) and response (policy measures taken for solution). They have been widely used by many countries in order to develop their own sustainability indicators. However, it should be pointed out that not all three items (cause–status–solution) are available for a particular indicator and it is often ambiguous whether the indicator is to be interpreted as a cause or a state. It requires determining the acceptable level of simplification which is a critical issue as simplification of complex issues is misleading and erroneous results can be the outcome. On the other hand, if the indicators are too complex or numerous, wider community may not understand. Among other factors that need to be considered in developing indicators include:

- Simple indicators for complex issues (too complex or numerous indicators are not easy to understand)
- Acceptable levels of simplifications (otherwise erroneous results)
- How far the indicators are applicable to the process of change
- Number of indicators (high number of indicators creates complex issues and also makes it understand the entire situation)
- Diverse measurement units of different indicators complicate the comparison and formulation of a meaning full result
- Areas of integration
- Appropriate methodology for measuring desired indicators

12.3 Research Method

To identify indicators for the measurement of sustainability performance in the Australian energy industry, Australian energy companies listed in the PLATTS Top 250 Global Energy companies were selected for a comprehensive content analysis. Those companies with respective ranking and the industry include Woodside Petroleum (57/oil and gas), Origin Energy (90/oil and gas), Santos (159/oil and gas), AGL Energy (227/multi utilities), The SP AusNet Group (241/electric utilities) and Caltex Australia (244/oil and gas) (PLATTS TOP 250 Rankings 2013). The Platts Top 250 Global Energy Company Rankings were launched in 2002 to recognize the top financial performers in energy. Content analysis of sustainability reports (covering the sustainability vision, targets for the year of reporting, performance for the year and the target for the coming year), vision statements and policy statements of these six companies has been conducted. In addition, government publications relating to sustainability have been also analyzed. These materials help to reveal owners' commitment towards sustainability and the indicators for measuring sustainability.

Content analysis is an effective approach to reveal the themes from various forms of recorded materials (Xia et al. 2012, 2013). The initial investigation focused on the significance of measuring sustainability to the business and the industry, sustainability commitments and the set targets for achieving sustainability, reporting framework to the stakeholders and the basis of reporting framework. After that, the research comprehensively investigated the indicators currently used by these energy companies to measure sustainability. Meanwhile, Australian government incentives towards measuring sustainability and government launched programs to measure sustainability have been also investigated.

12.4 Sustainability Indicators Proposed by the Australian Government

In 2012, the National Sustainability Council was established to advise sustainability issue and deliver public report against the sustainability indicators (Australian Government 2013). National Sustainability Council has developed sustainability indicators with due consideration to domestic and international best practice and with consultations of state and local governments, academic and research institutions, business and industry, and non-government and community organizations (National Sustainability Council Australia 2013). These indicators are based on social and human, natural, and economic capitals (see Table 12.1).

Table 12.1 Sustainability indicators-Australian government

Dimension	Details	Sustainability indicators
Social and human	Skills and education	Educational attainments
	Health	Self-reported physical health life expectancy
	Institutions, governance and community engagement	Level of trust in core institutions volunteering
	Employment	Under-employment unemployment
	Security	Feelings of safety
Natural	Climate and atmosphere	Air quality greenhouse gas emissions
	Land, ecosystems and biodiversity	Extent of native vegetation ground cover
	Water	Water quality
	Waste	Waste disposal to landfill
	Natural resources	Fish stocks timber resources mineral and fossil fuel reserves
Economic	Wealth and income	Household net worth income disparity
	Housing	Housing supply
	Transport and infrastructure	Vehicle and passenger kilometers travelled
	Productivity and innovation	Productivity

12.5 Sustainability Indicators Used by the Energy Industry

The energy industry is committed to conduct the business with due care in accordance with laws and regulations to ensure health and safety of employees; minimize the health, safety and environmental impacts on community. The energy companies measure and report sustainability performance to give the stakeholders an understanding of social, environmental and economical challenges that the company and the energy industry as a whole are facing. Annual Sustainability Reports explain to the stakeholders how they meet the stakeholder sustainability expectations over the year and the targets for the next year and beyond. These sustainability reports are in consistent with 'Global Reporting Initiative (GRI) Sustainability Reporting Guidelines (G3)' which provides the guidance for the companies to use as the basis for disclosing sustainability performance within universally applicable and acceptable framework that helps the stakeholders to understand the reported information.

Energy companies extensively discuss sustainability aspects within three dimensions, i.e. community, environment, and economy. The environment sustainability indicators commonly comprises air quality, greenhouse gas emissions, climate change management, bio diversity and land disturbance, carbon management, water management, waste management etc. Community sustainable indicators include community wellbeing, social investments, employment opportunities, social infrastructure developments, safety (of community and employees), workforce remunerations etc. Economic sustainable indicators comprise of business performance, new developments, transport and infrastructure development, etc. In particular, safety performance is paramount to all energy companies as failure to operate safely can cause damage to environment and disruption to community. Table 12.2 summarises the available information from their company project portfolio and web based sources. They report the sustainability performance against each of these indicators in compliance with the laws, regulations and contractual obligations.

As Australia's largest independent oil and gas company, Woodside Petroleum identifies the sustainability issues of significance to the stakeholders and the business through a 'Material Assessment' in accordance with AA100 Assurance standard and report the sustainability performance annually (Woodside Petroleum 2012). The sustainability indicators have been grouped under key themes of community, people, environment, and economic.

Origin Energy, a leading energy supplier in Australia and New Zealand has identified sixteen (16) activities that are of most interest and important to the business and stakeholders and referred these as 'Material Aspects' against which sustainability performance targets be achieved.

As one of the Australia's largest gas producers, Santos describes that the sustainability is responsibly managing environmental impact, working in partnership with communities, focusing on the health and wellbeing of the employees, and reliably managing the business. Key challenge over the short term to medium term

Table 12.2 Sustainability indicators-energy industry

Community	People	Environment	Economic
• Community engagement • Social investments • Community wellbeing • Indigenous engagement • Cultural heritage • Impact on regional community • Managing community impact from energy developments • Social infrastructure developments • Reputation	• Health and wellbeing • Safety • Governance and transparency • Diversity • Capability • Culture • Employee numeration and benefits	• Air quality • Biodiversity and land disturbance • Climate change management • Incidents and spills • Waste management • Water resources • Energy efficiency • Cleaner energy sources • Emergency preparedness	• Business partnership performance • Economic contribution • New project development and acquisition • Security • Risk Management • Supply chain performance • Customers and market • Energy affordability

for them is to ensure continuous delivery of energy from existing operations and develop new projects sustainably. To address this, Santos is keen to improve safety performance, responsibly manage resources, improve energy efficiency, and maintain strong governance of the business. They listen to the community needs and support the needs of the community. Monitoring and management programs are in place to protect water resources. Given that south-east area is one of the fast growing economic regions in Australia, they invest significantly to provide a secure, affordable and reliable supply of energy over the next 25 years. More importantly, they support the global transition to a low carbon economy through decarbonisation of the electricity sector, which accounts for over 30 % of Australia's greenhouse gas emissions. Santos' Sustainability report focuses on social, environmental and financial performance, and provides a comprehensive overview of the priorities and performance. 24 sustainability indicators are used in Santos to measure sustainability performance (Santos 2012).

AGL Energy, Australia's leading integrated renewable energy company, has diverse power generation from traditional thermal (oil and gas) as well as renewable sources (wind, hydro, solar, landfill gas and bio mass); (AGL Energy 2013). They measure and report sustainability performance through the sustainability reports since 2004. The performance data has been structured into six groups that include economic, customers, community, people and safety, sustainable energy and environment, with each having two focus areas, thus 12 indicators aiding decision making.

SP AusNet Group does energy distribution and transmission business in Victoria. It reports sustainability in accordance with GRI G3 and the GRI Electric Utility Sector supplement. The sustainability is discussed under key themes of social, environment and financial dimensions (SP AuaNet Group 2011).

As Australia's leading supplier of petroleum products, Caltex Australia has developed sustainability indicators based on key themes of safety, environment, society, and people and culture (Caltex Australia 2011).

12.6 Conclusion

The development of effective measures to monitor sustainability performance has become a global subject. International organizations (e.g. United Nations, Organization for Economic Cooperation and Development) and a number of countries including Australia have developed sustainability indicators with due consideration to domestic and international best practices. In particular, as the energy industry in Australia has a significant impact not only on its economy but also environment and society, energy companies has been continuously identifying activities that are of most interest and importance to the business and stakeholders and has developed various sustainability indicators to measure the sustainability performance against key dimensions in compliance with the laws, regulations and contractual obligations. Their sustainability reports give stakeholders an understanding of sustainability issues and opportunities ahead and how they have travelled over the year to achieve sustainability targets.

The findings of this study reveal that the Australian government and energy companies share similar sustainability perception in project developments. It is interesting to find that in addition to the three main sustainability dimensions (i.e. social, environmental and economic), people/human in the business has been identified as another major sustainability dimension that has been integrated with others. In particular, the energy companies have valued the employees of the business as one of the key areas that needs to be considered. Furthermore, the energy industry has developed various indicators to assess sustainability performance. The environment sustainability indicators commonly comprises air quality, greenhouse gas emissions, climate change management, bio diversity and land disturbance, carbon management, water management, waste management etc. Community sustainable indicators include community well being, social investments, employment opportunities, social infrastructure developments, safety (of community and employees), workforce remunerations etc. Economic sustainable indicators comprise of business performance, new developments, transport and infrastructure development, etc. In particular, safety performance is paramount to all energy companies as failure to operate safely can cause damage to environment and disruption to community.

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Chapter 13
Exploring Key Contributors to Achieving Sustainability in Infrastructure Projects: A Critical Review

Xiaohua Jin, Jian Zuo, Yingbin Feng and Peng Wu

Abstract Accelerating urbanization around the world has created an unprecedented demand for public infrastructure. Increasingly, governments around the world have been gaining finances through private sector capital, and utilizing such procurement methods as a vehicle for delivery. These procurement methods have the potential to gain efficiency, innovation and better Value for Money through pooling resources with the private sector while offering essential social and economic services to society. Meanwhile, the sustainability of all projects undertaken within the construction industry is progressively becoming more relevant. Importantly, infrastructure projects in the public sector have become more and more highly scrutinized on their sustainability. Previous studies ignored the facts that privately financed public infrastructure (PFPI) projects are substantially different from other construction projects mainly due to their long life cycle and resultant uncertainties and risks, and, subsequently, hold a distinct way of achieving sustainability goals and impacting on the interlinked human and built environment. Therefore, the achievement of overall sustainability and value-for-money in PFPI projects are hindered. This paper explores key factors contributing to the sustainability in PFPI projects. The findings will be utilized for a future research project to establish a particular way to facilitate the achievement of sustainability in public infrastructure projects.

Keywords Sustainability · Public infrastructure · Private participation · Construction projects

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13.1 Introduction

In 1987, the Brundtland Report defined sustainable development (SD) as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED 1987, p 37). As indicated by Chong et al. (2009) technology and knowledge are used in sustainable construction to enhance the sustainability of production processes, operations and practices and designs of infrastructures and achieve SD objectives. "*Green building*", a term commonly used to refer to environmentally sustainable building, involves creating structures and using processes that are environmentally responsible and resource-efficient (Falkenbach et al. 2010). This occurs throughout the life cycle of the building from when its site is determined, through the phases of design, construction, operation, maintenance, renovation, and deconstruction. This is extremely important, as buildings have a significant impact on environmental quality, resource use, human health and productivity (Dong and Wilkinson 2007). The environmental aspect of sustainability involves reducing ecological impacts today in order to preserve the environment for future generations (Jones et al. 2010).

It has been accepted that environmental sustainability should be implemented in construction companies and that there is an economic benefit associated with its implementation (Turcsanyi and Sisaye 2013; Beheiry et al. 2006; Kajander et al. 2012). Epstein (2010) indicated that some companies are successful at implementing sustainability while others are not and sought to establish success factors in managing social, environmental and financial performances simultaneously. Studies have been performed to identify CSFs contributing to environmental management systems and other aspects of sustainability (e.g. Daily and Huang 2001; Harris 2007; Perez-Sanchez et al. 2003; Robinson et al. 2006; Zutshi and Sohal 2004), but only the study performed by Epstein (2010) considered CSFs associated with implementation of environmental sustainability. However, no studies have been performed in Australia to identify CSFs associated with implementation of environmental sustainability.

Therefore, with respect to the implementation of environmental sustainability in construction companies, it is worth exploring what factors are indispensable for implementation of environmental sustainability. Based on the identified research gap, the research question is: What are the critical success factors for implementation of environmental sustainability in Australian commercial construction companies? Accordingly, the objective of the research is to identify critical success factors (CSFs) for implementation of environmental sustainability. In this paper, the candidate CSFs are discussed based on a literature review. Research methods are currently under design. In the following sections, a review of sustainability and the past research on the implementation of environmental sustainability in the construction industry is discussed. The candidate CSFs contributing to successful implementation of environmental sustainability are then identified.

13.2 Sustainability

Due to its importance, sustainability is one of the most discussed topics with respect to construction activities today (Fellows and Liu 2008). These activities have major impacts on social, environmental and economic aspects of sustainability (Zuo et al. 2012). They may be positive including contributing to gross domestic product (GDP), providing employment opportunities and producing buildings and facilities. However, there are also negative impacts which include the generation waste, greenhouse gas emission, noise and dust (Zuo et al. 2012).

There are a number of competing systems in sustainable development, as shown in Fig. 13.1. The key elements are the economic, the socio-environment, the socio-economic and the legal systems all with competing values. Policies and legislation, which are long term goals, may, in the short term constrain economic development. In addition, environmental protection measures that are socially desirable may constrain socio-economic activities in the short term (Liu 2006).

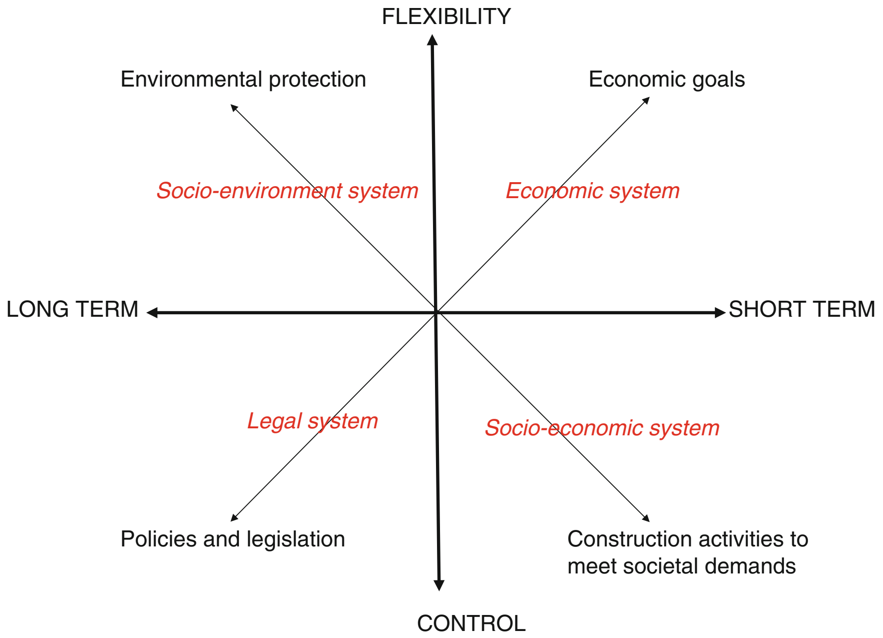

Fig. 13.1 Key systems in sustainable development (Liu 2006)

13.3 Identification of Candidate Critical Success Factors (CSFs)

A number of past research works on implementation of environmental sustainability and other programs such as environmental management systems have been reviewed in an attempt to identify candidate critical success factors (CSFs) to be used into the research into CSFs involved in successful implementation of environmental sustainability.

Zutshi and Sohal (2004) performed a study to determine the CSFs in the adoption and maintenance of environmental management systems. The factors identified in their study are shown in Table 13.1.

A study into corporate engagement in processes for planetary sustainability in the Non-Renewable Resource Extractive Sector (NRRES) in Australia was performed by Harris (2007). The author found a number of topics associated with corporate actions, responses and changes relating to the uptake of ecological sustainability. These were organised, grouped and named as factors which have been clustered into the broad theme of *capacity for engagement*. This relates to the preparedness, impetus and capability within an NRRES corporation relating to interest and participation in processes and practices for planetary sustainability and encompasses the five sub-themes or factors of leadership, resources, structures, understanding and culture, which are shown in Fig. 13.2. Leadership is identified as the most critical factor and therefore this factor is positioned at the centre of *capacity for engagement.* The other four factors of culture, structures, understanding and resources are connected with each other and as feeding back into leadership. This reflects the interrelatedness of the five factors and how they impact on each other.

Daily and Huang (2001) performed a study to identify the human resource factors required to achieve sustainability. They found that top management support, environmental training, employee empowerment, teamwork and rewards systems were key elements of the implementation process of an environmental management system.

The role of knowledge management in promoting corporate sustainability in the construction industry was considered by Robinson et al. (2006). It has been found that knowledge management is linked to corporate sustainability and that a methodical approach is required for successful knowledge management implementation.

Alkhaddar et al. (2010) investigated how aware people are when they deal with sustainability in their daily working environment, how much training and information construction employees have had on sustainability and whether a deep learning approach to sustainability teaching can impact everyday sustainability practises in the industry. Deep learning occurs where people seek to understand the meaning of the learning rather than merely to remember what they have learned. This would mean that employees embrace green issues instead of using them merely to meet criteria, deep learning would result in them grasping the concepts completely and consequently incorporating them into everyday practice. The findings of the study were that deep learning could be a potential opportunity and that it could result in continuous improvement in green practice.

Table 13.1 Critical success factors in adoption and maintenance of environmental management systems (Zutshi and Sohal 2004)

Critical success factor group	Critical success factors
Management leadership and support	Top management commitment
	Cultural change and organisational vision
	Allocation of resources
	Appointment of a champion
	Importance of communication
	Avoidance of personality clashes
Learning and training	Learning from other organisations' experiences and benchmarking
	Reference to industry guidelines/standards
	Employee induction and training
	General training and awareness for suppliers and other stakeholders
Internal analysis	Conducting cost-benefit analysis
	Initial environmental review/gap analysis
	Identification of aspects and impacts and setting of objectives and targets
	Necessity and usage of audits
	Document control system
	Integration of existing management systems
Sustainability	Life cycle analysis
	Design for disassembly (DfD)
	Industrial ecology

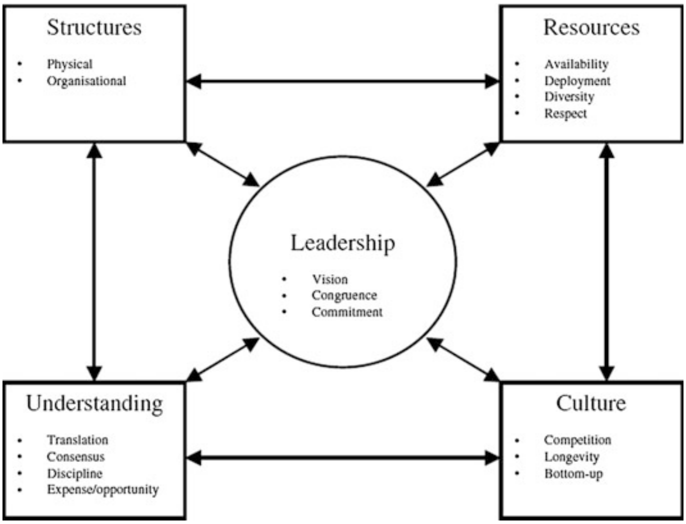

Fig. 13.2 Mapping capacity for engagement—factors, elements and connections (Harris 2007)

Perez-Sanchez et al. (2003) sought to describe and analyse the parameters that interact in implementing environmental management tools in small to medium enterprises. Their findings include:

1. financial support may be important in some companies,
2. the values and attitudes of managers/owners are highlighted through the long-term business strategy and business plan pursued,
3. internal expertise should be identified by focusing on knowledge, the need for increasing awareness and information about specialist issues and the revision of organisational structures, and
4. there is a need for enhanced technological development and a culture of innovation.

A research project was performed by Epstein (2010) to discover why some companies were successful in implementing environmental sustainability, while others failed in their attempts. The author also wished to examine how leading companies integrated economic, social and environmental aspects into their day-to-day activities. The research questions were therefore as follows:

1. How do companies and their managers effectively manage social and financial goals and performance simultaneously?
2. What are the challenges and barriers?
3. What characteristics of organisations, issues, and leaders enable more/less success?
4. What support systems (organisational design, performance evaluation, rewards, and culture) facilitate managing social and financial performance simultaneously?
5. What other support could be provided (leadership, strategy, organisational structure, communication, and formal and informal systems)?

The success factors identified by Epstein (2010) are included in Table 13.2.

Epstein (2008) developed a model, entitled "making sustainability work" based on his research (see Fig. 13.3). This figure shows the drivers and measures with regard to the successful implantation of corporate sustainability and includes cost management, capital investment, performance measurement, reward, and other formal systems that can be used to implement sustainability. Additionally, publications of surveys and online surveys into sustainability were reviewed to identify any additional candidate CSFs.

An online survey on corporate sustainability and climate change was conducted by NCSI (2012). This survey was aimed at Australian senior and executive corporate managers and its objective was to promote better understanding of trends in business sustainability and climate change. The survey questions included:

1. availability of policies;
2. whether there is a director or board member driving corporate environmental and sustainability matters;

Table 13.2 Success factors in managing social, environmental and financial performance simultaneously (Epstein 2010)

Success factors	Evidence
Balance financial and sustainability goals	• Trade-offs between the social, environmental and financial goals and performance are not seen as difficult—usually seen as win/win
	• Sustainability tensions are solved by using new ideas, creativity and innovation
Make sustainability the business case	• Keen awareness of anticipated stakeholder reactions to sustainability that ultimately have a financial impact
	• Stakeholder impacts are implicitly included in strategic and operational decision making
Leadership	• Consistent CEO and senior leadership support of sustainability and sustainability manager has authority across the company
	• Clear communication of sustainability strategy, policies, and goals
Strong culture	• Innovation, creativity, entrepreneurship, and volunteerism are the building blocks
	• Openness, autonomy, and initiative are the norms of supporting a strong, innovative culture
	• Broad sharing of culture through communication

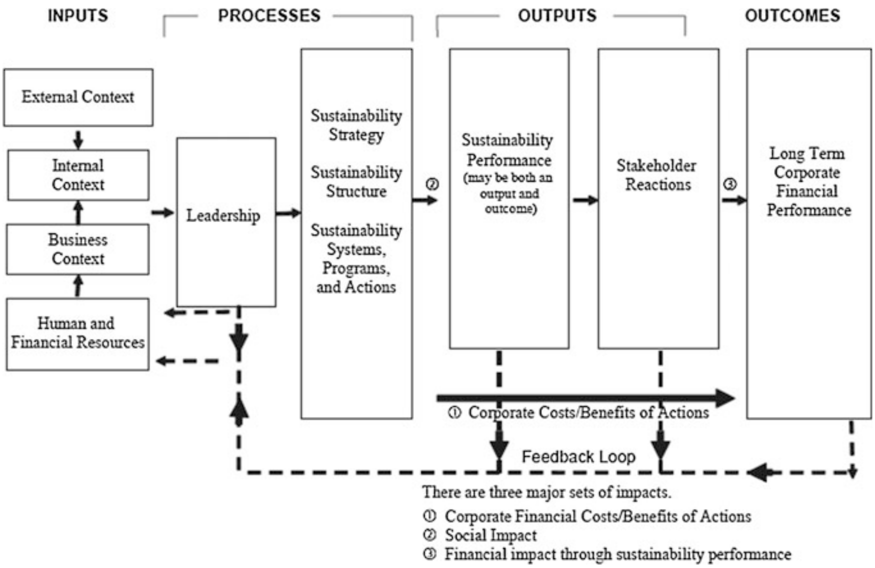

Fig. 13.3 Making sustainability work (Epstein 2008)

3. whether there is executive or top-management accountability for corporate environmental and sustainability matters;
4. whether there is a dedicated team responsible for these matters;
5. whether the company pays financial bonuses associated with environmental performance;

6. whether the company has procurement policies that give preference to environmentally preferable products, services and suppliers; and
7. whether the company releases a corporate sustainability report or whether sustainability reporting is included in the annual report.

The survey also asked the respondent to indicate the importance of a number of issues to the organisation based on its current performance and plans over the next three years. These issues include:

1. Corporate governance around environmental sustainability;
2. Customer requirements for environmental performance;
3. Regulatory compliance for the environment and greenhouse gas (GHG);
4. Measuring and reporting carbon emissions;
5. Reducing carbon emissions;
6. Buying carbon credits to offset emissions;
7. Improving energy efficiency;
8. Corporate sustainability reporting;
9. Marketing/brand benefits from environmental disclosure reporting;
10. Efficient compliance reporting systems and tools;
11. Staff engagement benefits from sustainability programs;
12. Community engagement benefits from sustainability programs; and
13. Independent assurance of environmental, sustainability and carbon reports

Another survey on environmental sustainability by SAP (n.d.) was extremely comprehensive and not unique to the construction industry. Background to this survey was not provided. Questions included whether a single person is responsible for environmental sustainability and to whom this person reports; whether there is a central corporate or shared services environmental sustainability organisation; the number of full time employees who support environmental sustainability; the average annual cost per full time employee involved in environmental sustainability; the number of reports that are being used for environmental performance tracking, analysis and reporting; the number of months between successive environmental sustainability performance reports. Respondents were also asked to rate their company with regard to a number of environmental sustainability best practices.

Results of a an international survey of attitudes towards sustainability conducted by the independent market research company Harris Interactive were considered to identify important questions (Dow-Corning 2007). This research studied:

1. the most important environmental factors;
2. who influences environmental/sustainability decisions;
3. factors driving environmental/sustainability decisions;
4. influence of environmental/sustainability factors on supplier selection; and
5. responsibility for sustainability decision-making.

MITSloan and Group (2012) performed a survey to understand whether companies that see sustainability as an opportunity and a necessity and change their business models as a consequence are successful. Questions in the survey included

Table 13.3 Candidate critical success factors for implementation of environmental sustainability and associated references

ID	Candidate CSF	Associated references
CSF1	Leadership and management commitment to environmental sustainability	Daily and Huang (2001), Epstein (2010), Harris (2007), MITSloan and Group (2012), NCSI (2012), Perez-Sanchez et al. (2003), Zutshi and Sohal (2004)
CSF2	Corporate environmental sustainability matters being driven by board member or director	NCSI (2012), Zutshi and Sohal (2004)
CSF3	Executive or top-management accountability for environmental sustainability outcomes	NCSI (2012)
CSF4	Single person responsible for environmental sustainability	MITSloan and Group (2012), NCSI (2012), SAP (n.d.), Zutshi and Sohal (2004)
CSF5	A dedicated team/function responsible for environmental sustainability	Harris (2007), NCSI (2012), Zutshi and Sohal (2004)
CSF6	Values and culture which include environmental sustainability	Epstein (2010), Harris (2007), Perez-Sanchez et al. (2003), Zutshi and Sohal (2004)
CSF7	Provision of training on environmental sustainability	Daily and Huang (2001), Perez-Sanchez et al. (2003), Zutshi and Sohal (2004)
CSF8	Financial bonuses and other rewards attached to environmental performance and sustainability	Daily and Huang (2001), NCSI (2012), Perez-Sanchez et al. (2003)
CSF9	Policies and procedures devoted to environmental sustainability	Epstein (2010), Harris (2007), Zutshi and Sohal (2004)
CSF10	Reporting on environmental sustainability	Perez-Sanchez et al. (2003), SAP (n.d.)
CSF11	Communication about environmental sustainability	Epstein (2010), MITSloan and Group (2012), Zutshi and Sohal (2004)

how the commitment to sustainability including management attention and investment has changed; which sustainability matters are on the agenda of senior managers; responsibility for sustainability in the organisation; what sustainability groups drive the agenda; and communication of sustainability efforts.

After reviewing the literature discussed above, the candidate CSFs are identified and shown in Table 13.3 together with the associated literature references.

13.4 Conclusion

This study explores key factors contributing to the successful implementation of sustainability in infrastructure projects. The identification of the candidate critical success factors (CSFs) is reported in this paper. In total, eleven candidate CSFs have been identified, including Leadership and management commitment to environmental sustainability; Corporate environmental sustainability matters being driven by board member or director; Executive or top-management accountability for environmental sustainability outcomes; Single person responsible for environmental sustainability; A dedicated team/function responsible for environmental sustainability; Values and culture which include environmental sustainability; Provision of training on environmental sustainability; Financial bonuses and other rewards attached to environmental performance and sustainability; Policies and procedures devoted to environmental sustainability; Reporting on environmental sustainability; and Communication about environmental sustainability. Currently the research methods are under design. The findings will be utilized for a future research project to establish a particular way to facilitate the achievement of sustainability in public infrastructure projects.

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Chapter 14
A Comparison Study of C&D Waste Management in Shenzhen and Hong Kong: A SWOT Perspective

Zhikun Ding, Yifei Wang, Hongtao Wang and Jiayuan Wang

Abstract With the rapid development of urbanization and acceleration of urban renewal, huge construction, renovation and demolition activities can be found across China causing the quantities of construction and demolition (C&D) waste to increase at a high speed. Successful C&D waste management (C&D WM) has a significant impact for long-term development of Shenzhen and Hong Kong. This paper firstly presents the status quo of C&D WM in the two cities. Then, a comparative analysis of C&D WM between them with SWOT framework is conducted. Finally, some effective management measures are proposed for Shenzhen as well as other mainland cities to further improve their C&D WM performance.

Keywords Construction and demolition waste · C&D waste management · SWOT

14.1 Introduction

Nowadays, nearly two-thirds of the cities in China are surrounded by waste and more than 500 million square meters of land spaces are occupied (Lu and Yuan 2011). Moreover, the amount of C&D waste in China had accounted for about 40 % of the total municipal waste. The demolition waste had been generated up to 200 million tons each year and the construction waste about 100 million tons (Wang et al. 2012).

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Such huge amount of C&D waste, if simply being discarded, will not only result in an enormous waste of resources but also introduce serious environment pollution (Shen 2002). Thus C&D WM has become one of the major issues of urban management. For Shenzhen and Hong Kong, C&D WM is of primary importance in terms of sustainable development. Shenzhen is the first reformation policy implementation area and the pioneer of C&D WM in China. Hong Kong adjacent to Shenzhen is one of the C&D WM most well regulated cities. If Shenzhen could learn from Hong Kong's C&D WM experience, not only could good experiences be borrowed by the former but also provide practical implications for other cities in China.

Based on a literature review of C&D WM, this paper analyzes the status quo of C&D WM in Shenzhen and Hong Kong with a SWOT framework. Through a comparison study, this paper can achieve the following objectives: Firstly, increase the awareness of academics, stakeholders and governments about the status quo of C&D WM. Secondly, identify the major issues in C&D WM and propose some suggestions for Shenzhen to improve her C&D WM further. Finally, provide guidance and suggestions for sustainable development of other cities in China.

The paper is organized as follows: research method is firstly introduced. Next, a comparison study of the status quo of C&D WM in Shenzhen and Hong Kong with a SWOT framework is conducted. Then some effective management measures are proposed for Shenzhen as well as other mainland cities.

14.2 Research Method

SWOT analysis is adopted to conduct the comparison study. SWOT stands for Strengths, Weaknesses, Opportunities, and Threats, which is a method to design development strategies (Ling 2009). SWOT analysis focuses on a system's internal and external environment with the purpose of identifying internal strengths in order to take advantage of its external opportunities and avoid external threats while overcoming its weaknesses. For example, Yuan utilized SWOT analysis to describe the status quo of C&D WM in Shenzhen and to provide seven critical strategies to address the C&D WM problems (Yuan 2013). It demonstrated that SWOT analysis is an effective tool for analyzing strategic problems in C&D WM.

14.3 Comparison Study of C&D WM in Shenzhen and Hong Kong

14.3.1 Status Quo of C&D WM in Shenzhen and Hong Kong

Shenzhen is the first special economic zone in China. After more than 30 years of development, Shenzhen has developed from a small town to be a new modern city with international reputation. However, a huge amount of C&D waste is generated in Shenzhen in the process of urban development. According to the Shenzhen Environmental Protection Department (SEPD), the total amount of construction waste generated from construction projects in 2005 was approximately 6 million tons which was, on average, about 17,000 tons per day (Lu and Yuan 2010). According to statistics of Shenzhen Urban Management Bureau, Shenzhen in 2012 produced about 25.6 million m^3 waste of which construction waste accounts for approximately 6.6 million m^3. The amount of C&D waste generated each year in Shenzhen vary with the change of urban construction activities but normally stay around 10 million tons. The quantities of C&D waste disposal in Shenzhen reached about 10 million m^3 in 2006 and 28 million m^3 in 2010. Construction waste generated during 2011–2020 was forecasted to be about 149 million m^3 in Shenzhen overwhelming the available landfill capacity (Wang et al. 2008). Sooner or later, the generated construction waste will be dumped in unauthorized areas, which will be detrimental to the environment and society. Hence, there is a huge gap for improving current C&D WM.

Hong Kong adjacent to Shenzhen is an international coastal city located in southern China. In the past decade, the large-scale construction activities have generated a huge amount of C&D waste, which incur serious challenges on the social and environmental sustainability of Hong Kong. Statistics show that C&D waste generated daily was 38,840 tons in 2001 of which 80 % was transported to public landfills and 20 % was processed and buried. The processed C&D waste accounted for 38 % of the total processed municipal solid waste per day (Hao et al. 2003). In 2004, C&D waste production reached nearly 20 million tons of which 88% was transported to public landfills and 12 % was buried (Poon 2007). According to the Hong Kong Environmental Protection Department (HKEPD), approximately 25 % of the landfilled solid waste comes from the construction industry in 2012. Furthermore, the annual government cost for C&D waste disposal is more than 200 million HK$ and the consumption of landfill space each day is nearly 3500 m^3. According to the HKEPD forecast, the landfill spaces will be completely consumed in the next decade with a 24 % annual increase in construction waste (Lu and Tam 2010). Therefore, similar to Shenzhen, effective C&D WM is of primary significance for Hong Kong.

14.3.2 Research Objectives

The SWOT framework is applied to analyze in depth the C&D WM in Shenzhen and Hong Kong to achieve the following objectives: The first one is to identify the strengths Shenzhen and Hong Kong have with respect to C&D WM. Next, identify the weaknesses in C&D WM which will cause a negative impact on future development of the two cities. The third one is to identify opportunities useful for the two cities to improve C&D WM. Finally, find out what threats the two cities have to face in order to reduce risks in C&D WM.

14.3.3 SWOT Analysis of C&D WM in Shenzhen and Hong Kong

14.3.3.1 Strengths

Strengths of Shenzhen (S.SZ)

Firstly, Shenzhen is geographically adjacent to Hong Kong (S.SZ1). While Hong Kong has accumulated a great deal of practical experiences about how to effectively manage the waste, Shenzhen can borrow some good practices from Hong Kong. Secondly, Shenzhen government has taken many measures for C&D WM and made some achievements (S.SZ2). For instance, Shenzhen government implements the on-site sorting of C&D waste. In addition, the government plans to launch a construction waste disposal charging scheme to motive project stakeholders to recycle the waste (Yuan and Wang 2014). Furthermore, Shenzhen is planning to build an industrial park for comprehensive utilization of construction waste. Thirdly, Shenzhen plays a leading role in China with respect to C&D WM issues (S.SZ3). Since 1990, Shenzhen has introduced a number of regulations on C&D WM. In March 2012, Shenzhen was listed as the first pilot city of construction waste reduction and utilization in China.

Strengths of Hong Kong (S.HK)

Firstly, Hong Kong is a reputable international city which attracts a lot of well-educated professionals for opportunities (S.HK1). For C&D WM in Hong Kong, industry professionals, experts and scholars put forward many constructive comments and help the government introduce a number of policies enabling the C&D WM to stay in the global forefront. Secondly, Hong Kong government and the general public have taken environment protection as one of the top priorities (S.HK2). The thousands of tons of construction waste generated from construction, renovation, demolition, and other projects, if not properly managed, result in serious negative impacts on the environment. Hence, there is a strong motivation to manage the waste effectively in Hong Kong. Thirdly, Hong Kong has implemented various strategies and introduced a number of regulations for C&D WM in the past two decades (S.HK3) (Deng et al. 2008). The typical strategies cover reduction, reuse, recycling, and disposal of C&D waste. A summary of the key related regulations of C&D WM is shown in Fig. 14.1 (Lu and Tam 2010).

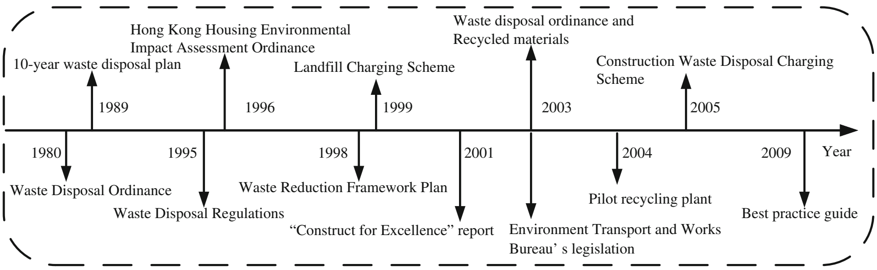

Fig. 14.1 C&D WM regulations and policies of Hong Kong

14.3.3.2 Weaknesses

Weaknesses of Shenzhen (W.SZ)

First of all, many construction companies do not pay much attention to the C&D WM because the costs are too high (W.SZ1). The application of record-tracking system and sorting of waste demand some human, material and financial resources. In addition, most of the C&D waste was mixed which makes it more expensive to be sorted. Secondly, the Shenzhen C&D WM regulations are not well refined (W.SZ2). For example, the allocation of responsibility for C&D WM is ambiguous under current regulations and the enforcement is not sufficient (Li 2010). Thirdly, C&D waste recycling is not sufficiently considered (W.SZ3). For instance, the distribution of C&D waste recycling facilities is not systematically planned, leading to the rise of transportation and recycling cost.

Weaknesses of Hong Kong (W.HK)

Firstly, the recycling of C&D waste materials encounters many difficulties in Hong Kong (W.HK1) (Tam 2006). For example, the main difficulties for non-inert material recycling are the poor quality of recycled products, the trouble of formulating overall recycling plan plus technical difficulties and high costs. Although some environmental performance reward schemes exist, few construction workers care about them (W.HK2). The main reasons are lack of supervision and enforcement, motivation and practical experience. The local government introduced a number of laws and regulations for the C&D WM but the outcomes are far from satisfactory (W.HK3) (Wang et al. 2010a, b). Take the waste charging regulation as an example. The cost of recycling C&D waste is so high in contrast with directly dumping to landfills that enterprises will not spend time and efforts in C&D WM.

14.3.3.3 Opportunities

Opportunities of Shenzhen (O.SZ)

The unique status of Shenzhen as a leading pilot city for reformation will continue to prevail (O.SZ1). Therefore, the status of Shenzhen as well as strong support and attention from the state government offer many opportunities and powers for C&D WM in Shenzhen. Green construction as one of the key themes laid down by Shenzhen government will contribute to effective C&D WM (O.SZ2) (Qu 2009). The government dedicates to build the city as “the capital of green buildings” and the “low-carbon eco-city”. Since C&D WM is one of the critical indicators of the above objectives, more time, resources and efforts will be spent on C&D WM.

Opportunities of Hong Kong (O.HK)

Hong Kong has benefited from interactions with the Pearl River Delta (PRD) Economic Zone (O.HK1) (Augustin-Jean 2005). The growth and development of the Pearl River Delta region, the experience that both sides have with “one country, two systems”, tight communication across the boundary and competition with the Yangtze River Delta region are three driving forces to sustain more intensive interactions between Hong Kong and the PRD region. Therefore, the development of PRD will bring new chances for C&D WM in Hong Kong. As the long-term partner of Guangdong Province, Hong Kong could contribute to the region’s growth and achieve the win-win situation (O.HK2). This partnership will definitely bring new opportunities for the region wide issues such as C&D WM (Zhong 2013).

14.3.3.4 Threats

Threats of Shenzhen (T.SZ)

Shenzhen landfill spaces are facing great shortages which could cause negative impact for her long term development (T.SZ1) (Wang et al. 2010a, b). Tang Lang Mountain landfill, Xi Xiang landfill, and Long Gang Central City landfill have now been up to their full capacity. Due to the limited land resources, the C&D waste will face the situation that no places are available to be filled. Currently, C&D waste recycling technology is not well developed and not widely used in Shenzhen (T.SZ2). If there is no advanced technical support, the processing costs of C&D waste are high. Therefore, most of the C&D waste have to be transported to landfills (Lu and Yuan 2010). The collection, transportation, storage, sorting, recycling of C&D waste demand large financial support (T.S3). For instance, the research of

C&D waste utilization and management such as standards of effective C&D waste landfill charge, the quality standards of recycled materials need investments. The inadequate funding becomes a bottleneck for C&D waste recycling (Wang and Tam 2014).

Threats of Hong Kong (T.HK)

The landfilling approach consumes a lot of land resources, thus exacerbating the land shortage in Hong Kong (T.HK1) (Wan and Shen 2014). According to the report by EPD, about 3440 tons of C&D waste was received at landfills per day in 2012. Thus, shortage of land resources will become an important threat. The other barrier in preventing Hong Kong from sustainably managing C&D waste is the culture of the industry (T.HK2). The labors in the construction industry generally do not prioritize environmental protection which results in a less responsible attitude towards managing waste (Lu and Yuan 2010). The failure to achieve integrated C&D WM imposes another threat to Hong Kong (T.HK3). C&D WM is a system which involves the generation, transportation, treatment, recycling etc. However, the various aspects of C&D WM are actually isolated in Hong Kong. Furthermore, the system stakeholders including the building enterprises, enterprises, research institutions, government and the public are relatively isolated making it difficult to achieve synergetic management (Yuan 2011).

14.4 Strategies for Promoting C&D WM

Based on the above analysis, key strategies for Shenzhen C&D WM development can be proposed as is shown in Fig. 14.2. The C&D WM strategies can be pinpointed from a macro-level and a micro-level perspective. Macro-level management

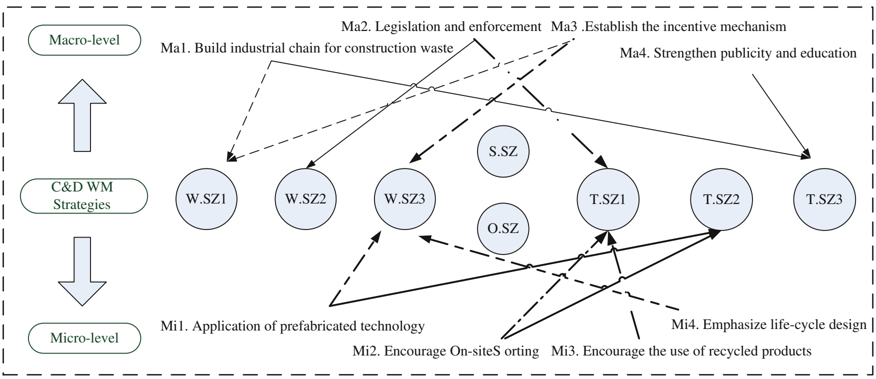

Fig. 14.2 Strategies for C&D WM in Shenzhen

refers to the regional level e.g. the development and implementation of policies. Micro-level management refers to the project level e.g. application of certain measures in specific construction activities to achieve the goal of waste reduction.

14.4.1 Macro-level Strategies

14.4.1.1 Build Industrial Chain for C&D Waste (Ma1)

C&D WM is not only a complex process but also a coordinated development process which involves multiple stakeholders. It is necessary to build good interactions between them and to maintain the stable operation. The basic operating procedure of the chain is shown in Fig. 14.3.

14.4.1.2 Legislation and Enforcement (Ma2)

The current policies for C&D WM are not complete although the promulgation of various C&D WM laws and regulations since 1990s has improved the situation. The most important issue is that most policies are not detailed enough for guiding and enforcing C&D WM. Therefore, the government should implement operational C&D WM policies to effectively guide waste sorting, reduction, reuse, recycling,

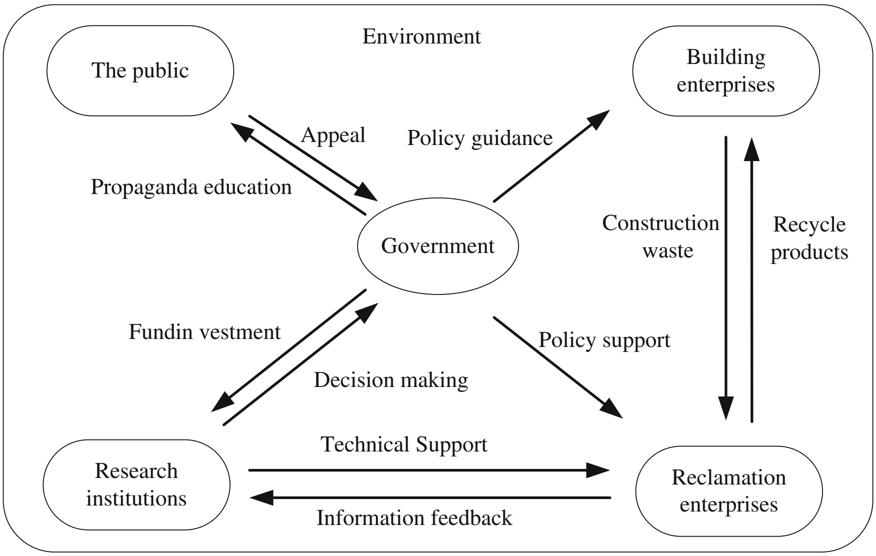

Fig. 14.3 Chain of C&D waste industry

and disposal. Meanwhile, improving legislative enforcement and making comprehensive environmental laws are necessary to improve C&D WM.

14.4.1.3 Establish the Incentive Mechanism (Ma3)

Most construction companies focus on short-term interests and believe C&D waste recycling does not produce extra values, so the government should set reasonable incentive mechanisms to increase their participation (Tam 2008). The promise of a reward to contractors which reduce the C&D waste and the punishment of contractors that do not attach importance to waste management will motivate them to invest time and efforts on C&D WM. Some specific measures are recommended as following: developers or contractors utilizing the materials and products reproduced from C&D waste can enjoy the preferential treatment of tax reduction or exemption; state banks can give preferential loans to those enterprises engaged in C&D waste recycling.

14.4.1.4 Strengthen Publicity and Education (Ma4)

C&D WM not only requires the government's involvement but also need collective participation of the general public. Therefore, the government should increase the public awareness of C&D waste recycling, enhance the involvement of environmental protection and active participation in the process of waste reduction e.g. hanging banners or posters in public places; advertising through the general media etc. In the mean time, it is very important to provide construction workers with professional training about environmental protection and waste management skills.

14.4.2 Micro-level

14.4.2.1 Application of Prefabricated Technology (Mi1)

Development of prefabricated technologies provides an excellent opportunity for the construction industry to reduce C&D waste. The application of prefabricated components not only reduces the construction site occupancy but also contributes to construction waste recycling. Meanwhile, not only is environmental pollution greatly reduced by making use of prefabricated components but also the use of raw materials is saved.

14.4.2.2 Encourage On-Site Sorting (Mi2)

On-site Sorting can effectively improve the recycling value of C&D waste so the Hong Kong government strongly promotes it as an important measure of C&D waste reduction. It can distinguish inert and non-inert construction waste to prevent the impact of non-inert waste on the inert waste and can be carried out on the construction site. The benefits of conducting on-site sorting include increasing the rates of reuse and recycling, reducing the cost for waste transportation and disposal, extending the lifespan of landfills for receiving construction waste and reducing the pollution.

14.4.2.3 Encourage the Use of Recycled Products (Mi3)

Government should motivate the construction companies and developers to use recycled products. Use of recycled products will achieve the purpose of saving resources, reducing construction waste and the occupation of land space. This could be achieved in two ways: on the one hand, government provides reward to enterprises which use the recycled products; on the other hand, government should increase tax for the use of raw resource products.

14.4.2.4 Emphasize Life-Cycle Design (Mi4)

Design change is one of the most important reasons for the huge construction waste generated. Construction design should take into account environmental protection and waste minimization. Reuse of C&D waste such as bricks and tiles, use of recycled materials such as recycled aggregates and asphalt, use of durable and recyclable materials such as metals instead of timber should also be encouraged. Meanwhile the innovative technologies from other counties can be adopted including low-waste construction technologies such as innovative formwork and low-waste structures, etc.

14.5 Conclusions

Based on the detailed comparative analysis of C&D WM in Shenzhen and Hong Kong with SWOT framework, the internal and external conditions of C&D WM in Shenzhen and Hong Kong were delineated. The results show that Shenzhen should build on its strengths to improve C&D WM and also have some weaknesses that need to be overcome. The findings also present some major opportunities that Shenzhen can utilize and some threats that need to handle in the future. Finally, macro and micro level strategies for improving the C&D WM situation in Shenzhen were proposed. The identified SWOTs are critical in contributing to successful

C&D WM in Shenzhen. They may also be useful references for other Chinese regions which intend to enhance the C&D WM.

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Chapter 15
Sustainable Construction Trends in Journal Papers

Bo Xia, Jian Zuo, Peng Wu and Yongjian Ke

Abstract Sustainable construction is gaining worldwide attention and has inspired research to identify and solve the problems involved in its implementation over a project lifecycle. While an impressive number of papers have been published on the topic to date, little has been done to review these papers to identify current research status or provide guidance for future research. This paper reviews existing sustainability papers in 12 internationally renowned construction journals. Based on a three-stage literature review, sustainability papers published in these journals from 2000 to 2012 are analyzed in terms of the annual number of papers published and the research interests involved. The number of sustainability-related papers in construction increases from 30 papers in 2000 to 127 papers in 2012, which shows an increasing trend in sustainability topics. A content analysis identifies seven major research interest in sustainability, including (1) sustainable project management; (2) sustainability assessment/evaluation; (3) sustainable technology/innovation implementation; (4) sustainable building/infrastructure performance; (5) government policy on sustainability; (6) enterprise sustainability; and (7) sustainability education. The results of this study provide a reference for scholars and

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academics to understand the current status of sustainability research in major construction journals.

Keywords Sustainability · Construction · Review · Research · Papers

15.1 Introduction

The construction industry has a major impact on the environment. It is estimated that one tenth of the global economy is dedicated to constructing, operating and equipping homes and offices. The activities involved in doing this account for 40 % of the material flows, much of the remainder being destined for roads, bridges and vehicles to connect the buildings (Roodman and Lenssen 1994). The construction industry has a responsibility to ensure the sustainability of both its products and processes. Sustainable construction is a realization of this responsibility (Hill and Bowen 1997), and it is generally used to describe a process that starts in the planning and design stage and continues after construction ends with a minimum impact on the environment.

The recurring theme of sustainability in the construction industry has motivated changes from its traditional nature and encouraged its modernization and adoption of collaborative and sustainable approaches. The industry is called upon to become more market responsive, reduce the number of accidents on site, put an end to its appalling pollution record, integrate all the stakeholders in the supply chain, and to create a far more ethical and enhanced sustainability profile (Myers 2005).

With the increasing importance of sustainable construction, an understanding of its current status is needed to help identify and solve the implementation problems involved. It has been suggested that this could be achieved by a systematic analysis of relevant recent papers published in academic journals (Tsai and Wen 2005). To date, no such analysis has been undertaken to the best knowledge of the authors. This motivates the analysis that follows of recent sustainability-related research topics published in major construction journals, to identify more clearly contemporary research issues and those in need of further treatment in future.

In this paper, we will provide an overview of the sustainability papers published in major construction journals from 2000 to 2012 in order to identify the research trends involved. In particular, it aims to reveal the main themes and interests of these publications over the prescribed period and provide a better understanding of previous studies and the development of sustainable construction. This will form a platform for future research in identifying areas in greatest demand.

15.2 Research Methods

A three-stage literature review was made to conduct a content analysis of sustainability papers in construction journals from 2000 to 2012 (see Fig. 15.1). Authors usually send their papers to journals with similar topics or areas of interests, so a list was made of journals publishing the most papers on sustainability during the period. This involved using several search engines, including SCOPUS, ScienceDirect, ASCE library and Google Scholar. A complete search focusing on "articles" was performed under the "title/abstract/keyword" (T/A/K search) field of the search engines. The keywords used include *sustainability*, *green construction/building*, *sustainable building* and *sustainability trends*. The result of this first stage identified the following 9 construction journals with the most sustainability papers:

- Automation in Construction (AC)
- Building and Environment (BE)
- Building Research and Information (BRI)
- Construction Management and Economics (CME)
- Energy and Buildings (EB)
- International Journal of Project Management (IJPM)
- Journal of Green Building (JGB)
- Proceedings of Institute of Civil Engineers (ICE)
- Renewable and Sustainable Energy Reviews (RSER)

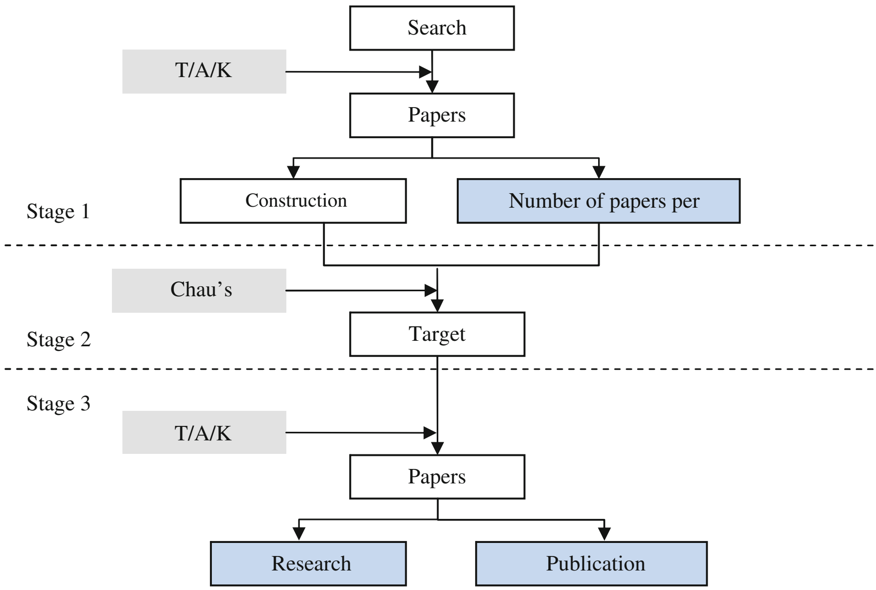

Fig. 15.1 Research framework [after Ke et al. (2009)]

Chau's famous ranking of journals of construction engineering and management (Wing 1997) ranking was used in the second stage to verify and validate the search. This also focused on construction journals with high impact factors and their number of sustainability papers. This results in the inclusion of three additional journals from Chau's ranking list:

- Journal of Construction Engineering and Management (JCEM)
- Engineering, Construction and Architectural Management (ECAM)
- Journal of Management in Engineering (JME)

The final 12 journals were progressed to the third stage of the work. This involved a closer look at the content of the papers in these journals to identify the authors' contributions based on researcher affiliations. The citation information for each paper and journal was also examined in the Scopus database. Finally, the main research topics were identified through a comprehensive content analysis. The research framework derived from Ke et al. (2009) is shown in Fig. 15.1.

15.3 Results and Findings

15.3.1 Number of Sustainability Papers Published Annually

The total number of papers published in the 12 target journals from 2000 to 2012 was 743, with an increasing trend in sustainability topics from 30 papers in 2000 to 127 papers in 2012. Table 15.1 shows the annual and total number of sustainability over the prescribed period.

As summarized in Table 15.1, the journals JGB, ICE, BRI and EB published the most sustainability papers (173, 137, 112, and 103 respectively) within the prescribed period. Figure 15.2 shows the number of sustainability papers published by these four journals and total number of papers each year. Although a growing number of papers are published in sustainability topics, it is worth noting that the numbers during 2006–2012 in JGB and ICE are relatively stable, while the number in BRI fluctuated since 2007. With the exception of ICE and BRI, there were very few before 2006.

15.3.2 Research Interests

Content analysis was applied to identify major sustainability research interests in the samples. Content analysis is a way to help classify textual materials through reducing them to more relevant and manageable bits of data (Weber 1990). Content analysis is frequently adopted to determine the major facets of a set of data, by simply counting the number of times an activity happens or a topic is depicted

Table 15.1 Sustainability papers published by 12 target journals from 2000 to 2012

Journal	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
AC	0	0	0	1	0	1	2	1	0	2	1	4	4	16
BE	3	2	3	2	3	4	4	17	8	9	14	11	13	93
BRI	11	12	6	5	2	9	5	13	10	7	5	10	17	112
CME	3	1	2	2	0	1	3	2	3	1	2	3	4	27
EB	0	2	2	3	4	2	4	9	9	9	12	18	29	103
ECAM	0	0	1	1	0	1	0	1	3	0	1	2	2	12
IJPM	0	0	0	0	1	1	0	1	0	1	0	0	1	5
JCEM	0	0	0	0	1	0	2	1	2	2	3	4	12	27
JGB	0	0	0	0	0	0	25	26	29	25	24	23	21	173
JME	0	0	0	0	0	1	0	0	0	2	0	2	4	9
ICE	12	1	6	17	10	14	10	10	12	11	10	11	13	137
RSER	1	0	3	1	1	4	2	1	1	3	2	3	7	29
Total	30	18	23	32	22	38	57	82	77	72	74	91	127	743

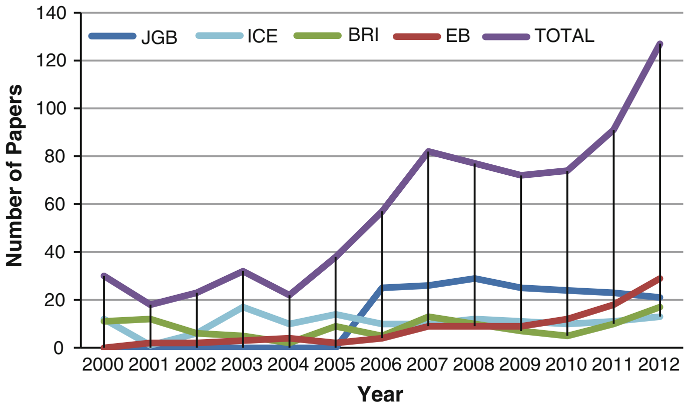

Fig. 15.2 Number of sustainability papers published by four journals with most sustainability publications

(Fellows and Liu 2009). Several steps are involved in content analysis. The first step is to identify the materials to be analyzed. The second step is to determine whether to use qualitative or quantitative content analysis. The choice depends on the nature of the research project and known issues to be addressed. In qualitative content analysis, emphasis is placed on determining the meaning of the data (i.e. grouping data into categories).

Qualitative analysis was carried out in this research and categorized the paper topics into several main themes. The title, keywords and year of each paper were first marked down. Content analysis was then applied to identify and assemble similar topics. Different main themes of research topics were finally crystallized from the results. For a paper covering more than one theme, the best fit was chosen. As a result of the analysis, seven categories were identified, including (1) sustainable project management; (2) sustainability assessment/evaluation; (3) sustainable technology/innovation implementation; (4) sustainable building/infrastructure performance; (5) government policy on sustainability; (6) enterprise sustainability; and (7) sustainability education. These topics are examined in more detail below.

15.3.2.1 Sustainable Project Management

Over the last fifteen years, there has been a growing attempt to deal with sustainability issues in construction and their practical implementation (González and Echaveguren 2012; Hill and Bowen 1997; Martínez et al. 2000). According to Wu and Low (2010), project management in sustainable construction should focus on processes such as stakeholder management, organizational structure/s and commissioning quite distinct from practice (e.g. technologies). A sustainable construction framework should cover various processes including urban planning, production development and design, manufacturing and construction, operation and deconstruction (Bourdeau 1999).

The papers collected for this topic cover issues of project management in pursuing sustainability at different stages of construction projects, such as design, planning, decision-making, development, construction, material planning and management, cost management, construction supply chain management, and building operation and facility management. Sustainability strategies are often discussed. Barriers and drivers of construction sustainability are identified. Ways to improve sustainable project management are studied including simulation and modeling of sustainable construction operations and delivery, the appropriate selection of sustainable project teams, stakeholder engagement, sustainable value management and risk management.

15.3.2.2 Sustainability Assessment/Evaluation

Sustainability assessment is a procedure used to ascertain whether environmental and societal changes arising from human activities and use of resources are decreasing or increasing our ability to maintain long-run sustainability (Forbes 2008). The design of built structures, their location within an urban system, the use of materials and energy resources in construction, operation and maintenance, and the waste and emissions occurring, all have an impact on the sustainability of the environment. The methods of assessing the impact of buildings on the environment are required to promote economy through the processes of building design, construction, management, operation and maintenance (AlWaer and Kirk 2010). Since the early 90s, many countries and international organizations have been working on sustainable development assessment by means of specific indicators (World Bank 1997; Segnestam 2003). The indicator approach is useful to provide information on the current sustainability situation and make prediction of future sustainability trends (Bottero and Mondini 2003; Winston and Pareja Eastaway 2008).

The sustainability assessment/evaluation summarized here is based on the sustainability papers of the target construction journals dealing with the assessment or evaluation of the environmental performance of buildings and infrastructures, their materials and service parts, their related design and construction activities and post-occupancy situations. This involves development of indicators, criteria, benchmarks or computer-based modeling programs as tools for sustainability assessment/evaluation. Some papers consider financial and risk issues in sustainability assessment criteria and indicators. Life cycle assessment/evaluation is also commonly discussed.

15.3.2.3 Sustainable Technology/Innovation Implementation

Innovation is the creative implementation of the new that takes place against a resistant background of path-dependent everyday activity (Binder 2008). With the ongoing campaigns for sustainable buildings, such as energy efficiency and greenhouse emission reduction, the relevance of implementing sustainable technologies and innovations is now gaining the attention of building practitioners around the world. It has provoked an increased awareness and willingness to strive for technologies that provide ameliorating measures that increase the sustainability of the building stock (West 2001).

Papers in this topic area mainly discuss the energy efficient and climate control technologies applied in building design and construction activities, including indoor climate and building service technologies, energy analytical modeling of building services and material innovation for building design, technologies of robotic systems, noise reduction and waste collection for on-site construction activities. Some papers target organizational approaches for promoting sustainable technology and innovation. Discussion of the ways to meet the requirements of sustainability rating systems is also popular. Field studies or case studies are often used to illustrate the successful application of sustainable technology/innovation.

15.3.2.4 Sustainable Building/Infrastructure Performance

Buildings/infrastructure worldwide contribute significantly to the high and still increasing fossil energy and resource consumption. There is an urgent need to apply sustainability concepts to the design and construction of buildings/infrastructure in order to minimize their environmental impact and amount of embodied energy (Lehmann et al. 2010). More builders have been using sustainable building materials, recycling construction debris, and incorporating environmentally-friendly and efficient architecture in building designs (Smith 2009). Sustainable buildings/infrastructure can be defined as those that have a minimum adverse impact on the built and natural environment in terms of the buildings/infrastructures themselves, their immediate surroundings and the broader regional and global settings. They involve considering the whole life of buildings, taking environmental quality, functional quality and future values into account (John et al. 2005).

This topic area includes discussions on the modeling of energy and resource flows of buildings and infrastructures for their performance simulation and measurement. Case studies on specific projects and markets of different country backgrounds are also extensively conducted to study existing building/infrastructure conditions and potential future trends for sustainable development.

15.3.2.5 Government Sustainability Policy

Many national, state, regional and local governments are currently attempting to address environmental and sustainability issues through establishing sustainable building programs and recruiting officers for sustainable building. Policies and initiatives have been developed with the aim of promoting a sustainable built environment at local, regional, national and international levels (Van Bueren and De Jong 2007). Existing experience has shown that governments are probably the best placed and equipped to implement policies that create more sustainable communities and buildings (Theaker and Cole 2001).

The papers in this topic area mostly study the sustainability policies of government from specific countries and discuss their applicability to other countries. These studies are conducted on the successes and failures of government policy, institutional regimes to motivate changes, and government challenges to promote sustainability and drive sustainability investment.

15.3.2.6 Enterprise Sustainability

The construction industry plays an important part in contributing to everyone's quality of life. Industry not only helps determine the nature, function and appearance of towns and countryside, it contributes to the formation of communities and has a significant environmental impact (Fairclough 2002). There is a need to encourage responsible construction firms to address the poor public and political image of the industry by meeting new requirements of sustainability (Myers 2005). Although sustainability is gaining favor worldwide, there is still skepticism over its business value. The impact of the social and economic development aspects of sustainability needs to be integrated with the concept of environmental prudence before any business value analysis can be performed (Beheiry et al. 2006).

Issues discussed in the topic of enterprise sustainability include company attitude to sustainability, corporate strategy and approach to sustainability, owner commitment to sustainability, business sustainability innovation, obstacles and rewards of enterprise sustainability, and sustainable organizational management.

15.3.2.7 Sustainability Education

The understanding of sustainability issues should be a key component of degree programs as it is widely regarded as being a central attribute of professional practice and responsible global citizenship (Brewer et al. 2008). Building and construction professionals make decisions that have a critical impact on the environment and society. This makes sustainability considerations including environmental, social and economic concerns a very important for the building and construction profession (Riley et al. 2007). Papers in this topic area are mainly concerned with sustainability teaching in design and engineering education and relevant model and tool development.

15.4 Conclusions

Sustainability is an increasingly important issue in the delivery of construction projects. It is also a topic that has received significant attention, with many studies reported in the past decade. This paper provides the results of an analysis of related journal publications. Twelve leading construction journals were first identified by use of search engines and an existing published list. A total of 327 papers relating to sustainability have been published between 2000 and 2012 in these journals, with the annual number of papers steadily increasing. A content analysis of the title and keywords of each paper identified seven major topic areas of sustainability research to date. These comprise: (1) sustainable project management; (2) sustainability assessment/evaluation; (3) sustainable technology/innovation implementation; (4) Sustainable building/infrastructure performance; (5) government policy on sustainability; (6) enterprise sustainability; and (7) sustainability education.

The results of this study provide a reference for scholars and academics to understand the current status of sustainability research in major construction journals. The discussion of existing research interests assists researchers and practitioners in exploring new sustainability research ideas and ways to provide sustainable development in the construction industry.

In terms of limitations, the overview provided is restricted to sustainability research in 12 major construction journals. The journals surveyed in this study may not fully reflect the whole picture of research in this area. Future work would benefit from a more detailed discussion of existing research on construction sustainability in consideration of a wider range of journals.

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Chapter 16
Quantification of the Carbon Emission of Road and Highway Construction in China Using Streamlined LCA

Huabo Duan and Jiayuan Wang

Abstract Road and Highway (R&H) construction is very resource and energy-intensive, and therefore inevitably results in serious environmental concerns, including the great energy use and carbon emission. There are a few valuable quantitative studies to focus on transportation sector. However, there is relatively little work to systemically and completely look at and compare the energy use and carbon emission from R&H construction industry in China. Especially, there is relatively little research on the methodology development. Thus, this paper is designed to characterize the R&H construction industry in China using national statistical data by the Ministry of Transport, on this basis, using Streamlined Life Cycle Assessment (SLCA) to answer: (1) How to streamline the process to dynamically quantify the carbon emission impact of R&H construction industry; (2) How to assess the expected confidence levels. Specifically, the activities related to R&H construction in China is formed which includes the length, types, design modes, and other aspects related to life cycle. The emissions factors corresponding to construction (design) methods and road making materials embodied impacts drawn from literature (China-specific case studies). In addition, China-based power mix is employed for the carbon emission factor including attendant uncertainty. To summarize, the outcomes are important from a policy standpoint and low-carbon technologies substitution point, and the methodologies are also important for future carbon emission quantifications of other transportation sectors in China and beyond.

Keywords Highway construction · Carbon emission · Streamlined life cycle assessment (SLCA) · China

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16.1 Introduction

China is the world's largest emitter of greenhouse gases from energy use and so the future of the world's climate depends to a significant extent on the willingness and ability of the country to make the transition to a low-carbon or at least a lower-carbon economy (Andrews-Speed 2012). During the past several decades, China's road construction witnessed rapid development. In 2012, revenue for the Road and Highway (R&H) construction industry in China is estimated at $226.9 billion. According to the 12th Five-Year Plan of Transportation in China issued in 2011 by the Ministry of Transport, the investment of fixed assets on road and highway construction is expected to total $787.4 billion between 2011 and 2015 (IBIS World World 2012). R&H construction are very resource and energy-intensive, and therefore inevitably results in serious environmental concerns, including the great energy consumption and carbon emission which are not well characterized (Essay et al. 2013).

Currently, there are a few studies to quantify energy use, carbon emission, and other environmental loads from China's Transportation (Li et al. 2013; Yang and Li 2013). However, there is relatively little work to systemically and completely look at and compare the energy use and carbon emission from R&H construction industry in China. From the LCA methodology development perspective, there are a few practitioners in abroad. For example, a general pavement LCA methodology is created by Loijos et al. (2013) that is applied to the life cycle of concrete pavements to quantify current emissions across the road network in the United States. Noshadravan et al. (2013) present a comparative life cycle assessment of pavements considering measurement uncertainty and the data-quality uncertainty. Seo and Kim (2013) have made attempt to quantify the carbon dioxide emitted from the consumption of main and basic materials for road, bridge and tunnel constructions in Korea. White et al. (2010) present a process for road designers and transportation officials to model the impact of road material production and road construction of different pavement types on climate change potentials. In addition, there is also research devoted to evaluate the low-carbon construction technologies for eco-design (Lu 2009; Shang et al. 2012; Yu and Lu 2012; Cai 2013) in China.

However, most of the analyses are static snapshots of pavement design and are not geared towards continuous and dynamic tracking of national scope of R&H construction. The system boundary definitions and pavement designs used vary considerably among studies. Attempts to estimate the carbon emission of R&H roads in the China must hurdle a few gaps in the existing literature. One objective of this study is to develop streamlined LCA methodologies for quantifying carbon emission of R&H roads in China. Because quantitative, primary data may not be available to represent certain activities, it may be helpful to leverage qualitative or secondary information to estimate inventory or impact data. For instance, modeling transportation activities may require data on distance traveled, mode of transport, and unit allocation of those impacts. These data need not be measured directly in order to evaluate them; they may be estimated by gathering qualitative data from the supply chain, website information, prior knowledge, literature, or database proxies. If such data prove to be key contributors of impact uncertainty, they may be targeted for specificity. This research aims to account for all potential uncertainty in data to inform the prioritization of primary data collection by leveraging secondary data (Zgola 2011).

To summarize, it is the focus of this research to develop a consistent, streamlined LCA approach to identify the activities and attributes around which algorithms should be developed, based on their contribution to impact uncertainty. The proposed methodology is applied to the case study of pavement construction. On this basis, to answer: (1) How to streamline the process to dynamically quantify the carbon emission impact of R&H construction industry; (2) How to assess the expected confidence levels (credibility) of the quantification.

16.2 Methodology

16.2.1 Scope and System Boundary

Paved roads in China mainland, from expressway to class 4 roads have been chosen for study, including cement concrete and asphalt roads. While most of roads are unpaved or only paved by sand or gravel, the calculation of them is excluded due to the minor impacts and there is not scientific data available. Regarding the life stage, both the materials and manufacturing, and the construction process (including transportation of materials) will be included.

16.2.2 Streamlined Life Cycle Assessment

Firstly, an attempt has been made to characterize the R&H construction industry in China using national statistical data by the Ministry of Transport and other literature. Secondly, using streamlined Life Cycle Assessment (SLCA) to quantify the carbon footprint of R&H construction. Specifically, the activities related to R&H construction in China is formed which includes the length, types, design modes, and other aspects related to the life cycle. This information was combined with the emissions data related to each activity to calculate the carbon emission. The uncertainty is also captured.

In addition, methodology to estimate the carbon emissions of the R&H construction industry in the China must hurdle a few gaps in the existing literature. One objective of this study is to develop Streamlined Life Cycle Assessment (SLCA) methodologies for quantifying carbon emission of transport service sector in China. Because quantitative, primary data may not be available to represent certain activities, it may be helpful to leverage qualitative or secondary information to estimate inventory or impact data. For instance, modeling transport activities may require data on distances traveled, modes of transport, and the unit allocations of those impacts. These data need not be measured directly in order to evaluate them. They may be estimated by gathering qualitative data from the supply chain, website information, prior knowledge, literature, or database proxies. If such data prove to be key contributors of impact uncertainty, they may be targeted for specificity. This research aims to account for all potential uncertainty in data and inform the prioritization of primary data collection by leveraging secondary data (Zgola 2011).

Overall, the purpose of this study is to describe the key driving factors of carbon emissions from R&H construction industry and recommend suitable measures to mitigate the emissions. From the methodology perspective, it is the focus of this research to develop a consistent, SLCA approach to identify the activities and attributes around which algorithms should be developed, based on their contribution to impact uncertainty. The proposed methodology is applied to the case study of transport service sector.

In detail, this SLCA is an extension of an ongoing initiative around the Product Attribute to Impact Algorithm (PAIA) methodology developed by MIT MSL (our previous work) (Olivetti et al. 2013a, b): a streamlined LCA method that maps the intrinsic attributes of information technology products to energy use and carbon emissions. There are several core steps involved in the streamlined LCA:

- Data collection and preliminary evaluation, including bill of activities (BOA) and life cycle inventory data. The inventory data is captured by materials embodied impact by kg CO_2 eq./kg (kilograms of carbon dioxide equivalent per kilogram), and manufacturing energy use factor by MJ/kg (Mega Joule equivalent per kilogram).
- Classification and identification of an appropriate probability distribution for these data. Monte Carlo simulation and sensitivity analysis that provides an understanding of the confidence assigned to the drivers of carbon emissions impact (digging down from life cycle phases to particular components within the product class of interest). Data refinement for areas of significant contribution to total impact and contribution to variation.
- Life cycle interpretation, analysis, and discussion of results.

The BOA is a list of pavement-related activities such as length of pavement by kilometer (L), and other aspects related to the life cycle (i.e., energy use). This information was combined with the emissions data related to each manufacturing activity, available from literature. These include the MJ (kWh)-equivalent emissions related to each activity, e.g., MJ (kWh) emitted per kilometer of each type of pavement, which expressed as embodied materials impacts (E) and construction process impacts (C) in the equations, and i is the Class type of Pavement (Express and Class I; Class II and III; Class IV, m is 3), t is the design type of pavement (cement concrete and asphalt concrete, with a breakdown of f).

The grid emission factor is the amount of carbon dioxide emissions associated with each unit of electricity produced by an electricity grid. It is common in carbon footprinting to use standard emissions factors for grid electricity, expressed as kg CO_2-eq/kWh (G). These emissions factors will vary by region according to which fuel sources produce the electricity supplying the grid. China-based power mix is employed for the carbon emission factor including attendant uncertainty.

Thus, calculation of the total GPW (Global Warm Potential) of each type of pavement is expressed in Eq. 16.1; Calculation of the total GPW of each Class of pavement is expressed in Eq. 16.2; calculation of the total GPW of all pavement roads is expressed in Eq. 16.3.

$$GWP_t = \left[\sum_{i=1}^{m} (L_t \times f \times E_t)\right] \times G_c \tag{16.1}$$

$$GWP_i = \left[\sum_{i} (L_{t-c} \times f \times E_{t-c}) + \sum_{i} (L_{t-a} \times (1-f) \times E_{t-a})\right] \times G_c \tag{16.2}$$

$$GWP = \left[\sum_{i=1}^{m} (L_{t-c} \times f \times E_{t-c}) + \sum_{i=1}^{m} (L_{t-a} \times (1-f) \times E_{t-a})\right] \times G_c \tag{16.3}$$

16.2.3 Data Inventory

Several sources offer annual R&H length and pavement type data. These include the 'Year Book of China Transportation and Communications' (China Transportation and Communications Society 2013), and the 'Sector Development Statistic Bulletin of Chinese and Transportation and Communications' (Ministry of Transport of China 2013); and the 'Yearbook of China Statistics' (National Bureau of Statistics of China) (NBSC 2014). The emissions factors corresponding to construction (design) methods and road making materials embodied impacts drawn from literature Lu (2009, Shang et al. (2012 and Cai (2013). The SLCA model incorporates grid mix data from PSI (Itten et al. 2013) and other sources (Gabi and Ecoinvent), for most of the countries in the world. Within many countries, there exist multiple electric grid regions, each with a unique mix of power generation resources.

16.2.4 Constrains and Limitations

There are several shortcomings associated with using sales data from literature as well as general constraints for the methodology proposed in this study, including:

- While we did collect the data on market (design) shares of pavement type (cement or asphalt) for the years around 2012, the uncertainty associated with these data is excluded. In addition, we used the same markets shares of pavement types of 2012 for other years since these are difficult to predict.
- Unpaved road construction in China is excluded. The methodology is demonstrated with paved road (from express way to level 4) only, which may not be representative of all carbon emission in road construction.
- The methodology can only be used to track regular road for transportation but not including the short length roads, such as the road spread in the large factories, institutes and etc.
- The data used to determine the unit energy consumption for each type of pavement (measured by MJ or kWh per kilometer) were from literature (China-specific scenarios experimental data) and may not be good enough to represent the actual but fast changing situation in whole China. In addition, we divided the roads in three groups by Expressway and Class I (Express and C-I), class II and Class III (C-II and C-III), Class IV (C-IV) since the designs for the roads categorized into the same group are quite similar. The emission factor of Class I road (Expressway and C-I) is the highest, and obtained from literature (raw data). The emission factor of C-II and C-III road is assumed to be a percentage of 45–50 % of the factor of Express and C-I road; and the emission factor of C-IV road is assumed a percentage of 45–50 % of the factor of Express and C-I road based on a comparable reference (Andrews-Speed 2012).
- Consideration of the data unavailability, neither the use stage (including vehicle extra energy use and road maintenance) nor the EoL dismantling and recycling are included in this study.

In addition, this SCLA model, based on a life cycle approach, is subject to the same limitations as LCA studies. The reliability of the results and the conclusions of the LCA depend in large measure on the quality of the inventory data that is used. Primary data on energy consumption during the manufacturing and construction of the focal pavement is scarce. Moreover, focusing on GWP impacts bears the risk that the analysis overlooks other relevant environmental impacts (Quack et al. 2012). Environmental management focused exclusively on GWP impact runs the risk of inadvertently shifting the problem to other environmental impacts when pavements are optimized to become more "green" (Laurent et al. 2012).

16.3 Results and Discussion

16.3.1 Road and Highway Construction in China

The development of the Chinese road transport industry is breathtaking, vigorous and influential. Since the 1990s, the road length has risen steadily, as it rose more in the following decade. In China roads are classified by administrative responsibility:

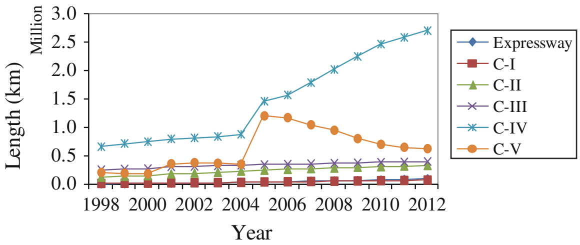

Fig. 16.1 Highway mileage and expressway mileage from 1998 to 2012

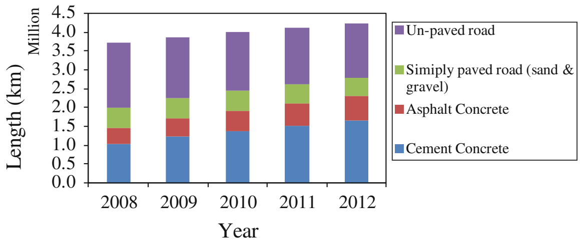

Fig. 16.2 Pavement type from 2008 to 2012

national, provincial, county, township and special highway as well as village roads. In accordance with technical classification, roads are classified by expressways, class I, class II, class III, class IV and unclassified roads. By the end of 2012, the Chinese road transport network comprised of 4.24 million km of public roads (of which 96,200 km were expressways). In 2012, the additional highway mileage reached 156,110 km, 4.3 % more than that of the previous year (Fig. 16.1). In 2012, the density of the Chinese highway reached 50.54 km/100 km^2, 4.3 % more than that of the previous year.

The materials—concrete, asphalt, and steel—are now the mainstays of highway and bridge construction throughout the world, as well as of most types of public works infrastructure. In China, roads are classified by pavement type: cement concrete, asphalt, sand and gravel road, and unpaved roads (Fig. 16.2). As a reminder, we divided the roads in three groups by Expressway and Class I (Express and C-I), class II and Class III (C-II and C-III), Class IV (C-IV) since the designs for the roads categorized into the same group are quite similar. The analysis on the statistic data is shown in Fig. 16.3.

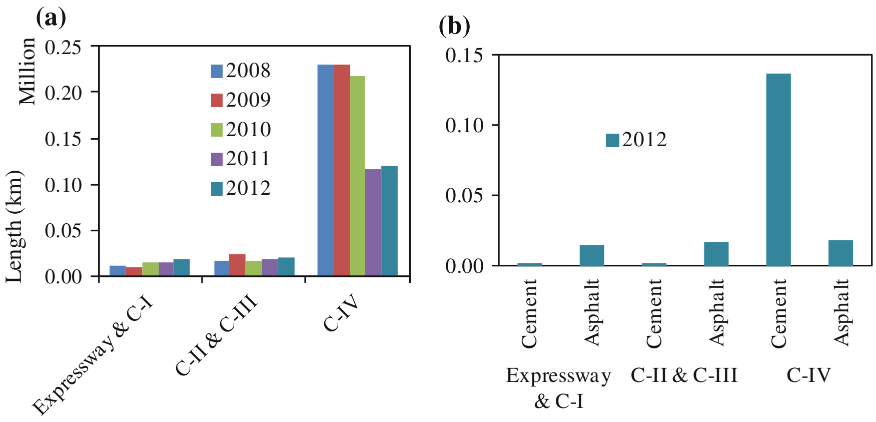

Fig. 16.3 Newly constructed pavement each year from 2008 to 2012: **a** by class type; **b** by road design type in 2012

16.3.2 Lifecycle Impacts

Evaluation of the carbon emissions throughout the life cycle of the newly constructed pavement is specified in Fig. 16.4 (by road class type and by road design type). The study shows that the C-IV road mainly made by cement concrete dominates other types in terms of energy consumption, comprising more than 84.2 % of the impact. The expressway and C-I roads are responsible for less than 10 % of total carbon emissions. The expressway and C-I roads burden is a bit higher than the C-II and C-III burden. As showed in Fig. 16.4b, cement road, which comprises more than 95 % of the overall R&H impact, is the dominant road type. Because the C-IV road or cement concrete road represents a significant impact

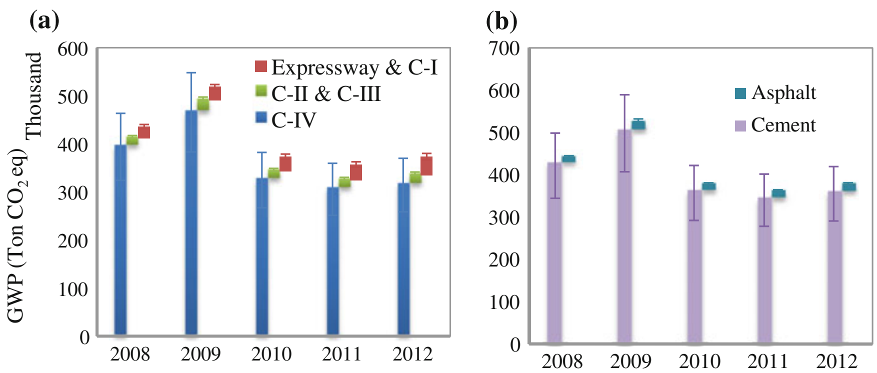

Fig. 16.4 GWP of newly constructed pavement each year from 2008 to 2012: **a** by road class type; **b** by road design type

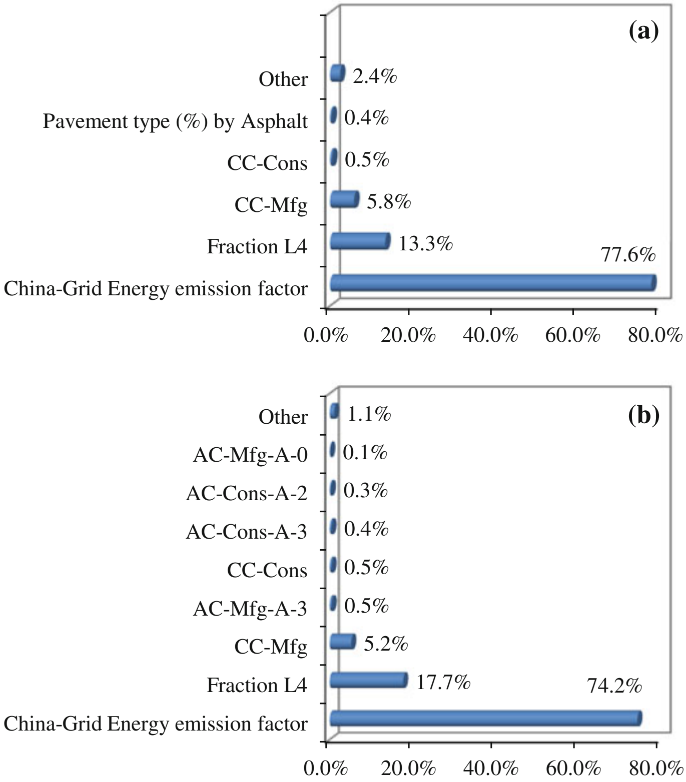

Fig. 16.5 Contribution to variance for GWP of newly constructed pavement in the year 2012: **a** cement concrete pavement; **b**: C-IV pavement

within the total carbon footprint; a sensitivity analysis has been conducted in followed section.

Figure 16.5 shows the sensitivity analysis results: contribution to variance for cement concrete pavement and for C-IV road. The parameters for this set revealed that the standard emissions factors for grid electricity, expressed as kg CO_2-eq/kWh, is the activity that most contributes to the overall uncertainty, with a contribution to variance of over 70 %, followed by the fraction of pavement design type, and the materials and manufacturing energy impact of cement concrete pavement.

16.4 Conclusion

The streamlined LCA has the potential to quantify the carbon emission of R&H construction in China. The uncertainty capture can greatly reinforce the quantitative results with the reduction and data effort and cost. From the perspective of carbon emission evaluation, R&H construction should be aroused attention for environmentally sound management in China. Radical institutional change across the policies and technologies in China will be required in order to accelerate the transition to a low carbon R&H construction. The authors have systemically conducted the analyses of potential carbon emissions of R&H construction for China. The outcomes are important from a policy standpoint, and the methodologies are also important for future carbon emission quantifications of other transportation sectors in China and beyond.

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Chapter 17
Decomposition of Energy-Induced Carbon Emissions in the Construction Industry of China

Dezhi Li, Yujie Lu, Bo Zhang and Peng Cui

Abstract With the rapid development of the global economy, the amount of China's carbon emission has been increasing consistently in a high speed, causing huge environment problems. The construction industry, as the leading pillar of the national economic and social development, accounts for a large proportion of the total carbon emissions in China. Several calculation methods have been used to calculate carbon emissions. However, the main influencing factors need to be found to reduce carbon emissions. In this paper, the Logarithmic Mean Divisia Index (LMDI) technique is used to decompose the energy-induced carbon emissions of the construction industry into four factors: construction areas, construction investment efficiency (output value per unit), energy intensity, and carbon intensity. Based on IPCC carbon emission factors and data from Chinese Energy Statistical Yearbooks and Chinese Construction Industry Statistical Yearbooks, the factors of energy-induced carbon emissions in China were decomposed with LMDI method and Kaya equation. Proper countermeasures are proposed to reduce the energy-induced carbon emissions of the construction industry in China.

Keywords Carbon emission · Construction industry · LMDI · Kaya equation · China

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17.1 Introduction

China is the largest emitters of carbon emissions in the world with estimated 8.3 billion tons of carbon dioxide produced in (2011). Among all industrial sectors, the construction industry is on the top list which contributes significantly to carbon emissions due to its massive use of high emission-embedded materials, such as cement and steel bars. Investigation of the carbon emissions in the construction industry therefore becomes a major issue in recent years and its results are critical to formulate better environmental policy for the industry. Currently, many factors influence carbon emissions, such as economic development, construction efficiency, used materials, etc. The essential step to tackle this challenge is to fully understand what factors are driving this change and how these factors evolve in the future.

Various methods exist to analyze the breakdown structure and influencing components for carbon emissions, such as regression and questionnaire-based survey. While both pros and cons for each method are still in debate, there is a growing trend of applying decomposition analysis for carbon emissions analysis. A decomposition analysis aims to decompose carbon emissions into different attributing factors in quantitative and explanatory ways. The decomposition could be period-wise or a time-series. Period-wise decomposition only compares emissions between the beginning and the end of a targeted time period for a given region. The time-series investigate yearly decomposition of emissions for a given place, so its results show greater details in terms of each explanatory factor. China's carbon emissions have been studied by a number of decomposition studies (Zhang et al. 2009; Wang et al. 2005; Liu et al. 2007). These studied decomposed energy-related carbon emissions in China by different times, industries, activities, and resources. In addition, Fan et al. examined the changes of aggregate residential carbon intensity in China and analyzed its driving factors during 1996–2008 (Fan et al. 2013). However, most of these studies delineated carbon emissions at national of multi-industrial level. Limited studies focused especially on the building and construction industry which is the second largest carbon emitter in China and play a critical role to achieve the national emissions target in the long term.

This research aims to use a time-series decomposition technique to identify the factors influencing the historic changes of carbon emissions for the Chinese construction industry in past 20 years, in particular from 1992 to 2011. This paper is organized as follows. Section 17.2 presents the decomposition method and Kaya equation; Sect. 17.3 illustrates the data collection process and summary; Sect. 17.4 analyzes the decomposition results and provides associated policy suggestions; Sect. 17.5 concludes the study by providing summary and future works.

17.2 Research Method

17.2.1 Calculation Method for Energy-Induced CO_2 Emissions

This research follows the factors-based calculation method, which was proposed by the IPCC, to calculate the total carbon emissions. The basic model is shown as below

$$\text{Carbon emissions} = \text{Activity data} * \text{Emission factors} \tag{17.1}$$

The activity data are typically the amounts of fuels combusted by human; carbon emission factor (CEF) is a representative value that relates the quantity of carbon dioxide emissions released to the atmosphere with an activity which releases emissions (IPCC 2006). This study uses Chinese construction industry as the focus of research, so the CEF are energy consumed related carbon dioxide emissions. Total carbon emissions can be calculated as follows.

$$\mathrm{T_{CO_2}} = \Sigma \mathrm{Ei} \times \mathrm{H} \times \mathrm{C} \times \mathrm{O} \times \frac{\mathrm{W_{co_2}}}{\mathrm{W}_C} \tag{17.2}$$

Here, $\mathrm{T_{CO_2}}$ is the total carbon emissions emitted by consuming energy. ΣEi indicates the total energy consumption for all energy sources, such as coal, gas, natural gas, etc. This research targets on the overall energy consumption which has already been converted into standard coal. H is the low heating value for one unit of standard coal. By referring to the Chinese energy consumption standard (2008), H uses the value of 29,307 kJ/kg. C is the embedded carbon for one unit of standard coal and it uses the national standard of 29.88 (IPCC 2006). O refers to the carbon oxidation rate of the consumed energy which is standard coal (in 10,000 t) and its value is 90 % (Zhang et al. 2008). $\mathrm{W_{co_2}}$ is the molecular weight of the CO_2 and it equals to 44; $\mathrm{W_C}$ is the atomic weight of carbon and it equals to 12.

17.2.2 The Decomposition Approach: Logarithmic Mean Divisia Index (LMDI) Method

The index decomposition analysis method was first investigated in energy-related carbon emission studied in 1991 (Xu and Ang 2013). Since then, many methods exist to find the most influential factors contributing to the carbon emissions. Among them, two methods are most popular: structural decomposition method and index decomposition method. While both methods show advantages in various aspects, the index decomposition method is much more popular due to its flexibility of use and accurate results (Ang et al. 1998). Ang and Zhang (2000) reported over

100 academic papers used index decomposition for the carbon emission study in the field of carbon decomposition. Due to different calculation mechanisms, the index decomposition method can be furthered categorized into Arithmetic mean divisia index and logarithmic mean divisia index (LMDI). This paper adopted LMDI to decompose the energy-induced carbon emissions in the construction industry and its formula is as follows.

$$\begin{cases} L(x, y) = \frac{(x-y)}{\ln(\frac{x}{y})} \quad x > 0, \quad y > 0 \\ L(0,0) = 0 \end{cases} \tag{17.3}$$

Combine the L(x, y) with factorization of $Z_t = X_t * Y_t$, the Z_t can be decomposed as followings.

$$\begin{cases} \Delta Z_x = L(Z_t, Z_0) * \ln(\frac{X_t}{X_0}) \\ \Delta Z_y = L(Z_t, Z_0) * \ln(\frac{Y_t}{Y_0}) \end{cases} \tag{17.4}$$

where, Z represents goal. x and y mean influential factors. t is time and t = 0 means the starting time. ΔZ_x and ΔZ_y are the changes of Z under the independent impact of x and y.

17.2.3 Decomposition of Factors

By using the Kaya equation, the carbon emissions can be recalculated as follows:

$$C = \sum BA \times \frac{OV}{BA} \times \frac{E_i}{OV} \times \frac{C}{E_i} \tag{17.5}$$

where

$$\begin{cases} P\_Eff = \frac{OV}{BA} \\ E\_Int = \frac{E_i}{OV} \\ C\_Int = \frac{C}{E_i} \end{cases} \tag{17.6}$$

where, C is carbon emissions, BA is total building and construction areas, OV is total output value of the construction industry, E_i is one source of consumed energy, and this study use standard coal as the source. Then, $Eff = \frac{OV}{BA}$ represents the production efficiency of the construction industry in terms of its output value per unit square meters; $E\_Int = \frac{E}{OV}$ represents the energy intensity of the construction industry in terms of its consumed energy associated with produced value; $C\_Int = \frac{C}{E_i}$ means the carbon intensity by measuring the carbon emissions per unit of consumed energy. By using LMDI to decompose the influences of above factors, the results can be shown as follows.

$$\begin{cases} \Delta C_{BA,t} = L_t * \ln(\frac{BA_t}{BA_0}) \\ \Delta C_{P\_Eff,t} = L_t * \ln(\frac{P\_Eff_t}{P\_Eff_0}) \\ \Delta C_{E\_Int,t} = L_t * \ln(\frac{E\_Int_t}{E\_Int_0}) \\ \Delta C_{C\_Int,t} = L_t * \ln(\frac{C\_Int_t}{C\_Int_0}) \end{cases} \tag{17.7}$$

where, $L_t = \frac{C_t - C_0}{\ln(\frac{C_t}{C_0})}$ and $C_t - C_0$ are carbon emissions for year t and year 0, respectively.

$$C = \sum BA \times \frac{P}{BA} \times \frac{Ci}{P} \times \frac{Ei}{OV} \times \frac{OV}{E} \times \frac{E}{E_i} \tag{17.8}$$

17.3 Data Collection

The data were collected from official channels of Chinese statistic bureaus. Specifically, the construction output value and areas were collected from Chinese construction industry statistical yearbooks. The construction industry refers to all construction related business, including but not limit to buildings, railways, roads, tunnel, bridge, ports, and other infrastructure construction. The energy-induced carbon emissions of the construction industry are those emitted during the construction life cycle process due to energy consumption, including burning gas, fuel, natural gas, etc. The consumed energy data were collected from Chinese energy statistical yearbooks, summarized in Table 17.1.

17.4 Results

17.4.1 Total Carbon Emissions

After compiling all data, the energy-induced carbon emission for the construction industry can be calculated and the result is shown in Fig. 17.1. During last 20 years, the lowest emissions of 34 million tons happened in 1997 and the highest emission of 170 million tons happened in 2011. The emissions in 2011 (170 million tons) are quadruped than the emission in 1992 which was 40 million tons. While there is a great increasing trend of the emissions, the emission history can be grouped into three

Table 17.1 Energy consumption, total output value, and building areas of Chinese construction industry in 1992–2011

Year	Energy consumption (10,000 ton standard coals)	Total output value (100 million RMB)	Building areas (10,000 m^2)
1992	1393	2174.44	51,885.4
1993	n.a.	3253.5	65,374.2
1994	1349.3	4653.32	78,032.2
1995	1334.5	5793.75	89,862.8
1996	1448.63	8282.25	129,087
1997	1178.99	9126.48	128,680.3
1998	1612.09	10,061.99	137,593.6
1999	1381.44	11,152.86	147,262.5
2000	2178.53	12,497.6	16,0141.1
2001	1452.8	15,361.56	188,328.7
2002	1610.13	18,527.18	215,608.7
2003	1771.91	23,083.87	259,377.1
2004	3259	29,021.45	310,985.7
2005	3403.31	34,552.1	352,744.7
2006	3760.73	41,557.16	410,154.4
2007	4127.52	51,043.71	482,005.5
2008	3812.53	62,036.81	53,0518.6
2009	4562.02	76,807.74	588,593.9
2010	5309.3	96,031.13	708,023.5
2011	5872.16	117,059.7	851,828.1

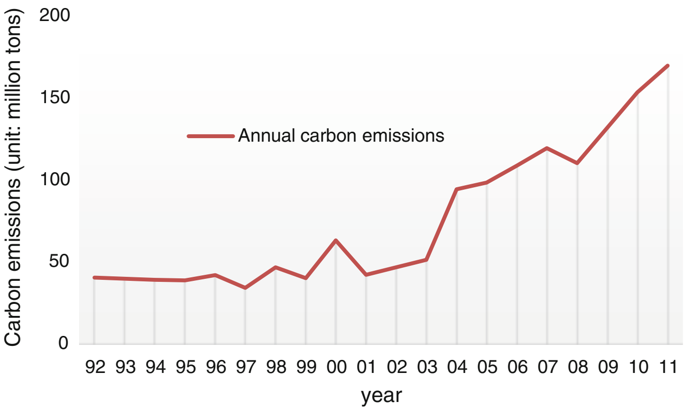

Fig. 17.1 Total energy-induced carbon emissions from Chinese construction industry during 1992–2011

phases. From 1992 to 1996, the emissions kept at a stable level of 40 million tons. During 1997–2003, the emissions fluctuated in a wide range of 34–51 million tons. For these years, the total building areas increased, while the emission intensity kept reduced. So the aggregated influences were neutralized and total emissions swung in a normal range. Starting from 2004, the carbon emissions have showed the tremendous growth rate for eight years except year 2008. Such a strong growth trend was strongly correlated with total building areas and construction production efficiency. The highest annual growth was 84 % in 2003–2004, and the recent four years of annual growth rate were over than 10 %. The 2008s pullback could be the reason of global economic recession and Chinese slow development of construction industry. The detail reason is further analyzed in the following decomposition results.

17.4.2 Decomposition of Carbon Emission Factors

Using LMDI to decompose the carbon emission, the results is shown in Fig. 17.2. Assuming the carbon emissions in year 1992 are set as benchmark and its value equal to zero, the influencing impacts of building areas (BA), construction production efficiency (P_Eff), and the energy consumption intensity (E_Int) are shown accordingly in Fig. 17.2.

The building area (BA) has the most significant impact on the carbon emissions. In 2011, over 252 million tons of emissions were attributed by the increase of building areas only, compared with 107 million tons of emission attributed by the production efficiency (P_Eff), which has moderate impact. In 2011, the emissions from production efficiency were half of the emissions from the building areas. The energy intensity (E_Int) however helps mitigate the emissions by adding negative emissions. The influence of carbon intensity (C_Int) on the carbon emissions is

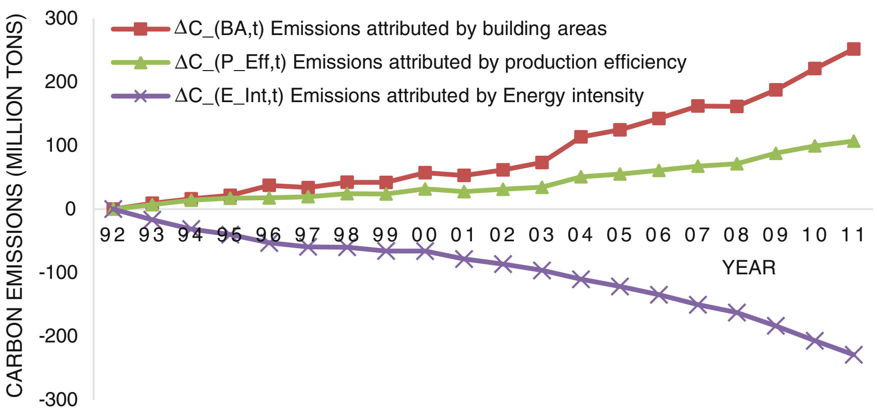

Fig. 17.2 The comparison of various influencing factors for energy-induced carbon emissions for Chinese construction industry between 1992 and 2011

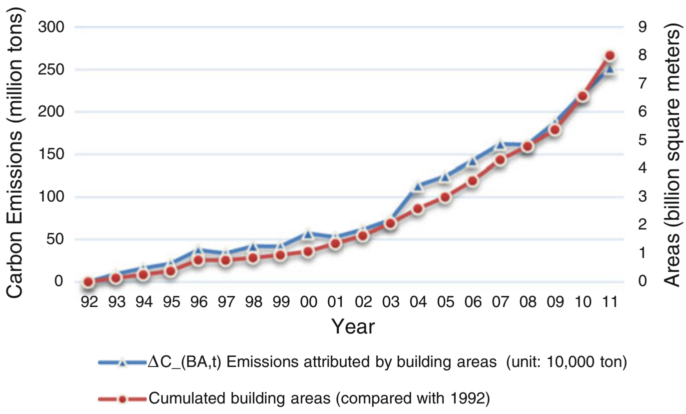

Fig. 17.3 Building areas and its attributed emissions for Chinese construction industry between 1992 and 2011

negligible, because this paper uses total energy consumption as the only energy source which was already converted into the standard coal consumption.

In terms of each factor's impact, Fig. 17.3 illustrates the relation between building area and its attributed carbon emissions in the past two decades. The building and construction areas kept the increasing trend, especially the growth rate became more rapidly in last few years. The reasons are assumed to the sky rocketed real estate market in China and also the government intensive economic stimulus policy for domestic infrastructure investment. Especially in 2008, the Chinese national council approved a 4,000 billion RMB investment plan in the next five years, causing an immediate jump of new building areas in 2009. As a result, the induced emissions were also accumulated at a historical high level since 1992. However, it is worth noting that starting from 2008, the emissions stop increasing and cross the lines with building areas. It means that although the building areas keep growing fast, the associated emissions are slow down and the new emitted emissions are less than the rate of new building areas. In other words, the emissions are off the hock with the building areas.

The relationship between construction production efficiency and its attributed carbon emissions is shown in Fig. 17.4. Both of two curves were increasing rapidly in the past. From 2007 to 2009, the production efficiency rate grew so rapidly. The increase of production efficiency indicates that the same building area can generate higher building values due to more building floors, complexity, and functions, and therefore it emitted more emissions to complete the work. As consequences, associated emissions were growing rapidly since 2007. In the near future, the attributed emissions could keep increasing if the production rate keeps the same trend.

Figure 17.5 represents the energy intensity and its attributed carbon emissions in past 20 years. Due to the continuous improvement of the energy efficiency for the construction industry, its energy intensity has significantly dropped from 0 in 1992,

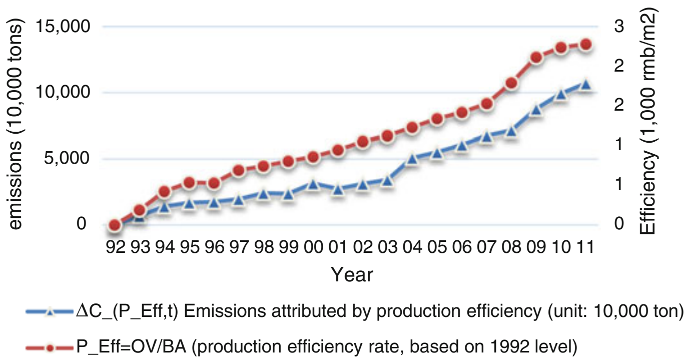

Fig. 17.4 Construction production efficiency and its attributed emissions for Chinese construction industry between 1992 and 2011

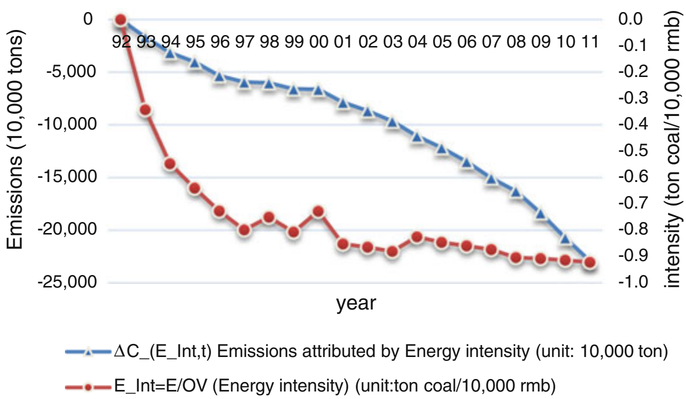

Fig. 17.5 Energy intensity and its attributed emissions for Chinese construction industry between 1992 and 2011

to −1.0 ton coal/10,000 RMB in 2011. This drop was very obvious in the 1990s, especially during 1992–1997. After 1998, the energy intensity changed slowly although it was still declined. A possible explanation is that China used most of its low hanging fruits in achieving energy efficiency during the 90s, and then it had to gradually transit to a state where the energy efficiency can only be reduced at a small margin. Consequently, the attributed emissions dropped significantly in last 20 years. This justified that energy efficiency was the major reason to mitigate emissions. However as the energy efficiency rate reaches a limited cap, the future emission reduction is supposed to stay at a relatively stable level.

17.5 Conclusions

This paper calculated the total energy-induced carbon emission for Chinese building and construction industry from 1992 to 2011. And then, it uses LMDI method to decompose energy-induced carbon emission into four factors: total building areas, production efficiency, energy intensity, and carbon intensity. The further analysis shows that the total building areas is the most influential factor for the carbon emissions. Along with its large expansion in last 20 year, it directly contributed a large amount of carbon emission to the construction industry. In addition, the production efficiency has moderate effects on the carbon emissions and only attributed half amount of emissions during the same time. Energy intensity is good evidence of helping mitigate carbon emissions by reducing the energy demand for the same unit of money. Therefore, the emissions from the same investment actually reduced significantly.

This research decomposes various factors which impact on the changes of energy-induced carbon emissions for Chinese construction industry in past two decades. It also provides explanatory analysis for these factors and provides future projections in the long term. By knowing this different factors and future trend, policy makers can make better and wise decisions. Practitioner, such as environmentalists, can also learn from the past reasons and factors and tune their responding policies to tackle the carbon emission challenges. The future works can consider to use multiple ways of decomposition, and to find multiple factors contributing to the carbon emissions changes.

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Chapter 18
Analysis of Factors Influencing the Performance of HVAC Retrofits

Shuo Chen, Guomin Zhang and Sujeeva Setunge

Abstract Existing Heating, Ventilation and Air Conditioning systems (HVAC) are faced with an escalated rate of obsolescence. In order to attract and maintain long-term tenants, building owners need to improve their assets and provide living space with excellent environmental credentials. As global warming has been recognized as a key issue in recent years, rapid enhancement of energy efficiency of existing HVAC is essential for a timely reduction in global energy use and promotion of environmental sustainability. Thus, HVAC retrofitting or refurbishment is identified as one of main approaches to improve the energy efficiency and reduce the greenhouse gas emissions. Various new retrofit technologies have emerged to improve the HVAC performance, but the outcomes present difference from expected, with some succeeded and some failed to meet the expected targets. This has given rise the so-called "gap" between the expected and actual performance of retrofitted HVAC. In order to close this gap in a real project, a questionnaire survey is conducted in this paper to identify the critical success factors (CSFs) during the planning, design, installation, operation and maintenance phases of HVAC retrofits. The results can help decision-makers to identify an optimal solution between alternatives, which presents the maximum green performance of retrofitted HVAC.

Keywords Existing HVAC · Retrofit · Critical success factors

18.1 Introduction

In contemporary buildings, the heating, ventilation and air-conditioning (HVAC) system is an essential building service system, which provides a comfortable indoor environment for people to live and work (ASHRAE 2000). As global warming has been recognized as a key issue in recent years, rapid enhancement of energy

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efficiency of HVAC in existing building is essential for a timely reduction in global energy use and promotion of environmental sustainability. Existing buildings are faced with an escalated rate of obsolescence. There is an ever-growing demand by building tenants for sustainability, which place greater pressure on existing building owners to improve their assets. In order to attract and maintain long-term tenants, building owners need to provide living space with excellent environmental credentials.

Many governments and international organisations have established a number of policies and regulations in order to improve building performance and reduce greenhouse gas emissions. The International Energy Agency (IEA) has launched a set of Annex projects to promote energy efficiency of existing building, such as Annex 46, Annex 50, Annex 55, and Annex 56 (IEA 2013). Energy performance contracting has been introduced as a market mechanism to provide great advantages for building clients to conduct building energy efficiency retrofit projects, which include energy savings guarantees and associated design and installation services for energy efficiency projects (Xu et al. 2011; Xu and Chan 2013). The Australian Governments has introduced more stringent regulations to improve building energy efficiency. The Energy Efficiency in Government Operations Policy (EEGO 2007) aims to reduce the energy consumption of Australian Government operations with particular emphasis on building energy efficiency. From 2010, Mandatory disclosure of National Australian Built Environment Rating System (NABERS) when selling or leasing a building will make carbon emissions more public and exacerbate this issue (Beattie 2009).

As the same time, innovative work has been carried out by architectural and engineering groups to retrofit HVAC in office buildings and to lower carbon emission (Ascione et al. 2011; Chidiac et al. 2011a, b; Dascalaki and Santamouris 2002; Gamtessa 2013). Efforts have been made by scholars and industry practitioners to create various new retrofitting technologies for HVAC systems, which are aiming at reducing energy cost and improving user comfort. However, the outcomes of retrofitted HVAC systems present difference from expected performance, with some succeeded and some failed to meet the expected targets (Mitchell 2009). This has given rise the so-called "gap" between the expected and actual performance of retrofitted HVAC, which has been widely documented in several studies (Asadi et al. 2012; Azar and Menassa 2012; Xing et al. 2011). The property owners and asset managers commonly have to tackle uncertainties and risks which have been regarded as considerable technical challenge. Thus, this paper aims to develop a set of critical success factors (CSFs) for HVAC retrofits. First, a comprehensive literature review is carried out to understand the success factors for HVAC projects and those factors relevant to retrofits. Second, a questionnaire survey is carried out with experts to solicit opinions regarding each of the nominated factors. Based on the data gathered from the survey, factor analysis method is used to investigate the underlying relationship among the identified CSFs to find out the clusters that can better represent the CSFs.

18.2 Success Factors for HVAC Retrofits

There has been no system research to investigate the CSFs which may affect the performance of the retrofitted HVAC in the public domain. However, in previous decades, various researches introduced a number of key factors that have significant impacts on construction projects and building retrofitting projects. Ma et al. (2012) maintained that success of a building retrofit programme is determined by six aspects, namely, policies and regulations, client resources participants-related factors, and external factors. Xu et al. (2011) developed a set of important factors of energy performance contracting for sustainable building energy efficiency retrofit of hotel buildings. The factors were categorised into six clusters, including (a) project organisation process; (b) project financing; (c) knowledge and innovation of EPC, sustainable development and M&V; (d) implementation of sustainable development strategy; (e) contractual arrangement; and (f) external economic environment. All the above classification methods have some similarity. Our list of proposed factors was derived from an extensive literature review. In general, the CSFs could be divided into four categories in Table 18.1: stakeholders related factors, project team management related factors, retrofit plan related factors, and HVAC technologies related factors.

The factors related stakeholders can be divided into two aspects: clients' characteristics and HVAC contractors & HVAC technicians' characteristics. The key role of the client is to create an organisational climate that encourages green retrofits. To foster this, certain capabilities and attitudinal aspects of clients play an important role. In many building retrofitting projects, clients, suppliers engineering companies lack awareness and information of new retrofitting technologies (Mitchell 2009). Most clients have willingness to reduce energy consumption. However, only few of them have experience in implementation of new retrofitting technologies. Lack of understating and experience on the part of clients impedes implementing the new technologies in HVAC retrofits or even leads to their failure. It is noticed that larger companies are more able to afford the investment of new technologies and more able to tolerate the risk of adoption, whereas smaller firms are more likely to value technologies and to use simpler decision-making process (Davis 2014). Therefore, the company size can be recognized as one of the important factors related to the decisions of procurement process. In addition, capability of financial resource is one of key ingredients influencing project success.

Contractors historically have emphasised the ability to manage labour and subcontractors, which are recognized as the key element in compositing pricing (Bediawan 2003). Technical background and skill of team members is stressed by researchers as one of the key reasons for project success (Belassi and Tukel 1996; Chan et al. 2004). Some of the characteristics of contractors & HVAC technicians are similar with clients'. Details of the factors from client's and contactor & technician's perspectives are shown in Table 18.1.

Project team management related factors include appropriate organization structure, project team cohesiveness, effective coordination, organizing skills, trust,

Table 18.1 A list of CSFs affecting the performance of retrofitted HVAC systems

Code			Preliminary factors	References
Stakeholders related factors	*Clients' characteristics*	E1	Awareness of green HVAC retrofits outcome	Xu et al. (2011), Mitchell (2009)
		E2	Competence of HVAC technical knowledge	Mitchell (2009)
		E3	Willingness to be involved in the project	Mitchell (2009)
		E4	Willingness to use new HVAC technologies for green outcomes	Mitchell (2009)
		E5	Ability to contribute ideas to HVAC retrofits design process	Mitchell (2009)
		E6	Ability to contribute ideas to HVAC retrofits construction process	Mitchell (2009)
		E7	Experience with the procurement process	Chan et al. (2004)
		E8	Financial resources capability	Chan et al. (2004)
		E9	Skilled leadership of organizing HVAC retrofits project	Xu et al. (2011), Chan et al. (2004)
	HVAC contractors and HVAC technicians' characteristics	F1	Availability of personnel resources	Belassi and Tukel (1996), Bediawan (2003)
		F2	Commitment of on-time and on-budget project delivery	Chan et al. (2004)
		F3	Familiarity with new HVAC technologies design related policies and regulations	Mitchell (2009)
		F4	Familiarity with new HVAC technologies construction related work	Mitchell (2009)
		F5	Company size	Davis (2014), Chan et al. (2004)
		F6	Experience of using new HVAC technologies	Mitchell (2009)
		F7	Diversity of technical capability	Bediawan (2003), Chan et al. (2004)
		F8	Number of subcontractors engaged on project	

(continued)

Table 18.1 (continued)

Code		Preliminary factors	References
			Bediawan (2003), Chan et al. (2004)
	F9	Availability of equipment resources	Bediawan (2003), Chan et al. (2004)
	F10	Willingness to use new HVAC technologies for green outcomes	Mitchell (2009)
	F11	Familiarity with new HVAC technologies maintenance work	Mitchell (2009)
	F12	Diversity of personnel	Belassi and Tukel (1996)
	F13	Financial resources capability	Chan et al. (2004)
	F14	Communication with suppliers	Bediawan (2003)
	F15	Skilled leadership of organizing HVAC retrofits project	Bediawan (2003)
Project team management related factors	G1	Project team cohesiveness	Bediawan (2003), Chan et al. (2004)
	G2	Commitment of the HVAC designer to achieve project goals and objectives	Bediawan (2003), Chan et al. (2004)
	G3	Commitment of the HVAC contractor to achieve project goals and objectives	Bediawan (2003), Chan et al. (2004)
	G4	Level of trust in the project team	Bediawan (2003), Chan et al. (2004)
	G5	Effectiveness of working relationship between client and the HVAC designer	Bediawan (2003), Chan et al. (2004)
	G6	Effectiveness of working relationship between client and the HVAC contractor	Bediawan (2003), Chan et al. (2004)
	G7	Effectiveness of teamwork and communication between the HVAC designer and the HVAC contractor	Bediawan (2003), Chan et al. (2004)

(continued)

Table 18.1 (continued)

Code		Preliminary factors	References
	G8	Effectiveness of developing an appropriate organizational structure to maintain work-flow	Bediawan (2003), Chan et al. (2004)
	G9	Skills of resolving problems	Mitchell (2009)
	G10	Effectiveness of project team coordination	Bediawan (2003)
Retrofit plan related factors	H1	Clarity of project scope	Mitchell (2009), Ma et al. (2012)
	H2	Clarity of client's objectives and requirements	Mitchell (2009), Ma et al. (2012)
	H3	Effectiveness of HVAC retrofit programming	Mitchell (2009)
	H4	Understanding of the HVAC's current state including problems and limitations	Mitchell (2009), Ma et al. (2012)
	H5	Clarity of HVAC performance assessment and diagnostic	Mitchell (2009), Ma et al. (2012)
	H6	Appropriateness of retrofits solutions	Mitchell (2009)
	H7	Completeness of documentation	Mitchell (2009)
HVAC technologies related factors	I1	Geographic location of the retrofitting building	Wong and Li (2006, 2008)
	I2	Orientation of the retrofitting building	Wong and Li (2006, 2008)
	I3	Condition of the existing HVAC systems	Wong and Li (2006, 2008)
	I4	Impact of occupancy schedule and churn on performance of HVAC systems	Mitchell (2009)
	I5	Operation schedule and maintenance records of the existing HVAC systems	Mitchell (2009)
	I6	Life span of the selected HVAC retrofitting technologies	Wong and Li (2006, 2008)
	I7	Ability of further upgrade of the selected HVAC retrofitting technologies	Mitchell (2009), Wong and Li (2006, 2008)

(continued)

Table 18.1 (continued)

Code		Preliminary factors	References
	I8	Control flexibility of the selected HVAC retrofitting technologies	Wong and Li (2006, 2008)
	I9	Compatibility with other building systems of the selected HVAC retrofitting technologies	Mitchell (2009)
	I10	Integration in building automation systems of the selected HVAC retrofitting technologies	Wong and Li (2006, 2008)

and project objectives control mechanism. A number of researches noticed that the top executive is in charge of the project and needs to have sufficient authority, personality, and reputation to provide guidance, instruction, direction, leadership to a group of other individuals in order to achieve aligned objectives. They must ensure that everything needed to be done for the benefit of the project. Level of collaboration in project team has been recognized as a key element determining a project's success (Barclay and Osei-Bryson 2010). In order to set up a successful project organization, the trust and effective coordination are necessary (Chan et al. 2004; Davis 2014). Also, project team cohesiveness and the commitments of different stakeholders are the contributing factors, which support the each level of the activities working smoothly and finally achieving the align goals. Meanwhile, effective teamwork and communication among different stakeholders are indispensable.

Retrofit plan related factors contains effectiveness of HVAC retrofit programming, clarity of project scope and client's objectives, understanding of the HVAC's current state, clarity of HVAC performance assessment and diagnostic, accuracy of retrofits solutions, and completeness of documentation. In order to achieve successful HVAC retrofitting project, pre-retrofit activities are required in order to better understand HVAC operational problems and limitations (Ma et al. 2012). Mitchell (2009) enclosed four most common deficiencies mostly during retrofit planning of numerous unsuccessful retrofitting projects, which are (1) a limited detailed understanding of the current state resulting in incorrect assumptions regarding their reuse and subsequent scheduling delays; (2) an incomplete documentation and communication of tenancy access and working hours; (3) inadequate consideration of seasonal timing for thermal plant upgrades; (4) poor management of an extended program. Thus, comprehensive retrofits plan and project objectives control mechanism are the key missions directly affecting the performance of retrofitted HVAC systems. These are the requirements for delivering sustainable HVAC retrofit projects smoothly.

Retrofit technologies are energy conservation measures used to promote building energy efficiency and sustainability. Retrofit technologies range from the use of energy efficient equipment, advanced controls and renewable energy systems to the changes of energy consumption patterns, and the application of advanced heating and cooling technologies. Retrofit measures should be considered in their order of economic payback, complexity and ease of implementation (Estes 2011). The effectiveness of a building retrofit is also dependent on building-specific information, such as geographic location, building type, size, age, occupancy schedule, operation and maintenance, energy sources, utility rate structure, building fabric, services systems, etc. For a particular project, the optimal retrofit solutions should be determined by taking into account building specific information.

18.3 Research Methods

18.3.1 Questionnaire Design

In order to achieve the objectives of this study, questionnaire survey is conducted to collect data from various groups of experts for analysing the significance of the nominated success factors. Firstly, a pilot study was conducted to screen a comprehensive list of nominated success factors to ensure validity, reliability, and significance of questionnaire items before the ground analysis. Then, item analysis was administered to test that each item could separate one participant from the others. The results indicated that each item was significant. The significant values of all items were under 0.05, and zero was excluded from the 95 % confidence interval of the difference. Cronbach's Alpha was used to test whether the items were consistent and reliable. The Cronbach's Alpha value for the questionnaire was 0.922, indicating high internal consistency (Barclay and Osei-Bryson 2010). Further data were collected through questionnaire survey data for analysing the significance of the list of selected factors in Table 18.1. In responding to the questionnaire, respondents were invited to indicate the level of significance of each of the factors. The level of importance is measured on a 5-point Likert scale, where 5 denoted extremely important, 4 important, 3 neutral, 2 unimportant, and 1 extremely unimportant. At the beginning of the questionnaire, basic information of respondents was also collected, such as their position, education background, experience, type of enterprise, etc. The survey was conducted during March–June 2014. The questionnaires were distributed via e-mail, LinkedIn, and personal delivery to increase the rate of response and sample representation. A total of 400 questionnaires were delivered to the respondents, 144 valid copies were retrieved (36 % return rate). Among the respondents, 16 respondents were from clients, 36 respondents were from HVAC contractors, and 92 respondents were from HVAC designers.

18.3.2 Data Analysis Techniques

The collected data was analysed with the Statistical Package for Social Science (SPSS 21.0). Three data analysis techniques were used as follows: (1) Mean ranking; (2) Factor analysis. These methods were performed to determine if there were statistically significant differences for some items in the same category or for the ranking of importance for these CSFs by different participants in HVAC retrofits. Also, factor analysis was applied to identify the most important CSFs that influence the performance of the retrofitted HVAC systems. These results can be used to develop dedicated HVAC retrofit assessment model and help all participants in the industry undertake performance-based retrofits. The significance level hurdle in this research followed the usual level for statistical significance of 0.05.

18.4 Data Analysis and Findings

18.4.1 Ranking of CSFs

The first analysis ranked the nominated factors according to their mean values of the responses. If two or more factors happened to have the same mean value, the one with the lowest standard deviation would be assigned the highest importance ranking among these factors. The factors with means exceeding or equal to 4 were recognized as CSFs based on the consensus of the respondents. Twenty-night factors were recognized as CSFs that significantly influenced the performance of retrofitted HVAC systems.

18.4.2 Factor Analysis

A long list of 29 CSFs is not very helpful to succinctly explain the success of a HVAC retrofit project. Factor analysis was used to explore and detect the under lying relationships among the identified CSFs. This statistical technique can recognize a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables. Factor analysis is a series of methods for finding clusters of related variable sand hence an ideal technique for reducing a large number of items into a more easily under stood framework. It focuses on a data matrix produced from the collection of a number of individual cases or respondents. In this paper, factor analysis is applied to explore the underlying constructs of the identified CSFs of HVAC retrofit projects. In this research, 29 CSFs were subjected to factor analysis using principal components analysis and oblimin rotation. The first stage of the factor analysis is to determine the strength of the relationship among the variables, namely, the 29 identified CSFs, measured by the correlation coefficients of

Table 18.2 Cluster matrix after oblimin rotation

	Component							
	1	2	3	4	5	6	7	8
G9	0.727							
G4	0.647				0.354			
G10	0.614	0.304						
G1	0.571							−0.335
H1	0.520			−0.360				
G5	0.488					0.335		
I9		0.819						
I8		0.722						
I10		0.677						
F4			0.727					
F3			0.621					
E8	0.383		0.531					
H4				−0.536				
E4			0.328	−0.533				−0.340
H2				−0.446	−0.361	0.301		
F15				0.440		0.398	0.323	
I7					0.746			
I6			0.328		0.660			
F6				−0.424	0.437			
H6						0.804		
H5						0.693		
G7	0.365					0.572		
G6				0.313		0.435	0.336	
H7					0.306	0.409	0.405	
F2							0.672	
F1			0.313				0.664	
G3								−0.695
G2								−0.666
H3							0.348	−0.496

each pairs of the variables. The correlation coefficients show that the CSFs share common factors. The KMO and Bartlett's test of sphericity is 2010.683 and the associated significance level is 0.000, suggesting that the population correlation matrix is not an identity matrix. The value of the Kaiser-Meyer-Olk in measure of sampling accuracy is 0.842, which is higher than 0.5 and hence is considered acceptable. The results of these tests show that the sample data is appropriate for factor analysis. In order to avoid confusion between the extracted factors and CSFs, it is necessary to rename the extracted factor as a "cluster" in the interpretation of the results of the analysis. Eight clusters with eight values greater than 1 are extracted. Table 18.2 lists the cluster matrix after oblimin rotation. Table 18.3 shows the final

Table 18.3 Final statistic of principle component analysis

Component	Initial eigenvalues		
	Total	Variance (%)	Cumulative (%)
1	9.448	32.580	32.580
2	2.092	7.214	39.794
3	1.680	5.792	45.586
4	1.439	4.963	50.550
5	1.408	4.854	55.404
6	1.204	4.150	59.554
7	1.177	4.057	63.611
8	1.122	3.869	67.481

statistics of the principal component analysis, and the clusters extracted account for 67.481 % of the variance.

18.4.3 Most Important Eight Clusters

The eight most important factors effecting HVAC retrofits, identified by factor analysis, are described as follows:

Cluster 1 includes six variables: skills of resolving problems (G9), level of trust in the project team, effectiveness of project team coordination (G10), project team cohesiveness (G1), effectiveness of working relationship between client and the HVAC designer (G5), and clarity of project scope (H1). Therefore, cluster 1 is "general project organization skills and teamwork".

Cluster 2 is "control flexibility and system integration of retrofitted HVAC". It is a combination of control flexibility of the selected HVAC retrofitting technologies (I8), compatibility with other building systems of the selected HVAC retrofitting technologies (I9), and integration in building automation systems of the selected HVAC retrofitting technologies (10).

Cluster 3 refers to "stakeholders' knowledge and financial capability", including familiarity with new HVAC technologies design related policies and regulations (F3), familiarity with new HVAC technologies construction related work (F4), and financial resources capability (E8).

Cluster 4 has high positive loading for understanding of the HVAC's current state including problems and limitations (H4), clarity of client's objectives and requirements (H2), willingness to use new HVAC technologies for green outcomes (E4), and skilled leadership of organizing HVAC retrofits project (F15). It can be labelled "team preparedness for green HVAC retrofits".

Cluster 5 consists of life span of the selected HVAC retrofitting technologies (I6), ability of further upgrade of the selected HVAC retrofitting technologies (I7), and experience of using new HVAC technologies (F6). This cluster is named as "contractors & designers experiences in HVAC retrofits with new technologies".

Cluster 6 contains clarity of HVAC performance assessment and diagnostic (H5), appropriateness of retrofits solutions (H6), completeness of documentation (H7), effectiveness of working relationship between client and the HVAC contractor (G6), and effectiveness of teamwork and communication between the HVAC designer and the HVAC contractor (G7). Those CSFs are about "HVAC retrofit focused documentation and relationship management".

Cluster 7 covers only two items: availability of personnel resources (F1) and commitment of on-time and on-budget project delivery (F2). It can be labeled "contractors & designers' sufficient resource for on-time and on-budget project delivery".

Cluster 8 focuses on the "stakeholder's commitments to project goals". It includes commitment of the HVAC designer to achieve project goals and objectives (G2), commitment of the HVAC contractor to achieve project goals and objectives (G3), and effectiveness of HVAC retrofit programming (H3).

18.5 Conclusions

This aim of this paper is to develop a set of CSFs for HVAC retrofits. Firstly, 51 nominated factors were selected based on the literature review. Then 29 CSFs were identified based on questionnaire survey. Factor analysis was used to group the 29 CSFs into eight clusters. There are general project organization skills and teamwork, control flexibility and system integration of retrofitted HVAC, stakeholders' knowledge and financial capability, team preparedness for green HVAC retrofits, contractors & designers experiences in HVAC retrofits with new technologies, HVAC retrofit focused documentation and relationship management, contractors & designers' sufficient resource for on-time and on-budget project delivery, and stakeholder's commitments to project goals. The result will contribute to the understanding of the risk and challenges encountered in undertaking HVAC retrofits. Also, it will help improve the performance of retrofitted HVAC to better meet the project targets.

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Chapter 19
Identification of Risk Factors Influencing the Implementation of Industrialized Building System in China

Chao Mao, Liyin Shen, Lizi Luo and Zhengdao Li

Abstract Industrialized building system (IBS) has been regarded as an effective residential building system globally in line with promoting sustainable construction, with its benefits including higher quality, lower costs, shorter time, better flexibility and waste reduction. However, the development of this system is limited in China, even though the system is considered particularly valuable for the huge plans of Chinese urbanization in coming years. Compared with conventional construction, as an innovation technology in building sector, IBS expose themselves to potential risks. Thus, the developers in China are reluctant to implement IBS without comprehensive acknowledge. Therefore, special attention from developers must be paid to identifying and analyzing these risks. Based on a survey, 24 risks inhibiting the implementation of IBS in China are identified through a questionnaire survey and face-to-face interviews. Further discussion of risks is conducted with 3 case studies. The research findings provide valuable references to practitioners and decision-makers for adopting adequate risk management methods and policies in order to promote the implementation of industrialized building in China.

Keywords Industrialized building system · Risk · Developer · China

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19.1 Introduction

Risk is a significant factor that impacts the success of enterprises for launching an innovation (Teece 1992). The presence of risk in an innovative activity can lead to greater resistance than that presented in general operation activities (Fidler and Johnson 1984). This risk feature applies to business activities in all industries, including construction. ISO 31000 (2009) defined risk as an effect of uncertainty on objectives. Uncertainty plays a critical role in the adoption of technological innovations by organizations, particularly by home builders (Toole 1998). Industrialized building system (IBS) documented in previous literature is defined as a set of interrelated elements that act together to enable the designated performance of a building and the building elements are produced in a factory and assembled on the site (Gibb 1999; Warszawski 1999). IBS is an innovative method to conventional construction, which changes the steps, scope, and interfaces of construction (Hsieh 1997; Lovell and Smith 2010). These changes increase the complexity of project implementation, and consequently potential risks from the complexity become the new problem presented to decision-makers.

As modern construction technologies that replace conventional cast-in situ constructions, IBS started to attract a large amount of attention because of its technological superiority, which includes, a reduced labor demand, time and cost savings, the ability to meet high health and safety standards, low resource depletion, reduced construction waste, noise and dust reduction, improved quality control and so on. These advantages have significantly increased the performance of the entire construction industry for developed and developing countries. However, only a small amount of attention has been given to risk-related issues during the implementation of prefabrications. These risks are embedded in the entire construction process and significantly influence the successful delivery of prefabricated constructions. Especially the typical obstacles in applying industrialized building, such as higher initial investment, longer lead-in time, and shortage of knowledge and professionals (Blismas et al. 2005; Jaillon and Poon 2008; Pan et al. 2007, 2008), would contributed to more uncertainties and risks in the process of implementing industrialized building. Therefore, an understanding of the risks associated with implementing IBS contributes to promoting successful implementation of the new building system.

This paper fulfills the knowledge gaps by identifying 24 risks hindering the implementation of industrialized building in China. Improved strategies to mitigate the risks to promote the implementation of industrialized building in China are also developed. The identification of risks and management strategies in this study provide valuable references to practitioners and decision-makers for adopting adequate risk management methods and policies. This research also contribute to further development of IBS in China, effectively reducing adverse impacts of construction industry on environment.

19.2 Risk Factors Associated with Industrialized Building

Few previous studies investigated the risk factors specifically in the implementation of industrialized buildings. Closely related to that are the barriers in implementing industrialized building which have attracted the attention of some scholars and practitioners. In business activities, risk is often seen as a potential barrier (Pindyck 2009). The chance of loss that brought about by risk may largely contribute to the low adoption of industrialized building. Based on the close interrelationship between risk and barrier, this paper identified the risk factors through the barriers documented previously. For example, higher initial cost, lack of expertise, and long lead-in time are identified in the past literature.

A high initial cost is considered as the most significant barrier against the adoption of industrialized building (Blismas et al. 2005; Pan et al. 2007). Zhang et al. (2014) conducted a research on the challenges to the use of industrialized residential building in China through a questionnaire survey. 89 professionals and practitioners finally participated in assessing 16 identified factors hindering the use of industrialized building. A high initial cost ranked the first of the 16 factors as the most significant factor. Jaillon and Poon (2008) compared prefabrication and conventional construction methods in an economic context. A questionnaire survey and several case studies in Hong Kong were involved in the research. Their results showed that the higher initial cost of prefabricated components were one of the major economic constraints.

Lack of expertise is also regarded as a significant factor impeding industrialized building by many researchers. Arditi et al. (2000) indicated that lack of expertise in precast concrete systems may lead to poor design, poor plant management and production, and poor erection practices which prevented the extensive adoption of these systems. Polat (2008) analyzed the factors affecting the use of precast concrete systems in the United States. The conclusion indicated that lack of expertise may result in severe conflicts between manufacturers and designers in initial stage, lead to failures in the production stage which may in turn cause delays in delivering components to the construction site, bring about delays in the erection schedule, and prevent the gaining of the expected cost savings of contractor though speedy erection.

Long lead-in time, as a significant barrier, is well documented in previous research. Pan et al. (2007) conducted a questionnaire survey of top 100 house builders in UK. The findings indicated that a wider take-up of industrialized building is largely being inhibited by long lead-in time. Goodier and Gibb (2005) showed that long lead-in time often lead to delay of the planning process which was an inevitable hindrance to decision-makers.

Risk also exists in supply chains of the implementation of industrialized building. A high level of integration among partners in a construction project is required in the industrialized process of construction due to the high coordination that needs to be maintained among the manpower, materials, and equipment within one project (Čuš-Babič et al. 2014). This coordination is kept by means of frequent information exchanges which led supply chains to be longer and more complex (Aydın et al. 2012), increasing the supply chain risk.

Other risks affecting the extension of industrialized building includes lack of skilled labor (Zhang et al. 2014; Jaillon and Poon 2008), transportation of prefabricated components to the site (Blismas and Wakefield 2009; Jaillon 2009; Pan et al. 2007), lack of codes and standards (Goodier and Gibb 2005), lack of government incentives (Shen 2008; Zhang et al. 2014; Blismas and Wakefield 2009) etc.

19.3 Research Methods

This study adopts a combination of several methods including literature review, questionnaire survey, case studies and face-to-face interviews with senior managers who have experience or knowledge in applying industrialized building systems in China.

19.3.1 Formulation of Preliminary Risk Factors

The preliminary risk factors were selected through a literature review of previous studies. Subsequently, face-to-face interviews with five experts in industrialized building were conducted before the questionnaire survey. Consequently, 24 potential risk factors hindering implementing industrialized building system were proposed and formed the main content of the questionnaire design (See Table 19.1).

19.3.2 Data Collection

To understand the significance of these identified risks listed in Table 19.1, a questionnaire survey was conducted from May to August 2012 to solicit opinions of experienced professionals.

A total of 100 questionnaires were distributed through email and via the professional online questionnaire platform www.sojump.com to professionals in Chinese construction market who work in Top 10 real estate developers, top 5 contractors, 2 large suppliers and 5 consultancies.

These firms are considered representative to the operation of the construction industry in China. 41 valid responses were received, giving a response rate of 41 %. Table 19.2 provides the frequency distribution of respondent's profile.

Previous studies suggested that one of the effective methods to assess the significance of risk is by employs two parameters: *the likelihood of risk occurrence*, denoted by α; and *the degree of loss if the risk occurs*, denoted by β (Shen et al. 2001;

Table 19.1 A list of proposed risks associated with implementing industrialized building

Code	Risk factor
R1	Enormous difficulty for return on high initial investment
R2	Cost disadvantages due to higher performance materials cost
R3	Few chances to get preferential policies on tax, loan, and subsidy
R4	Incompetence of designer, manufacturers and suppliers of prefabricated components
R5	Lack of experiences of current contractors or subcontractors on assembly prefabricated components
R6	Lack of quality monitoring on prefabrication components by professional institution
R7	Loss due to insufficient law for industrialized building
R8	High cost pressure without economics scale effect
R9	Rapid growth of skilled labor cost
R10	Terminal user's conservatism and scepticism
R11	Monopoly of techniques by a few firms
R12	Poor cooperation between multi-interface
R13	Lack of management practices and experiences
R14	Unreasonable site layout of prefabricated components
R15	The regular need for mobile crane to lift large load components
R16	Monotony of structure type
R17	Poor skills assembling and hoisting precast components on site
R18	Inability to modify design scheme during construction stage when needed
R19	Errors and defects due to poor design ability of designers
R20	Inappropriate design codes and standards for industrialized building
R22	Longer lead-in time during design stage
R22	Damage of prefabricated elements during transportation access to the building site
R23	Incompetence of technology and equipment
R24	Durability of prefabricated unproven

Table 19.2 Frequency distribution of respondents for questionnaire survey

Respondents											
Developer	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Sub-total
	6	1	2	1	4	1	1	1	3	1	21
Contractor	C1	C2	C3	C4	C5						Sub-total
	2	2	2	2	2						10
Consultant	D1	D2	D3	D4	D5						Sub-total
	1	2	1	2	2						8
Supplier	S1	S2									Sub-total
	1	1									2

Table 19.3 Frequency distribution of respondents' opinions

Risk Factor	Likelihood α					Loss level β (grade)				
	0.1	0.3	0.5	0.7	0.9	1	2	3	4	5
R1	2	3	11	15	10	1	5	16	18	1
R2	5	10	11	7	8	1	11	24	4	1
R3	4	6	6	12	13	2	6	23	9	1
R4	0	9	14	13	5	0	5	26	9	1
R5	4	9	10	13	5	2	7	21	10	1
R6	1	5	11	16	7	0	3	25	12	1
R7	2	7	12	12	8	0	7	22	11	1
R8	3	2	13	13	10	1	9	21	8	2
R9	2	5	11	12	11	0	20	16	4	1
R10	5	4	12	14	6	4	18	14	4	1
R11	5	10	12	11	3	2	16	19	4	0
R12	1	5	15	13	7	0	4	17	20	0
R13	1	4	10	19	7	1	2	22	15	1
R14	5	9	11	11	5	0	4	20	12	5
R15	2	10	13	13	3	1	1	15	18	6
R16	1	7	9	16	8	1	6	20	13	1
R17	0	11	15	11	4	0	8	23	9	1
R18	3	6	13	9	10	1	1	23	11	5
R19	2	8	10	17	4	1	5	15	17	3
R20	0	6	10	15	9	0	4	17	19	1
R21	6	6	14	11	4	5	4	18	11	3
R22	3	9	14	10	5	1	5	19	15	1
R23	1	9	8	15	6	0	3	22	15	1
R24	12	9	8	11	1	3	1	15	19	3

Zou and Zhang 2009; Zhang et al. 2012). A five-point Likert scale was employed as a measurement scale to evaluate these two parameters. In considering the parameter α, the respondents were required to judge *the likelihood of risk occurrence* by selecting one of the five proposed levels, namely 0.1 (very low), 0.3 (low), 0.5 (average), 0.7 (high), 0.9 (very high). Regarding the parameter β, the respondents were asked to judge *the degree of loss* if a specific risk dose occur by selecting one of five options, namely 1 (slight or no less), 2 (some loss), 3 (bad), 4 (very bad), 5 (worst).

The response data collected from the questionnaire survey are summarized in Table 19.3. The figures in the table denote the frequency of respondent's opinions on a certain level of likelihood and loss of each risk factor.

This paper employed Cronbach's coefficient alpha to measure internal consistency amongst the risk factors to assess the reliability of the five-point scale. Test value of this study was 0.910, which was higher than the 0.5 threshold, showing that the five-point scale measurement was reliable at the 5 % significance level

(Pallant 2010). Therefore, the collected sample could be seen as a whole, and is suitable for further data analysis.

19.3.3 Data Analysis

To assess the relative significance among the 24 risks, Risk Significance Index (RSI) is used and can be calculated by formula (19.1):

$$RSI^i = \frac{\sum_{j=1}^{N} \alpha_j^i \beta_j^i}{N} \tag{19.1}$$

where RSI^i denoted the risk significance index value for risk i; α_j^i is the likelihood of the occurrence of risk i, assessed by respondent j; β_j^i is the degree of loss of risk i if it occurs, assessed by respondent j; N is the total number of the effective respondents.

The RSI^i in formula (19.1) is a weighted average score. Previous study appreciated the disadvantage of using weighted average score since the average measure does not consider the degree of variation between individual respondents in making judgment (Zhang et al. 2012; Wang and Yuan 2011). In fact, a smaller variation between individual responses presents a better result in terms of rank when two same arithmetic mean values are compared. The typical technique adopted to mitigate the weakness of weighted average score is to incorporate the coefficient of variation. Therefore, it is considered that the effective assessment on ranking the significance of risk factors should use the combined value of both RSI^i and the coefficient of variation. This combined value is denoted by R_{co}, through the following formula (19.2):

$$R_{co} = RSI^i + \frac{RSI^i}{\sigma_i} \tag{19.2}$$

where σ_i denoted the standard deviation of the risk significance index for risk i.

It is appreciated that the difference in judgment between respondents exists. In order to check whether the difference between individual respondents' opinions is acceptable, Kendall's concordance test is adopted in data analysis. Kendall's coefficient of concordance (also known as Kendall's W) is to measure whether or not different respondents within a group respond in a consistent way on the significance of risks (Chan et al. 2009; Siegel and Castellan 1988). The Kendall's W is computed by the following model:

$$W = \frac{12\sum_{i=1}^{n} R_i^2 - 3m^2 n(n+1)^2}{m^2 n(n-1)} \tag{19.3}$$

where R_i is the sum of the ranks given by all individual respondents for a particular risk factor i; n is number of risk factors; m is number of respondents; i denotes for risk

Table 19.4 The relative significance of risks

Risk factor	RSI^i	Std. deviation σ_i	$R_{co} = RSI^i + \frac{RSI^i}{\sigma_i}$	Rank
R12	**2.11**	**0.78**	**4.83**	**1**
R20	**2.19**	**0.91**	**4.59**	**2**
R13	**2.12**	**0.87**	**4.56**	**3**
R1	**2.20**	**0.98**	**4.44**	**4**
R6	**2.00**	**0.87**	**4.32**	**5**
R16	**1.96**	**0.85**	**4.27**	**6**
R23	**1.93**	**0.89**	**4.09**	**7**
R15	**1.95**	**0.93**	**4.05**	**8**
R19	**1.98**	**0.96**	**4.04**	**9**
R18	**2.04**	**1.03**	**4.02**	**10**
R04	1.85	0.86	3.98	11
R17	1.68	0.75	3.91	12
R08	1.96	1.02	3.88	13
R22	1.75	0.86	3.79	14
R07	1.89	0.99	3.78	15
R03	1.96	1.11	3.72	16
R14	1.77	1.03	3.49	17
R09	1.68	0.93	3.48	18
R05	1.69	0.98	3.40	19
R21	1.67	1.11	3.18	20
R11	1.34	0.74	3.16	21
R10	1.53	0.96	3.12	22
R02	1.53	0.98	3.09	23
R24	1.44	0.96	2.94	24
Number (n)		41		
Kendall's W		0.051		
Level of Sig.		0.000		

factor 1, 2, 3…. The value of W ranges from 0 to 1, where 0 means "no consensus" within a group on the ranking between risks, and 1 reflects "complete consensus". It is suggested that if the level of significance value of W is at the level of 0.05 or below, a general consensus amongst respondents is accepted (Chan et al. 2009).

The values of R_{co} and W are generated by using the statistical package for social science with 17.0 Version (SPSS 17.0), as shown in Table 19.4.

19.4 Survey Results

The 24 risk factors was ranked according to the relative significance value of R_{co}, as shown in Table 19.4. The top 10 risk factors have the value of R_{co} higher than 4.0. The computation results of Kendall's W is 0.051, and the level of significant of W

Table 19.5 Detailed basic information of three cases

Project	Location	Project type	Floor area (m^2)	Finished year	Precast (by volume) (%)	Risks encountered (the main 10 risks)
Case A	Shanghai	Residential	185,320	2007	15	R1, R5, R4, R8, R12, R13, R18, R20, R21, R22
Case B	Shenzhen	Residential	216,000	2012	10	R1, R5, R2, R9, R12, R13, R15, R14, R18, R23
Case C	Changsha	Residential	–	2010	15	R1, R6, R5, R15, R12, R13, R8, R21, R24, R22

is at 0.000, indicating that the respondents have a consensus on the rankings of risk factors of the adoption of industrialized building.

According to the data presented in Table 19.4, the most significant risk affecting the implementation of industrialized building is “Poor cooperation between multi-interface”, with the highest value of $R_{co} = 4.83$. “Inappropriate design codes and standards for industrialized building” is considered as the second important risk factor. The risk “Lack of management practices and experiences” was ranked third according to survey results, with the value of $R_{co} = 4.56$. The risk factor “Enormous difficulty for return on high initial investment” ($R_{co} = 4.44$) is another significant risk ranked the fourth. Another important risk is considered as “Lack of quality monitoring on prefabricated components by professional institution”, ranked fifth with $R_{co} = 4.32$.

19.5 Risk Analysis

In order to engage in-depth investigation on these top risks ranked in Table 19.4, case studies and further interviews were conducted. Table 19.5 provides the information of the employed cases (Case A, Case B, Case C).

In the course of discussion, interviewees were invited to identify the major 10 risks encountered in their projects (listed in the last column of Table 19.5). The identifications of these risks in three case studies are echoed by most those identified in the questionnaire survey results presented in Table 19.4.

Cost has been widely considered as a major barrier inhibiting the implementation of industrialized building. The initial investment may not be returned due to market changes, and this present a risk of economic losses for either client or contractors. The project managers from all the three case studies have a consensus that the higher initial investment is the most crucial factor affecting the decision-making on whether industrialized building system should be adopted.

The interviewees in the case studies also responded that it is difficult for owners to find good skill contractors or suppliers and consultants in local market to conduct industrialized building, and to make them work effectively in collaboration. The quality of prefabricated components and buildings therefore cannot be guaranteed because of the poor labour skill and collaboration.

Previous studies indicated that “monotony of structure type”, “Terminal user’s conservatism and scepticism” would influence market demands (Pan et al. 2007; Jaillon 2009; Shen 2008). The interviewees emphasized that the monotony of structure type in their projects indeed cannot satisfy the diversification and personality requirements of consumers due to the lower level prefabrication techniques at current stage in China.

Majority of the project managers opined that the typical technical risks associated with implementing industrialized building in China are “Errors and defects due to poor design ability of designers”, “Poor skills in assembling and hoisting precast components on site”, “Incompetence of technology and equipment”. These risks contribute particularly to time delay and poor quality of construction. In Case A, it was the first time for the owner and the designer team to implement industrialized building project, which directly resulted in time delay and poor quality, such as leaking of external wall. The project owner suffered significant amount of losses from compensating customers for the poor quality results.

19.6 Conclusions

While industrialized building system has been widely used in developed countries, it is still not being extensively adopted in China. The new building system which claims to improve housing quality, shorten construction duration, reduce building cost and minimize environmental effects, maybe an inevitable option for China in future urban development. However, risk factors affecting the application of industrialized building in China are not yet found in previous studies. The identification of risks present, specifically in China, is a contribution to the development of the theoretical basis for further understanding the challenge of implementing industrialized construction in a large, developing market.

24 risk factors existed in the process of implementing industrialized building, with different levels of relative importance are identified and examined in this study. The top five risks are “Poor cooperation between multi-interface”, “Inappropriate design codes and standards for industrialized building”, “Lack of management practices and experiences”, “Enormous difficulty for return on high initial investment”, “Lack of quality monitoring mechanism in the process of production”. In line with the promotion of industrialized building, a concerted effort from all building stakeholders including government, owner, contractor, designer and supplier is needed in order to mitigate the risk effects.

Further research could investigate more practical cases for further promotion of industrialized building system in larger developing market.

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Chapter 20
Initial Tradable Emission Permit Allocation of Civil Airport Based on DEA Model

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Abstract In this paper Weight-SBM-Undesirable DEA model to the problem of initial tradable permit allocation is presented. It assumes that airports produce two types of outputs: desirable and undesirable outputs (namely carbon dioxide emissions, airport noise, the number of delayed flights and so on.). The criterion of allocation is to produce more desirable outputs and less undesirable outputs relative to less inputs. The proposed approach is the improvement of traditional allocation (Grandfathering, GF); it is non-radial and non-oriented and does not require information on input and output prices. According to mathematical analysis, although the novel allocation is not as effective as the auction model, it improves the equity-fairness and effectiveness of allocation and can be better use in practice. What's more, the model is applied on a dataset from 39 Spanish airports.

Keywords Energy saving and emission reduction · Initial tradable emission permit allocation · Cap-and-Trade · Undesirable outputs · Data envelopment analysis

20.1 Introduction

Civil airport is the beginning and end of air transport, which is not only the convenient facilities of transportation, but also plays a positive role in regional development. Airport does not like the industrial project which produce physical products, but only provide a kind of intangible products, namely the space position transfer of passenger and cargo. As the industrialization and urbanization process accelerating,the promoting of annual passenger throughput annual cargo throughput and aircraft traffic movements of airports will continue to increase, which makes the airport really become the "Energy Consumption-Hungry" (Adler and Berechman

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2003). Especially the large space airport terminal that owns central air-conditioning, its energy consumption of per unit building area is generally three to eight times as many as the energy consumption of public buildings. High energy consumption is bound to lead to high emission of greenhouse gas, which seriously affects the sustainable development of regional environment. What's more, it has far-reaching influence on national and global climate warming (Martini et al. 2003). However, airport is the engine of national and regional economic growth, its related data and the development of national economy have very significant positive correlation. Federal Aviation Administration said that the total economic outputs of American airports are $1.3112 trillion, which accounted for 5.2 % of US GDP. Therefore, there is contradictory conflict between positive economic benefits and negative environmental pollutions along with the operations of airports.

In order to solve the contradiction between environment and economy, the national civil aviation sector has always delicated to the technology and policy of energy conservation and emissions reduction, but most of which are limited to the technical level. According to the Coarse Theorem, this paper is to achieve the goal of energy conservation and emissions reduction by carbon emissions trading at the civil airport from the perspective of market-based. The first nut for us to crack is initial tradable emission permit allocation, which mainly including Grandfathering and Auction in both practice and theory study at present (Anthony and Peng 2013). Grandfathering is the most common allocation method, and which designates the allocation of emission permits according to historical emissions or production data. Although Grandfathering has so many advantages, there are still some problems, such as obsolete historical data, "Rent-seeking" behavior, unfair allocation and low efficiency and so forth (Bohringer and Lange 2005; Ahman et al. 2007). Auction allows reduced tax distortion, provides more flexibility in distortion of costs,provides greater incentives for innovation, and reduces the need for politically contentious arguments over the allocation of rents, but the airports have to bear the high management and transaction costs (Cramton and Kerr 2002). Therefore, we need to put forward new solution to initial tradable emission permit allowance.

In this paper,we present a Weight-SBM-Undesirable DEA approach to emission permit allowance allocation. The approach is the improvement of traditional DEA, because the criterion of DEA is to produce more outputs relative to less inputs. But in actual initial allocation of the carbon emissions at the airport, the desirable outputs are expected, the undesirable outputs are also need to be considered (Simsek 2014), e.g. carbon dioxide emissions, airport noise, the number of delayed flights and so on. At the same time, the criterion is to produce more desirable outputs and less undesirable outputs relative to less inputs. So, we need to improve the traditional DEA model (Lozano et al. 2013). Tone using the method of operational research, directly puts the slack variables into the objective function, and it comes up with the non-radial and non-oriented SBM-Undesirable model, which solves not only the slackness of input-output but also technical efficiency in the presence of undesirable outputs (Tone 2001). On the basis of above mentioned analysis, we introduce the weight factor and propose initial allocation model of carbon emissions to improve the equity-fairness and effectiveness of allocation.

20.2 The Determination of the Initial Allocation Mechanism of Emission Rights

Suppose that there are n DMUs (Decision Making Units, namely airports) and each have three factors: inputs x, desirable outputs y^d, undesirable outputs y^{und}, and $x \in R^m$, $y^d \in R^{s_1}$, $y^{und} \in R^{s_2}$. If define matrices $X = [x_1, \ldots, x_n] \in R^{m \times n}$, $Y^d = [y_1^d, \ldots, y_n^d] \in R^{s_1 \times n}$, $Y^{und} = [y_1^{und}, \ldots, y_n^{und}] \in R^{s_2 \times n}$, and assume $X > 0$, $Y^d > 0$, $Y^{und} > 0$. For constant returns to scales (CRS) technology, the production possibility set is defined as:

$$P = \left\{ (x, y^d, y^{und})\big|_x \geq X\lambda, y^d \leq Y^d\lambda, y^{und} \geq Y^{und}\lambda, \lambda \geq 0 \right\} \tag{20.1}$$

In the equation, $\lambda \in R^n$ means intensity vector.

Tone pointed out that under the undesirable outputs, if there is no vector $(x, y^d, y^{und}) \in P$ so that $x_o \geq x$, $y_o^d \geq y^d$, $y_o^{und} \geq y^{und}$ with at least one strict inequality, then $\mathrm{DMU}_o(x_o, y_o^d, y_o^{und})$ is efficient. According to this definition, the efficiency of SBM-Undesirable DEA suggested by Tone (2001) is modified as:

$$\rho^* = \min \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{s_i^-}{x_{io}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{r=1}^{s_1} \frac{s_r^d}{y_{ro}^d} + \sum_{r=1}^{s_2} \frac{s_r^{und}}{y_{ro}^{und}}\right)} \tag{20.2}$$

$$\text{s.t. } x_o = X\lambda + s^- \tag{20.3}$$

$$y_o^d = Y^d\lambda - s^d \tag{20.4}$$

$$y_o^{und} = Y^{und}\lambda + s^{und} \tag{20.5}$$

$$s^- \geq 0,\ s^d \geq 0,\ s^{und} \geq 0,\ \lambda \geq 0$$

where the variables s denote slack variables of inputs, desirable outputs and undesirable outputs, the vectors $s^- \in R^m$ and $s^{und} \in R^{s_2}$ express excesses in inputs and undesirable outputs, while $s^d \in R^{s_1}$ corresponds to shortages in desirable outputs. The objective function (20.2) is strictly decreasing with respect to $s_t^- (\forall i)$, $s_r^d (\forall r)$, $s_r^{und} (\forall r)$, and the optimal value $0 < \rho^* \leq 1$. For specific DMU_o, it is efficient, if and only if $\rho^* = 1$, that is to say: $s^- = 0$, $s^d = 0$, $s^{und} = 0$. However, if $\rho^* < 1$, DMU_o is inefficient, we can improve and make it efficient by augmenting the shortfalls in desirable outputs and deleting the excesses in inputs and undesirable outputs by the following projection:

$$\widehat{x}_o \leftarrow x_o - s^- \tag{20.6}$$

$$\widehat{y}_o^d \leftarrow y_o^d + s^d \tag{20.7}$$

$$\widehat{y}_o^{und} \leftarrow y_o^{und} - s^{und} \tag{20.8}$$

It is noted that the objective function is complex expression, $s_r^{und}/y_{ro}^{und} \leq 1$ and $s_i^-/x_{io} \leq 1$ as the constraints (20.5) and (20.3) concerned. What's more, s_r^d/y_{ro}^d is unbounded via constraint (20.4), but in the real world, if we need a constraint, we can use:

$$\frac{s_r^d}{y_{ro}^d} \leq M_r$$

where M_r stands for the upper bound of the growth rate of y_{ro}^d.

In accordance with the above analysis, the fractional linear program can be translated into an equivalent linear program by using Charnes-Cooper transformation (1962), the expression can be written as:

$$\tau^* = \min t - \frac{1}{m} \sum_{i=1}^{m} \frac{S_i^-}{x_{io}} \tag{20.9}$$

$$\text{s.t. } 1 = \mathrm{t} + \frac{1}{s_1 + s_2} \left(\sum_{r=1}^{s_1} \frac{S_r^d}{y_{ro}^d} + \sum_{r=1}^{s_2} \frac{S_r^{und}}{y_{ro}^{und}} \right) \tag{20.10}$$

$$x_o t = X\Lambda + S^- \tag{20.11}$$

$$y_o^d t = Y^d \Lambda - S^d \tag{20.12}$$

$$y_o^{\mathrm{und}} t = Y^{\mathrm{und}} \Lambda + S^{\mathrm{und}} \tag{20.13}$$

$$S^- \geq 0,\ S^d \geq 0,\ S^{\mathrm{und}} \geq 0,\ \Lambda \geq 0,\ t > 0 \tag{20.14}$$

If we let the optimal solution of linear program be $\left(t^*, \Lambda^*, S^{-*}, S^{d*}, S^{\mathrm{und}*}\right)$, the optimal solution can be obtained by:

$$\rho^* = \tau^*, \lambda^* = \frac{\Lambda^*}{t}, s^{-*} = \frac{S^{-*}}{t^*},\ s^{d*} = \frac{S^{d*}}{t^*}, s^{\mathrm{und}*} = \frac{S^{\mathrm{und}*}}{t^*} \tag{20.15}$$

Similarly, the dual program of linear program (20.2) can be demonstrated as:

$$\xi^* = \max \xi \tag{20.16}$$

$$\text{s.t. } \xi + vx_o - u^d y_o^d + u^{und} y_o^{und} = 1 \tag{20.17}$$

$$-v\mathrm{X} + u^d Y^d - u^{und} Y^{\mathrm{und}} \leq 0 \tag{20.18}$$

$$v \geq \frac{1}{m}\left[\frac{1}{x_o}\right]$$

$$u^d \geq \frac{\xi}{s_1 + s_2}\left[\frac{1}{y_o^d}\right]$$

$$u^{und} \geq \frac{\xi}{s_1 + s_2}\left[\frac{1}{y_o^{und}}\right]$$

where $\left[\frac{1}{x_o}\right]$ denotes row vector $\left(\frac{1}{x_{1o}}, \ldots, \frac{1}{x_{mo}}\right)$. The dual variable vector $v \in R^m$, $u^d \in R^{s_1}$, $u^{und} \in R^{s_2}$ are equivalent to the constraints (20.11)–(20.13), the dual linear program can be signified as the following expression by deleting ξ.

$$\max u^d y_o^d - v x_o - u^{und} y_o^{und} \tag{20.19}$$

$$\text{s.t. } u^d Y^d - vX - u^{und} Y^{und} \leq 0 \tag{20.20}$$

$$v \geq \frac{1}{m}\left[\frac{1}{x_o}\right] \tag{20.21}$$

$$u^d \geq \frac{1 + u^d y_o^d - v x_o - u^{und} y_o^{und}}{s_1 + s_2}\left[\frac{1}{y_o^d}\right] \tag{20.22}$$

$$u^{\mathrm{und}} \geq \frac{1 + u^d y_o^d - v x_o - u^{und} y_o^{und}}{s_1 + s_2}\left[\frac{1}{y_o^{\mathrm{und}}}\right] \tag{20.23}$$

We can interpret the dual variable v and u^{und} as the virtual costs of inputs and undesirable outputs, at the same time, u^d can be understood as dual prices of desirable. The aim of dual linear program is to obtain the optimal virtual costs and prices of DMU_o so that maximizes $u^d y_o^d - v x_o - u^{und} y_o^{und}$ and $u^d Y^d - vX - u^{und} Y^{und}$ is at most zero for every efficient DMU, moreover $\xi^* = 1$.

Apparently, if you have some preference on desirable and undesirable outputs, you can impose weights to the objective function (20.2), so we can get the efficiency score of Weight-SBM-Undesirable DEA Model:

$$\rho^* = \min \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{w_i^- s_i^-}{x_{io}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{r=1}^{s_1} \frac{w_r^d s_r^d}{y_{ro}^d} + \sum_{r=1}^{s_2} \frac{w_r^{und} s_r^{und}}{y_{ro}^{und}}\right)} \tag{20.24}$$

where w_i^-, w_r^d, w_r^{und} denote the weights of inputs, desirable and undesirable outputs, in the mean time, $\sum_{i=1}^{m} w_i^- = m$, $w_i^- \geq 0 (\forall i)$, $\sum_{r=1}^{s_1} w_r^d + \sum_{r=1}^{s_2} w_r^{und} = s_1 + s_2$, $w_r^d \geq 0 (\forall r)$, $w_r^{\mathrm{und}} \geq 0 (\forall r)$.

When the government makes a decision to the allocation of emission rights, the efficiency score of airport is the primary consideration, besides, the contribution to the regional economic efficiency also needs to be considered. Which both combine the allocation principle of equity-fairness and effectiveness, and avoid the occurrence of excessive allocation for large-hub airport and a small amount of allocation for small airport. Therefore, using the comprehensive contribution efficiency of each calculated airport DMU_n to determine the ratio of allocation, formula is as follows:

$$A_j = \frac{\rho_j^* \alpha_j}{\sum_{j=1}^{n} \rho_j^* \alpha_j} \tag{20.25}$$

where A_j denotes the indicator of allocation for DMU_j (j = 1,…, n); ρ_j^* means the efficiency score of Weight-SBM-Undesirable DEA for DMU_j; and α_j is the contribution to economic efficiency of DMU_j, $\alpha_j = y_j^d / \sum_{j=1}^{n} y_j^d$, y_j^d denotes the desirable outputs of DMU_j, for instance, income, prime operating revenue and so on, $\sum_{j=1}^{n} \alpha_j = 1$.

Thus it can be seen that A_j reflects the contribution of decision making unit j (DMU_j) in the whole aviation industry. The greater the value, the greater the instructions for contribution to the aviation industry as a whole. So, the initial allocation of emission rights mainly relates to the total control of emission and the contribution of comprehensive efficiency. If we assume the indicator of allocation for DMU_j (j = 1,…, n) is A_j in the stage of T, the total control target of T + 1 stage is U_p^{T+1}, then the allocation of each DMU is as follows:

$$e_i = A_j U_p^{T+1} \tag{20.26}$$

This allocation scheme can increase overall effectiveness and equity-fairness, and the government need not to consider the price of inputs and outputs, but only to the number of inputs and outputs; What's more, it can motivate the improvement of technical efficiency, and not just assign to previous high energy consumption and emission airports or as compensation of outputs. In theory, although the proposed method is not as effective as the auction model, it is the improvement of traditional allocation (Grandfathering, GF), and it will not increase extra cost to DMU (airports) and limit (restrict) production. Therefore, the proposed allocation scheme is easier to be used than auction in practice.

20.3 Application of the Proposed Approach to Spanish Airports

In this section, the proposed approach is applied to 39 Spanish airports, the inputs are considered as total runway area, apron capacity, number of baggage belts and check-in counters and boarding gates; the desirable outputs contains annual passenger throughput, annual cargo throughput, aircraft traffic movements; the undesirable output is identified as number of delayed flights. Furthermore, we should choose the base year, which is the typical period of time at best. In this case, we choose 2008–2010 as base year to determine the next phase allocation of emission rights. All the corresponding data are available on Spanish Airport and Air Navigation Agency (AENA) and the Central Office for Delay Analysis service of Eurocontrol website.

By employing the Weight-SBM-Undesirable DEA model described in (20.24) and put three ratios of weights on desirable and undesirable outputs: (1:0.3), (1:1), (1:3), we can get the efficiency score in these three cases. Taking (1:1) model as example, we use LINGO software, the Weight-SBM-Undesirable efficiency score ρ^* as well as the inputs and outputs slacks are shown in Table 20.1 after calculation. What's more, we can easily plot radar graph of (1:1)-SBM-Undesirable DEA model (see Fig. 20.1).

Note that 13 airports are technical efficient, 5 airports are basically efficient, these suggest that the slacks of inputs and outputs are equal to zero, namely inputs and outputs are all achieve to the optimal state. So we can interpret that it has positive externality (They will get much more emission allowances in the stage of T + 1 than actual emissions of T stage). The efficient airports can expand the production scale, develop efficient technical efficiency, and further stimulate regional economy; However, Airports can sell redundant emission allowances to get the corresponding returns as well in the secondary market, which is the rewards and incentives for efficient operation of airport. At the same time, 21 airports are regarded as inefficiency, especially 14 airports are quite low, the main reason comes from low utilization (high energy consumption, much less throughput than the nominal capacity) or excess delays, this means that the inefficient airports obtain much less emission allowance in the stage of T + 1 than actual emissions of T stage. So they can carry out technical improvement, then improve efficiency and reduce energy consumption, or buy the shortages of emission allowance in the secondary market, which is the punishment for low efficiency of airport operation. No matter which way you choose, it will improve efficiency as a whole. Figure 20.2 shows the change of three weights of SBM-Undesirable DEA efficiency score without efficient airports.

Apparently, it can be noted that the efficiency of most inefficient airports does not change much from weight (1:0.3) to (1:3), but it gives the range of the change (lower bound to upper bound), you can choose the right weight to allocate emission permits. Hence, to illustrate this problem, we pick the weight (1:1) out as the allocation standard of emission permits. If we assume that the government regulates

Table 20.1 Results of (1:1)-SBM-Undesirable DEA and slacks

Airport	ρ*	S−(1)	S−(2)	S−(3)	S−(4)	S−(5)	S+(1)	S+(2)	S+(3)
A Coruna	0.3024	0	0	1.0171	3.246	0.4219	611.08	10,697.5	0
Albacete	0.99795	0	0	0	0	0	0	0.00084	0.037
Alicante	0.47178	0	2.8485	3.1603	4.413	0	7443.2	0	12,364
Almeria	0.00475	6265.52	0	1.8862	9.015	1.6887	392.11	0	23,185
Asturias	0.09469	0	0	1.1786	0.756	4.1264	647.57	27,398.3	4594
Badajoz	0.91649	1.72574	0	0	0	0	0	0.0018	0.015
Barcelona	1	0	0	0	0	0	0	0	0
Bilbao	0.26495	61,260.4	0	3.1003	12.13	1.0602	3980.9	24,405.2	9280
Cordoba	1	0	0	0	0	0	0	0	0
El Hierro	1	0	0	0	0	0	0	0	0
Fuerteventura	0.20465	14294.1	15.524	4.9089	14.74	0.6811	3525.5	36,484.4	8378
Girona-Costa Brava	0.14212	0	2.6908	0.0167	1.597	0	4396	0	9650
Gran Canaria	1	0	0	0	0	0	0	0	0
Granada-Jaen	0.02643	26,674.8	0	1.2155	5.02	0	358.75	0	12,081
Ibiza	0.31161	0	2.9701	4.2075	22.31	0.2263	6014.9	15,587.4	11,076
Jerez	1	0	0	0	0	0	0	0	0
La Gomera	0.99857	0	0	0	0	0	0	0.00528	0.037
La Palma	1	0	0	0	0	0	0	0	0
Lanzarote	0.37075	0	3.8005	4.4178	24.47	4.9621	5019.8	4761.42	8413
Leon	1	0	0	0	0	0	0	0	0
Madrid Barajas	1	0	0	0	0	0	0	0	0
Malaga	1	0	0	0	0	0	0	0	0
Melilla	0.99988	0	0	0	0	0	0	0.02112	0.018
Murcia	0.00376	0	0	2.0834	6.669	0	832.8	0	4949

(continued)

Table 20.1 (continued)

Airport	ρ*	S−(1)	S−(2)	S−(3)	S−(4)	S−(5)	S+(1)	S+(2)	S+(3)
Palma de Mallorca	1	0	0	0	0	0	0	0	0
Pamplona	0.99948	3.17922	0	0	0	0	0.0361	0.03222	0.055
Reus	0.99987	0	0	#####	0	0.0001	0.0195	0	0.031
Salamanca	0.02075	65,939	0	1.0059	0.268	0	0	11,582.1	178.3
San Sebastian	0.07836	0	0.1079	0.662	0	0.0704	379.46	23,946.3	1029
Santander	0.00855	0	0	0.2312	0	1.6797	519.75	0	8846
Santiago	0.11744	29,373.8	4.8646	3.048	8.595	6.6679	1586.6	39,726.8	2606
Saragossa	0.12292	175,903	0.1873	0.3087	0	0.1842	472.47	17,271.5	0
Seville	0.40371	13384.3	4.106	2.0872	19.39	0	1764.6	14484.9	1640
Tenerife North	1	0	0	0	0	0	0	0	0
Tenerife South	0.28013	0	19.095	9.8142	58.59	8.8495	5014.3	18,543.3	8361
Valencia	1	0	0	0	0	0	0	0	0
Valladolid	0.03032	25,188.8	0	0.3538	0	1.3022	368.06	6247.91	9632
Vigo	0.12636	4220.92	0	1.3464	4.674	2.2578	1001.8	35,207.4	539.4
Vitoria	1	0	0	0	0	0	0	0	0

Fig. 20.1 Radar graph of (1:1)-SBM-undesirable DEA model

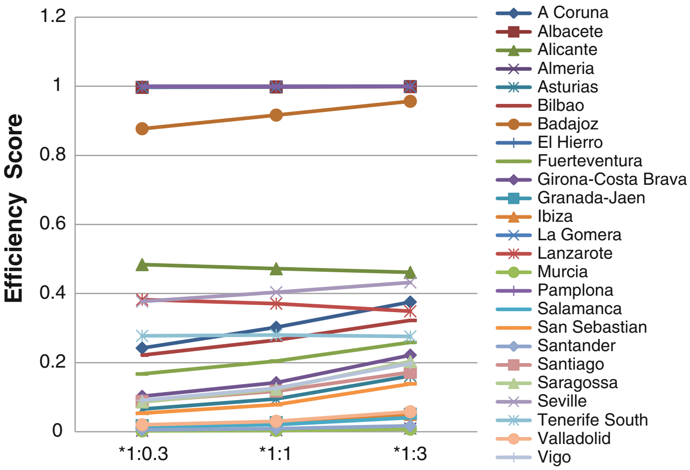

Fig. 20.2 Change in efficiency between inefficient airports

Table 20.2 Initial tradable emission permit allocation of 39 Spanish airports

Airports	ρ_j^*	α_j	$\rho_j^* \alpha_j$	A_j	e_i
A Coruna	0.315732	0.00465	0.001468	0.00175929	6333
Albacete	0.997944	7.61E−05	7.59E−05	9.0983E−05	328
Alicante	0.530949	0.037212	0.019758	0.02367792	85,241
Almeria	0.005007	0.004406	2.21E−05	2.6439E−05	95
Asturias	0.095889	0.005964	0.000572	0.00068539	2467
Badajoz	0.916486	0.000339	0.000311	0.00037282	1342
Barcelona	1	0.129135	0.129135	0.15475686	557125
Bilbao	0.284991	0.016667	0.00475	0.00569252	20,493
Cordoba	1	8.61E−05	8.61E−05	0.00010316	371
El Hierro	1	0.000747	0.000747	0.00089508	3222
Fuerteventura	0.218847	0.018291	0.004003	0.00479729	17,270
Girona-Costa Brava	0.146347	0.018742	0.002743	0.00328714	11,834
Gran Canaria	1	0.04298	0.04298	0.05150771	185,428
Granada-Jaen	0.026501	0.005332	0.000141	0.00016933	610
Ibiza	0.335537	0.018782	0.006302	0.00755235	27,188
Jerez	1	0.005761	0.005761	0.00690453	24,856
La Gomera	0.998568	0.000163	0.000163	0.0001948	701
La Palma	1	0.004797	0.004797	0.00574917	20,697
Lanzarote	0.410229	0.022627	0.009282	0.01112418	40,047
Leon	1	0.170125	0.170125	0.20388071	733,971
Madrid Barajas	1	0.213462	0.213462	0.2558155	920,936
Malaga	1	0.053149	0.053149	0.06369438	229,300
Melilla	0.999874	0.001307	0.001307	0.00156666	5640
Murcia	0.003759	0.007395	2.78E−05	3.331E−05	120
Palma de Mallorca	1	0.092761	0.092761	0.11116545	400,196
Pamplona	0.999487	0.001756	0.001755	0.0021031	7571
Reus	0.999868	0.005322	0.005321	0.00637683	22,957
Salamanca	0.020725	0.000207	4.3E−06	5.1472E−06	19
San Sebastian	0.079199	0.001668	0.000132	0.00015828	570
Santander	0.008561	0.00304	2.6E−05	3.1191E−05	112
Santiago	0.121873	0.008106	0.000988	0.00118397	4262
Saragossa	0.124507	0.002776	0.000346	0.00041417	1491
Seville	0.437567	0.017488	0.007652	0.00917038	33,013
Tenerife North	1	0.017632	0.017632	0.0211302	76,069
Tenerife South	0.314259	0.034899	0.010967	0.01314339	47,316
Valencia	1	0.022946	0.022946	0.02749851	98,995
Valladolid	0.031034	0.001946	6.04E−05	7.2394E−05	261
Vigo	0.129567	0.00526	0.000682	0.00081674	2940
Vitoria	1	0.001997	0.001997	0.00239271	8614

the total control target in T + 1 stage is 3,600,000 t CO_2 equivalent, according to the formula (1.24) and (1.25), we can get the following results (Table 20.2).

20.4 Conclusion

In this paper, we have presented a new DEA approach for emission rights allocation in 39 Spanish airports. It involves three units,namely inputs (runway area, apron capacity, number of check-in counters, baggage belts and boarding gates), desirable outputs (annual passenger throughput, annual cargo throughput, aircraft traffic movements), undesirable output (delayed flights). For each airport, the model computes an efficiency score and the ratio of allocation. It is different from the traditional EDA model, which does not take undesirable output into account. But in real situations, it will cause loss of efficiency without considering undesirable outputs to a great extent, such allocation scheme is distorted and out of reality. So in the form of initial allocation, the proposed approach is improvement on traditional grandfathering allocation, it really improves the equity-fairness and effectiveness of allocation. What's more, it can be applied to emission permit allocation in electric power, building, oil refining, steel, cement, glass, paper and other industries. About possible continuations of this research, one is enlarging the datasheet with observations from other airports; Another venue of this research, more difficult to achieve, is to explore subsystems of airport so that we can analyze the emission allocation of each subsystem separately.

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Chapter 21
Research on Cognition of Green Building in Chongqing

Huilin Shao

Abstract Application of green building is a fast path to achieve sustainable development in the housing industry. It has become the consensus of the Insiders, but the key for the promotion of the green building is the awareness of the market to it. As the green building in China started relatively late, and many of its buyers is poorly understood. This article will study the awareness of the potential buyers to green building concept in Chongqing by statistical methods in order to determine the different classes of buyers who give the Level of understanding and acceptable level to the green building. So as to the housing market can do the customer segmentation and give convenience to the relevant government departments which draw up the development strategy of the green building.

Keywords Green building · Cognition · Chongqing

21.1 Introduction

China is in a stage of rapid development of urbanization, the scale of urban construction is unprecedented, however, it accompanies by the severe energy resources and ecological environment. According to currently statistics, China's building-related energy consumption accounted 46.7 % of social energy, including building energy consumption (energy construction, life energy, heating and air conditioning, etc.) about 30 %, as well as building energy consumption in the production process is 16.7 %, as a major energy consumer, the construction industry r also need innovation and finds a sustainable model construction. While green buildings follow some basic principles of sustainable development which include environmental protection, conservation of resources, ensuring the quality of the living environment

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has been extremely pro-gaze. From the 1990s, the concept of green building introduced in our country. Green building (Green Building) (GB/T 50378 2006) refers to the entire life cycle of the building, to maximize conservation of resources (energy, land, water, materials), to protect the environment and reduce pollution, so as to provide people with healthy, suitable and efficient use of space in the building in harmony with nature.

Since the rise of green building, currently there are many scholars of green building development in China has made some study. Zhang et al. (2006) believes that the reason which green building is difficult to promote is the problem of economic externalities. The common practice to solve the economic externalities is government intervention and on this basis, from an economic point of economic incentives for green building principles are analyzed. The author also focused on analyzing external economic of green building and the external diseconomies of non-green buildings and made a number of recommendations to promote industrial development of green buildings. Liu et al. (2007) analyzed the foreign-related Incentive policies and measures of green building and the factors that hinder the development of green building, then the author thinks that the Government should adopt a mandatory policy, economic incentives and other measures to promote the development of green building. Liu (2012) analysis and design incentives framework and content system of green building in Beijing Municipal from the aspects of the market supply and demand. The author intends to adopt Probit of Discrete Choice Model to research the awareness of the green building.

21.2 The Current Status of Green Building Development in Chongqing

As a modern social-ecological city, saving city, circular economy, green building is an important influence elements of urban construction, it affects the security and stability of the functional organization structure changes and also affects the efficiency of the urban eco-system service capabilities, which will play an important role in improving the ecological living systems health Quality (Li and Li 2011).

First, green Building information asymmetry: At present, Since some green building providers use consumers who get insufficient, lag and not clear information as well as for their own interests, they conceal the true information products so that they can get big economic interests in the name of the “green”, So various “fake” green building is flooded in the construction market. Once consumers find they were deceived by this “green”, they will reduce the degree of trust to the green building in market, then integrity of the market will be destroyed, thus it will prevent the demand of consumer for green buildings. Due to the adverse selection effects arising from asymmetric information, it will cause a real green building at a competitive disadvantage, or even out of the market, at last a phenomenon will be appear that is the “bad money drives out good money”.

Second, lack of green building cognitive: Currently, the society has not fully aware of the meaning of green building, lack of basic knowledge of green building, so the “green building” is equivalent to “green.” Even some real estate agency play green building signs to the so-called for luxury and high-tech, so that “green = expensive” understanding is growing in popularity. The green building construction is equivalent to the aristocracy during the Ordinary people and even some industry personnel. This “green” errors greatly reduces market demand for green buildings and hinders the development of green buildings.

Third, immature of green building technology and products: The green Building in our country exists some problems which includes lag of basic research, immature of Building materials and products, high cost and the type of failure, supporting the construction of technical complexity, easily emerging some engineering problems after using, which results developers who lack of interest in trying to energy-efficient buildings. Not to mention the green building that need to get involve more new technologies, new materials to support. If extensive use of foreign advanced equipment and technology, it will inevitably lead to expensive green building, which is not conducive to the promotion of the application of green building.

Fourth, the initial investment of green building is large, long-term economic benefit is not obvious: From the current development status in our country, the initial investment of green building is higher, although the long-term social, environmental and ecological benefits are obvious, but the direct economic benefits (energy efficiency) is relatively low cost and have a long payback period. In the current market economy-oriented society, the investment risk considerations for investors tend to chase short-term profits and quick return of funds for green building, so they are lack of enthusiasm in green building, but in order to seek a selling point, the words “green building” more appears in the advertisement Developers hype, rather than the actual construction.

Fifth, lack of green building professionals and agencies: At present, although some scholars passion for green buildings is very high, but quite a lot of designers are not familiar with green building design, because use of green building programs tend to increase the workload and difficulty of the work, thereby reducing the enthusiasm of green building practices. AT the same time, Implementation of green building, it need to have more than one type of work early in the project, a number of the responsible party participation “overall design” concept and throughout the project planning, design, construction and use of the latter part of the whole process. In China, the start of the program does not take a lot of mature and then further adjusted, it is difficult to realize the full life cycle of green building features. Therefore, an urgent need to set up construction-related professional organizations and train professionals in green building, so that all types of mutual coordination and overall operations.

According to the analysis of several main factors which affect the development of the Green Building in Chongqing, conclusions of insufficient demand for Green Building in Chongqing can be draw. To a great extent, buyers lack knowledge about the Green Building. They cannot accept it from the bottom of heart. What’s more, the price of so-called Green Buildings on the current market are relatively high, which makes most buyers have a wrong perspective that Green Building is high-consumption. Thereupon, this paper is intended to first start with the buyers' awareness of Green Building. According to the quantitative analysis of questionnaires for the awareness of Green Building from the different income groups, this paper is supposed to figure out whether consumers mistake the Green Building for high-consumption on the current market, which makes the potential costumers of Green Building limited and restrains the development of Green Building.

21.3 Green Building Awareness Analysis

Since the original model of probit is $y_i = X_iB + u_i$ and y only can get 0 or 1, by the Utility Model $U_i^1 = X_iB^1 + \varepsilon_i^1$; $U_i^0 = X_iB^0 + \varepsilon_i^0$, from subtracting between the two formula, it gets formula $U_i^1 - U_i^0 = X_i(B^1 - B^0) + (\varepsilon_i^1 - \varepsilon_i^0)$ and marks $y_i^* = X_iB + u_i^*$, in this formula y_i^* refers to the dependent variables, X_i refers to the argument, B refers to the parameters to be estimated, u_i^* refers to the random disturbance term. So, $P\ (y_i = 1) = P(y_i^* > 0) = P(u_i^* \geq -X^iB) = 1 - F\ (-X^iB) = F(X^iB)$, if u_i^* obeys the normal Distributed in this model, it can form Probit discrete choice model parameter estimation.

In order to forecast different income groups for awareness of green building, the test collects data by the method of questionnaire. Survey respondents are divided into three classes in this article: low income group (monthly income of 3,000 yuan), middle income group (monthly income from 3,000 to 6,000 yuan), the high-income group (monthly more than 6,000 yuan). Due to the large number of questionnaires are distributed (distributed 160 copies, recovered 130 copies, discarded 30 parts), so the author just takes the 30 sets of data to analysis, data directions (because the limitations of the model, the test only makes quantitative predictions on the degree of understanding of green building): 0 refers to unknown, 1 refer to the understanding in the column awareness; 1 indicates the low-income, 2 indicates middle-income class, 3 indicates high-income groups in the income class column. This is the data after finishing.

Lever of understanding	Income groups
0	1
0	1
1	2
1	2
0	1
0	2
0	1

(continued)

(continued)

Lever of understanding	Income groups
0	1
0	2
0	1
0	1
1	3
0	2
0	1
1	1
0	1
0	2
0	1
0	1
0	1
1	2
0	1
1	2
1	3
0	3
0	1
1	3
0	1
0	3
0	1

Assuming the original model is $y_i = \alpha + \beta x_i + u_i$, $i = 1, 2, 3, \ldots, 30$, making use of the discrete choice model parameter estimation software calculates the following results in the Table 21.1.

From the Table 21.1, it can get the result: $\hat{\alpha}_1 = -2.318979$, $\hat{\beta}_1 = 0.965319$, but the value of R^2 is too small at this time, it is only 0.232201, the reason for this result is the different variance. So using the weighted discrete choice model parameter estimation can get the Table 21.2:

From the parameter estimation results, it can get the probit model YF = 1 − @CNORM[−(−0.408778 + 0.407488X)], combining to the equation, this test can get the different results when the X get different value when the X is 1, checking the standard normal distribution table gets the cumulative normal distribution of 0.00129 is 0.496, so the predictive value of y is 0.504 when the X is 2, checking the standard normal distribution table gets the cumulative normal distribution of 0.406198 is 0.3328, so the predictive value of y is 0.6672 when the X is 3, checking the standard normal distribution table gets the cumulative normal distribution of 0.813686 is 0.1867, so the predictive value of y is 0.8133. The results showed that low-income people has the minimum degree understanding of green

Table 21.1 The discrete choice model parameter estimation

	Coefficient	Std. error	z-statistic	Prob.
C	−2.318979	0.715764	−3.239867	0.0012
X	0.965319	0.359683	2.683805	0.0073
McFadden R-squared	0.232201	Mean dependent var.		0.266667
Std. dependent var.	0.449776	S.E. of regression		0.396769
Akaike info criterion	1.023850	Sum squared resid		4.407912
Schwarz criterion	1.117263	Log likelihood		−13.35775
Hannan-Quinn criter.	1.053734	Restr. log likelihood		−17.39746
LR statistic	8.079413	Avg. log likelihood		−0.445258
Prob. (LR statistic)	0.004477			
Obs. with Dep. = 0	22	Total obs.		30
Obs. with Dep. = 1	8			

Table 21.2 Weighted discrete choice model parameter estimation

	Coefficient	Std. error	t-statistic	Prob.
C	−0.408778	0.054558	−7.492479	0.0000
X		0.049530	8.227131	0.0000
Weighted statistics				
R-squared	0.707375	Mean dependent var.		−0.100245
Adjusted R-squared	0.696924	S.D. dependent var.		0.191818
S.E. of regression	0.118241	Akaike info criterion		−1.367835
Sum squared resid.	0.391469	Schwarz criterion		−1.274422
Log likelihood	22.51752	Hannan-Quinn criter.		−1.337951
F-statistic	67.68568	Durbin-Watson stat.		1.616067
Prob. (F-statistic)	0.000000			

building, followed by middle-income earners, while high-income earners has the highest level of understanding of green building.

21.4 Suggestions About Developing Green Building in Chongqing

Although the higher awareness of consumers for green building shows that the market has strong demand for green building, which provides the direction for the development of green building, obviously just relying on the awareness of consumer is difficult to rapidly promote the development of green building. So government mandatory regulations and economic incentives play an irreplaceable role. Energy-efficient buildings, green buildings will eventually need to rely on the government's coercive means to fully promote.

First, strengthening green building advocacy, considering the entire life cycle of the building, launching a public discussion of energy conservation, cost savings and the concept of environmental protection. In order to raise public awareness of the use of sustainable building and train the needs in the market, we need to transport advanced concepts of green building. we need to Strengthen the social responsibility of real estate developer and promote the economic and market opportunities of green energy efficient building. Whether it is real estate development companies, or design units, construction units, etc. should recognize that green building is in line with the trend of social development and the trend of the times, which is a must to a company for the survival and development. Those lacking of green business concept will be eliminated sooner or later.

Second, according to the requirements under different climatic conditions and the development of technology in all regions, government should continue to improve laws and regulations and building codes and continuously improve building energy efficiency standards through legislation. For green building, although currently it can't rely on law to enforcement, it also need to publicize and promote through national policies.

Third, in addition to the national legislative controls and sanctions, it also need to strengthen national economic incentives. For the business units and individuals which use green energy technology government can give preferential policies in taxation, loans, land, water, electricity, etc., in order to offset part of increasing cost because of using new technologies. In the early implementation of green energy-saving buildings, the state can give enterprises and individuals which use green energy-saving technologies and equipment direct cash subsidies. In other words, in order to improve their motivation to accelerate green building concept publicity and promotion of green energy technology and equipment, we should rely our country on paying the part "green" of construction.

Forth, strengthen the construction of green building certification and evaluation system Promoting the work that identifies green building rating level is conducive to fully exert and mobilize the enthusiasm of real estate developers for green building. It will promote green building comprehensive and rapid development and improve the overall level of China's green building and promote the development of the real estate market.

Fifth, strengthen the business training for construction workers and professional jobs. In the use of new building materials and building components in the process of modernization, professional workers should be trained. In most cases, the reason why the construction quality don't improve, because many construction workers lack the expertise, which results in the actual operating capacity that can't meet the requirements.

21.5 Conclusion

By Probit of Discrete choice models, This paper draws high-income earners who has high awareness of green building and has green the maximum demand for green building. So in the initial application of green building, real estate Developers should develop green buildings in some of the upscale residential district to meet the needs of high-income consumers, when it forms a certain scale, then applying to the low-end housing. But at the same time, green building certification system should be carried out strictly. Don't give consumers a false impression "green buildings and high-end residential equated. Finally, government should give advocacy and policy guidance about green building according to the market demand conditions. Believing that green building will be developed rapidly in Chongqing Municipality and will become an effective way for sustainable construction industry in Chongqing.

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Chapter 22
Exploration on Sustainable Construction of University Campus: An Analysis Based on Evaluation on Campus Environment of Zhejiang University

Jiahui Shen, Yuzhe Wu and Xiaoling Zhang

Abstract Nowadays, with rapid process of urbanization, sustainable construction has become the global trend in the area of city development. Meanwhile, university campus is a place that integrates education, living, communication and other functions, the satisfaction of which will surely have significant impact on students' potential and their health both physically and mentally. In view of this, this paper built up the comprehensive evaluation indicator system from the perspective of safety, health, convenience, comfort and sustainability and performed satisfaction evaluation on campus environment, taking the five campuses of Zhejiang University for example. Finally this paper put forward suggestions on sustainable construction and improvement of campus environment.

Keywords Sustainable construction · Campus environment · Satisfaction evaluation · Analytical hierarchy process · Zhejiang University

22.1 Introduction

As is known to all, living environment is the total of living, recreation, communication and many other aspects. As fruits of labor, it is both the base for human survival and the space that links human society and nature (Li et al. 2001).

Living environment has raised much concern since the United Nations Conference on Environment and Development in 1992.

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With the rapid process of urbanization, it has become a very tough challenge that urban sprawl recklessly and many problems occurred such as resource depletion and environmental pollution. Meanwhile, people became more and more concerned about living quality, which can be seen from the example of PM2.5 and PX projects.

For university students, university campus is a place that integrates education, living, communication and other functions, the satisfaction of which will surely have significant impact on students' potential and their health both physically and mentally. In view of this, based on the review of relevant research results at home and abroad, this paper built up the comprehensive evaluation indicator system from the perspective of safety, health, convenience, comfort and sustainability and performed satisfaction evaluation on campus environment, taking the five campuses of Zhejiang University, namely Zijingang, Yuquan, Xixi, Huajiachi and Zhijiang, for example. Finally this paper put forward suggestions on sustainable construction and improvement of campus environment.

22.2 Literature Review

22.2.1 Living Environment

In a narrow sense, living environment means the physical surroundings where we live in, but in a broad sense, it also includes social, economic and cultural environment (Asami 2006). When it comes to urban resident environment, it is a comprehensive system that takes people as the main body and can be divided into two parts, inside living environment and outside living environment (Luo 2001), among which inside living environment contains lighting, ventilation, water, electricity, heat insulation, sound insulation and warmth, etc., while outside living environment stands for infrastructure, landscaping, open space as well as social spirit of the environment.

Researches conducted by foreign scholars were always linked with urban planning, urban management, urban governance and other issues in different stages. At the beginning of industrial revolution, in response to housing shortage and industrial pollution, the concept of industrial cities was proposed. In the upper half of 20th century, theories of organic decentralization, neighborhood unit and humanistic were applied to practice. When the government found out that the model of the original garden cities couldn't meet the need for space and housing, the concept of new urbanism, smart growth and compact city came to the fore, which put emphasis on the improvement of living environment quality in the practice of the regulation of urban development scale.

22.2.2 Evaluation on Living Environment

With the development of computer science and statistics, quantitative evaluation on living environment became mature gradually. Early in the 1970s, American scholars used the tool of profile diagram, assessment of demand and socioeconomic data to perform quantitative evaluation on living environment. Then the technology of GIS was introduced.

When it comes to theoretical basis, human-land relation theory, urban ecology theory, natural geographic regional differentiation theory and so on laid the foundation of evaluation on living environment. Its evaluation content varied from green building to water and air quality. In the meanwhile, England, America and Canada drew up kinds of evaluation systems using a classification lists combined qualitative and quantitative methods.

In China, researches on evaluation on living environment started late and most were focused on the urban scale. Wu set up the sciences of human settlements and its theoretical framework, on the basis of which he proposed the construction principles to human-centered. Ning and Zha (1999) discussed the mechanism of changes in human settlements, taking Shanghai for example. Liu (2002) performed individual and comprehensive evaluation on living environment in Beijing and put forward suggestions on its optimizing and sustainable construction. It could be concluded that the breadth and depth of evaluation on living environment need to be further excavated and it would be better if the evaluation could be linked with the hot spots of society such as sustainable construction.

22.3 Research Objects and Methods

In consideration of data accessibility and reliability of evaluation, this paper took the five campuses of Zhejiang University, Zijingang, Yuquan, Xixi, Huajiachi and Zhijiang campuses as the research objects and investigated the students and teachers there to acquire research data. The basic information of the five campuses was listed in Table 22.1.

Since the five campuses of Zhejiang University were located in different orientations of Hangzhou and they were different in many aspects such as architectural style, geographic location and condition of fundamental facility, which made it possible that people in different campuses had different ideas on residential security, health, convenience, comfort and sustainability so they had high distinguish degree in the evaluation on campus environment.

Evaluation on living environment consists of two parts: one is objective evaluation which performed quantitative evaluation and the other is subjective perception evaluation that analyzes residents' satisfaction about every aspect of living environment. This paper paid more attention to the latter and content analysis method, questionnaire survey method as well as statistical analysis were used here.

Table 22.1 Basic information of the five campuses

Campus	Location	Area (acres)	Distance from the nearest commercial service center (km)	Condition of fundamental facility within 1 km
Zijingang	North-west of Hangzhou	5856 (total planning area)	1.9	1 Hospital, 4 banks, 6 bus stations, 6 bus lines and 6 markets
Yuquan	North-west of the West Lake	1700	1.6	1 Hospital, 10 banks, 9 bus stations, 15 bus lines and 8 markets
Xixi	High and new technology industrial development zone	684	1.7	4 Hospitals, 10 banks, 10 bus stations, 20 bus lines and 7 markets
Huajiachi	Neat the east railway station	1484	1.8	3 Hospitals, 5 banks, 10 bus stations, 25 bus lines and 5 markets
Zhijiang	On the banks of the Qiantang River	650	9	0 Hospital, 2 banks, 4 bus stations, 12 bus lines and 2 markets

22.4 Indicator Selection and Weight Decision of Evaluation on Campus Environment

The evaluation indicator of evaluation on living environment varies and in 1961 World Health Organization presented the basic four concepts of living environment, which were safety, health, convenience and comfort. Asami (2006) added sustainability to the former four concepts and believed it was of great importance to take environmental and social sustainability into consideration.

According to previous studies, this paper put safety, health, convenience, comfort and sustainability to subsystem layer. Meanwhile, since the research objects here, the five campuses of Zhejiang University was somehow different from traditional settlement, we dealt with the evaluation indicator to make it more adapted to the actual situation of university campus. So there were 28 evaluation indicators in criterion layer, each of which was classified to the 5 subsystem layer. What needed to be emphasized was that we paid more attention to subjective perception evaluation that analyzes residents' satisfaction about every aspect of living environment and this could be seen from the 28 evaluation indicators chosen in this paper.

Delphi technique and Analytic Hierarchy Process method were chosen to calculate the weight of every indicator in this paper and the result passed consistency examination, which meant the random consistency ratio was smaller than 0.1. The evaluation indicator system and the weight of every indicator were shown in Table 22.2.

Table 22.2 Evaluation indicator system and their weight of campus environment

Goal layer	Subsystem layer			Criterion layer		
	Code	Content	Weight	Code	Content	Weight
Evaluation on campus environment of Zhejiang University	A	Safety	0.497	A1	Transportation safety	0.166
				A2	Public security	0.761
				A3	Natural disasters	0.073
	B	Health	0.133	B1	Noise level	0.028
				B2	Air quality	0.468
				B3	Hygienic conditions	0.368
				B4	Sunshine and ventilation	0.136
	C	Convenience	0.261	C1	Parking	0.068
				C2	School canteen	0.291
				C3	Medical facility	0.019
				C4	Library	0.059
				C5	Playground	0.034
				C6	Commercial facilities around including dining, shopping and entertainment	0.137
				C7	Public transport	0.126
				C8	Traffic jams	0.015
				C9	Internet service	0.223
				C10	Physical distribution service	0.029
	D	Comfort	0.073	D1	Building density	0.206
				D2	Architectural form	0.052
				D3	Land layout	0.279
				D4	Green coverage	0.101
				D5	Open space	0.024
				D6	Campus features	0.043
				D7	Cultural heritage	0.017
				D8	Relationship between students and teachers	0.187
				D9	Self-identity and adscription	0.091
	E	Sustainability	0.035	E1	Quality of construction	0.857
				E2	Daily operations	0.143

22.5 Results and Analysis

22.5.1 Evaluation Result

The authors of this paper designed a questionnaire named *Evaluation on Campus Environment of Zhejiang University's five campuses* and published it online (http://www.sojump.com/jq/3341908.aspx). A total of 200 respondents were sampled and a total of 197 were deemed usable for the analyses, a 98.50 % usable response rate, among which the number of respondents living in Zijingang, Yuquan, Xixi, Huajiachi and Zhijiang campus was 60, 32, 19, 21, 65 respectively, showing a comparatively reasonable distribution structure.

The questionnaire was divided into two parts, the first one contained personal basic information and the second one investigated respondents' subjective view of the 28 indicators listed above. Respondents were asked to give each indicator a score ranging from 1 to 5 and the higher the score was, the more satisfied they were. After calculating average score of every indicator and did some organization with the score and weight, the results were shown in the Tables 22.3 and 22.4.

It could be concluded that in the layer of safety, there was no significant difference between five campus but the score of Zhijiang and Yuquan was little higher than that of other ones. In the layer of health and comfort, Zhijiang and Xixi ranked first and last respectively because the former located in scenic spot with beautiful surroundings but the latter located in the downtown. When it comes to convenience, Zijingang and Yuquan, being as the biggest campuses among the five, had more advantages than others. Zhijiang and Yuquan were ahead of other three campuses in sustainability. To sum up, the comprehensive evaluation result showed that the rank from best campus environment to worst one was Zhijiang, Yuquan, Zijingang, Xixi and Huajiachi, from which we could divide them into two groups since the former three campuses had high and very close comprehensive score while the latter two's score was left behind.

22.5.2 Analysis of Evaluation Result

There were three indicators in the layer of safety and it had the highest weight among subsystem layers. For transportation safety, college students usually took bicycles as a means of transport and the speed of motor vehicle in campus were limited at 30 yards, so the five campuses had high and similar score in this indicator. With the improvement of campus openness, foreign workers can enter the campus itself, which creates opportunities for criminals. Huajiachi was located near east railway station and Zijingang was in suburban area and these two districts gathered a large number of floating populations, which made public security conditions tougher than other campuses. As for natural disasters, university campus

Table 22.3 Preliminary results from the investigation

Goal layer	Subsystem layer and weight	Criterion layer and weight	Solution layer				
			Zijingang	Yuquan	Xixi	Huajiachi	Zhijiang
Evaluation on campus environment of Zhejiang University	A(0.497)	A1(0.166)	0.207	0.203	0.196	0.208	0.186
		A2(0.761)	0.192	0.207	0.202	0.177	0.223
		A3(0.073)	0.202	0.197	0.173	0.212	0.216
	B(0.133)	B1(0.028)	0.200	0.195	0.180	0.189	0.236
		B2(0.468)	0.190	0.196	0.174	0.186	0.254
		B3(0.368)	0.212	0.196	0.184	0.192	0.217
		B4(0.136)	0.213	0.195	0.184	0.214	0.194
	C(0.261)	C1(0.068)	0.208	0.199	0.185	0.200	0.208
		C2(0.291)	0.242	0.237	0.169	0.162	0.191
		C3(0.019)	0.229	0.250	0.162	0.232	0.127
		C4(0.059)	0.232	0.187	0.168	0.207	0.206
		C5(0.034)	0.226	0.205	0.203	0.210	0.156
		C6(0.137)	0.223	0.217	0.228	0.235	0.098
		C7(0.126)	0.199	0.225	0.239	0.212	0.124
		C8(0.015)	0.229	0.198	0.183	0.213	0.176
		C9(0.223)	0.200	0.183	0.197	0.202	0.218
		C10 (0.029)	0.211	0.213	0.202	0.205	0.169
	D(0.073)	D1(0.206)	0.208	0.197	0.164	0.207	0.224
		D2(0.052)	0.205	0.191	0.194	0.178	0.232
		D3(0.279)	0.186	0.202	0.202	0.201	0.208
		D4(0.101)	0.194	0.196	0.190	0.204	0.216
		D5(0.024)	0.220	0.198	0.167	0.212	0.203
		D6(0.043)	0.199	0.203	0.173	0.192	0.234
		D7(0.017)	0.164	0.218	0.185	0.183	0.250
		D8(0.187)	0.194	0.204	0.195	0.203	0.205
		D9(0.091)	0.208	0.213	0.191	0.190	0.199
	E(0.035)	E1(0.857)	0.188	0.212	0.190	0.178	0.232
		E2(0.143)	0.211	0.204	0.187	0.191	0.207

Table 22.4 Evaluation results on campus environment of Zhejiang University's five campuses

Goal layer	Subsystem layer	Solution layer				
		Zijingang	Yuquan	Xixi	Huajiachi	Zhijiang
Evaluation on campus environment of Zhejiang University	Safety	0.195	0.205	0.199	0.185	0.216
	Health	0.201	0.196	0.179	0.192	0.232
	Convenience	0.221	0.213	0.195	0.198	0.174
	Comfort	0.197	0.201	0.188	0.200	0.214
	Sustainability	0.191	0.211	0.189	0.180	0.228
	Comprehensive evaluation t	0.203	0.206	0.194	0.190	0.207

was equipped with open playgrounds and squares, with construction fitting the standards of fire and earthquake protection, they won high score in this aspects.

Health layer was divided into four aspects, noise level, air quality, hygienic conditions and sunshine and ventilation. In this layer, Zhijiang campus surpassed other campuses more than 0.03 benefited from its location that on the banks of the Qiantang River, which provided good ecological environment. Zijingang ranked second in this layer for the reason that it was newly constructed in 2001 and the concept of low carbon and sustainable development was well integrated into its construction. However, the other three campuses' scores was low and the condition of noise, air quality and hygiene needed improvement.

University campus is a place that integrates education, living, communication and other functions, which makes the convenience layer of great importance. In this paper, convenience layer containing 10 indicators included four aspects, convenience of daily life, facilities, transport and social service. In this layer, Zijingang and Yuquan, being as the biggest campuses among the five, had more advantages than others while Zhijiang ranked last with a geographically remote location. For example, Zijingang once had the largest dining hall in Asia and students there didn't have to worry about the problem of eating even though it wasn't exactly the time for dinner. From Table 22.1, we could see that all the campuses except Zhijiang were accessible to big commercial service centers, the distance of which was within 2 km, making students' dining, shopping and entertainment activities full of variety. Beyond that, all the campuses were well equipped with library, playground and other living facilities so score in there indicators had little significance.

When it comes to comfort layer, the evaluation result was somehow similar with that of health layer: Zhijiang ranked first and then successively came Yuquan, Huajiachi, Zijingang and Xixi, but the gap was not large. In the indicator of land layout, green coverage, relationship between students and teachers as well as self-identity and adscription, all the campuses showed high satisfaction. However, advantage of Zhijiang campuse was in campus features and cultural heritage. As it known to all, Zhijiang had saved fairly complete modern university buildings including more than 10 buildings like western-style garden and library. Antique campus environment, small population density and relaxed pace of life, all of which were the strength of Zhijiang and Huajiachi.

As for sustainability layer, considering that it was difficult to descript and characterize subjective feelings from students on sustainability of university campuses, sustainability indicators in this study was relatively simple designed. Xixi and Zijingagn had low score in the indicator of quality of construction but in the aspect of daily operations, all people had shown a high degree of satisfaction.

22.6 Conclusions and Suggestions

22.6.1 Conclusions

Based on the review of relevant research results at home and abroad, this paper built up the comprehensive evaluation indicator system from the perspective of safety, health, convenience, comfort and sustainability and performed satisfaction evaluation on campus environment, taking the five campuses of Zhejiang University, namely Zijingang, Yuquan, Xixi, Huajiachi and Zhijiang, for example. It could be concluded as follows.

In safety layer, the score of Zhijiang and Yuquan was little bit higher than others. In health layer, Zhijiang surpassed other campuses more than 0.03 benefited from its location that on the banks of the Qiantang River while Xixi ranked last. In convenience layer, Zijingang and Yuquan, being as the biggest campuses among the five, had more advantages than others while Zhijiang ranked last with a geographically remote location. The evaluation result in comfort was somehow similar with that of health layer: Zhijiang ranked first and then successively came Yuquan, Huajiachi, Zijingang and Xixi, but the gap was not large. As for sustainability layer, Zhijiang and Yuquan took the lead. To sum up, the comprehensive evaluation result showed that the rank from best campus environment to worst one was Zhijiang, Yuquan, Zijingang, Xixi and Huajiachi, from which we could divide them into two groups since the former three campuses had high and very close comprehensive score while the latter two's score was left behind.

22.6.2 Suggestions on Sustainable Construction of Campus Environment

Comprehensive evaluation result showed that the proportion of five campuses was all around 0.2, indicating a relatively high satisfaction. With the goal of being a world-class university, there is a long way for Zhejiang University in sustainable construction of university campus.

Emphasis on enhancing campus security to protect life and property safety of teachers and students is the basis for everything else especially for Zijingang and Huajiachi which have high degree of opening and people around are dragons and fishes jumbled together. It is good ways as to increase security patrols density, strengthen nighttime lighting and improve students' self-precautionary alertness. Improvement on campus environment, such as continue to strictly control the noise situation on campus is also of great importance. Perfect logistical support could enhance campus convenience and the management of dining hall, library and school infirmary needs innovation. Finally, in the aspect of comfort and sustainability, campus features as well as cultural heritage needs to be further digged to strengthen students' self-identity and adscription.

All in all, the concept of sustainable development would better be integrated into the daily operations and future development of each campus, which means to look at things from a development perspective so that each campus would walk the road of sustainable construction whether in physical form or ideology.

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Chapter 23
Analysis on the Effectiveness of Implementing Green Construction Guidelines

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Abstract Green construction is an important strategy for energy saving in construction, thus contributing to the mission of sustainable construction. By appreciating the importance of green construction, this paper presents the key principles of Green Construction Guidelines (GCG) introduced by the Chinese government, including energy saving, land saving, water saving, materials saving, and environment protection (4S1E). Four case studies are chosen to examine the effectiveness of the principles defined in GCG. Green construction technology and management methods adopted in these cases for implementing green construction are particularly investigated through comprehensive survey. The impacts and benefits from implementing GCG have been presented.

Keywords Green construction · Effectiveness · Guideline · Technology · Management

23.1 Introduction

China has been developing rapidly over last several decades, driving by the massive scale of urbanization process. In line with this, the energy consumption on buildings and construction activities has been rising year by year, which has become one of the main contributor to the China's energy consumption. The research report by the Chinese Research Institute for Built Environment (CRIBE 2005) suggests that the construction activities adds the environmental load with 15–45 % of total

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burden on environment; construction caused waste is 40 % of the total waste; the energy consumed for building materials, transportation accounted for 10 % of total construction energy consumption; energy for operating building accounts for 20–40 % of total energy consumption. According to the study by Zhang and Huang (2006), the energy for implementing construction activities in China amounted to 32 % of the whole energy consumption in the country. It is estimated that by year 2020, the energy consumption for construction will be the largest part of total energy consumption in China. Therefore, energy saving by implementing sustainable construction practice will make significant contribution to the achievement of sustainable development in China.

The Ministry of Construction in China issued a Green Construction Guidelines (2007), hereinafter referred to as the "Guidelines", which is designed to provide guidance for the implementation of green construction. The guidelines project promote the green construction technology for the aim of achieving the saving of energy, land, water and material, and the environmental protection, so called "Four Savings and One Protection". The Guidelines are the premise of assurance for the maximum resource conservation and minimum construction activities' negative influence on environment. In 2006, the Ministry of Construction issued the Criteria for the Green Building Evaluation (GB/T50378—2006), requiring that in the construction and management, principles of green building construction should be actively implemented by adopting proper measures (RT-GCAC 2006). In 2008, the Ministry of Construction established an office responsible for evaluation of management, marking the first step of green building assessment activities. In conducting the evaluation, green buildings are divided into three categories: one-star, two-star and three-star. To gain the three-star level of green building, the practice of green construction is a must. As the end of 2013, a total of 1260 green building projects have been awarded green building throughout the country, including 480 one-star buildings, 530 two-star projects and 312 three-star projects (Sina Estate Nets 2014). And each year, the country provides a total of 20 billion cubic meters construction projects. Considering the size of the construction industry in China, the number of the buildings awarded as a green building is extremely limited. The green practice in construction has just started in many areas. Management in many construction enterprises is still lack of green construction knowledge. Therefore, studies on the green construction technologies, and promoting the green construction guidelines, either for conservation of natural resources or protect environment, all bringing about the positive significance.

Existing studies have examined extensively the present progress in practicing green construction, but mostly they studies have focused on technical measures, management methods. Among them, Zhong (2011) examined a commercial plaza project as an example which has adopted various green construction technologies. In this project, advanced management and technical measures were applied, aiming at reducing as much as possible the negative effects of construction activities on the consumption of resources and environment. Wen (2009) discussed the ways of energy-saving and water-saving in construction sites. Guo et al. (2011) opined that the construction firms are largely lack of the green construction technology in China and suggested developing a green construction technology innovation system to mitigate the problem of insufficient innovation. Xiong (2010) conducted an analysis on the status quo of the implementation of current green standards and regulations, and pointed out that green construction has been effectively applied in many good cases. He identified a number of feasible measures for the implementation of green construction though examining a number of cases. And there are still other studies of green construction, for example, Sun (2011a) and Liu (2011).

These studies have made important impacts on promoting green construction development. Nevertheless, little studies have investigated the influence or the effectiveness of the Guidelines since its introduction. Therefore this paper aims for analyzing the effectiveness and benefits of the Guidelines on the development of green construction practice.

23.2 Research Methods

Several methods are incorporated in conducting this research. Literature review was conducted to confirm the understanding on the definition of green construction, the principles of the Guidelines. Sample building projects are used to examine the application of green construction technology and management measures. These samples are also used for comparative analysis on the effects of Guidelines to gaining the benefits of green construction. Furthermore, interviews are conducted to generate further research data to support analysis, in which four experts are involved in the interview survey.

23.3 Evaluation Indices in the Guidelines

The Guidelines are divided into six parts, namely, preface, general principles of green construction, overall framework of green construction, key aspects of green construction, the development of green technology, equipment, materials, and the demonstration project in the application of green construction. In general principles, the objective of “Four Savings and One Protection” is defined. The overall framework of green construction can be shown in Fig. 23.1.

Green construction is defined as including six criteria: the green construction management, environmental protection, saving material and material resource use, water saving and water resources utilization, energy saving and utilization, land saving and construction land protection. Specifications on these six elements are described from the perspective of technology and management. The further analysis in this paper focuses on the principles of these six elements.

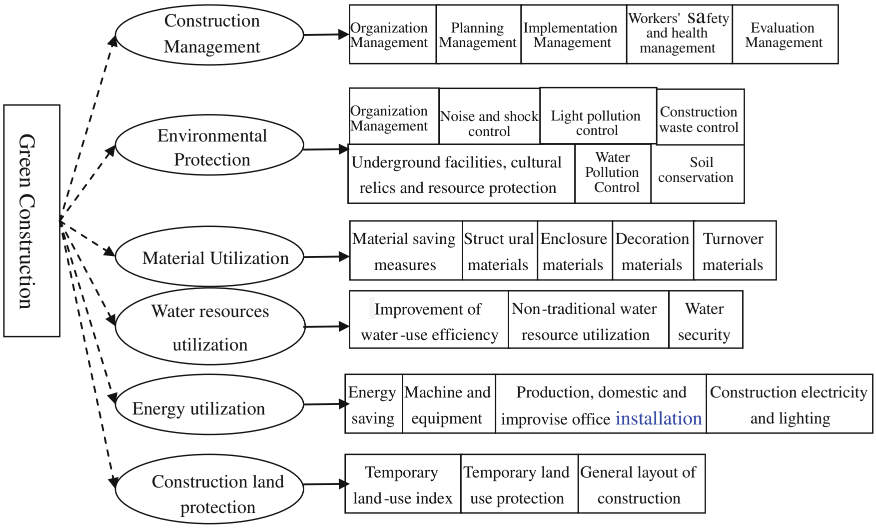

Fig. 23.1 Framework of green construction assessment

23.4 Case Studies on the Application of the Guidelines

23.4.1 Background of Case Studies

Four sample green building projects are selected for study, including two public buildings, one commercial project and one residential project. The details specifications of these sample cases are shown in Table 23.1.

Table 23.1 The sample green construction projects

Code of project	Location	Starting time	Structure type	Scale (km^2)	Project type	Remarks
A	Shanghai	10/2007	Frame-tube	198	Commercial	Conservation-oriented project
B	Hangzhou	07/2008	Reinforced concrete frame	34	Public	Three-star green buildings
C	Beijing	04/2010	Frame shear wall	25	Residential	Non-specified project
D	Chongqing	08/2011	Reinforced concrete	74	Public	Green project

Sun 2011b, Wu et al. 2011, Wu 2008

23.4.2 Green Construction Management

As shown in Fig. 23.1, the green construction management is defined in several aspects, including organization, planning, implementation, evaluation and staff safety and health. It is required that the green construction project manager, as the primary person of responsibility in the preparation of construction plan, should take into account of the measures for "Four Savings and One Projection", strengthening management and supervision of the construction links, and performing the evaluation on the green construction and using innovation technology and equipment. Safety and health of construction personnel are particularly emphasized in examining green construction. There are five categories defined in the Guidelines from the perspective of construction management:

1. Organization Management (OM)
   OM1—establishing organization for implementing green construction
   OM2—allocating staff responsible for green construction
2. Planning Management (PM)
   PM1—produce green construction plan
   PM2—define methods for implementing plan
3. Action Management (AM)
   AM1—supervise all implementation procedures
   AM2—training for staff
   AM3—promotion and building up green construction culture
4. Evaluation Management (EM)
   EM1—self evaluation
   EM2—comprehensive evaluation
5. Safety and health management (SHM)
   SHM1—identify safety protection measures
   SHM2—proper arrangement on site
   SHM3—healthy living and working environment

As indicated in Table 23.2, the project A and B were conducted for construction in an earlier time, these two projects made good influence on implementing green practice in local construction market. In particular, the Project B is a three-star green building, demonstrating the active participation in practicing green construction although the Guidelines was just issued that time.

It is noted that the project management team in these projects contributed good efforts in promoting green practice through close supervision and providing proper training to staff. Nevertheless, it appears that safety and health are not given sufficient attention except the management for Project C having taken measures for safety and health.

Table 23.2 Comparison of the construction management measures

Measures	Case projects			
	A	B	C	D
OM				
OM1	Unspecified	Unspecified	O	O
OM2			O	O
PM				
PM1	Unspecified	O	O	O
PM2	Unspecified	Unspecified	O	O
AM				
AM1	O	O	O	O
AM2	O	O	O	O
AM3	O	O	O	O
EM				
EM1	O	Unspecified	O	O
EM2	X		X	X
SHM				
SHM1	Unspecified	Unspecified	O	Unspecified
SHM2			O	
SHM3			O	

23.4.3 Environmental Protection Measures

Environmental protection measures weigh heavily in the Guidelines, which requests for the implementation of seven aspects, including dust, noise, light pollution and so on. In line with these seven aspects, this study selected 20 specific technical measures for comparison, which are described as follows:

1. Dust control (DC)
   DC1—To avoid polluting the external environment during the process of materials delivery
   DC2—To limit the level of dust emission
   DC3—To plan the measures for controlling the dust from mechanical or explosive activities
2. Noise and Vibration Control (NVC)
   NVC1—To control on-site noise
   NVC2—To use low-noise and low-vibration tools
3. Light pollution control (LPC)
   LPC1—To adopt lampshade for night lamp during construction
   LPC2—To provide shielding measures for welding activities
4. Water pollution control (WPC)
   WPC1—To meet the national wastewater discharge standard (GB8978-1996)
   WPC2—To provide measures for sewage treatment
   WPC3—To monitor the standard of wastewater

Table 23.3 Comparison of the environmental protection measures

Measures	Case projects			
	A	B	C	D
OM				
OM1	Unspecified	Unspecified	O	O
OM2			O	O
PM				
PM1	Unspecified	O	O	O
PM2	Unspecified	Unspecified	O	O
AM				
AM1	O	O	O	O
AM2	O	O	O	O
AM3	O	O	O	O
EM				
EM1	O	Unspecified	O	O
EM2	X		X	X
SHM				
SHM1	Unspecified	Unspecified	O	Unspecified
SHM2			O	
SHM3			O	

WPC4—To protect the groundwater environment

5. Soil protection (SP)
   SP1—To protect the surface environment of the land and preventing from soil erosion
   SP2—To recycle the toxic waste
   SP3—To restore the destructed vegetation land
6. Construction Waste Management (WM)
   WM1—To produce waste reduction plan
   WM2—To achieve the rate of 30 % for waste reuse and recycle
   WM3—To provide enclosed garbage containers
7. Protection for underground facility and resources (UFR)
   UFR1—To plan the measures for protecting the underground facilities
   UFR2—To plan the measures for protecting the historical trees
   UFR3—To analyze the CO_2 emission

The application of these measures in the four case studies are shown in Table 23.3.

It can be seen that the specifications of dust control, noise control, vibration control, light pollution control and water pollution control are well practiced in practice. There is a need for efforts to improve waste management and monitor the quality of water. In particular, the management in the organization needs to give due attention on these areas.

23.4.4 Material Savings and Resource Utilization Measures

The Guidelines specifies five areas on materials saving, and each areas include various specific specifications. This study refers to the four sample projects and examines 26 specifications under the five areas, which are addressed in the follows:

1. Materials saving measures (MS)
   MS1—material loss is 30 % lower than the norms
   MS2—proper arrangements for the purchase of materials and the time for delivery to site
   MS3—material stacked orderly
   MS4—transport of materials properly to avoid double handling
   MS5—the procurement of materials within 500 km more than 70 %
2. Structural Materials (SM)
   SM1—use of ready-mixed mortar
   SM2—use of high-strength reinforced and high-performance concrete
   SM3—reinforcement steel processing and distribution
   SM4—optimal method for materials cutting and installation
   SM5—optimal method for special construction activities
3. Maintenance materials (MM)
   MM1—applying the materials with weather-bearing and good durability
   MM2—insulation and soundproofing of doors and windows
   MM3—insulation of accessory materials
   MM4—structural solution for the insulation system
4. Decoration Materials (DM)
   DM1—overall layout of veneer materials
   DM2—use of new materials
   DM3—meeting the requirements for adopting sewage coating grassroots
   DM4—synchronization of the embedded components with construction
   DM5—procurement for wood products and glass lamp from manufactures
   DM6—reduction in using liquid adhesive on site
5. Replaceable Materials (RM)
   RM1—Durable and easy for maintenance and demolition
   RM2—Production of formwork by professional firm
   RM3—Using steel formworks or steel-framed bamboo formworks
   RM4—Optimal the methods of using formwork
   RM5—Replacement of concrete formwork with the external wall insulation board
   RM6—Applying multiple-uses and moveable site office

The application of these measures in the four case studies are summarized in Table 23.4.

It can be seen from Table 23.4 that the project B adopted fewer measures for materials saving and resource utilization, while the projects A, C, and D are found adopted more measures for materials saving, structural materials and recyclable

Table 23.4 Comparison of the material savings and resource utilization

Measures	Case projects			
	A	B	C	D
MS				
MS1	O	Unspecified	O	O
MS2	O		O	O
MS3	X		X	O
MS4	O		X	O
MS5	X		O	X
SM				
SM1	O	X	X	O
SM2	O	X	X	X
SM3	X	X	X	X
SM4	X	O	O	O
SM5	O	X	X	X
MM				
MM1	Unspecified	Unspecified	O	O
MM2			O	O
MM3			O	X
MM4			X	X
DM				
DM1	Unspecified	Unspecified	Unspecified	O
DM2				O
DM3				O
DM4				O
DM5				O
DM6				O
RM				
RM1	O	Unspecified	O	O
RM2	X		X	X
RM3	X		X	O
RM4	O		X	O
RM5	O		X	X
RM6	O		X	O

materials. Among them, the projects A and D put more emphasis on the optimization and use of recyclable materials, with particular focus on the optimization of using formwork. Regarding maintenance materials and decoration materials, the project C adopted due measures. There are three reasons behind this: Firstly, according to the existing building energy efficiency design specification, it is required to apply insulation and sound insulation in order to meet these standards. Maintenance materials and insulation materials should both comply with the relevant norms and standards, so there is no need to add additional measures; Secondly, these two technologies are not difficult for application, and they have gained the popularity in practice; Thirdly, China Construction Industry Association developed a Checklist of the National Construction on the Implementation of Green Construction Demonstration Projects, upon which the two items assumes lower score, thus they do not attract attention from construction firms.

23.4.5 Water Saving and the Utilization of Water Resources

The Guidelines specifies three areas on water saving and water resourcing, including improvement of water utilization efficiency, use of non-traditional water resources, and water use safety. Each areas include various specific specifications. This study refers to the four sample projects and examines 9 specifications under the three areas, which are addressed in the follows:

1. Water utilization efficiency (WUE)
   WUE1—use of advanced water-saving construction techniques
   WUE2—reducing the use of municipal tap water
   WUE3—proper arrangement for water supply network
   WUE4—water recycling device and its use
   WUE5—water quota and measurement
2. Non-traditional water resources (NTW)
   NTW1—use of foul-water and collection of rainwater harvesting
   NTW2—use of underground water
   NTW3—use of non-traditional water and recyclable water for more than 30 %
3. Water use safety (WUS)
   WUS1—test of water quality and water safety measures

The application of these measures in the four case studies are summarized in Table 23.5.

It can be noted from the above table that the importance to efficiency of water use, especially to the reduced use of municipal tap water has been considered across all the four sample projects. Project D, in particular, planned properly the water use arrangement on site. The advantage of the height difference of the terrain was fully taken to collect rainwater, along with the establishment of a collecting pool for hydrocephalus in pits and the rinse water for pumps. In this project, water metering system was established, water saving statistics was properly recorded, and the project was considered well meeting the requirements of the Guidelines for improving water use efficiency.

Furthermore, the practice of using non-traditional water sources was implemented across all the four surveyed projects, especially the collection of rainwater and proper use of underground water. For ensuring the quality of water sources particularly the non-traditional water and recycling water, effective water quality testing and health protection measures should be provided in order to avoid adverse effects

Table 23.5 Comparison of water saving practice

Measures	Case projects			
	A	B	C	D
WUE				
WUE1	O	O	X	O
WUE2	O	O	O	O
WUE3	X	X	X	O
WUE4	O	X	O	O
WUE5	X	X	X	O
NTW				
NTW1	O	O	X	O
NTW2	O	O	O	O
NTW3	X	X	X	X
WUS	O	Unspecified	Unspecified	Unspecified

on human health. In this regards, the project A provided adequate facilities for this, and projects B, C and D did not specify how the water quality can be assured.

23.4.6 Energy-Saving and Energy Use

Energy-saving and energy use is addressed in the Guidelines in four areas, including the energy-saving measures, Management for equipment and tools, temporary facilities for living and production, and electricity for construction and lighting. The detailed specifications for investing the four case studies are as follows:

1. Energy-saving measures (ESM)
   ESM1—To define the norms of energy consumption for construction
   ESM2—To provide Energy-saving construction equipment
   ESM3—Set standards for electricity control and measurement in different allocations
   ESM4—Optimization of equipment resources
   ESM5—The use of renewable energy
2. Management for Equipment and Tools (MET)
   MEM 1—Establish equipment management system
   MEM 2—Selection of adequate mechanical equipment
   MEM 3—To improve the utilization and load rate for equipment
3. Temporary facilities for production and living (TFPL)
   TFPL1—proper design for temporary facilities, attention to sunlight, ventilation and lighting
   TFPL2—use of energy-saving materials
   TFPL3—regulating the number of air conditioning facilities and their use time
4. Electricity for construction and lighting (ECL)

Table 23.6 Comparison of energy-saving and energy utilization measures

Measures	Case projects			
	A	B	C	D
ESM				
ESM1	O	X	X	X
ESM2	O	O	X	O
ESM3	X	X	O	O
ESM4	O	X	X	O
ESM5	X	X	X	O
MET				
MET 1	O	O	O	O
MET 2	O	X	X	O
MET 3	O	O	X	O
TFPL				
TFPL1	Unspecified	Unspecified	Unspecified	X
TFPL2				X
TFPL3				O
ECL				
ECL1	O	O	O	O
ECL2	X	X	X	X

ECL1—use of energy-saving lighting appliances
ECL2—illumination ≤20 %

The applications of these specifications in the four sample projects are summarized in Table 23.6.

As seen from Table 23.6, the construction enterprises have given proper attention to energy conservation measures. Various measures for ensuring the availability of construction equipment and their management are adopted across all the four sample projects. Nevertheless, the temporary facilities for production, living and site office vary between different projects because of the restrictions by the topography and site size. The projects A, B and C are absent of the relevant instructions, and even D that can only provide the air conditioning configuration requirements and the restrictions on the use of time.

23.4.7 *Land Saving and Land Protection During Construction*

The Guidelines specifies three areas for land saving and land protection during construction, including land quotation for temporary use, land protection for temporary use, and construction site plane. There are 11 specific measures specified under the three areas, which are described as follows:

Table 23.7 Comparison of land saving and protection during construction

Measures	Case projects			
	A	B	C	D
LQT				
LQT1	Unspecified	Unspecified	O	O
LQT2	Unspecified		X	X
LPT				
LPT1	Unspecified	Unspecified	O	O
LPT2			X	O
LPT3			X	O
CL				
CL1	Unspecified	Unspecified	O	O
CL2			O	O
CL3			O	O
CL4			X	O
CL5			O	O
CL6			O	O

1. Land quotation for temporary use (LQT)
   LQT1—proper provision of temporary facilities and design for them for minimum land area
   LQT2—utilization rate of temporary facilities >90 %
2. Land protection for temporary use (LPT)
   LPT1—reducing the amount of excavation and backfill
   LPT2—try best to use wasteland
   LPT3—protect the existing green vegetation
3. Construction layout (CL)
   CL1—make full use of the existing buildings, roads for temporary facilities
   CL2—shorten on-site transportation distance
   CL3—meet the need for the temporary office and living room
   CL4—use movable fences in construction site
   CL5—proper road system on site
   CL6—avoid dismantle and moving of temporary facilities

The applications of these specifications in the four sample projects are summarized in Table 23.7.

From Table 23.7, it can be seen that some projects such as A and B do not have proper measures for protecting land during construction, whilst projects C and D have established various measures for ensuring that land is proper used and protected for temporary facilities during construction. In fact, temporary facilities during construction process can have major impacts on land pollution, thus good efforts must be contributed by senior management in construction organization to this important aspect.

Table 23.8 Measures of Green Construction Techniques

Measures	The scores on various aspects for green building					
	The score in the guideline	The score by A	The score by B	The score by C	The score by D	Average compliance (%)
Construction management (M1)	12	6	3	11	8	58
Environmental protection (M2)	20	10	4	13	16	53.7
Material utilization (M3)	26	10	1	9	17	35.6
Water utilization (M4)	9	6	4	3	6	52.8
Energy saving (M5)	13	7	4	3	9	44.2
Land protection (M6)	11	0	0	7	10	38.6
Total techniques (T)	91	39	16	46	66	45.9
Rate of adopted techniques (Pi) (%)	100	42.8	18	50.5	72.5	

23.5 Discussion

The above sections have demonstrated the application of various measures in the four sample projects under the six categories, namely, green construction management, environmental protection, materials utilization, water utilization, energy saving, land protection. The Guideline has specified various number of techniques for each categories for awarding green building. However, in reality, the measures in each categories are not fully implemented in practice. For example, the Guideline has specified 12 technical points (12 scores) for the category Construction Management, as shown in Table 23.8. However, the sample project A only receives 6 score in this category, and B with 3, C with 11 and D with 8. Table 23.8 provides the summary of the application status in applying the Guidelines between the four sample projects.

23.6 Conclusion

Implementation of green construction requests for the full cooperation between construction stakeholders including contractor, client, government department and various professional bodies. The Guidelines for implementing green building is available, but this study suggests that the measures and specifications in the Guidelines are not well applied by construction industry. The four sample projects examined in this study show that green performance can be achieved if good efforts are contributed throughout the organization, particularly, the efforts from senior management are essential to ensure the application of green practice.

This study also demonstrates that the grading system defined in the Guidelines provides effective mechanism for promoting green performance. The analysis in the paper suggests that those projects with good compliance with the Guidelines would receive higher grade of green building. The effectiveness of the Guidelines will be further studied with collecting more sample projects in the further stage of this study.

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Chapter 24
Theoretical Exploration of Construction Site Management Practices

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Abstract The construction industry is vital to the existence of other industrial sector and provides the environment under which other sectors operate. It is the largest industry and contributes about 10 % of the gross national product (GNP) in industrialized countries. It also plays a major role in development and reaching the goals of society. The current study aims to identify the factors required in the management of good site management on construction sites in Swaziland. The study is conducted with reference to existing theoretical literature, published and unpublished research. The study is mainly a literature review/survey on site management practices on construction sites. Findings emanating from the study reveal that realistic studies have identified a number of problems on site management practices such as management and administration problems, technical problems and communication problems. It also indicates that site management involves a mixture of activities which turn basic sources to a finished product. The study presents a strong background on site management practices on construction sites in the Swaziland construction industry.

Keywords Construction industry · Site management · Swaziland

24.1 Introduction

Construction industries are currently faced with the problem of securing sufficient work to remain viable in an industry that contains many companies capable or at least willing to undertake almost any type of work for clients (Harris and McCaffer 2001). Construction projects represent some of the largest and most complex undertakings known when completed. It could be viewed in two forms, the tech-

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nical (in terms of concrete, steel, wood and pipes) and the complex set of roles and relationships (how the contract is planned, administered and managed) without which nothing could be achieved. These roles and relationships include how the participants interact with each other so that the project is a success and how they resolve tricky issues encountered during the course of the project Gilbreath (cited in Obiegbu 2002). According to Mohammed and Anumba (2006) there is an increasing number of construction organizations that are applying project improvement initiatives to improve their performance. The fundamental objectives are to deliver construction projects to the required quality more quickly and improve project performance. Unfortunately, practice is not that simple as construction work has become more complex technically and administratively, and there are several challenging engineering and management problems that occur on the site. The aim of the paper is to identify the factors required in the management of good site management on construction sites in Swaziland. The paper starts with an overview of the concept of site management practices, followed by an explanation of the methodology design; presentation of the findings before conclusion are drawn.

24.2 Theoretical Literature on Site Management Practices

Site management practice is defined as a fundamental integrating process used to achieve organised and purposeful results in the area where building or construction work is being carried out, whether it is within, adjacent to, or separate from an existing occupied building. The main function of a site management team is to organise, inform, coordinate, order, instruct and motivate others to undertake site activities (Ashworth 2001). Generally, the site management team has responsibility for:

- General control of all activities on the site (Newcombe et al. 1993).
- Production management in respect of the work undertaken by the main contractor and carried out directly on site (Santos 2002).
- Control of sub-contractors and specialists on site (Holroyd 1999).

According to Walker (1997) there are three most important factors considered by a site management team to be 'critical success factors' in measuring their performance. These include: completion on time; completion within budget; and attaining the specified quality level. When designing a formal system for site management, the ranking of the functions and the critical success factors should be addressed. This is necessary if high quality site management is to be attained. The site management team is also responsible for maintaining accurate records of the important happenings on site. The information should be properly recorded, so that whenever necessary it can be quickly retrieved for future use.

Site Management on construction sites involves a mixture of activities, which turn basic resources into a finished product (Mohammed and Anumba 2006).

Bamisile (2004) drew attention to the fact that the effectiveness of managing production process cannot be economically attained by force, but requires the creation of conditions that will encourage self-motivation and bring about team spirit that is important to an efficient project execution. Obiegbu (2012) indicated that construction can be seen as the conversion of raw resource inputs into defined functioning output, by means of a managed process. Construction activities can range from organization of the materials, labour, and other resources on the site activities which control the flows of information and finance (Mohammed and Anumba 2006). The construction site is, therefore, seen as a key area where money is made or lost and where there is considerable scope for improving efficiency, productivity and quality. Obiegbu (2012) highlighted the following reasons why practicing of good site management is imperative:

- Ensuring the most efficient and effective use of resources;
- Maintaining high standard of quality and workmanship;
- Maintaining high standard of health and safety on building sites; and
- Building trust and good relations with suppliers, other professionals and support organisations which leads to fewer problems, delays and disruptions.

According to Mohammed and Anumba (2006) site management practices is made up of the following six sub-processes:

- Management, supervision, and administration of sites: Including correspondence, minutes, labour allocations, payroll, progress reporting, notices/claims, instruction, drawing register, and technical information.
- Commercial management: This covers estimating, valuations, sub-contracting, payment, variations, day works, cost-value reconciliation, final accounts, and cash flow management.
- Legal, health and safety: Management of legal, health and safety requirements on sites. This considers safety policy, insurance and building regulations.
- Planning, monitoring and control: This covers all activities associated with project planning and scheduling, typically the production of Gantt charts, network analyses, method statements, resource levelling, progress reports and exception reports.
- Delivery and materials' handling: The activities associated with the management of deliveries and the subsequent handlings of materials on site are covered including requisitions, purchase orders, material call off, and plant returns.
- Production on-site and off-site: This considers activities supporting production such as testing, setting out, dimensional checks, and plant maintenance.

Bamisile (2004) opine that the effectiveness of managing the production process according cannot be economically achieved through the use of force but through creation of conditions that will encourage self-motivation and create team spirit which is efficient to project execution.

24.3 The Role and Responsibilities of Construction Site Managers

The main responsibility of construction site managers is to put together an effective team, as well as dealing with outside influences such as the local labour market, competitors, local authorities and suppliers (Newcombe et al. 1993). Griffith and Watson (2004) see the main roles of construction site managers as: forecasting, planning, organising, controlling, motivating, coordinating and communicating. Furthermore, Styhre and Josephson (2006) take the view the site manager as a project leader who is responsible for a number of different activities and processes including production planning, procurement, administration, staff management activities, leadership works, and meeting with stakeholders such as clients, end users and customers. In terms of responsibility, Djerbarni (1996) found that construction site managers carry out one of the toughest and hardest jobs in the construction industry. Site management is characterised by a high work overload, long working hours, and many conflicting parties to deal with, including (amongst others) management, subcontractors, subordinates, and the client. Moreover, Mustapha and Naouni (1998) argue that the site manager stands at the heart of the success or failure of a project. In the project context, the site managers are assigned an intermediary role between the 'thinking' (top management) and the 'doing' (subordinate workers). Styhre and Josephson (2006) suggested that the experience of being stuck in between project objectives and day-to-day administrative routines has imposed an additional workload on site managers and caused some concerns. The site manager is responsible for directing and controlling all on-site activities within the limits of the organisational hierarchy. Therefore, how they spend their time is of critical importance. Griffith and Watson (2004) revealed that 25 % of the site managers' time was being spent on administrative duties, instead of concentrating on managing the site more effectively. Construction site managers must have certain skills such as managerial skills and the competencies to overcome daily problems and constraints on the construction site. According to Newcombe et al. (1993), an effective site manager needs the certain skills which are essential ingredients for managing the construction site.

24.4 Components of Site Management Procedures

Effective site management procedures provide the foundation for a successful construction project. The key components of site management procedures contributing to the success of a project are: the site organisation; site policies and procedures; planning; supervision; and meetings and reports (Newcombe et al. 1993).

24.4.1 Management, Supervision and Administration of Sites

For any construction project it is a fundamental need to have appropriate management of the site. Basically, all the information collected on site needs to be referred back to the Head Office. It must be submitted on time so that the department receiving it can process the information. The site management team will have required timings and calculations for such items as the following: wages, plant, materials received on a weekly basis; valuations, sub-contract details on a monthly basis, and correspondence and general information as necessary. Although the site management team will receive information on costs on a monthly basis, wages arrive weekly, and general data also arrives weekly. For the purposes of communication it is customary for site managers to design suitable standard forms to be used in as many situations as necessary and which everyone finds easy to understand (Forster 1989). Important information includes correspondence, minutes, RFIs, labour allocations, payroll, progress reporting, notices or claims, instruction, drawing register and technical information.

24.4.2 Commercial Management

It is important for construction site managers to fully appreciate that commercial management is essentially a management technique, not a quantity surveying technique. A cost control system should be designed so that it enables the site management team to satisfactorily collect and produce information from which the monitoring of actual costs can be compared to estimated costs. This covers estimating, valuations, interim payment, variations, day works, cost-value reconciliation, final accounts and cash flow. To get maximum benefits from the system that the site management team employs, crucial actions are required (Griffith and Sidwell 1995).

24.4.3 Health and Safety Management

Effective health and safety (H&S) management is founded on the provision of a safe and healthy working environment with safe systems of work at its core. The key to success is to ensure that H&S aspects are carefully considered and the risk of danger and hazard to persons, as a result of site activities, is systematically safeguarded. According to Mohamed (2002), the major causes of accidents on site have been identified and can be directly attributed to unsafe design and site. H&S management on the construction site should include the following: safety policy; COSHH and CDM regulations, insurance, building regulations, British Standards and Codes of Practice. The achievement of the H&S management implemented is evidenced in the effectiveness of information gathering through monitoring and the methods by which it is recorded. Different organisations will have their own procedures for documenting H&S activities on site. Typical approaches include the use of a set of forms which are completed by supervisors and operatives as elements of the H&S plan are implemented (Griffith and Watson 2004).

24.4.4 Planning, Monitoring and Control

Planning is the process of determining, analysing, devising and organising all resources necessary to undertake the project. The core element of planning is the establishment of a programme which reflects the planning process in relation to real time (Griffith and Watson 2004). In practical terms, construction planning is the total process of determining the method, sequence, labour, plant, and equipment required to undertake a building project. It is also to obtain the necessary volume and speed of output, and ensure quality. Harris and McCaffer (2001) argued that construction planning involved two main elements: method study and work measurement. The method study is to record work procedures, provide systems of analysis and develop improvement. It gives improved planning and control and better use of material, plant and manpower. The work measurement is the measurement of the time required to perform a task so that an output standard of production for a worker and machine may be established. The main aim is to assess human effectiveness to production planning, estimating and incentive scheme on site. This covers all activities associated with project planning and scheduling, typically the production of a Gantt-chart, network analyses, method statements, resource levelling, progress reports and exception reports.

24.4.5 Delivery and Materials Handling

This process is to bring to the project the appropriate materials at the right time, quantity and price to enable the construction work to proceed according to programme and to the necessary quality standards (Newcombe et al. 1993). There are four types of information considered useful for the delivery and materials' handling process: the specification, the contract drawings, the bill of quantities and architect's instruction issued during the construction. The activities associated with the management of deliveries and the subsequent handlings of materials on site are covered including requisitions, purchase orders, material call off, and plant returns. Clearly a site manager or his/her sub-ordinate has to carry out a crucial task to monitor the performance of materials on-site including quality and quantity checks on arrival. The quality checks include: visual checks on all materials; examination of ready-mixed concrete by hand for texture and check using slump tests; and carry out visual and handling checks on bricks and the like for broken edges. The quantity checks can be by: a site or public weighbridge, counting and volume checks. According to Holroyd (1999) site control measures should be kept by the site manager.

24.4.6 Production on and off Site

Applying quality procedures to production on-site and off-site will enhance quality levels by reducing defects. Examples of activities supporting production include Quality Assurances (QA) plans and report, contract terms, drawings, specifications, setting-out and measurements. The QA plan is important for the site management team to have as a benchmark against which to control quality on site. QA focuses upon consumer protection and offers clients an assurance that the building has been built properly under satisfactory conditions of quality controls and that the building has been judged suitable for its intended use.

24.4.7 Problems on the Construction Site

There are several challenging engineering and management problems that occur on construction sites. These problems affect the time, budget and plans, and specifications (Trauner 1993) and often cause defects, disputes and delays (Clarke 1988). According to Holroyd (1999) many construction site procedures and methods have not changed over the years and the same mistakes are being repeated. The main reasons are because the site management is characterised by high work overload, long working hours and many conflicting parties to deal with, including the management of the sub-contractors and liaison with the clients (Griffith and Watson 2004). For instance, the problems identified within site management practices can be categorised into three: management and administration problems; technical and engineering problems; and site communication problems.

24.4.8 Management and Administration Problems

Most site organisations have policies which lay down procedures for the site managers to observe regarding management and administration problems. These problems have to be addressed in order to ensure that project objectives are achieved. Additionally, there is a wide range of constraints which could occur on-site and the site managers should be prepared to deal with each of them in a systematic and efficient way. This can be achieved through training or education on how to deal with the unexpected (Forster 1989).

24.4.9 Technical Problems

Plant problems: Maintenance of construction plant and plant management (Ogunlana and Olomolaiye 1989). Many construction organisations tried to avoid these costs by providing the minimum of maintenance, which has often resulted in unexpected breakdowns, lost production and inefficient machinery (Harris and McCaffer 2001). Piling construction: Methods used for recording the pile information may duplicates effort and potentially places the integrity of the pile at risk. Data transfer errors made from the schedule and miscalculation during pile construction can result in nonconforming piles being constructed, leading to additional costs, delays, and client dissatisfaction (Ward et al. 2003). Existing services: The utility services such as existing sewers, water distribution pipes, electricity cables, gas mains and telecommunications cables can disrupt construction works (Illingworth 2000).

24.4.10 Communication Problems

The nature of the relationships was the main factor behind the poor communication; as a result of the historical development and fragmentation of trades, professions and responsibilities. In fact, top management often do not know what was happening on site (Tah and Carr 2001; Barber et al. 1999). Communication difficulties often occur during the construction stage because it is here that the level of information available to all parties reaches its peaks. However, Emmit and Gorse (2003) suggested that as information is received from structural engineers, architect, mechanical engineers, and other consultants, discrepancies, drawings should be expected, and checks should be made to find where instructions are incompatible. Any problems must be reported to the contract administrator and meetings should be held with the aim of quickly resolving any differences. In addition, developments in information technology and communication have changed organisational communication. Information is now available to site managers and other employees faster, more reliably and in larger quantities than before. Information now has to be systematically managed and information networks carefully designed and monitored (Fryer 2004).

24.4.11 Management Approaches to Improve Construction Site Management

According Griffith and Watson (2004) successful organisations are those that have drastically changed or re-engineered their business processes. Consequently, other industrial sectors such as manufacturing and petrochemical industries are commonly able to benefit from better prospects in attracting skilled workers, either by providing superior working conditions or in being able to pay higher levels of remuneration. Improvement of the construction site management processes has focused on attempts to change practices to be more responsive to customers and to improve performance in quality, time, speed and reliability, while reducing production costs. There are several management approaches implemented to improve construction site management. These approaches include total quality management, just-in-time, business process re-engineering, concurrent engineering and knowledge management.

24.5 Findings and Lesson Learnt

Findings from the review of literature reveal that the effectiveness of managing construction site production process can economically be achieved through creation of conditions that will encourage self-motivation and the creation of team spirit which is efficient to project execution but not through force. Also, the site manager was found to be responsible for directing and controlling all on-site activities within the limits of the organisational hierarchy and must have certain skills such as managerial skills and the competencies to overcome daily problems and constraints on the construction site. As an essential ingredients for managing the construction site, an effective site manager needs some skills to provide the foundation for a successful construction project. It is also customary for construction site managers to design suitable standard forms to be used in as many situations as possible which every employee will find easy to understand for the purposes of communication. They also need to some crucial actions in order to get maximum benefits from commercial management. Unsafe design has been identified to be the major causes of accidents on site. There is the need for planning, control and measurement on site to assess human effectiveness, as well as performance monitoring of materials on-site. Defects will also be reduced and quality levels enhanced when on and off-sites production is applied. Management and administration, technical and communication were identified as the major challenging engineering and management problems that occur on construction sites. Total quality management, just-in-time, business process re-engineering, concurrent engineering and knowledge management are the required approaches by management to improve construction site management.

24.6 Conclusion

It can be concluded from the findings that effective management of the production process cannot be economically achieved through force. The construction site manager is responsible for directing and controlling all on-site activities within the limits of the organisational hierarchy and must have skills to provide the foundation for a successful construction project. Total quality management, just-in-time, business process re-engineering, concurrent engineering and knowledge management can be used to solve the major challenging engineering and management problems on construction sites.

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Chapter 25
Are Green Project Management Practices Applicable to Traditional Projects?

Andrew Hand, Jian Zuo, Bo Xia, Xiaohua Jin and Peng Wu

Abstract As the social environment begins to create more awareness in the area of conserving the natural environment, a new generation of building has emerged. A trend of constructing buildings that minimise impacts on the environment has been established in the construction industry. Therefore, suitable project management practices have been adopted to efficiently manage the construction of these green buildings. This study aims at investigating practices of project management in traditional and accredited green construction projects, with the purpose of discovering if Green Project Management (GPM) practices can be applied to traditional projects to achieve more successful outcomes. The process of GPM contains what applied to traditional projects, could possibly result in benefits in terms of budget control and constructability. Currently the construction industry has been known to suffer difficulties within these areas; therefore GPM practices could possibly hold a solution to these common problems.

Keywords Green project management · Traditional projects · Contractors

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25.1 Introduction

The construction industry is changing paradigm that is influencing the way buildings are constructed. As time progresses, the construction industry is being held accountable for the impacts of construction activities on the environment, which is one of the most significant out of all sectors in the economy (Zuo et al. 2012). This has pushed the need for construction companies to start thinking about how they can reduce impacts on the environment during construction and motivating clients to think about adapting sustainable building designs. Growing social and economic trends are also creating drivers to the endorsement of sustainable technologies, as the general public begins to adapt to the thought of sustainable living. This is a growing public concerns on environmental issues, therefore it can be predicted that the need for more sustainable buildings will become a priority in the future. A focus been placed on the working environment that buildings create for their occupants, which motivates the green building developments.

The development of green buildings takes on a different process to that of standard building projects. There are various concepts and certification processes that will need to be considered in order to construct a functional building without exceeding cost parameters and profitability margins. The role of a Project Manager in these projects is vital to ensure project success, as a much more integrated approach is required when compared to traditional project management methods. Identifying the differences in Project Management procedures between standard and sustainable construction is vital to delivering a green project on time and within budget, as failing to do so may result in major problems and implications for all stakeholders involved. As social and economic pressure builds on clients to develop green buildings, more focus will be placed on the methods involved to construct these buildings. This study aims to investigate whether or not it is feasible to apply green project management practices in traditional projects.

25.2 Literature Review

25.2.1 Early Team Integration

In order to achieve sustainable goals, a building must be considered and analyzed over its whole life cycle. This will include assessing the buildings purpose in the future refurbishments, as creating a building that is multi-functional and can be adapted to different uses can reduce its impact on the environment (Huang et al. 2012).

During the conception phase of a project, clarification of project and client goals must be conducted in order to get a scope of the overall project (Kurland and Zell 2011). Establishing these green goals from a managerial level early in conception will form a solid basis for the project to work towards, and can be achieved through integrating the construction and design teams as early as possible. It is evident that a fundamental activity in the production of a green building project is an initial meeting with all project stakeholders to set goals and discuss limitations of the project in formulation. This pre-design meeting is a way of integrating the project team early and involves the input of all stakeholders such as project managers, estimators, ESD consultant, and contractors.

A common issue in relation to construction costs within a project is closely linked to the relatively isolated technical services each team (e.g. engineers, architects etc.) can offer to the building project (Robichaud and Anantatmula 2011). It is common in construction for each specialized consultants to provide their service without much consideration to the trades to follow. Nominated as the "silo effect" by Robichaud and Anantatmula (2011), this separation of the technical consultants makes it difficult to create a project that contains costs through looking at the development in a "holistic" sense. Improving the communication between these trades to construct a project with a common goal in mind can significantly help to mitigate costs.

25.2.2 Procurement Methods

The design and delivery of a green building project must be considered early with the project conception, similar to the formulation of the green project goals (ASHRAE GreenGuide 2006). In order to optimize the best outcome for the building project and its stakeholders, an evaluation must be undertaken to decide how much control is desired over critical areas of the project such as design, cost and risk allocation (ASHRAE GreenGuide 2006). Each specific project will have different requirements in regards to building procurement.

The procurement of a "green" building project may not always differ that greatly from that of a traditional project. The specific methods of project procurement such as Design and Build or Design-Bid-Build contracts can be applied to all forms of construction projects to achieve successful outcomes, however, ultimately it will come down to the preferences of the client or major stakeholders as to what procurement method is selected (Walker and Rowlinson 2008).

25.2.3 Trade/Material Selection

Although the construction of green projects is becoming a more common practice, barriers still exist which is limiting the adaptation of the new technology. According to Hwang and Tan (2012), one of the main barriers limiting this new building process is the high initial costs to the developers and contractors. As green technology is relatively new, the cost of the required materials and the processes involved still remains relatively expensive, creating greater risk for associated stakeholders. The unexplored nature of the green building industry also creates a lack of information on green building products, causing further barriers to this building design.

This speculates a barrier to green construction being within the building contractor's willingness to absorb these additional costs of construction, when they are unlikely to receive the benefits of lower running costs after the building commissioning (Hwang and Tan 2012). Developers must absorb the high cost premium for the construction process whilst only the tenants will receive the majority of the benefits. The cost of these additional risk costs cannot readily be passed on the tenants, although it is common for contractors to allow for this risk in their tenders. The lack of information on green products will commonly require the addition of a green building consultant, further elevating the costs of sustainable construction to the developer (Hwang and Tan 2012).

25.2.4 Commissioning and Handover

The commissioning of a building project is a process that essentially should be implemented throughout all stages of the construction process (predesign, design, construction, acceptance and commissioning). This implementation across the whole building timeline is especially crucial in green building construction, as it forms a part of quality control methods to ensure the "green goals" of the project are consistently kept in check and all requirements are met (ASHRAE GreenGuide 2006). In order to understand what is required on a building project and to continually work towards meeting these goals, an "owners project requirement" (OPR) must be provided by the owner. This document will state the functional requirements of the project and how it is intended to be used and operated. Commonly this document is also provided in the bidding documents provided during project procurement (ASHRAE GreenGuide 2006). The information commonly included in a typical OPR is: project and design goals, measurable performance criteria, budgets, schedules, and success criteria.

Once all quality control commissioning has been conducted and the construction phase is completed, it is important that adequate handover be conducted to the new buildings occupants. In both green accredited buildings and traditional projects the importance of ensuring and documenting that all building systems and assemblies perform in accordance with the contract and relevant specifications. This documentation is especially crucial from a contractor's perspective, as this will aid in protecting them from further legal issues. It is common that traditional buildings do not require as detailed handover requirements in relation to building system overviews.

Table 25.1 Profiles of interviewees

Interviewees	Organization
Interviewee A	Contractor
Interviewee B	Engineering consultant
Interviewee C	ESD consultant
Interviewee D	ESD consultant
Interviewee E	Contractor
Interviewee F	ESD consultant
Interviewee G	Engineering consultant
Interviewee H	Contractor
Interviewee I	Architect

25.3 Research Methodology

Semi-structured interviews were undertaken with selected interviewees to solicit their views on the feasibility of applying GPM theories to traditional projects. Interviewees were selected based on their experience relative to the delivery of both green building projects and traditional projects. A total of nine industry professionals were interviewed. Their profiles are shown in Table 25.1.

Main interview questions are:

- What are the differences between the project management of green buildings and traditional project management practice?
- What is required by Australian Green rating accreditation systems and how does this affect the Project Management of the building?
- What problems exist in traditional Project Management and GPM, and will these form barriers to adopting GPM practices?
- Can the principles of GPM practices be applied to traditional construction projects to achieve a more desirable outcome?

Each interview took around 1 h. The information collected is largely qualitative. Content analysis was conducted in order to highlight the emerging trends from the comments made by interviewees.

25.4 Findings

25.4.1 DIFFERENCES Between Green and Traditional Project Management

When directly compared to each other the differences between the project management of green buildings and traditional buildings emerge. The more complicated nature of green buildings requires a much more detailed documentation and construction process in order to achieve the requirements set out by the various accreditation systems such as Green Star. The more complicated design and construction process also involves a higher level of communication in order to ensure all ideas are communicated between the project team and ensure they are working towards the same goals.

An example of how this communication within the construction of accredited green buildings differs to that in traditional construction can be seen in the way the project is tendered. Commonly in GPM the client may utilize the skills of a nominated sub-contractor, as it is likely that a specific contractor would have been involved in the early pre-design stages of the project to give advice on constructability and scheduling issues. In cases where a constructability advice was given by a third party construction manager or consultant, it is likely that the project will take on an "open-book" tendering process, where all information describing how the tender amount was achieved must be disclosed. This increased level of communication will improve the delivery of the project and return beneficial savings to the client and possibly the contractor. Tendering in a traditional construction project commonly takes on a "hard-bid" method, where the lowest tender will be awarded the contract. This can result in contractors severely cutting into profit margins purely to win the contract, possibly leading to a sub-standard product for the client.

It is possible that the differences discovered between GPM and Traditional PM are largely influenced by the impact of the relevant accreditation systems such as Green Star. The Green Star accreditation system specifically evaluates the use of accredited green professionals in the pre-design phase, along with the integration of green project goals throughout the project design and construction. Overall the process involved with the formation and construction of a green construction project seems to result in benefits to the stakeholders and members involved as the process appears much smoother. This is a direct result of the early integration of the project team to define common goals, and ensure they are upheld.

25.4.2 PROBLEMS Existing in Green and Traditional Project Management

In order to evaluate the benefits that could be received from adapting GPM practices to traditional construction projects, first the weaknesses of both PM styles must be evaluated and identified. A common problem was raised by a majority of the interviewees when asked what is the most common problem encountered in green building procurement. The majority of interviewees stated that too often the building design had been partially decided before the input of contractors, therefore it was difficult to approach the project with a "holistic" attitude. This reflects the separated approach that is commonly seen in traditional project management, as discussed in previous studies (Robichaud and Anantatmula 2011; Evbuomwan and Anumba 1998). Interviewee B stated that in the case where the construction team enters the project late in design, the perceived costs to achieve the green building goals can be overestimated due to either inexperience of the construction team, or inflated costs by the contractor to mitigate risk. This issue can in turn affect the tendering process for the project, and negatively impact the project profitability from a client's perspective.

Although it is preferred that the construction team be largely involved with the formulation of the building design, Interviewee D also brought forth an interesting point. He recommended that it would be beneficial for the design team to not have the issue of constructability forced upon them until at least the schematic phase, therefore allowing for more creative building designs. Interviewee D believes that in cases where constructability is considered too early in the design phase, the overall creativity of the design team's final design could be impaired. Interviewee D also stated that it is important the integrate the project team at the right time, as doing so will allow the design team to discuss and evaluate different strategies before the influence of the construction team is introduced. In turn Interviewee D was able to provide a problem that can be discovered in green building projects, as design teams may be negatively impacted when constructability is forced upon them early in their design. This calls the need for careful planning when integrating certain members of the project team. Through the influence of the Project Manager it may be possible to separately integrate team members to allow the design consultants time to propose and evaluate alternate ideas.

Once the building has been procured, issues within trade and material selection can be discovered. In traditional projects this may not always form a barrier to the project success, although green buildings rely heavily on material selection. Interviewee F stated that in regards to green construction, alternative material selections may be proposed by subcontractors. These alternative solutions must always be verified by an environmental consultant, but sometimes subcontractors will substitute materials without gaining proper consent. This can occur during both tender and construction phases and will often result in discrepancies and arguments when discovered. Interviewee D also provided an interesting insight in regard to the issue of alternative materials, stating that commonly within the industry there is a perception of "newer is better" and that overseas products are more sustainable or superior. As a result products are being sourced from overseas and local or established green building systems could be overlooked. Interestingly this is the exact opposite to traditional construction, which commonly disregards new innovations with a preference to stick to already trialed and tested building and operating systems (de Valence 2010). This issue discovered in green construction projects will not impact upon traditional projects in the same way, but it is important to note when discussing the problems existing in GPM. Another significant issue in GPM is presented by Interviewee C, providing details on the issue of poor documentation in regards to working drawings and specifications. Poor drawings and specifications can lead to the final product not complying with the target accreditation points, therefore expensive variations and remedial work must be done to achieve the goals, which can also make the delivery of the green building project very difficult. This will have a large impact on the project budget and time, which are vital to the level of success tin any building project. This problem can also be discovered in traditional building projects, and the consequences are relatively the same. Variations to design and specification as a result of poor working drawings and specifications can add to the project durations and consequently inflate the overall budget. This will also make handover to the new building tenant difficult.

When prompted on the problems and affects that the accreditation systems such as Green Star and NABERS had on the project management of a building, Interviewee A provided an interesting issue that can be associated with the Green Star system. Interviewee A stated that often in projects that are formulated to achieve green accreditation, a "point chasing" or formulistic approach is taken to the building design and management therefore in some ways the importance on achieving a good design or a sustainable design outcome can be lost in the chase to achieve as much accreditation points as possible. Along with the negative impact on design discovered through enforcing constructability on the design team too early; these factors can result in a green building design that is limited in its innovation.

25.4.3 INDUSTRY View of Applying Early Integration and Third Party Commissioning to Traditional Projects

After conducting interviews with relevant industry professionals it is evident that the early integration of a project team is becoming more desirable in construction projects. Out of the all the interviewees, each and every interviewee agreed that all construction projects could benefit from a more integrated approach. In addition to this, three interviewees stated that they expected this practice should be employed by Project Mangers in the industry today. The procurement method used in the building formulation will be important to adapting this GPM method. In most Design and Build procurement contracts a certain level of project integration is already achieved as discussed by Baiden et al. (2006), although as discovered from relevant interviewees, achieving a higher level of integration could be beneficial. Interviewees stated that the level of integration would be most beneficial to the design of the building, which is discussed in previous studies (Robichaud and Anantatmula 2011; Evbuomwan and Anumba 1998). This was also agreed by Interviewee F, stating that along with an improved design process, the ability of the project team to forecast possible risks and put in place management strategies was received from integrating the project team early in the design phase.

Interviewee B states that projects that follow a traditional Design-Bid-Build procurement approach will struggle to implement this theory, as commonly any input from a contractor will not be received until the project has been put out to tender and the project has been awarded to a specific company. As previously identified, the Design and Build procurement method provides the best method towards an integrated approach, although as a result the client may lose some control over the building design (ASHRAE GreenGuide 2006). This control can be somewhat regained through the use of an in depth RFP, therefore the client can achieve a solid integration of the project team whilst also retaining a large amount of control over the project design.

Many of the industry professional interviewed provided barriers to the adaption of this method to traditional construction projects, despite the benefits that can be received towards building constructability and accurate costs. Although agreeing that the benefits to the project would be present, the additional cost involved with integrating the construction team earlier in project conception cannot be ignored. An important point was also raised by Interviewee E, as he stated that often the client's perspective may prevent the integration of the project team early in conception, especially when it is hard to define the long term benefits to the project through doing so. Ultimately interviewees stated that the client's willingness to adopt the innovative idea would be the main barrier to overcome. As previously touched upon the type of procurement method will also form a barrier, as in contracts such as a traditional Design-Bid-Build the contractors will not largely be involved with the design process unless nominated by the client.

The possibility of a third party commissioning process in traditional projects was one that was commonly rejected by interviewees. Interviewee H agreed the reliability and benefits to be received from this process were valid, but in traditional construction projects where certain design and performance criteria may not be as crucial to the success of the building it would be hard to convince the client to incur the additional cost. In accredited green projects this style of commissioning is required to meet accreditation criteria and also ensure performance outcomes, but traditional projects require less stringent measures to ensure quality control. Interviewee G's response was also similar, stating the ultimately a third party commissioning process was an unnecessary additional cost when the same result can be received from a contractor or company based commissioner.

25.5 Conclusions

In conclusion, the principles and practices throughout the management of green building projects have qualities that make them compatible with traditional construction projects. This study revealed that the integration of a project team early in the construction phase can have a positive influence over the project as a whole. This early integration is forced upon green projects through the relevant rating systems and can impose additional costs to the projects, but I believe the benefits received as a result of these pre-design meetings in traditional projects will outweigh any direct costs incurred. The idea of adapting this process is evident in previous studies, but not explicitly expressed. However, achieving Green Star accreditation is a process that must be closely monitored, programmed and managed throughout the project similar to Quality Assurance and OHS&S, which in turn incurs additional costs in the form of attendance fees. It could be possible that the perceived additional cost associated with constructing green buildings comes from achieving the accreditation itself; therefore in traditional projects that don't require green accreditation it is unlikely a significant amount of these additional costs will be incurred.

The benefits to be expected from the integration of the project team will rely on the moment that the team is integrated. The design team should have significant time to evaluate and discuss alternative concept and design strategies before the issue of constructability is introduced into the equation. This allows for a more creative design process, rather than the input of construction consultants limiting design to an easily built building that may lack innovation. The result of a well-integrated team on overall success of a project can be significant. In turn a team with a holistic feel on the required outcomes work towards a defined outcome and can produce a project that considers the impacts of their actions on the trades to follow.

After evaluating the proposal of adapting a third party commissioning process to traditional projects, it is hard to argue there are any benefits to be received to a traditional project that are crucial to the success of the project as a whole. In accredited green building projects this third party commissioning is assessed in the Green Star rating system and also will be required to ensure that specific green building systems are operating at the desired performance, but traditional projects do not need to meet these stringent guidelines in relation to operational performance. The benefits of this process are recognized in previous studies, although the commissioning process can be undertaken by a contractor-commissioner and produce similar results, therefore, the additional cost to the client to hire a third party commissioner is hard to justify.

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Chapter 26
Case Study on CO_2 Emission by Construction of Structural Elements of a Residential Project in Singapore

Yingbin Feng and Yun Zhong

Abstract This paper provides a detailed examination of the energy consumption and CO_2 emission associated with the construction of structural building elements in Singapore. A case study of a residential project in Singapore is conducted. It is found that the transportation of concrete from supplier distribution centre to site accounts for 82% of the total CO_2 emission by main building materials transportation; the largest proportion of CO_2 emission is produced by operation of crane (56%) and lower one is produced by site lighting, office operation and workers' accommodation (20%). It is recommended that designers and contractors pay more attention to choosing lighter structural materials and using those technologies or materials with higher construction efficiency, which may be helpful for enhancement of the sustainable performance at construction sites and reduction of energy consumption and associated costs.

Keywords Site energy consumption · Site CO_2 emission · Sustainable design

26.1 Introduction

26.1.1 Background

26.1.1.1 Climate Change and Sustainability Concern

Climate change is one of the most important challenges in the world today. This kind of environmental recognition was first discussed in the 1973 United Nations

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Conference on the Human Environment in Stockholm. Furthermore, the ideas of sustainable development have been discussed in the 1980 World Conservation Strategy (WCS). The World Commission on Environment and Development (WCED) published a report called Our Common future in 1987. The report incorporated the sustainable development concept and became known as the Brundtland report and has since been widely accepted and quoted (Canada Wood Council 1997).

According to International Panel on Climate Change (IPCC), the global climate is influenced by the emission of four gases: CO_2, N_2O, CH_4 and CFCs. Since CO_2 emission takes more than 99% of the total gas emission during a building's life cycle, the value of CO_2 emission is the most sensitive indicator and need to be highlighted (Castro-Lacouture et al. 2008). Therefore, CO_2 emission has been widely used as one of the most important criteria for environmental impact evaluation.

26.1.1.2 Buildings Take a Large Part of CO_2 Emission

World Business Council for Sustainable Development (WBCSD) in year 2009 report that buildings today account for 40 % of the world's energy use (Chen et al. 2001; Cole 1999). This proportion expresses the huge potential of reduction energy consumption of buildings.

Chen, Burnett, and Chau also indicate that energy use in buildings accounts for nearly half of the total primary energy use in Hong Kong (CIRIA 1993). Until now, studies have primarily focused on energy conservation in building operation, even though recent research has indicated that the embodied energy used in residential buildings could account for up to 40 % of the life-cycle energy used in residential buildings.

As a responding, The International Energy Agency (IEA) calls for buildings to contribute 17 % of the total emission reductions below business-as-usual (BAU) in 2050.

26.1.1.3 Huge Potential for CO_2 Emission Reduction by Proper Structure Design and Construction

Elnimeiri and Gupta report that structure accounts for approximately 20–25 % of the total construction cost in a tall building (Dimoudi and Tompa 2008). However, it is resulted by Dimoudi and Tompa (2008) that the embodied energy of the structure's building materials (reinforced concrete) represents the largest component in the building's total embodied energy for both buildings, and the CO_2 equivalent emissions of the structure's building materials(concrete and reinforcement steel) represent more than 70 % of the building's total equivalent CO_2 emissions (Defra 2008). There is a huge potential for CO_2 emission reduction by proper structure design and construction. Therefore, sustainable issues should be incorporated in structure design and construction so that the overall architecture environmental performance can be enhanced.

26.1.2 Research Scope and Objective

26.1.2.1 Research Objective

Since designers face difficulties in establishing the relative merits of using different materials through a lack of information on the energy used in processing (Guggemos and Horvath 2005), it is important to conduct this study with the following objectives:

- To identify those works and machineries that have energy demand in construction of substructure and super structure;
- To find out the main producer of CO_2 emission.

26.1.2.2 Research Scope

The scopes of this research are:

- Only construction stage has been involved in this study. Manufactory stage, overseas transportation stage, occupancy stage, and demolish stage has not been considered;
- The energy consumption related to sub-structure and super-structure (frame works) has been traced. The construction processes of envelope, M&E, and other external works such as swimming pool and landscape are not included in this paper;
- Residential building in Singapore.

26.1.3 Previous Studies

26.1.3.1 Studies on CO_2 Emission or Energy Consumption Associated with Building Structures

The previous studies on CO_2 emission or energy consumption associated with building structures are mainly focus on two aspects: one is reporting construction energy consumption together with energy consumption and CO_2 emission caused by the manufactory, operation, maintenance to conduct life cycle analysis of a building (Jönsson et al. 1998; Milford 2005). The other one is to compare the environmental impact caused by different structure types such as RC structure, steel structure and wood structure (Elnimeiri and Gupta 2008; WBCSD 2009; Suzuki and Oka 1998).

26.1.3.2 Studies on Construction Energy Usage Categories

To examined the energy and Greenhouse Gas (GHG) emissions associated with on-site construction, five categories have been used by Cole (1999): worker transportation, material transportation, equipment transportation, on-site construction equipment, and supporting construction process (Yohanis and Norton 2002). Milford (2005) pointed out, there are three primary ways that energy is used in construction; the energy used in extracting, refining, manufacturing and transporting construction materials and products; the energy used in construction activities on site or, increasingly, in the factory; the operational energy used including related transportation and finally the energy used in deconstruction at the end of a buildings life.

The construction condition in Singapore is not exactly same with that of Cole's research in Canada, nor Milford's research, for example, worker transportation does not exist in this project; the energy consumption by equipment transportation is so small comparing with other construction process. Furthermore the energy consumption associated with site operation and worker accommodation actually takes a big part of total energy consumption which has not been mentioned by previous studies. Therefore, the categories used in this study are: the energy used in material transportation, the energy used in on-site construction equipment, the energy used in on-site operation and the energy used in worker accommodation.

26.2 Method

26.2.1 Case Study

The purpose of this study is to investigate those contributors of construction energy consumption and therefore the CO_2 emission produced by them. A major strength of case studies is that they are able to probe in-depth insight of the phenomena under investigation. Case study is a widely accepted research method used for such exploring the ground study. In this paper, a residential project constructed by China Construction (South-pacific) Co. is selected for case study.

26.2.2 Description of the Case

This residential project is located in north-west of Singapore, 10 storeys height, 3 condominium blocks with Gross Floor Area of 14,200 m^2. The construction duration is 31 months, and the duration of foundations and frames elements are 20 months. Construction technologies adopted in this project are conventional in Singapore.

26.2.3 Data Collection

To find out the exact amount and types of energy resources used in this project, The following data is collected in the way of on-site observation, analysis on the documents provide by site quantity surveys and finally double check by the project manager.

26.2.3.1 Trips of Main Materials Transported from Suppliers' Distribution Centre to Site

It is simply assumed that average transportation distance of each main material is same for three reasons. Firstly, almost all building materials in Singapore are imported from other countries, the distribution centres of material suppliers may be located in any point around Singapore. In addition, Singapore is not a big city. The effect due to distance difference takes a small percentage in the whole energy consumption. Thirdly, this study is conducted for the purpose of being a reference of other projects in Singapore.

26.2.3.2 Monthly Bills of All Types of Energy Sources Used on Site

Monthly bills are valid evidence for the amount that each type of energy source has been consumed. It also helps to calculate the energy consumption in a particular duration like the diesel consumption by diesel generator during the first two months.

26.2.3.3 Machinery Type Used in Each Construction Process

During the construction of this project, all of machineries and processes that need energy supply and corresponding energy types have been recorded so that the overview and details of on-site machineries and energy consumption could be matched.

26.2.3.4 Energy Consumption Associated with Workers

Since the contractor provides on-site accommodation for workers, there is no transportation for workers. The energy consumption associated with workers is energy for lighting and air-conditioning.

26.3 Results

26.3.1 Materials Transportation from Suppliers' Distribution Centre to Site

Four materials are mainly used in the construction stage of sub-structure and frame elements: concrete, steel, sand and cement. The transportation of materials from suppliers' distribution centre to site is valued by trips. The transportation trips for concrete is extremely constitutes the biggest part (91 %) of total trips for these four material (refer to Fig. 26.1). Even with consideration of transportation trips of those envelop materials like glass, brick and paint, the transportation trips for concrete is also extremely constitutes the biggest part (82 %) of total trips for these nine material (refer to Fig. 26.2).

26.3.2 On-Site Energy Consumption and CO_2 Emission

26.3.2.1 Energy Consumption Breakdown

According to the record of energy consumption, the categories of works, machineries, as well as energy resources types are listed in Table 26.1. It is found that three

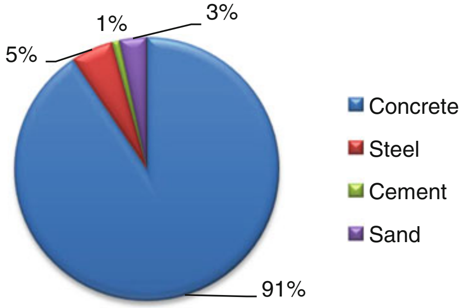

Fig. 26.1 Transportation trips portfolio (four main materials)

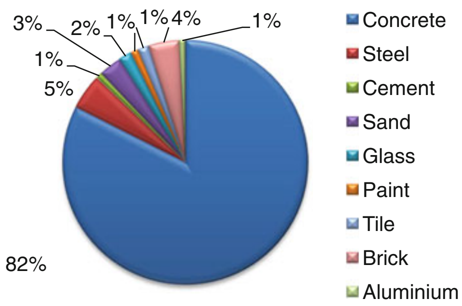

Fig. 26.2 Transportation trips portfolio (nine main materials)

Table 26.1 Components of energy consumption during structural construction

Work	Energy usage	Energy type
Site excavation	• Excavator	Diesel
	• Bulk bin	
Pilling installation	• Excavator	Diesel
	• Piling rigs	
	• Crawler crane	
	• Welding set	Electricity/gas oil
Cast-inst (pile cap, beams, columns, slabs, stair-case, roof)	• Crane	Diesel
	• Concrete vibrator	Gas oil
	• Air compressors	Electricity/fuel
	• Pump	
	• Rebar cutting	
Whole process	• Mixers	Electricity
Site office operation	• Lighting (includes site lighting, office lighting, and room lighting)	Diesel (before connecting to grid electricity net)
	• Air-conditioning	
Workers accommodation	• Other (computers, printers, etc.)	Grid electricity (after connecting to grid electricity net)

kinds of energy resources have been used in this project: diesel, gas oil, and grid electricity.

26.3.2.2 CO_2 Emission Analysis Breakdown

CO_2 emission produced by each energy resource is calculated by multiplying the consumption amount of each energy resource and the convert Greenhouse gas conversion factors reported by IPCC in 2008. It is resulted that in the first 20 months, till frame elements and roof are finished, Diesel is the biggest

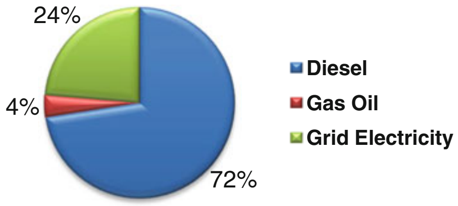

Fig. 26.3 CO_2 emission breakdown (by energy type)

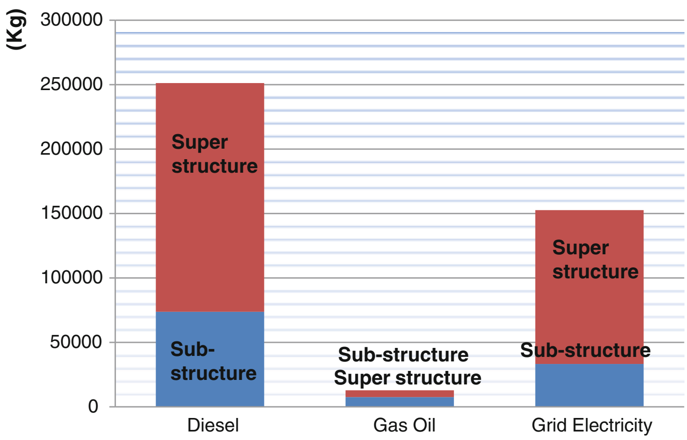

Fig. 26.4 CO_2 emission breakdown

contributor to CO_2 emission which takes account 72 % of the total CO_2 emission in this stage (refer to Fig. 26.3). CO_2 emission produced by grid electricity is 24 %, and only 4 % is produced by gas oil.

Although the duration of sub-structure construction is 12 months, which is longer than the duration of super structure construction (8 months), it is shown in Fig. 26.4 that CO_2 emission produced by constructing super structural elements is 2.65 times of that by constructing sub-structure. 56 % of total CO_2 emission (192,316 kg) is produced by the operation of crane, in which, 52 % is produced by crane used for super structure construction, and the other 4 % is produced by pedrail crane which is used for sub-structure construction. The second biggest contributor of CO_2 emission is grid electricity used for office operation, workers' accommodation and site lighting, which takes account 20 % of the total CO_2 emission in this stage. Before the site was connected with national grid electricity net, diesel generator had been used. This constitutes 17 % of the total CO_2 emission. The percentage of CO_2 emission produced by vibrators and electrical machinaries such as mixers, welding machines and cutting machines are only 3 and 4 % (Fig. 26.5).

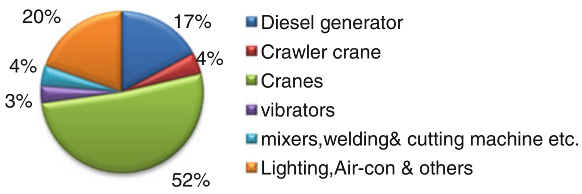

Fig. 26.5 CO_2 emission breakdown (by machinary and usage)

26.4 Conclusion

This paper provides a detailed examination of the energy consumption and CO_2 emission associated with the construction of structural building elements in Singapore. The transportation of concrete from supplier distribution centre to site contributes more than 80 % in the CO_2 emission produced by the transportation of 9 main building materials.

From the beginning of this project to the completion of super frame, CO_2 emission produced by crane and crawler crane is the biggest contributor (56 %) among those on-site machineries. The energy consumption by crane is actually determined by the operational hour, which is mainly affected by the amount of materials that need vertical transportation. It means that CO_2 emission might be reduced by choosing lighter structural materials.

CO_2 emission produced by site lighting, office operation and workers' accommodation constitutes 20 % of the total CO_2 emission. The energy consumption of his part is determined by one factor which is construction duration. CO_2 emission reduction may also be achieved by using those technologies or materials which may improve construction efficiency or reduce construction duration.

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Chapter 27
Impediments to Implementing Design for Construction Safety

Xuehao Yu, Chun Qing Li and Guomin Zhang

Abstract While many studies have indicated that design for construction safety (DFCS) has potential ability to function effectively to improve construction site safety, there is no clear evidence DFCS has been or will be widely implemented in the construction industry. The objective of this paper is to identify impediments to implementing DFCS through a comprehensive literature review. This paper reviewed widely current construction industry safety condition in Australia and DFCS concept and toolkits. Safety regulations between United States and Australia were compared as well. Six impediments were identified from both designers' and contractors' perspectives. This paper is part of "A toolkit for optimizing design for construction safety" project. Based on the identified impediments, potential ways for overcoming these barriers will be investigated in the next phase of the research project.

Keywords Design for construction safety · Impediments · Implementation · Construction industry

27.1 Introduction

Construction industry is always suffering a relatively high safety and health risk rate in Australia. According to the statistic from 2008 to 2010, there were 4.26 fatalities per 100,000 workers, which is nearly twice the national fatalities rate of 2.23, and construction industry accounted 11 % of all serious compensation claims versus 9 % of employed Australian workforce (2012c).

To minimize safety hazards and incidents, seven different action areas, including healthy and safe by design, supply chains and networks, health and safety capabilities, leadership and culture, research and evaluation, government, responsive

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and effective regulatory framework, were raised in the Australian Work Health and Safety Strategy 2012–2022. Healthy and safe by design, especially for construction, is identified as a priority area for action. Design for construction safety is to explicitly consider construction site safety through optimised design in design phase. A number of earlier studies suggested a significant proportion of construction accidents originate from the building process itself and are related to pre-construction process including planning, scheduling and design (Suraji et al. 2001; Whittington and Spracklen 1992). One European study contends that 60 % of construction accidents could have been eliminated, reduced, or avoided with more thought at the design phase (ECI 1991). Another investigation of 224 construction fatalities in America showed that 42 % of these cases were linked to failure of implementing design for construction safety concept (Behm 2005). A study of an intervention to prevent musculoskeletal injuries to construction workers was also conducted to confirm a relationship between construction injuries with construction design, planning, scheduling and material specifications (Hecker et al. 2001).

Although researchers and industry people expressed their desires and high expectations on design for construction safety, design for construction safety was staying in theory phase until the end of 1990s. Earlier studies indicated design for construction safety had the ability to function effectively to improve workers' health and safety; however, widespread application of this intervention in Australian construction industry is not warmly welcomed. The objective of this research is to identify impediments to implementing DFCS. Understanding these impediments helps to better understand the concept of DFCS and promote to implement safety design appropriately. It redresses some misunderstanding in DFCS, especially from designers' perspectives as well. Additionally, this research established a foundation for future investigation of solutions to eliminate and minimize the identified impediments.

27.2 Previous Research

27.2.1 What Is Design for Construction Safety

Design for construction safety, which is also known as safety by design, prevention through design or engineering for safety, has been widely interpreted by professionals or research institutions from different countries. A code of practice published by Safe Work Australia (SWA) in 2012, which aimed to set guidance for "Safe Design of Structures", defined safe design as the integration of control measures early in the design process to eliminate or minimise risks to health and safety throughout the life of the structure being designed. An earlier similar code published in 2008 emphasized on the principle that everyone has a right to be protected from unnecessary risk of injury, and hazards should be eliminated at the design stage as much as possible. Traditionally designer focuses safety consideration on end-users of the building. DFCS concept also pays attention to construction site safety, especially construction workers safety. On the other hand, construction safety covers more than construction phase, and safety of maintenance is remarkable in DFCS concept. Designers should consider potential hazards not only on construction site, but also during the operation phase. Both construction workers and structure end users will benefits from designers' involvement in safety management. To highlight this point of view, Health and Safety Executive (HSE) from UK indicated that safety by design is about incorporating safe design principles in the design, construction and maintenance of workplaces.

Relatively, a similar concept 'Construction Hazards Prevention through Design' (CHPtD) from American researchers delivers a diverse viewpoint. National Institute for Occupational Safety and Health (NIOSH) addressed designers' obligation to prevent work-related hazards and risks only in design process. Toole (2014) explicitly and repeatedly demonstrated that CHPtD does NOT involve the designer having anything to do with the safety on the construction site once the project has started. He emphasized designers have the opportunities to eliminate site hazards in their design phase, without being involved in later construction process and CHPtD does not compel designers to fulfil construction work.

While there are a few differences in researchers' opinions from different countries, all of these designing for construction safety concepts demonstrated a high expectation on eliminating potential construction hazards and improving site safety at design stage. Szymberski (1997) discussed the effectiveness of safety management measures through project schedule. The ability to influence worker safety decreases exponentially over the design process. Research results from Behm (2005) and other professors led to a close relation between design and construction safety as well.

27.2.2 Toolkits for DFCS Measures

In 1997 a research conducted and sponsored by the Construction Industry Institute attempted to accumulate best practices that can be implemented into a project's design in order to minimize or eliminate construction site hazards (Gambatese and Hinze 1997). After the development of this preliminary "Design for Construction Safety Toolbox", researchers and organizations devoted to the establishment of better safety by design tools or management processes. These kinds of tools could be classified as construction hazards checklists, safety by design management process and digital design tools.

Although many large companies have developed best practices manuals or safety checklists to facilitate the design and review process, these tools often fall short of successfully integrating safety into design process (Gambatese and Hinze 1997). Hazards checklists consist of three functions: construction hazards identification, risk level assessment and design options selection. To achieve these effects, a research conducted by CII, which started in early 1994, accumulated over

Table 27.1 Digital tool for construction safety design

Digital tool	Approach	Technology	Citation
Construction Safety and Health Monitoring System (CSHM)	Monitor project performance	Online databases	Cheung et al. (2004)
Virtual Construction Laboratory (VCL)	Simulation and review of innovative processes	Virtual reality	Li et al. (2003)
Design for Safety Process (DFSP)	Simulation and review of construction process for design related safety issues	Virtual reality	Hadikusumo and Rowlinson (2002)
Decision Support System (DSS)	Assist monitoring and control of operations	GIS	Cheng et al. (2002)
Patterns Execution and Critical Analysis of Site Space Organization (PECASO)	Critical space-time analysis	4D CAD	Mallasi (2006)
Safety Analysis of Building in Construction (SABIC)	Structural analysis	BIM	Hu (2008)
Construction Hazard Assessment with Spatial and Temporal Exposure (CHASTE)	Construction job safety analysis and evaluation of operational risk levels	BIM	Rozenfeld (2009)
Computer image generation for job simulation (CIGJS)	Simulation for job safety analysis	Virtual reality	Patrucco et al. (2010)

400 design suggestions to address construction site hazards and minimize these potential hazards (Gambatese and Hinze 1997; Gambatese 1999). In conjunction with design suggestions, CII research group developed a computer-based design tool, which is much easier to update the database compared with traditional cumbersome written document. SliDeRule (Safety in Design Risk Evaluator) is another safety by design checklists with more than 1600 suggestions to help designers assessing the construction safety risk associated with their designs.

Except design for construction safety checklists, various digital design tools have been developed to check construction hazards and confliction during the design phase. Building information modeling is a widely acceptable digital tool to perform modern design and construction (Hu and Zhang 2011; Sulankivi et al. 2009). However, BIM was regularly used as a spatial conflict examine tool by designers contractors and subcontractors (Hu and Zhang 2011), and this function did not reveal the outstanding advantages of BIM in information integration. Series of other digital tools such as Virtual Reality and Online Databases have been developed by researchers to implement design for construction safety as well. Several digital design tools were listed in Table 27.1.

27.2.3 Why DFCS Is Not Well Received

Although researchers and industry people expressed their desires and high expectations on design for construction safety, design for construction safety was staying in theory phase until the end of 1990s. Some research has been done to identify factors impacting DFCS implementation. Six factors were identified based on earlier researches (Hinze and Wiegand 1992; Hinze and Gambatese 2003) including: absent regulatory requirements, safety responsibility, narrow specialization of construction and design, limited DFCS tools and guidelines, limited preconstruction collaboration, limited education and training. Gambatese et al. (2005) studied on viability of designing for construction worker safety, and they investigated factors impacting implementation of DFCS and the impacts caused by DFCS implementation. Some more factors were added to the list includes designer motivation, designer knowledge of the concept, ease of implementation of the concept and competing design/project objectives. Above all, this research indicated implementation of DFCS would impact on projects characteristics (e.g. cost, quality, constructability, etc.), facility characteristics (e.g. operator safety, operability, maintainability, etc.) and design firm liability, profitability.

27.2.4 Impact of Project Delivery System on DFCS

One significant change to promote the implementation of design for construction safety is the change of project delivery process. The traditional design-bid-build project has become the design-bid-redesign-rebid and build project (Levy 2006), induced by cost and schedule delays problems most of the time. Later, construction manager (CM) concept was brought into assist owners in managing the process of construction. As the CM concept matured, owners recognized the value of bringing the expertise of a contractor into design stage when their advice on constructability and costs bring considerable value to the project. Furthermore, design-build method existed as an evolutionary project delivery system (Levy 2006). In a traditional design-bid-build project, the client directly engages a designer to under take detailed design. In this traditional project delivery method, the project safety decisions during the design stage are the result of collaboration between the designer and the client (Safe Work Australia). This induces two specified problems: it is hard to get contractors involved in the design for construction safety, who actually have construction site safety expertise; the client has little experience on safety management and the designer has little experience on how to implement safe design.

It is obvious design-build projects offer more opportunities and fewer barriers for DFCS implementation. Design-build delivery method encourages the collaboration between designers and contractors. Actually, according to the explanation of Design-Build Institute of America, design-build is a method of project delivery in which one entity works under a single contract with the project owner to provide design and construction services. It brings higher profit margin, decreases administrative burden, reduces litigation and increases market share.

Another significant opinion to point out is that some research results indicated designers' role in construction will become increasingly important and diversified with the progress of design for safety (Toole and Gambatese 2008; Hinze and Wiegand 1992). Toole (2005) discussed the opportunities and barriers facing American construction design and design-build engineers. He suggested design engineers could play a more important role on site safety in designer tasks other than design stage. Toole and Gambatese (2008) also predicted designers will increasingly perform construction engineering in the future as a trajectory of implementing PtD.

27.3 Impediments to DFCS Implementation

Although safe design as an intervention to improve construction workers' safety has been illustrated, designers seem not to fully embrace this intervention as a part of their design practice (Morpurgo 1992). Several fundamental impediments that may affect designers' involvement in construction safety management have been identified. They mainly stem from designer perceptions and concerns. The most critical impediments include designers' concern about increased liability, increased cost and designers' lack of safety expertise (Toole 2007). Others include concerns about schedule problems, diminished design creativity and designers' lack of interest (Gambatese et al. 2005).

To better understand barriers that prevent designers from implementing DFCS, a broader definition of designer in safety design process is prerequisite. Designers may include architects, consulting engineers, surveyors, structure engineers and specialist subcontractors. The most related two types of designers in construction industry are architects and engineers. Architects are trained and licensed professionals who design buildings and structures to be functional, safe and economical (2010). Engineers meanwhile, are trained and licensed professionals who design economical solutions to enable the construction and function of buildings, infrastructure and other facilities. They include civil, structural, mechanical, electrical, plumbing and other engineers. Both architects and engineers, known as the design professionals, also inspect construction work and in some cases, participate in supervising the work (Bello 2012). The main requirement of designers is to deal with health and safety issues by designing them out 'so far as is reasonably practicable', that is balancing the risk against the cost of averting it (HSE 2007b).

27.3.1 Designers' Lack of Safety Expertise

It is imperative that designers should possess some degree of expertise in construction safety and some knowledge of construction processes to contribute to construction worker safety (Toole 2005; Bello 2012). In a study by Gambatese et al. (2005), designers' lack of safety expertise is identified as one of the most critical impediments to implement design for construction safety.

To promote DFCS implementation, the most important requirement for designers is to understand DFCS concept and principal process. Designers are required to have some knowledge of how individual construction tasks are performed as well, to facilitate cooperation with constructors. They will also require knowledge on the sequencing between the tasks, and how different trades coordinate their work (Toole 2005). In different procurement projects, designers' obligation and task scope will change. Lastly, designer should possess some knowledge of safety standards and regulations. This section mainly discussed safety design skills, not designers' obligation. Regulations here relate to guidance such as code of practice or safety strategy in Australia, which provide designers instructions or suggestions to follow.

A significant majority of design professionals have had limited or no academic exposure to construction safety management (Toole 2005). According to an American research in 2002, only 20 % of the 75 US surveyed design firms indicated that over 50 % of their employees had received safety training while nearly 70 % indicated that less than 25 % of their employees had received safety training. The same study also indicated less than one-quarter of the US participants believed that employees in their firms were capable of identifying site hazards to which workers are exposed (Toole 2005). Although a research by Toole and Gambatese (2008) indicated United States lag other countries including members of European Union and Australia, these countries are facing the same barriers to the diffusion of Construction Hazards Prevention through Design (CHPtD) such as designers' lack of safety expertise.

Many issues induced to current designers' lack of safety expertise. Lack of safety curriculums and safety training can result in the absence of knowledge. Design firm's lack of safety records can lead to the absence of proactive measures in construction hazards. Complicated DFCS implementation process may make designers hard to understand their tasks and cause potential fear about obligation. Limited DFCS tools, guidelines or other resources also restrict designers to implement DFCS.

In Australia, to assist designers to better understand and carry out safety by design, a code of practice, 'Safe Design of Structures', was published in 2012 (SWA 2012). This code of practice presents a standardized approach to stimulate designers carrying out safety design in design-build construction process. Actually Australian government required designers to consider safety of on-site workers. The Work Health and Safety Act, published by Safe Work Australia in 2011, clarified the responsibility of designers during design phase to keep workplace safety, with detailed penalty amount attached (SWA 2011). This practice should be.

27.3.2 Designers' Exposure to Liability

The fear of undeserved liability for worker safety appears to be the primary concern voiced by designers. The study by Gambatese et al. (2005) indicated most designers believe design for construction safety implementation will increase their liability exposure, and additionally only 37 % of designers surveyed were interested and willing to implement design for construction safety.

Gambatese also suggested the legal ramifications of these requirements on designers are similar to those resulting from design for the end-user in research. But this suggestion and current legislation did not reach an agreement in US. There are obvious differences in construction safety legislation between US and Australia. Occupational Safety and Health Administration (OSHA) standards in the United States clearly ascribe primary safety responsibility for construction workers to their employers and designers have no site safety responsibilities (Toole 2002). Regulations from OSHA clearly place the burden for worker safety solely on the constructor (Behm 2005). On the contrary, construction contracts and regulatory clauses from Work Health and Safety Regulations in Australia and Construction Design and Management (HSE 2007a) in UK clearly indicate the responsibilities of designers related to construction safety and designers should assume the design induced construction accidents.

There is no conclusion which regulation is better to promote DFCS implementation. Just focusing the construction accident rates, United Kingdom and Australia appeared to perform better in construction safety. Toole (2005) pointed out current contracts of America do not clearly and explicitly prohibits project designers of record from reviewing construction document to ensure reasonable worker safety or from creating document for workers safety as part of their design process. Other researchers also suggested that designers should not be held partially responsible for construction accidents, and should consider the safety as a moral related aspect. In the same study, some designers even commented that legal counsel specifically advised them not to address construction worker safety in their design. Korman (2001) reported that current legal and insurance system in the US has caused architects to be uninterested, up to the point of being afraid of getting involved in safety. Design engineers can easily justify their continued non-involvement in site safety under this legal environment (Toole 2005). Anyhow designers' concerns with the responsibilities are a remarkable component of factors that impede implementing design for construction safety. Nevertheless, designers believe DFCS will interfere with the contractor's means and methods and this, they feel, is a major barrier to DFCS (Gambatese et al. 2005).

27.3.3 Increased Cost

The concern that implementing design for construction safety will increase costs for designers is another barrier which cannot be ignored. In the study by Gambatese et al. (2005), 74 % of designers stated implementing design for construction safety would result in increased cost, including both design and construction cost.

Toole explicitly explained direct and overhead increased costs brought by safety-related actions (Toole and Gambatese 2008; Toole 2005). Project costs may increase due to additional protective features incorporated into the design and temporary protection system and facilities in construction process (Hinze and Gambatese 2003). Safety-related design work requires more time to accomplish. Protective features in design and protection system on site may result in an impact on project schedule. The time spent on extension of work should be primary on other billable tasks. It is however important to note that, implantation of DFCS may also eliminate the need to install temporary protection systems or some other features. Decreased project costs may be result in Bello (2012).

The indirect costs include safety training for designers as part of their professional development and additional insurance premiums induced by absolving designers from responsibility for construction worker safety. The result of this increased safety design costs makes designers have to choose owners who are willing to pay extra design fees or bonus as safety action awards. This would in turn make them less competitive with those still utilizing the traditional design process without design for construction safety implementation (Toole 2005). It was suggested liability was also an aspect of cost as well.

An important basis to investigate construction safety is to consider cost performance of interventions. A five year study by NIOSH led to a consequence of cost effective graph of safety resources applied to interventions and incident rate. It indicates that at some point an additional allocation of man-hour does not necessarily impact incident rate reduction substantially (Shakioyea 2009). Aminbakhsh et al. (2013) validated an analytic hierarchy process to evaluate construction safety hazards and identified an optimal equilibrium point between prevention costs and injury costs.

From a life cycle perspective of the project cost, a safer design would lead to increased productivity and decreased worker compensation, which results in slight reduction of project total cost (Toole 2005). As a result this is another reason design-build method could prompt design for construction safety. However, the cost-benefit analysis on design for construction safety may be missing on projects using traditional design-bid-build lump sum price contract.

27.3.4 Schedule Problems

DFCS implementation extend project schedule more or less. In the study by Gambatese et al. (2005), roughly half of the designers surveyed stated that DFCS would lead to schedule delays. In the same study, designers identified time constraints as a significant barrier to DFCS.

The incorporation of protective features into design leads to longer design phase and additional time requirements to install them. Design period may also extend due to designers safety training and more time to review designers' drawings. DFCS may also result in increased schedule needs for the project design phase as safety will be yet another criterion for design and analysis (Toole 2005).

27.3.5 Diminished Design Creativity

Designers' creativity and constructors' target always conflict. Considering construction issues, sometimes safety issues, elaborate design features will be diminished. This is particularly true for the fact that functional features that are aesthetic and creative add value to projects (Bello 2012). In light of such implications, a number of designers surveyed by Gambatese et al. (2005) stated that DFCS would lead to decrease in project quality by limiting design creativity. Also in the same study, increased project complexity and reduction in quality of design concepts were identified as barriers to DFCS.

27.3.6 Absence of Motivation

The absence of motivation may be due to all the impediments reviewed above. DFCS implementation radically depends on the motivation of designers. The absence of motivation can be reflected from inadequate information input to safety design process. Due to lack of interest, there may be inadequate site information, lack of awareness of information required for safety, inadequate pre-research etc. As a result, this inadequate information input leads to inadequate design output in relation to construction safety.

Project owner's lack of motivation may lead to more critical issues. Lack of safety strategy, poor safety management supervision, lack of safety training and lack of workers commitment all have remarkably negative impact on construction safety, not just limited in design phase.

Legislation or regulation is a mandatory method to require designers to fulfil their obligations. However, the purpose of this paper is to identify the impediments and encourage designers to overcome these barriers.

27.3.7 Procurement Measures

Procurement methods will decide the level of collaboration among clients, designers, contractors, subcontractors and other participants who will further significantly impact the implementation of DFCS. The client choices on project delivery method, contract type and the scope of work from construction feasibility phase to construction phase are all related influencing factors. As reviewed above, designers' role in construction will become increasingly important and diversified with the progress of design for safety and designers will increasingly perform the work of construction engineering (Toole and Gambatese 2008; Hinze and Wiegand 1992). This anticipation is a reflection of the trend in future construction process and a significant aspect of this trend will affect how owners choose the project delivery method, especially for large-scale project.

In design-build project, as the designer and contractor are one entity, liability for site safety incidents during construction will be relocated to one entity as well, the design-build firm (Bello 2012). Since the designers and contractors are engaged at the same time, the contractor will be involved in project design phase, where contractor's safety and construction knowledge can be utilized to improve constructability and construction safety. Meanwhile the issue of fear about increased liability becomes inapplicable.

The major differences between design-build project and non-design-build project are on contractual relation and operational approach. In a design-build project, the direct individuals involved in contract are just owner and design-build entity, and the requirements from owner are also performed by design-build entity. This delivery method provides a platform for designers and contractors, to improve collaboration and integration. Besides reductions in project costs and duration, compared with CM and design-bid-build projects (CII 1997), design-build projects can effectively improve the safety in the workplace. Getting contractors involved in the design process shares designers with construction technique, and therefore this knowledge sharing process decrease the potential hazards induced by inappropriate design. The challenges of design-build project concern institutional relation changes and contract. Researchers indicated cost-plus-guaranteed maximum price contract is preferable to lump sum or stipulated sum contract (Toole 2007; Toole and Gambatese 2008; Levy 2006). Toole pointed out GMP is more acceptable for a process with which designers are not familiar. And Sidney focused on the character of this form of contract and the process of the design-build project. GMP is generally signed before the design documents have been fully completed and it allows for an early start to the project with some safeguard to the owner for total project cost.

Table 27.2 Impediments to implementing DFCS

Impediments to implementing DFCS	Root causes of impediments
Designers' lack of safety expertise	Lack of safety training
	Lack of safety curriculums
	Lack of safety records
	Complicated DFCS implementation process
	Limited DFCS tools
Designers' exposure to liability	Regulation defects
	Contract issues
Increased cost	Extra protective features to build
	Extra design cost
	Extended schedule
	Safety training cost
Schedule problems	Extra protective features to install
	Extended design time
Diminished design creativity	Conflict between safety and creativity
Absence of motivation	

27.3.8 Research Gaps and Further Directions

According to the critical literature review stated above, six impediments are identified, together with an analysis of potential causes of these impediments. This result can guide to the next stage of research on investigating solutions to these barriers. These impediments are majorly identified on human factors. More subjective factors may also lead to difficulty to implementing DFCS such as the scale of the company and the value of the project. Toin validate a toolkit for optimizing DFCS by pilot projects and cases, project background should be regarded as a significant influencing factor (Table 27.2).

Another matter to point out is that these impediments are not independent. There is internal correlation in each barrier, especially specific issues under each barrier. For instance, designers' lack of safety training is a significant factor leads to designers' lack of safety expertise. To solve this issue, safety training is inevitable and it may result in increased project budget and extended schedule both for designers and owner. Another example is the term of contract. From safety perspective this research concerns, project delivery method decides the general type of project contract. The term of contract impacts designers' exposure to site safety liability to a large extent. As a result of affording more safety responsibilities, designers may require more retribution from owner.

The next stage of this research is to collect solutions to these barriers, which may be from DFCS checklist or other toolbox. And at last, a framework for optimizing DFCS is expected to develop.

27.4 Concluding Remarks

Construction site hazards, root causes of safety hazards and factors influencing safety management have been widely discussed in earlier research. Specifically, this research focuses on investigating the impediments to implementing DFCS. These identified barriers can be connected with general causes of accidents, such as poor attitude towards safety, deficient enforcement of safety, poor supervision and etc. To explicitly identify impediments to DFCS implementation is more crucial in this research, especially considering finding appropriate solutions to these barriers.

Besides the impediments identified in this research, there are a number of organizational factors can impact safety performance, which can influence DFCS as well. Larger construction firms have more opportunities to implement DFCS, and larger construction projects facilitate designers to consider safety issues in their design. The number of firms involved in a project may also impact the implementation of DFCS, through increasing dispersion of relevant information.

As promoting collaboration between designers and contractors is considered to be one of the most effective methods to enhance construction safety, design-build projects seem to have more opportunities to embed safety consideration in design. Some of impediments are eliminated or minimized in design-build projects. Designer from design-build firms are considered to have more construction knowledge and safety design measures that may impact worker safety. Gambatese explained it as designers considered construction process and they had already addressed construction worker safety in their design in design-build firms. The issue of liability exposure also becomes inapplicable as designer and contractor are one entity. Cost and schedule issues may be solved to some extent as well. As costs increased and benefits brought by DFCS can be considered over the design and construction phase, design-build firms should be able to capture the overall economic resulting from DFCS.

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Chapter 28
Environmental Emissions of Construction Equipment Usage in Pile Foundation Construction Process—A Case Study

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Abstract The level of emissions to the environment imposed by different human activities has been increasing at an alarming rate over the past decades. Measurement and control of air pollutant emissions into the atmosphere can lead towards reducing the emission level considerably. Construction industry is a major contributor to the environmental emissions due to the extensive use of construction equipment, which is responsible for greenhouse gas emissions and harmful substances such as carbon monoxide, nitrogen oxide and particulate matter emissions. Pile foundation is extensively used in high-rise buildings construction and it involves operation of heavy construction equipment. This study developed a process-based model to quantify environmental emissions of equipment usage in a typical pile foundation construction using the US EPA methodology. The emissions of excavation works govern the total emissions at site because of the high usage hours of excavators. In general the emission rates of piling rig and concrete pumping truck were found to be the highest although excavator emission rates are higher for carbon monoxide and particulate matter. It is seen that careful selection of machines and equipment can reduce the emissions up to 10 %. These findings of the study could be effectively used for minimizing the environmental emissions by careful selection of suitable equipment and technology.

Keywords Environmental emissions · Pile foundation · Process based model · US EPA

28.1 Introduction

While the life cycle of a building is widely recognized to consume a large amount of energy and materials and contribute significantly to environmental emissions, it appears that most research efforts in the life cycle assessment of the building were

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focused on design, operation and maintenance phases, with much less interest in measuring the environmental impact pertaining to the construction phase. As a critical phase in the development of high-rise buildings, foundation construction involves activities like demolition of existing structures if any, excavation, piling works, extensive concrete works which take time and use heavy construction equipment and techniques. Therefore, foundation construction accounts for a considerable amount of environmental emissions. However, emission studies have seldom concentrated on environmental emissions on foundation construction (Guggemos and Horvath 2006; Guggemos 2003; Junnila and Horvath 2003). Several reasons may lead to exclude the measurement of emissions of foundation construction. One reason is that the complexity of activities in foundation construction which results in difficulty in recording the required data, which might due to time consuming nature of the recording work and construction specific features such as disturbance. Another reason is that after completion of the building, foundation is physically hidden from the environment and therefore given less exposure to receiving public criticism. Among all the reasons, the main reason is that the conclusion of negligible environmental emissions at construction phase compared to its use phase (Guggemos 2003). Although it is true that use phase governs the emissions of a building during its life cycle, construction phase should also be given importance at an aggregate level because construction phase is relatively smaller (Usually 1–3 years) when compared to the lengthy use phase of usually around 50 years.

Pile foundation is considered to be a type of deep foundation which is often used in high rise building construction where heavy loads are expected (Vesić 1975; Poulos and Davis 1980). Pile foundation is suitable for soils which have low bearing capacity and when the heavy loads are to be transferred to the hard rock or to the surrounding soil directly. Pile foundation can be of two basic types i.e., bored pile and driven pile. Bored pile construction involves excavation of pile core and pouring of concrete along with the reinforcement installation whereas driven pile construction involves driving a precast pile into the soil at the desired positions (Tomlinson 2001; Paul 1937; Hannigan et al. 1997). Bored piles are preferred over driven piles in urban areas because of the extensive noise generation in the driven pile construction. The case study discussed in this paper is a project undertaken in densely populated urban area and thus bored pile was used as the foundation type. This paper aims to map the construction process of a bored pile construction, and develop a model to measure the equipment emissions associate with bored pile construction, and demonstrate its application through an empirical case study.

28.2 Past Research on Emissions at Construction Phase

Buildings consume a considerable amount of natural resources and emit a number of pollutant substances to the environment. According to Guggemos et al. (2003) buildings accounts for one sixth of the world's freshwater withdrawals, one quarter of wood harvest and two fifth of its material (Guggemos 2003). Several studies point out that buildings are one of the seven dominant sectors that greatly contribute towards greenhouse gas emissions throughout its life cycle (Chau et al. 2012; Mao et al. 2013; Yan et al. 2010). Apart from greenhouse gas emissions, especially the construction phase of a building is responsible for non-greenhouse gas emissions such as carbon monoxide (CO), nitrous oxide (NOx) and particulate matter (PM) (Guggemos 2003; Guggemos and Horvath 2006). Guggemos et al. in their studies conclude that CO and NO_2 pollutant substances are pre dominant in non-greenhouse gas emissions at the construction stage. Although these emissions are smaller than CO_2 emissions, a smaller amount would be harmful to human health (Guggemos 2003). However, many studies have ignored the analysis of non-greenhouse gas emissions at the construction stage while considering only on the greenhouse gas emissions on their studies (Yan et al. 2010; Graham et al. 2008; Chen and Zhang 2010). Several studies have attempted to explore the environmental emissions at construction stage (Guggemos 2003; Chen and Zhu 2008; Seo and Hwang 2001; Mao et al. 2013; Chen and Zhang 2010; Li et al. 2010). Guggemos et al. compared the environmental emissions in concrete and steel building construction whereas Li et al. developed a life cycle impact assessment model for construction processes. Mao et al. compared greenhouse gases of off-site construction methods and conventional construction methods. However, none of these studies have concentrated in-depth comparison of emissions of construction equipment usage and techniques.

Very few studies have concentrated on emissions at foundation construction. One study concentrated on environmental emissions on horizontal directional drilling (HDD) project in USA (Sihabuddin and Ariaratnam 2009). In this study, data collection was conducted on-site for every operation of the machines and equipment that were in use. The study concluded that transportation has a major effect on the emissions at the project. Another study compared emissions between trenchless pipe replacement and open cut utility construction (Ariaratnam and Sihabuddin 2009). It is evident that very few studies have carried out a comprehensive analysis on the emissions of foundation construction. Out of the literatures reviewed, none of the studies have made an attempt to effectively estimate emissions (both greenhouse and non-greenhouse gas emissions) in pile construction. The summary in Table 28.1 provides a comprehensive review on how different studies have concentrated on different aspects of emissions in a building.

28.3 Research Method

The section covers the data collection framework development, explanation of the scope and the limitations of the study and the methodology development for the case study.

Table 28.1 Different topics covered by different emission studies on buildings

Topic covered	1	2	3	4	5	6	7	8	9
Material phase	x			x	x	x	x	x	
Construction phase	x		x	x	x			x	
Use phase	x			x	x	x	x	x	
End of life phase	x			x	x			x	
Emissions from construction equipment		x							x
Topic covered	10	11	12	13	14	15	16	17	18
Material phase					x	x	x	x	x
Construction phase		x							
Use phase					x	x		x	x
End of life phase						x		x	x
Emissions from construction equipment	x		x	x					

1 Seo and Hwang (2001), *2* Abolhasani et al. (2008), *3* Sihabuddin and Ariaratnam (2009), *4* Guggemos (2003), *5* Mao et al. (2013), *6* Monahan and Powell (2011), *7* Verbeeck and Hens (2010), *8* Li et al. (2010), *9* Frey et al. (2010), *10* Jung et al. (2009), *11* Ariaratnam and Sihabuddin (2009), *12* Kean et al. (2000), *13* Lewis et al. (2011), *14* Kok et al. (2006), *15* Xing et al. (2008), *16* Huberman and Pearlmutter (2008), *17* Fay et al. (2000), *18* Dong et al. (2013)

28.3.1 Framework Development for Data Collection

Before commencement of data collection, a process was developed to identify the major activities that contribute towards emissions in bored pile construction. Extensive literature review was carried out to identify the major activities in bored pile construction. In addition, expertise suggestions from industry personals were also considered in this development. Figure 28.1 illustrates the activities that contribute towards environmental emissions. These activities mentioned in Fig. 28.1 can vary significantly according to the construction site and condition. For example, installation of temporary casing is required only when the bearing strength of the soil is very poor which is not common to all the construction sites. Sub activities such as emissions due to labour transportation are hard to capture for a construction site located in urban areas where public transportation is used extensively. Thus the framework developed for data collection is a generic process for identifying the activities that contribute towards environmental emissions in bored pile construction.

28.3.2 Scope of Study and Limitations

The main scope of this paper is to analyse the emissions of construction equipment usage in bored pile construction. Thus there are exclusions and limitations adopted

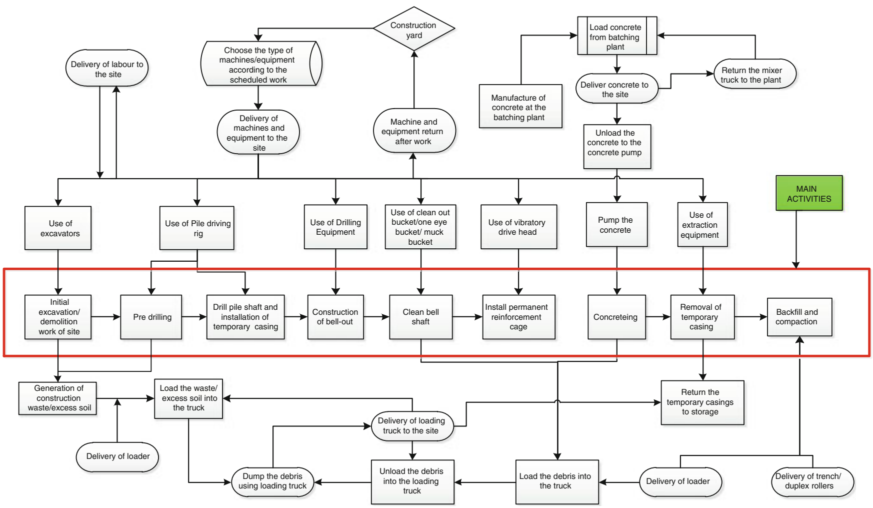

Fig. 28.1 Major activities related to environmental emissions in a typical bored-pile foundation construction

Table 28.2 Limitations and exclusions of the study

Excluded section	Reason
Energy and emissions from materials	Out of the scope for this paper
Emissions from construction waste	Out of the scope for this paper
Installation of temporary casing	No temporary casing was installed in the case study
Removal of temporary casing	No temporary casing was installed in the case study
Delivery of labor to the site	Labor was using public transportation as the project was in urban area

for the study to address the intended scope. These limitations and exclusions are listed in Table 28.2.

28.3.3 Methodology Development

The emissions usually vary according to factors like efficiency of the machine, deterioration, age of the machine. United States Environmental Protection Agency (US EPA) is a governmental agency with the responsibility of safeguarding the environment and human health. It establishes standards and undertakes assessment through various studies and research to enhance environmental protection

(Sihabuddin and Ariaratnam 2009). It also takes initiative to improve public awareness by conducting various awareness programs. The standards published by this agency are important to various entities. US EPA published emission factors for non-road modelling and mobile machineries. Non-road machines symbolises off-road machines whereas mobile machineries symbolises on-road vehicles. These standards are published by the Assessment and Standards division at the Office of Transportation and Air Quality in US EPA. It provides emission factors for air pollutants for more than 80 types of machineries which include marine engines, generators and construction equipment. These emission factors takes into account includes all possible machine variations in calculation of emissions of construction equipment. Thus it generates a unique emission factor for every equipment used based on its usage. This unique emission factors will pave the way to a comprehensive analysis of emissions on equipment usage. The methodology provided by US EPA for estimating of emissions from non-road equipment involves the following general equation.

$$E_i = EF_i * P * T * LF \tag{28.1}$$

EF_i is the emission factor for the emission element considered in g/(hp-hr); P is the rated power output of the equipment considered in horsepower; T is the hours of use of the equipment for the construction activity considered; LF is the load factor which is the fraction of available power in operation of equipment. Determination of emission factor EFi involves the procedure suggested by US EPA whereas the other variables are machine and activity based variables which need to be measured onsite. The methodology for calculation of emission factors are described below.

1. Emission factor calculation for HC, CO, NOx

Emission factor for HC, CO and NOx for a construction equipment depends on the steady emission state of the equipment (EFss), deterioration factor (DF), transient adjustment factor (TAF). After accounting for these adjustments, the emission factor for these emission elements can be expressed as follows:

$$EF_{HC,CO,NO_X} = EF_{SS} * DF * TAF \tag{28.2}$$

Transient adjustment factor (TAF) encounters the difference of operating conditions and test conditions, and can be directly obtained from the given values in report published under the topic ‘Exhaust and crankcase Emission Factors for non-road modelling’ by US EPA. Deterioration factor DF is given by,

$$DF = 1 + DF_{rel} * (Age\,factor), \quad For\,Age\,factor < 1 \tag{28.3}$$

$$DF = 1 + DF_{rel}, \quad For\,Age\,factor < 1 \tag{28.4}$$

where: $\text{age factor} = \frac{\text{cumalative hours} * \text{load factor}}{\text{median life at full load, in hours}}$ and DF_{rel} is the constant for a given pollutant/technology type.

2. Emission factor calculation for PM

Emission factor for PM can be determined similarly from Eq. 28.5 while accounting for the sulphur content of the fuel. This is because the PM emissions are directly dependent on the sulphur content presented in the fuel. Therefore, the above equation can be modified as follows to determine the emission factor for PM.

$$EF_{PM} = EF_{SS} * DF * TAF * S_{PMadj} \tag{28.5}$$

where, S_{PMadj} is the sulphur content adjustment to PM emission factor which can be estimated from the equation given below.

$$S_{PMadj} = BSFC * 453.6 * 7.0 * soxcnv * 0.01 * (soxbas - soxdas) \tag{28.6}$$

BSFC represents Brake Specific Fuel consumption which is adjusted fuel consumption for the respective machine in use in lb/(hp-hr). 453.6 is the value of conversion of pounds to grams and 7.0 is the ratio between grams of PM sulphate to grams of PM sulphur. The term soxcnv represents the fraction of diesel fuel sulphur converted to PM. This term depends upon the technology type of the machine. Soxbas is the default certification fuel sulphur weight percentage and a default value of 0.33 is by the model. Soxdsl is the episodic fuel sulphur weight percentage specified by user. These values also can be obtained from the report on non-road modelling provided by US EPA. For diesel engines all the PM emissions are assumed to be less than 10 μ.

3. Emission factor calculation for CO_2

Emission factors for CO_2 are calculated based on the BSFC. The carbon that utilizes for HC emissions are subtracted to correct for the correlation for unburned fuel. The equation for emission factor for CO_2 calculation is as follows:

$$EF_{CO_2} = (BSFC * 453.6 - EF_{HC}) * 0.861 * (\frac{44}{12}) \tag{28.7}$$

EF_{CO_2} is emission factor for CO_2 in g/(lb-hr); BSFC is brake specific fuel consumption in lb/(hp-hr); 453.6 is the conversion from pounds to grams; EFHC is the adjusted emission factor for HC emissions in g/(hp-hr); 0.861 is the carbon mass fraction for Australian diesel; (44/12) is the ratio of CO_2 molecular mass to carbon molecular mass.

28.4 Case Study

This paper estimates carbon dioxide (CO_2), carbon monoxide (CO), hydro carbon (HC), nitrogen oxide (NOx) and particulate matter (PM) emissions from construction equipment. The case selected is a typical high-rise construction in Melbourne. The foundation consists of 84 piles of 750 mm diameter. The depth of a pile is around 20 m. The advantage of this construction site is that the water table is below the designed depth of the pile. A capping beam of size varies from 480 to 1000 mm width to 500 to 1300 mm depth is placed to connect all the piles. Among the construction of 84 piles, 54 were closely monitored and data were collected. Although the construction time of most of the piles were in the same range, some piles were taken more time to complete construction, largely due to underground disturbance, rain and minor equipment malfunctions. Table 28.3 outlines the machine characteristics and the activity hours of the machines used at the site during construction. Apart from the main construction, machines were in operation to complete various sub tasks at the construction site. These activities are presented in Table 28.4. Total hours of operation for each machine are given in Table 28.3. The emissions are compared with respect to the activities as well as according to the machines.

28.5 Results and Discussion

The results obtained are discussed under two different scenarios of emissions based on the activity type and emissions based on the equipment. The emission comparison between different activities is presented in Table 28.4.

From Table 28.4, it is seen that the carbon dioxide emissions govern the emissions from the quantity point of view. It should be noted that carbon monoxide and nitrous oxide emissions are also considerably high. It can be seen that the excavation works (i.e. Excavation of pile shaft and main excavation works) contribute significantly towards environmental emissions in bored pile construction.

Table 28.3 Details of machines used during pile construction

Machine used	Label	Power (kW)	Total operation (h)	Total idle time (h)	Idle operation (%)
Excavator 1	A	260	139.85	5.7	4.08
Excavator 2	B	202	153.20	8.8	5.74
Excavator 3	C	30	60.70	6.2	10.21
Piling rig	D	328	113.37	8.2	7.23
Crawler crane	E	212	24.86	1.5	6.04
Concr. pumping truck	F	421	23.64	1.75	7.4

Table 28.4 Emissions from various equipment based on the activity performed

Activity	Machine used	Total hours	HC (kg)	CO_2 (Mt)	CO (kg)	NO_x (kg)	PM (kg)	SO_2 (kg)
Excavation of the pile shaft	D	105.18	7.85	24.55	42.48	116.25	6.464	19.56
Cleaning the pile bottom	D	8.19	0.61	1.91	3.31	9.05	0.503	1.52
Concreting	F	23.64	2.32	7.09	13.80	33.80	2.726	5.65
Lifting and placing reinforcement cage	E	24.86	1.19	3.76	9.89	17.76	1.697	2.99
Pushing the reinforcement cage	A, B	4.59	0.29	0.86	3.63	4.19	0.397	0.68
Excavated soil removal	A, B	17.06	1.06	3.19	13.49	15.57	1.477	2.52
Main excavation works	A, B	174.75	10.04	30.05	127.42	146.73	14.04	7.21
Demolition works on land	A, B	96.65	4.97	14.86	63.27	72.57	7.03	16.49
Other works related to construction	C	60.70	0.31	1.40	0.36	7.10	–	8.81
Total			28.639	87.66	280.01	423.26	34.33	69.45

Table 28.5 Emission rates for each machine used in the case study

Machine	HC (g/h)	CO_2 (kg/h)	CO (g/h)	NO_x (g/h)	PM (g/h)	SO_2 (g/h)
PilingRig	74.40	232.75	402.70	1102.05	61.28	74.40
Excavator 1	48.56	145.20	619.68	709.31	69.16	48.56
Excavator 2	62.43	186.99	790.77	912.97	86.60	62.43
Excavator 3	5.12	23.01	5.97	117.00	–	5.12
Concrete pumping truck	93.32	285.07	555.28	1359.55	109.65	93.32
Crawler crane 80 T	52.73	159.01	517.95	761.35	71.79	52.73

This contribution varies from 57.20 to 74.34 % for the emission substances considered with CO emissions having the highest of 74.34 %. Table 28.5 summarizes the emission rates of the machines used at site. Concrete pumping truck and piling rig have high emission rates compared to other machines. Although it is said so, these emission rates are not significantly high. Out of the machines used excavator 3 had the least emission rates.

Figure 28.2 shows the different emission variations are not similar for a specific machine. Although CO emissions are relatively low for the piling rig, CO_2, NOx and SO_2 emissions are comparatively higher than other machines.

This is because in US EPA model the CO emissions are lowest for the machines in the range of 300–600 hp. Thus, if the major pollutant concern is CO, it is better to

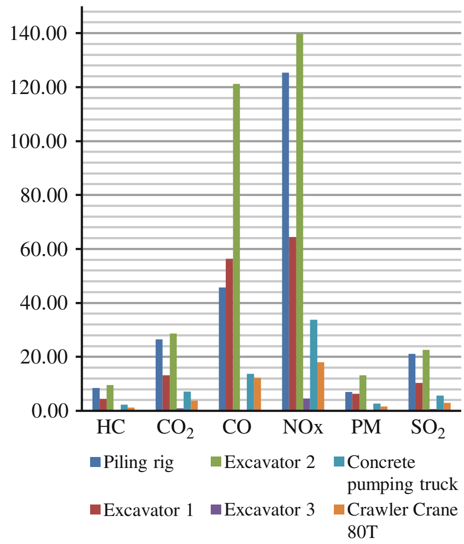

Fig. 28.2 Emission variations based on the machine

Table 28.6 Emission variation based on excavator substitution

Condition	Power (hp)	HC (kg)	CO_2 (Mt)	CO (kg)	NO_x (kg)	PM (kg)	SO_2 (kg)
Original emissions	260	28.64	87.66	280.01	423.26	34.330	69.45
Condition	202	26.57	81.26	253.80	392.06	31.659	64.40
Difference (%)	22.31	−7.40	−9.36	−7.37	−7.30	−7.78	−7.27

use a machine at a power range of 300–600 hp. The main purpose of analysis of the case study is to identify in which aspects environmental emissions can be reduced in pile foundation construction. Therefore, the emissions were re-calculated according to the following two cases. i.e., emission variation based on machine replacement and emission variation based on better work scheduling.

Case 1—Replacement of machines with different features

The emission variation was monitored by replacing the excavator 2 with an excavator of features that of excavator 1. The comparison to be realistic the capacity of excavator 1 and 2 should be similar. It was observed that both excavators 1 and 2 performed same activities on site with same activity time. Although there is a power reduction in excavator 1 it is not that significant. Therefore this substitution is realistic. The following table shows the total emissions variation for case 1 (Table 28.6).

It can be seen that when the power reduces by a percentage of around 22 %, there is an emission reduction in the range of 7–10 % with CO_2 emissions having the highest reduction. This is because fuel consumption of low power machine is

Table 28.7 Emission variation based on different excavation usage hours

	Condition	HC (kg)	CO_2 (Mt)	CO (kg)	NO_x (kg)	PM (kg)	SO_2 (kg)
Total emissions	Original emissions	28.639	87.66	280.01	423.26	34.330	69.45
	10 % reduction	27.92	85.25	274.67	411.72	33.573	67.54
	20 % reduction	27.76	84.70	272.92	409.04	33.385	67.10
	35 % reduction	25.24	77.14	237.48	371.83	29.69	61.15
Excavator emissions	Original emissions	16.67	50.35	208.17	246.17	22.94	39.73
	10 % reduction	15.96	48.17	199.47	235.54	21.97	38.01
	20 % reduction	15.25	46.01	190.77	224.91	21.01	36.30
	35 % reduction	14.18	42.75	177.21	208.97	19.55	33.73

lower than the high power machine. The results show that emission could have been reduced by proper selection of machines on site. It can be concluded that this case study has utilized an over powered excavator which has led to higher emissions.

Case 2—Emission variation based on better work scheduling

To understand the effect of better work scheduling the analysis was calculated by reducing the hours of use for excavators by 10 and 20 %, which can be achieved through reduced idle time and proper work planning. Table 28.7 shows the emission reduction of excavators and total emission reduction under the two different conditions. It is seen that when the hours of use of excavators are reduced by 10 and 20 % the excavator emissions are reduced by 4 % and total emissions are reduced only by 2 %. A 35 % reduction of excavator hours of use will reduce the total emissions only by 10 % although the reduction of excavator emissions is about 15 %. But this reduction is practically impossible to achieve.

28.6 Conclusions and Suggestions

From this study it can be concluded that carbon dioxide emission level governs the total emissions in construction activities such as piling foundation. Thus most of the studies only focus on CO_2 emissions in their studies. However, it is advisable to consider the emissions such as carbon monoxide, nitrous oxide and particulate matter because smaller amounts of these substances would affect the human health enormously. This paper developed a process-based model to quantify environmental emissions of equipment usage in a typical pile foundation construction using the US EPA methodology. The case study indicated that in addition to carbon dioxide emissions evaluation, non-CO_2 emissions such as CO, NOx and PM should be included to make way for a comprehensive emission analysis of construction stage. The results show that the excavation works govern the total emissions mainly due to high usage hours of equipment for excavation on site. It is also observed that the emission patterns of machines are significantly different from each other. The observed results indicate that CO emissions are considerably smaller for piling rig compared to other emission substances. The analysis shows that better work scheduling such as planning machine usage to reduce idle time would not reduce the emissions significantly rather efficient site-planning and careful selection of machine and equipment can reduce the emissions at construction phase up to 10 %. Further studies are suggested to include material usage and transportation aspects to draw more conclusive results. Consideration of life cycle effects is also encouraged to compare the impact of construction phase over its life cycle.

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Chapter 29
Application of Energy Performance Contracting in the Greener Government Buildings Program in Victoria: Incentives, Barriers and Strategies

Guomin Zhang, Xiao-hua Jin and Malik Khalfan

Abstract The Victorian Government, through its Department of Treasury and Finance's (DTF) Greener Government Buildings (GGB) Program, has been delivering energy saving and facility improvement projects across the State's departments and agencies since 2009. The majority of these projects are being delivered through Energy Performance Contracting (EPC), where efficiencies created eventually re-pay the investment in the projects. The EPC market in Australia and the Energy Service Companies (ESCOs) which contract through the model is underdeveloped, in comparison to other markets. While the GGB program has been a driving force for many ESCOs entering the Victorian market, the difference in development and experience, coupled with the altered environment in which the GGB program operates means that there is a degree of uncertainty in many aspects of operating EPCs in Victoria. These uncertainties can lead to inefficiencies in delivering EPCs which may affect the decision to proceed, as well as project success. This paper seeks to understand the GGB program in the context of EPCs globally, the challenges that it faces and how they are being approached through the three main themes: (1) the incentives to stakeholders (clients and ESCOs) to be involved in the program; (2) barriers to the EPC and ESCO industry in Victoria; (3) strategies that have been adopted throughout projects, and the effect this has had on project success and stakeholder collaboration.

Keywords Energy performance contracting · Energy service company · Asset management · Greener government buildings · Victoria

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29.1 Introduction

Since 2009, the Victorian Government through its Department of Treasury and Finance (DTF) has been initiated the Greener Government Buildings (GGB) which aims to reduce the energy and water consumption of State infrastructure and buildings by retrofitting these systems with more energy efficient equipment and methods of service supply. The GGB program suggests using a contractual model known as Energy Performance Contracting (EPC) for the majority of the high value projects within the program. Simply put, this method repays the finance cost of implementing efficiency projects through savings in operating costs. It offers advantages and disadvantages to traditional delivery methods, and therefore needs to be suited to each project in question. Within the broad concept of EPC there are many differing models with a variety of functional and contractual relationships between the stakeholders involved, as well as the scope, depth and process to which EPC may be implemented in each case.

The market in which EPC operates is a significant factor in the success of the delivery method. The EPC market in Australia and the Energy Service Companies (ESCOs) which contract in the model is relatively undeveloped, in comparison to the United States, European and some Asian markets (Sichivitsa et al. 2013). The GGB program has been a driving force for many ESCOs entering the Victorian market. The difference in development and experience, coupled with the altered environment in which the GGB program operates means that there is a degree of uncertainty in many aspects of operating EPCs in Victoria. These uncertainties can lead to inefficiencies in delivering EPCs which may affect the decision to proceed, as well as project success. Conversely, greater knowledge of the environment in which an EPC operates, as well as insights from case studies in similar circumstances allows for a greater degree of planning, optimisation and confidence in EPC projects.

When optimised, EPCs can be applied to a greater extent because of the higher returns, which benefits the client's financial goals and the environment, while having a reinforcing effect on the local EPC and ESCO market. This paper will present the GGB program in the context of the global EPC and ESCO industry, based on the available literature and a series of interviews with stakeholders in GGB projects. This will enable a more widespread development of understanding of the basic theory behind the method, and look at influencing factors in case studies from relevant situations. In particular this paper will be structured around (1) incentives to stakeholders (clients and ESCOs) to be involved in the program, (2) barriers to the EPC and ESCO industry in Victoria; and (3) Strategies that have been adopted throughout projects, and the effect this has had on project success and stakeholder collaboration.

29.2 Energy Performance Contracting

Energy Performance Contracting is a delivery method that enables clients to conducting energy efficiency projects by outsourcing the scope of work to an ESCO. While many different forms of EPC exist, they typically allows a client's project to be internally funded over time through the operational savings of efficiencies created (Xu et al. 2011). Once the initial financing has been paid, an EPC project continues to produce operational savings for the client with the added benefit of upgraded infrastructure. Depending on the client's experience, needs and contract form, ESCOs may provide a full range of services including organising the initial funding, and taking on the majority of the risk involved by guaranteeing the performance savings of their implemented project (Painuly et al. 2003).

Within EPC there are two widely accepted models for financing performance; shared savings and guaranteed savings. Under a guaranteed savings model a client will arrange for third party finance of the project, and in return receive a 'savings guarantee' from the ESCO. In this method the technical risk is assumed by the ESCO, the business risk of managing the parties is assumed by the financier (Bertoldi et al. 2006). In contrast, in a shared savings model the project finance is arranged by the ESCO, either through in house resources or as a third party loan. As hinted at by the name, the performance savings are split between the ESCO and client, which spreads some of the project performance risks onto the client (Bertoldi et al. 2006). Figure 29.1 gives a basic model of the risk structure of each model (Dreesen 2003).

As of 2001, it was estimated that revenue for ESCOs in all markets outside of the US were less than a half to a third of the US market (Vine 2005), however these international markets are increasing with the rise in interest from European and Asian countries. The driving forces in European markets have been cited as a combination of market liberalisation and energy efficiency targets (Bertoldi et al. 2003). In some Asian markets the ESCOs incentive has been the inefficient production and use of energy, creating a huge market potential, coupled with government support (and regulation) of measures which reduce emissions (Da-li 2009).

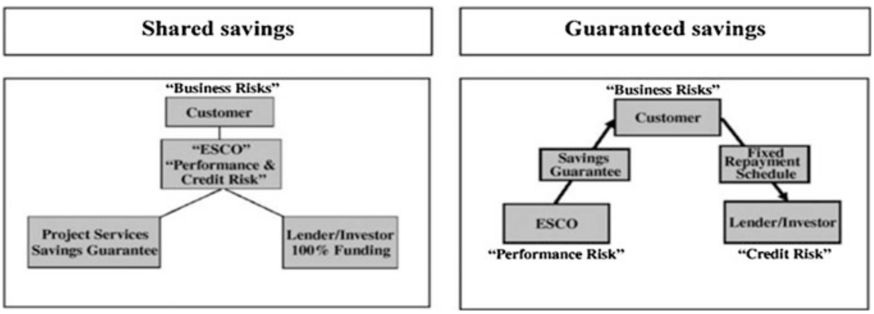

Fig. 29.1 Shared savings and guaranteed savings EPC models

Government EPC programs in Australia began in 1998 with the New South Wales Treasury Loan Fund. This scheme provides low interest capital loans to government sector energy and water efficiency projects—with a condition that performance contracts are used on high value projects (OEH 2012). The fund has lain dormant until relatively recently with the majority of activity occurred at the beginning of its life. In 2001 Queensland opened the Government Energy Management Strategy (GEMS), which operated similarly to the NSW program however involved staff to facilitate projects and policy to motivate agencies to undertake projects. In 2012 the provision of facilitation ended and the policy was removed, however the program and funding source still exist. There have been other standalone projects completed in both the private and public sectors across the country, however the largest program to date is the Victorian Government's GGB Program which began in 2009 and is the focus of this paper.

Overall EPC uptake and the ESCO industry is growing worldwide, both in already established markets and developing countries. There seems to be a widespread acceptance of the benefits of the contracting method, however barriers to implementation exist. The Victorian DTF'sGGB program is evidence of both the continual desire to implement EPCs and the expansion of the ESCO market, as well as the need to understand the barriers and success factors in implementing projects.

29.3 Research Method

The data for this paper was collected through a variety of methods. A comprehensive literature review was conducted to establish the parameters of what constituted an EPC project, the variations and different models within this method, and the history and current state of the industry. The specific research questions were also evaluated in this manner, although in a very general sense, as almost all peer reviewed literature on the subject comes from outside Australia. To avoid lengthy description, the literature review content which was presented in another paper (Sichivitsa et al. 2013) will not be presented in this paper.

The authors then conducted interviews with 10 participants (A to J) involved in the GGB program and Victorian ESCO industry to identify the incentives, barriers, strategies associated with EPC application in GGB. These stakeholders were drawn from the wide spectrum of those involved in the GGB program and local EPC industry, including GGB clients, ESCOs, GGB program facilitators and EPC industry bodies. The data was objectively evaluated for accuracy against information provided by other parties and fitting in with the overall picture of the GGB program and local ESCO industry. Discrepancies were followed up further between stakeholders and weighted towards those who had more involvement and authority on the issue in question.

29.4 Greener Government Buildings Program

GGB program is a Victoria Government's initiative that aims to reduce the water and energy consumption of Victorian public assets and therefore the operating costs and environmental footprint of the Government's operations (DTF 2012c). Each GGB project is designed to go through a number of stages, i.e. (1) Determine project scope, (2) Request for Expression of Interest (EOI) from pre-approved ESCO panel, (3) Request for Proposal (RFP) from 3 best suited ESCOs in a competitive tender, (4) Detailed Facility Study (DFS) Agreement with preferred ESCO, (5) Preferred ESCO undertakes DFS to agreed standard, (6) Seek funding from DTF, (7) Energy Performance Contract is negotiated between parties, (8) Installation of agreed solutions, and (9) Measurement & Verification (M&V) of solutions to prove the energy savings. The GGB program is comprised of:

1. a mandate from State Government that their departments and agencies would meet predetermined targets of their portfolio to undertake the GGB process;
2. an interest free funding source for projects that meet the payback period requirements;
3. a set of standardised templates for project contracts, procurement and process procedures, and a panel of preapproved contractors; and
4. facilitation support from within the DTF.

29.4.1 Mandate and Input Targets

The Victorian Government has predetermined targets for the GGB program, which are mandated across all departments and agencies. While energy efficiency targets have been in place prior to the GGB, these have been based on energy efficiency output. The GGB differentiates itself in that it specifies input targets, that is percentages of government portfolio that has committed to the GGB process (Participant-A). 20 % of the sites responsible for the Victorian Government's GHG emissions were to have been committed by June 30 2012 (which was achieved), and 90 % of the Government's total emissions by June 30 2018 (DTF 2012c).

Changing the emphasis from output targets to input targets allows each area of the Government's portfolio to be assessed on its potential for implementing energy efficiencies, rather than demanding a set energy saving when a current asset may already be highly efficiency. This process creates potential for energy efficiencies to be found, and then implemented in a cost effective way provided they meet the process criterion (Participant-A).

29.4.2 Funding and Payback Period Criterion

For projects which meet the payback criterion, funding is available through the DTF in the form of a temporary repayable advance from the public account under Section 37 of the Financial Management Act 1994 (DoH 2012). It is made from the public account to the specific government department, who in turn transfers it to the agency (if applicable)(DTF 2012b). Figure 29.2 shows these relationships.

The EPC model used is a guaranteed savings model, with the ESCO contractually guaranteeing the savings generated by the project. These savings are used to repay this advance from the DTF over a 7 year period following practical completion of the project, with the ESCO obliged to make up any shortfall if the savings do not meet the guarantee given (DTF 2012a).

Projects that are identified to have a 7 year simple payback period or less can secure Treasury funding, while anything outside of this will not. The intention behind this is to ensure that the funding is effectively spent, and will pay for itself over a reasonable period (Participant-A). It is important to note that it is not the program's intention for the payback period of projects to be as low as possible, but rather to capture as many energy efficiency measures that fit within the 7 year payback period as possible (Participant-E). As such, the 7 year payback criterion is used as a compliant/non-compliant assessment criterion when evaluating ESCO project proposals, with the comparison in compliant proposals between which can deliver more a greater amount of GHG and water savings (DTF 2012b)

The GGB program is an energy efficiency program, which predominantly uses EPC as a procurement method. It does allow for an equivalent procurement method to be used when it is more suited than EPC, however the 7 year payback period still needs to be met to be eligible for funding (DTF 2012b).

The 7 year payback criterion was determined through analysing previous projects and determining the Net Present Value (NPV), greenhouse gas reduction, and water savings from different payback periods. This allowed for optimisation

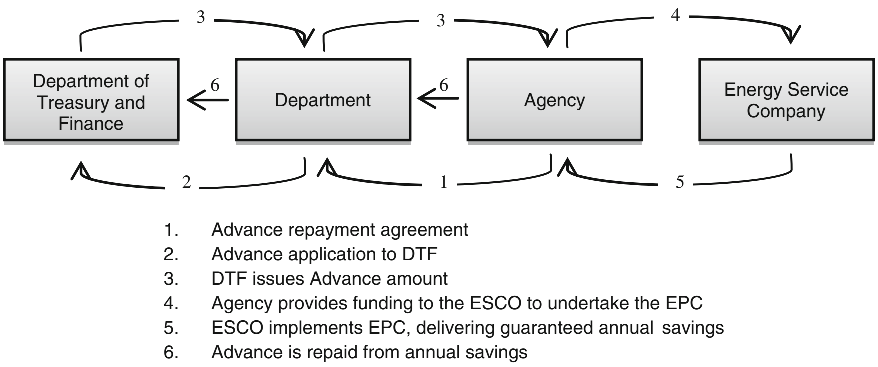

Fig. 29.2 Relationships between different parties involved in funding GGB projects (DTF 2012b)

between very short payback period efficiencies and efficiencies which have large benefits over the life of the investment (such as a new chiller), but a longer payback period (Participant-A). At the outset of the GGB program the payback criterion was 8 years, however this was modified to 7 years in March 2011 as it maximised the economic benefits, without significantly reducing the environmental benefits (DTF 2012c).

29.4.3 Standardised Project Templates

Due to the complexity of setting up and administering EPC projects the DTF has created a number of standardised templates for departments and agencies (the clients) to use in GGB projects. Clients, rather than the DTF itself, are responsible for implementing projects and applying for funding, therefore standardisation of project templates and processes allows for consistency across projects when they are being delivered by a variety of clients (DTF 2012b). These templates provide the clients with a clear process to follow through each stage of the GGB process and include a standard form of the relevant contract or agreement for each stage which can be can be modified to reflect the specific needs and risks with a client (DoH 2013a).

29.4.4 Facilitation Support

The DTF has a small team of program facilitators available to provide support for the GGB program. The team is available to assist departments and agencies with facilitation services for the scoping, procurement, implementation and contract management of energy performance contracts (DTF 2012b), and briefs the Treasurer on specific projects before an advance is made (Participant-A). Furthermore, the GGB facilitators are engaged in continuing to optimise and streamline the EPC process used in the GGB (Participant-B).

29.4.5 Current Status

The GGB program met its first input target of at least 20 % of the Victorian Government's commitment to the GGB program by 30 June 2012 with 20.48 %. This was achieved through 26 projects being tendered, and 9 of 11 departments meeting their individual targets. The departments that did not meet their 2012 targets, the Department of Health (DoH) and Department of Justice (DoJ), have since developed plans to meet the 30 June 2018 target (DTF 2012c). At 30 June 2013 the DoH had committed to the GGB process at sites representing 26 % of the health portfolio's total energy use (DoH 2013b), up from approximately 5 % the year before (DTF 2012c). To date more than $100 million has been committed to GGB program projects (Participant), and the program has been a factor in several new local and international ESCOs entering the Victorian market (Participant-E).

The GGB program facilitators have continued to refine the program's processes, in response to the results of the pilot program and initial years of the program (Participant-B). Some of these measures will be discussed in the following sections.

29.5 Incentives

29.5.1 Client

EPC under the GGB program offers Victorian Government departments and agencies (the clients) a variety of advantages over traditional procurement models. Primarily these come from the risk management and financial aspects of EPC, and the facilitation support in the program, although various other incentives do exist.

Under the GGB program one of the big incentives to government departments and agencies is the access to capital (Participant-B). Under the model, projects are funded outside of a department's normal budget, whereas without this funding source government clients would have to fit into their budget timelines; submitting applications in November, to be approved by May and actioned in July (Participant-A). The GGB program allows departments and agencies to tap into this fund for works that needs to be done (Participant-F), and allows them to actually expand the scope to create a holistic approach to energy efficiency, looking at multiple energy systems in a single project. In some cases the scale and intrusiveness of the work allow for significant infrastructure renewal work to be completed within the GGB project (Participant-E, Participant-H).

While this funding source is available to all GGB projects not only via EPC, it is the presence of EPC's externally guaranteed savings that built the business case to allow the funding to be available (Participant-A, Participant-C). Furthermore, while the terms of the funding are at the discretion of the Treasurer, to date all advances have approved interest free (DoH 2012). Under the GGB, EPC contains the contractual and technical mechanisms to ensure and give credibility that the guarantee is going to be made, and the savings can be verified (Participant-C).

Historically there has existed an information asymmetry between ESCOs and would-be clients, where the client doesn't feel that that they know sufficient information to make the optimal decision, and to negotiate and get the best deal possible. With the GGB program this factor is negated by the program facilitators—they provide the support to departments or agencies as required to provide the best outcome (Participant-D, Participant-B).

29.5.2 ESCOs

ESCOs have a vested business incentive to participate in EPC projects within the GGB: it is their area of expertise and where they choose to make a profit. The GGB program offers ESCOs the opportunity to deal with projects which are consistently run in a similar way, there is a good level of knowledge, good information flow and there is a pipeline of projects (Participant-D).

The GGB program allows ESCOs the opportunity to access upgrade projects in areas of the Government's portfolio that have previously not been accessible. This can be where a client organisation might have traditionally carried out projects in house or could not implement projects at all. Under the GGB, ESCOs now have this opportunity, and they have the chance to look at the opportunity holistically, with the potential in some cases for a scope across a variety of building services. Delivering GGB projects using EPC takes advantage of this point—by their nature the potential of EPC is maximised when it encompass all the building systems, and are designed with the synergy between individual systems in mind (Participant-C, Participant-E). This doesn't restrict EPC being used for a single piece of plant; however it incentivises ESCOs to look at the building, or precinct (in the case of several GGB projects) as an interdependent system in order to place a competitive tender (Participant-E). In most cases this will increase the size of the project contract, and consequently the profit.

Several of the GGB's pre-approved ESCO panel of providers produce proprietary systems. Implementing EPC projects with these proprietary systems may allow ESCOs to add additional value in their contracts, or a high potential of maintenance contracts (Participant-C). Being locked into proprietary systems by ESCOs has been cited as disincentive to engage with the ESCOs who provide them (Participant-C), however in at least two GGB project ESCOs have worked with clients in an open manner so that systems are future proof (Participant-H). This can be a winning result for both the client and the ESCO.

29.5.3 Financier

The funding for the GGB program comes from within the Victorian Government, from the DTF. In a sense the program can be seen as self-funded at a general level, although the EPC relationships place the Government departments and agencies as clients, and the DTF as the financier. This complexity between parties does not typically exist when third party finance is used in projects, however in this case it adds additional incentives to the program.

The source within the DTF is an advance which allows future energy savings to be generated, along with the associated financial savings, through loans rather than grants. Through the GGB program the DTF uses a market based mechanism to find and implement these efficiencies, which drives the competitiveness and the innovativeness of the proposed solutions. The funding is fundamentally a cash flow aid, is recouped by the treasury, with an end result of reducing the energy expenditure of the whole of Victorian Government (Participant-A, Participant-E).

In addition, administering the GGB program gives the DTF an opportunity to build the ESCO market capacity through creating different tiers of the market; large complex projects which attract some of the established local and international ESCOs, and smaller projects that may allow local start-ups into the market. There is recognition that for EPC to grow in both the private and public sectors then not only does the demand need to be there, but also the supply capacity of a quality market also needs to exist (Participant-E, Participant-B).

As a Government entity, the DTF can justify the program beyond a purely financial perspective. The GGB program is creating jobs, stimulating growth in certain areas and all with a model that is self-repaying, transferring risk to the private sector and resulting in innovation (Participant-E).

In summary, there are various incentives for stakeholders to be involved in EPC projects in the GGB program, however initially it appears that the majority of these do not conflict. While stakeholders have indicated that there remain barriers to full engagement of the market and efficiency in the GGB program, there seems to be potential for it to be mutually beneficial to all parties.

29.6 Barriers to the EPC and ESCO Industry in Victoria

It appears that the majority of EPC projects currently being implemented in Victoria fall within the GGB program. There was limited information available on specific EPC outside the program, and for this reason the discussion in this section will focus on barriers within the GGB program and the general barriers to EPC in the State.

29.6.1 Timing

Within the GGB program the most commonly conveyed and stressed barrier from those interviewed was the timing of the individual projects within the program and the effect that this has on ESCO's cash flow (Participant-F, Participant-A, Participant-C). The time and investment that an ESCO puts into bidding for a GGB project is a large commercial risk, which, because of the GGB's structure, isn't recouped unless they are awarded the DTF(Participant-B, Participant-G). Even then ESCOs don't have any opportunity to be paid for works completed until the end of the DFS stage either through the DFS walk away fee, or the first invoice within the EPC. Some of the players in the GGB panel have felt this burden and pulled back, and in some cases effectively withdrawn from the program (Participant-F, Participant-I).

The timeline of project stages can also vary significantly and is generally seen as a product of the inefficiencies between parties involved in the program (Participant-A, Participant-C). This exacerbates the cash flow impact on ESCOs.

The release of tenders themselves is also seen as a barrier relating to the capacity of the industry. With a consistent release of tenders and flow of projects going on the DFS, the industry has the capacity to organically grow and meet demand, however if floods of tenders are being released without contracts being signed then growth, and therefore meeting demand is limited (Participant-C). Release of tenders generally rests on the approval of the client's board, and approval timelines consequently vary across departments and agencies (Participant-A, Participant-B, Participant-C).

29.6.2 Existing Infrastructure Compatibility

The effect of implemented solutions on the existing area networks has been commonly mentioned as creating significant complexities (Participant-A, Participant-C, Participant-H). Examples include cogeneration, which offers a myriad of advantages in a holistic retrofit; however cogeneration systems require integration into the existing electricity distribution network, which was designed for bulk generation rather than at a building level (Participant-C). Another example is waste water treatment systems at an individual building level, where the feedback has been that it is fouling up the existing system (Participant-H).

29.6.3 Payback Period

The 7 year payback period adopted in the GGB is justified by the DTF through the argument that 7 years provides the largest net present value for projects, with only slight reductions on environmental benefits. Stakeholders have expressed their concerns for the limitations of this criterion (Participant-E, Participant-H, Participant-C), as they believe it limits the viability of some holistic approaches with longer paybacks, and restricts some innovative approaches.

29.6.4 Reward

In organisations outside government there is an awareness of the opportunities for energy efficiency; however the primary demands of running the business mean that these opportunities regularly are overlooked. This couples with energy often representing a relatively small outgoing, so that although it might be possible to save a high proportion of the energy outgoings it may not seem like an effective use of resources, e.g. a 50 % saving on 3 % outgoing would yield a 1.5 % improvement in total (Participant-A, Participant-D, Participant-J).

29.6.5 Complexity

For all of its benefits there is no escaping the fact that EPC is a complicated model. For the vast majority of potential users this complexity is a large deterrent (Participant-D, Participant-F, Participant-G), as it is seen as a risky model that has the potential to seriously damage participants if not well managed, and the complexity and associated overheads do not make it commercially viable (Participant-D).

29.6.6 Underlying Scepticism of Emission Reduction Potential

There is a discrepancy in understanding the potential for demand side abatements in the movement against climate change. For example, the International Energy Agency believes that in order for the 450 ppm CO_2 targets to be met in 2020 that 66 % of the GHG reduction will need to come from energy efficiency measures (IEA 2011). In contrast, Department of Treasury (DoT) forecasting of the emissions reductions shows the abatements from supply side to be a minor in the overall picture, with the contribution actually diminishing with time (DoT 2011). It has been suggested that this contrast shows that, at a senior government level, the demand side potential of energy efficiency is undervalued. Furthermore, this is suggested to be an indication of the underlying mentality to energy efficiency in the Australian business landscape—that the energy efficiency potential for emissions reduction low, and not an area worth pursuing (Participant-B).

This failure to fully appreciate the environmental potential of energy efficiency at the highest levels of governance can lead the efficiency industry to be valued almost purely for its financial savings, and not its environmental potential. It could be speculated that additional uptake of efficiency incentive programs may occur if its value was fully realised, and therefore a stronger energy efficiency and EPC market in the public and sector could exist.

29.7 Strategies

29.7.1 Current GGB Strategies

Through the GGB's composition, the DTF attempts to overcome the barriers which have plagued previous government EPC based programs in Australia (Participant-A).

The mandate that requires take up of the program and achievement of input targets is credited with giving the program the participation that it has seen to date. In addition, because this mandate is given by the Department of Premier and Cabinet to the DTF, the two privileged departments within government, as they hold and allocate resources, it may also be seen to create institutional inertia (Participant-D). In previous programs this structure did not exist, which has led to a lack of widespread departmental engagement. The existence of input targets allows for the engagement of departments to be measured, and progress within them tracked. Departments are required to create strategic plans on how they will meet these targets (DTF 2012b).

Funding the GGB program from within the DTF takes away many of the risk and complexity factors associated with third party finance. The mechanism to gain finance has been set up under the GGB business case, and individual projects have a clearly defined process to go through to access this resource (DTF 2012b, Participant-A).

Standardisation of processes and templates across different GGB projects allows for much of the complexity in administering EPC projects to be reduced (Participant-C). New and updated templates that cover different stages in the program have been released since the inception of the GGB in an attempt to continue to streamline and standardise the process (Participant-B). Ongoing support by the GGB facilitators is crucial to this; they are in continual contact with ESCOs and clients, can appreciate the difficulties in the process and develop further strategies to reduce these (Participant-A, Participant-B, Participant-E).

There was a range of issues raised by interviewees over the timing of GGB projects as discussed in the barriers section above. Many of these barriers can be overcome through improved management efficiency of projects at a structural level within the program, with increased standardisation templates across the process (Participant-B, Participant-C, Participant-F). In addition, project structure has been modified so that client organisations are required to give significantly more approval to the processes prior to RFP stage, reducing some of the potential for delays in projects that there has been to date (Participant-B, Participant-C).

Modifications have been made to the program to reduce the cash flow burden on ESCOs in being involved in the early stages of GGB projects. In the program to date there has been an unclear scope in what baseline should be used, which resulted in ESCOs tendering for different sections within a RFP, i.e. tenderer 1 looking at the entire site, tenderer 2 looking at 5 buildings and tenderer 3 looking at only 2 buildings. RFP scopes have been clarified and generally reduced so as to allow a representative sample of the project for the ESCOs to tender for, and contestant baselines to be developed (Participant-B, Participant-C).

In addition to program optimisation, GGB facilitators provide support to clients. Assisting clients in different aspects of a project may reduce the time taken at different stages, and allow for better project outcomes. The benefits of providing facilitation assistance to clients has been shown through Queensland's experience with the GEMS program—when facilitation support was removed applications to the program dried up (Participant-A).

29.7.2 Suggested GGB Strategies

In response to the 7 year payback period being a barrier, increasing the payback period was consistently cited across a variety of stakeholders (Participant-E, Participant-F, Participant-G, Participant-H, Participant-C). Justifications predominantly focused on increasing the range of viable solutions, the reduction of overheads as a proportion of the contract and an ability to perform a deeper level of retrofit, with more functionality for the client.

29.7.3 Strategies Outside of the GGB

From the strategies employed within the GGB program it can be seen that there is a significant amount of work being done to provide standardisation and dissemination of information across EPC processes and projects. The GGB model is currently being adapted into the dormant Treasury Loan Fund with the NSW OEH (Participant-A, Participant-D), and is potentially going to be adopted at other level of government around Australia.

The Energy Efficiency Council (EEC) is an industry body that represents the EPC stakeholders interests (within and outside of Government), and is engaging in improving standardisation and accreditation in the industry. The EEC plays a facilitating role in providing training in M&V and accrediting industry personnel to the internationally recognised level of Certified Measurement and Verification Professional (EEC 2013a). In addition, the EEC has proposed a model that would give accreditation of individuals that have experience overseeing and coordinating all parts of an Integrated Energy Efficiency Retrofits (IEERs) of commercial buildings. Accreditation of industry professionals allows retrofit providers to demonstrate their experience, and ensure that retrofit projects are undertaken by people with the right skill set. EPC falls under the umbrella of an IEER, and therefore the benefits from this initiative would flow to the EPC industry (EEC 2013b).

There are positive signs for the increase in energy efficiency project uptake in the commercial sector as well. The National Australian Built Environment Rating

System (NABERS) is a national system that aims to measure the environmental performance of Australian buildings, tenancies and homes (OEH 2013). This initiative allows potential clients of buildings to assess a property based on its performance characteristics, and consequently increases the value of properties with higher ratings. In this way there is an increasing motivation for owners to improve the performance of their properties (Participant-B, Participant-J). In addition, the nationally mandated Commercial Building Disclosure (CBD) program requires full disclosure of the NABERS rating of any commercial office space 2000 square meters or more to prospective buyers or tenants (DoI 2010). This larger side of the market is where EPC has the greatest advantage, and the increased returns and emphasis on performance could grow the usage of EPC in the private building sector (Participant-B).

29.8 Conclusions

Energy performance contracting (EPC) is deployed in the Greener Government Building program in Victoria State, with the intentions to cut the operating costs, greenhouse gas emissions and water use of State operations while upgrading energy and water assets. However, the engagement of EPC in upgrading government building and publicly owned assets in Victoria has not been widely accepted, due to a lack of awareness of incentives and the existence of barriers. Through interviews with practitioners in the GGB program, this paper has highlighted the incentives of engaging EPC for clients, energy service companies and financiers, and identified six major barriers and strategies and their impacts on the application of GGB through EPC in the State of Victoria. These findings may potentially guide industry practitioners in planning and implementing deep energy retrofit using EPC in Victoria State and beyond.

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Chapter 30
Payback Period Based Prioritization of Building Retrofit Technologies: An Innovative Use of Critical Path Method

Anthony Ziem, Sujeeva Setunge and Guomin Zhang

Abstract Most metropolitan office buildings in Australia were built in 1980s and have out of date building services, consuming high level of energy and water as compared to new built green buildings. With a wide range of retrofit technologies/options available in the market, building asset managers often find it difficult to develop a retrofit plan and select appropriate technologies. This paper categorized the retrofit technologies into three stages (passive control, active control and substitution control), and then proposed an innovative prioritization model using the concept of critical path method to design sequential implementation of sustainable retrofit technologies based on payback period. A few new concepts such as Add-on Effect and Drag-on Effect were introduced to measure the impact of a selected technology on the payback period of a chain of retrofit technologies. An empirical case was used to demonstrate the application of the model. The prioritization model supplemented with other tools such as GreenStar rating and risk management will guide building managers to develop a more effective building retrofit plan.

Keywords Payback period · Prioritization · Building retrofit · CPM

30.1 Introduction

In the metropolitan cities in Australia, most buildings built in 1980–1990s are subject to structural deterioration and high level of energy and water consumption. In response to building owners' endeavour to achieve the "Green" target and reduction of energy and water consumption, many architects and engineers hungry for credentials in completing these types of green projects, may specify innovative products coming to market recently (Quatman and Manies 2008). However, the lack of experience in the design and construction of these green building tech-

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nologies may result in poor performance and create risk of disputes and claims among all parties involved in the project (Quatman and Manies 2008). It is well recognized that the application of green building technologies in retrofit buildings is commonly subjected to uncertainty and risk (Lam et al. 2010) and guidance on the application of such innovative technologies and the management of risks associated with their green efforts should be provided to industry practitioners to help manage the delivery of green building projects (Mosly and Zhang 2010). These technologies should be carefully selected/considered, and should be installed in an optimised sequence in order to not choose over/undersized technologies.

The biggest driver of green building retrofit is the lower running cost (Mosly et al. 2011). While implementing sustainable technologies may reduce the environmental impact, it does not always result in a lower running cost. It is important that all stakeholders involved in retrofitting sustainable technologies are aware of what the main driver is in order to select what technology suits. The technologies that are considered in retrofitting a building must have a reasonable payback period in order to have financial savings and also be capable of reducing the carbon footprint. Furthermore, the considered technologies should be implemented in a sequence so that they are sized correctly. Failing to take these considerations will result in a retrofit that is not adequate and could have an end result of high running costs which defies the purpose of the retrofit upgrade. This paper aims to introduce a payback period based model to prioritize building retrofit technologies using critical path method.

30.2 Issues Related to Building Retrofit Technologies

Before attempting to design a building retrofit, accurate information about the current performance of the building including energy and water consumption as well as user comfort should be gathered. Having the knowledge on how the building performs will not only help decide which technology is appropriate but also help estimate what consumption saving can be expected once these technologies are implemented. Developing an estimate is a complex task. If the project is large and there are many technologies considered, things can be more complex.

30.2.1 Sustainable Technology Classification

Sustainable technologies may include passive and active technologies. Passive energy is typically the natural energy that can be used to achieve a desired outcome, and active energy may be used in conjunction with natural energy to generate an expected outcome. A number of systems fall within the passive technologies and take advantage of natural energy in some form. The most common passive technology is using natural light for lighting. One of the main characteristics of passive control is that there is no running cost associated with it apart from maintenance. In contrast to passive controls, active controls use energy to reduce energy consumption by using more efficient technologies, such as air quality sensors, building management systems and light controls. In this paper, substitution controls are highlighted as a third category, such as solar panels and cogeneration. The difference between active controls and substitution controls is that substitution control technologies substitute partially or completely our consumption.

30.2.2 Sequence of Implementation of Retrofit Technologies

Once all the possible technologies have been identified it is important to plan the sequence that the technologies should be implemented, in order to avoid undersizing or oversizing of certain technologies. To map out which technologies should be implemented first, three stages are developed. Stage 1: identify a list of new and existing passive technologies that will be considered for the building retrofit. These technologies will reduce the loads/demands of the building and should be implemented first because they will impact the application of active technologies. Stage 2: identify a list of new and existing technologies that will either meet efficiently and effectively the loads of the building or will reduce loads/demands of an active successor (s) technology. Stage 3: identify a list of substitution technologies, such as cogeneration and tri generation. These technologies will be implemented once all passive and active technologies have been implemented or considered.

30.2.3 Sustainable Technology Cost Saving

Measuring the cost saving for each technology (i.e., adding a totally new technology, replacing an existing technology, or adding to an existing technology) is a difficult task especially when technologies have not been proven in a building that has similar physical or usage characteristics to the one planned. There are several software tools to help estimate energy savings, when estimating simple retrofits such as different shading and insulation solutions. The annual energy savings will be the calculated savings based on the impact of this technology to the building. Electricity, gas and water savings can be calculated separately. It is important to differentiate between the cost saving of a new technology or the upgrade of an existing technology when calculating the cost savings.

30.2.4 Budget Constraints

When looking at retrofitting new sustainable technologies it is important to first understand the desired outcome. Low running cost and sustainability are not always aligned due to some technologies might have higher running costs. Now due to budget constraints it is important to plan the retrofit upgrade based on the lifecycle of the existing technologies. This is to ensure that we do not oversize or undersize the technology being implemented. There are several aspects that need to be considered:

1. Choose the correct technology for the building
2. Select the right size technology based on future retrofits plan
3. Install the technology in the correct sequence

Not taking into account the above aspects could lead the retrofit into an unsuccessful project. Understanding the capital budget for the building is important when selecting the technology due that it will dictate which and when it should be implemented.

30.3 Prioritisation Model Based on CPM

Sustainable retrofits are a capital investment that resets the building life, improves its performance and makes the building more predictable for an extended period of time. Significant amount of effort has been made to understand the impact of the retrofit (Chidiac et al. 2011; Poel et al. 2007). However there is still a lack of information in regards to new technologies and building behaviour, which brings uncertainty to the equation when evaluating sustainable retrofits (Menassa 2011).

The main methods that building owners and consultants rely on when evaluating sustainable retrofits are payback period, internal rate of return and net present value. There are some reported intensive studies based on Geometric Brownian Motion (GBM) (Menassa 2011). These methods have been successful when assessing a particular technology. However when looking at multiple technologies and their relationships, the methods used in the past failed to take into account the interdependencies between technologies. In this paper we present a possible prioritization model which not only concentrates on the financial implications, but also evaluates the implementation of new technologies based on forecast budget and the stage and sequence of implementation in order to make the most cost savings with limited funds.

In order to capture the input described previously, an innovative concept based on Critical Path Method (CPM) will be developed to deliver the outcome expected. CPM is a project modelling technique that can be used with all forms of projects. Any project with interdependent activities can use this method; hence it has potential to consider optimum combinations retrofitting sustainable technologies to

Table 30.1 Comparisons of CPM and the proposed prioritization model

CPM	Proposed prioritization model based on CPM
Identify activities	Identify the sustainable technologies considered
Determine activity duration	Determine the payback period for each technology considered
Determine sequence of activities	Determine the sequence of implementing technologies
Draw network diagram	Connect the network of technologies according to their type of consumption and impact on other technologies
Identify the critical path which is the longest duration path through the network	Identify the critical path which presents the best payback period of implementation of technologies
Network has a start and a finish	Network has a start and a finish, and technologies should be implemented in a sequence

an existing building. There are several similarities as per Table 30.1. There is also the potential to use adaptive CPM in asset management when deciding which components should be upgraded or replaced in order to expend the budget efficiently.

Step 1

Firstly we need to have an understanding of the behaviour of the building in order to comprehend which technologies should be considered as a sustainable retrofit. The technologies considered will be based on their installation cost and their projected annual energy saving, given the fabric and orientation of the building. Then, the annual saving will be calculated by subtracting the annual maintenance from the annual energy savings:

$$\text{Annual Savings} = (\text{Annual Energy Savings} - \text{Annual Maintenance Cost})$$

The annual saving might be on electricity, gas or water, or a combination of them. The annual energy savings will be based on estimation which can be calculated using building simulation models; the annual maintenance cost will be the cost arising from this new technology which might exceed the existing annual maintenance or it might decrease depending on the technology we are replacing it with. If it is a new technology for the building then the annual maintenance cost will need to be calculated based on that technology only. The annual savings will help map out the type of control and identify their dependencies between them, in order to classify them into different stages, as per Fig. 30.1.

Step 2

Once the network diagram is finalized, The calculation of key parameters in the activity box can be proceeded. The activity box is similar to CPM, but the payback period (PP) rather than duration of the activity will be used for scheduling. Payback period (PP) of a technology is calculated in the following way:

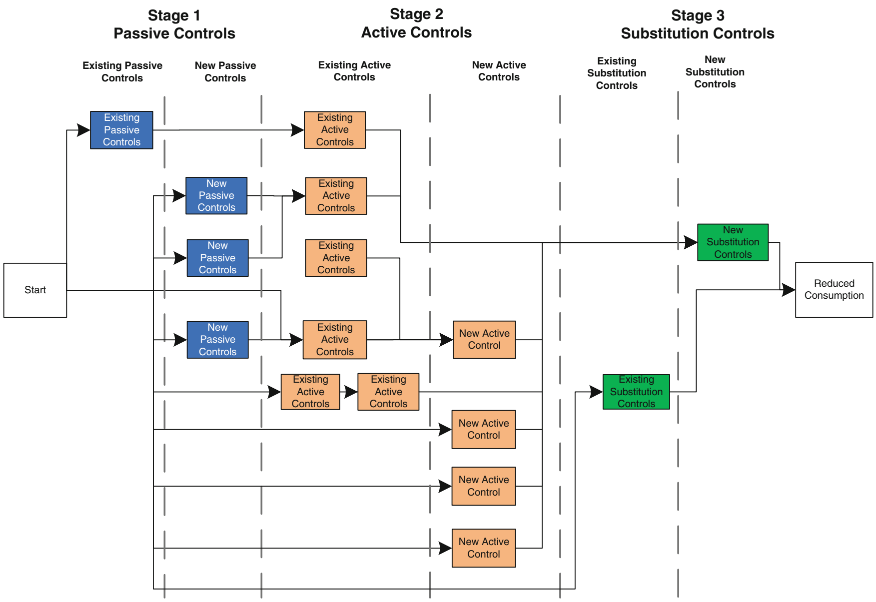

Fig. 30.1 Principal sequence of implementation of sustainable technologies

For upgrading an existing technology (like for like technology)

$$PP = \frac{IC_{new} - IC_{ll}}{AS}$$

For installing a new technology

$$PP = \frac{IC_{new}}{AS}$$

where,

IC_{NEW} Installation cost of the new technology
IC_{LL} Installation cost for like for like technology
AS Annual savings due to the installed new or like for like technology.

In this paper, instead of considering the payback period of an individual technology, the researchers seek to measure the payback period of a chain of technologies (from start to the observed technology). If a technology sits in different technology chains, a set of key terms are defined below.

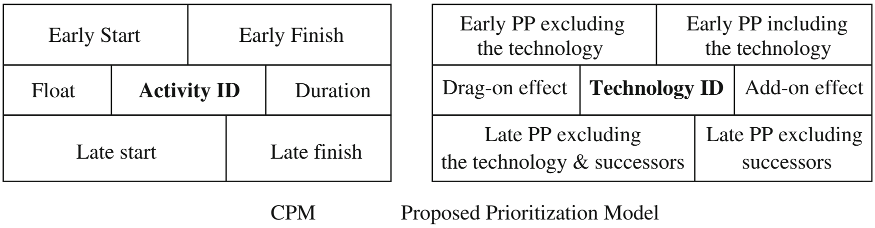

Fig. 30.2 Activity box representing retrofitting technologies

1. "Early payback period (PP) including the technology" means the minimum payback period of different chains of technologies which include the observed technology.
2. "Early payback period (PP) excluding the technology" means the minimum payback period of different chains of technologies which proceed to the observed technology.
3. "Payback Period (PP) of the retrofit project" means the minimum payback period of different chains of technologies in the whole retrofit project.
4. "Late payback period (PP) excluding successors"means the maximum PP of the chain of technologies excluding the successors of the technology, that is, the maximum PP of the chain of technologies including predecessors and the technology, to maintain the "payback period of the retrofit project".
5. "Late PP excluding the technology and successors" means the maximum PP of the chain of technologies excluding the technology and successors, that is, the maximum PP of the chain of predecessors of the technology, to maintain the "payback period of the retrofit project".

The technology activity box used in the proposed prioritization model is similar to that of CPM, as shown in Fig. 30.2.

Where, *Add-on Effect* and *Drag-on Effect* are defined below.

Add-on Effect = (Early PP including the technology) − (Early PP without the technology). *Add-on effect* is a defined parameter to measure the impact that the observed technology may have on the payback period of the chain which consists of predecessor technologies and the observed technology. Hence, the *Add-on effect* is chain based.

Drag-on Effect = (Late PP excluding successors) − (Early PP including the technology). *Drag-on Effect* is a defined parameter to measure the impact that the observed technology may have on the payback period of the chain in comparison to parallel technologies at the same stage. Hence, the *Drag-on Effect* is stage based.

Forward Pass Calculation

Forward pass algorithms will be developed to identify the critical chain of technologies

1. Suppose the project start date is day 0, i.e., PP Start = 0, which is also the earliest start of every technology in Stage 1 Passive Controls.
2. "Early PP including the technology" of the first and all the other parallel technologies, is calculated using the following equation. Suppose A is the first technology to be installed.

$$Early\ PP\ including\ technology\ A = \frac{IC_A}{AS_A}$$

   where IC_A is the installation cost of technology A, and AS_A is the annual saving due to technology A.
3. Early payback period of the successor technology B: As explain previously, early payback period of the successor technology B is defined as the payback period of technology chain A → B.
   FS (finish to start) dependency: "Early PP excluding technology B" equals to the "Early PP including technology A".
   Early PP including technology B can be calculated using the following equation.

$$Early\ PP\ including\ technology\ B = \frac{IC_A + IC_B}{AS_A + AS_B}$$

   where IC_A and IC_B are the installation costs of technology A and B, and AS_A and AS_B are the annual savings due to technology A and B. Note that if there are more than one predecessor technologies (A_i) for technology B, the "early PP excluding technology B" is the minimum "early PP including the predecessor technology A_i".

$$Early\ PP\ excluding\ technology\ B = \text{Min}\ \{\text{early PP including technology}\ A_i\}$$

4. This is continued until the early PP of every technology has been calculated using forward pass chain. The minimum PP of the last technology (or technologies) in all chains decide the shortest payback period of the retrofit project, which is defined as the *payback period of the retrofit project*.
5. The *Add-on effect* for each technology can be obtained by subtracting the "early PP excluding the technology" from the "early PP including the technology", as presented previously.

Backward Pass Calculation
The *payback period of the retrofit project* is the target that the retrofit project team aims to achieve when planning all technology activities in the chains. Based on this assumption, using backward pass calculation can work out the "late PP excluding successors" and the "late PP excluding the technology and successors", to keep the retrofit project finished at the *payback period of the retrofit project.*

1. For the last technology ended in the chains, the "late PP excluding successors" equals to the "early PP including the technology", which also equals to the *payback period of the retrofit project*.
2. "Late PP excluding the technology and successors" is obtained by subtracting the *Add-on Effect* of the technology from the "late PP excluding successors". Suppose for technology B:

$$\begin{aligned} &\textit{Late PP excluding the technology B and successors} \\ &\quad = \textit{Late PP excluding successors} - \textit{Add on Effect} \end{aligned}$$

3. Late payback period of predecessor technology A: As explain previously, late payback period of the predecessor technology A is defined as the maximum payback period of the technology chain exclude technologies B → A, to maintain the "payback period of the retrofit project".
   FS (finish to start) dependency: "Late PP excluding successors" for technology A is the "late PP excluding the technology B and successors".
   Note that if there are many successor technologies (B_i) for technology A, the "late PP excluding successors" for technology A is the maximum value of "late PP excluding the technology B_i and successors".

$$\begin{aligned} &\textit{Late PP}\ \text{excluding successors for technology A} \\ &\quad = \text{Max}\ \{\text{Late PP excluding the technology}\ B_i\ \text{and successors}\} \end{aligned}$$

4. This is continued until all the "late PP excluding successors" and "late PP excluding the technology and successors" on the chains using backward pass algorithms are calculated.
5. The *Drag-on Effect* of each technology will be calculated using the equation provided in previous section. Those technologies with zero *Drag-on Effect* indicate that they are critical technologies which should be implemented with first priority. Those critical technologies will form a chain of technologies which represent the critical path of carrying out the building retrofit.

30.4 Demonstration of the Model Application

For the demonstration of the model application, the main office of City of Kingston in Victoria State was used as a case study. Norman Disney and Young was appointed to undertake a detailed energy simulation modelling to assess the performance potential of a range of building upgrade measures, which included different types of shading, insulation and changes to the Building Management System (BMS) in order to minimise the energy consumption of the building. This assessment included collation and analysis of existing building information and performance data, and development of a baseline model for verification against existing energy consumption data for the building. Based on these results, combined scenarios, comprised of multiple upgrade options, were developed and assessment of

Table 30.2 Key information related to technology upgrade in Kingston' main office (only technologies that have impact on electricity consumption are included)

Technologies	Type	Successor	Installation cost ($)		Annual electricity saving ($)
			Like for like	New	
Behaviour change	Passive	Other equipment	N/A	5000.00	300.00
Shading A	Passive	Chiller	N/A	800,000.00	2958.00
Shading B	Passive	Chiller	N/A	1,000,000.00	3786.00
Insulation A	Passive	Chiller	N/A	250,000.00	−985.00
Insulation B	Passive	Chiller	N/A	300,000.00	−1800.00
Co sensors	Active	Chiller	N/A	3500.00	696.57
BMS controls	Active	Chiller	80,000.00	100,000.00	6717.72
Light controls	Active	Light fittings	80,000.00	150,000.00	4500.00
VSDAHU	Active	Co-generation/ tri-generation	N/A	10,000.00	512.00
VSD pumps	Active	Co-generation/ tri-generation	N/A	15,000.00	391.47
VSD car park	Active	Co-generation/ tri-generation	N/A	8000.00	666.00
Solar panel Option A	Substitution	Co-generation/ tri-generation	N/A	50,000.00	500.00
Efficient office equipment	Active	Co-generation/ Tri-generation	1,300,000.00	1,500,000.00	25,000.00
Chiller	Active	Co-generation/ Tri-generation	350,000.00	400,000.00	13,318.72
Light fittings	Active	Co-generation/ Tri-generation	350,000.00	600,000.00	25,000.00
Co-generation/ tri-generation	Substitution		N/A	785,000.00	50,000.00

these allowed the overall total potential energy reductions to be estimated. Table 30.2 gives information of the technologies considered, estimated annual cost savings and the installation costs.

Using the prioritisation model based on CPM proposed in the previous section, the network diagram can be developed for implementing technologies which may affect electricity consumption, as shown in Fig. 30.3. In the diagram, the *Add-on Effect* and *Drag-on Effect* of each technology are calculated and shown. Technologies with zero Drag-on Effect are critical technologies to be implemented with first priority. The critical technologies form the critical path as highlighted in Fig. 30.3.

After the critical path technologies are identified, funds will be allocated to implement these technologies. If the spent is less than the allocated budget of the retrofit project, a second (less) critical path can be identified using a similar approach to find more retrofit technologies to be implemented.

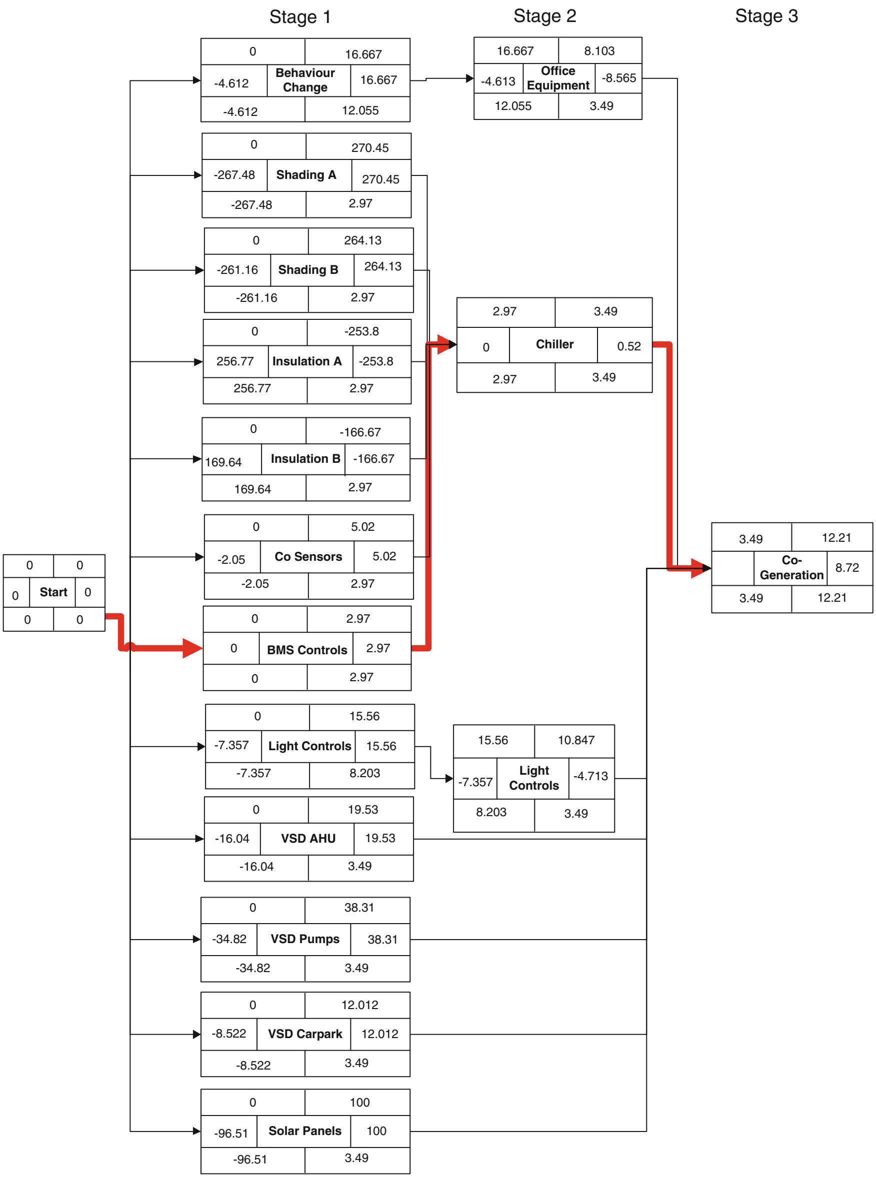

Fig. 30.3 Network diagram and critical path for implementing retrofit technologies

30.5 Conclusions

Most local councils are constrained by a lack of understanding of the process required to prioritize maintenance and renewal activities. Identifying the most effective retrofit technologies considering life cycle cost and benefit as well as payback period remains a major technical challenge. Retrofit technologies are highly interactive, particularly at building subsystems level. Lack of network/system thinking will result in problems such as oversizing or undersizing certain technologies and unnecessary constraints in addition to the limited budget available. This paper proposed a prioritisation model based on CPM method to design sequential implementation of sustainable retrofit measures based on payback period. The model is currently tested in the building maintenance and renewal program in the Kingston City Council as presented in the case study and has achieved good outcome. The prioritisation model can be extended to optimising the maintenance and renewal activities of other types of infrastructures and assets.

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Chapter 31
Measuring Competition Degree of Building Maintenance Market in Hong Kong: A Conceptual Model

Yuhan Niu, Weisheng Lu and K.W. Chau

Abstract Competition is a key to maintaining a healthy market without price distortion. With the occurrence of increasing anti-competition conducts and climbing project price in the building maintenance business in Hong Kong, it is of importance to examine the appropriate degree of competition (DOC) in this booming market. Market share concentration, entry barrier and other factors have been proposed by previous studies to examine the market competition individually. However, method that takes all factors into consideration for measuring the competition degree of the building maintenance market has not been established. This study aims to provide a conceptual model, by taking these factors on board to measure the DOC of the building maintenance market in Hong Kong. The model could be used to guide data collection, data processing and the calculation of the DOC. Measurement outcomes from this model may provide a basis for assisting the enforcement of the Competition Ordinance enacted from 2012 as well as alarming the enterprises with malpractices in the market.

Keywords Competition degree · Building maintenance market · Market share concentration · Entry barrier · Hong Kong · Conceptual model

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31.1 Introduction

The building maintenance market has been booming these years. There are one third of buildings in Hong Kong with over 30-year ages and it is estimated that the number of 30-year old buildings will increase to 22,000 in a decade (Tan et al. 2014). Therefore, Mandatory Building Inspection Scheme (MBIS) and Mandatory Window Inspection Scheme (MWIS) have been implemented in Hong Kong since 2012 to ensure the safety of aging buildings, which require inspections to be carried out for building components and particularly for windows of aging buildings (the Building Department [BD] 2012). There will be 2000 buildings selected for MBIS and 8500 projects selected for MWIS each year (BD 2012). As Building Ordinance requires, if inspectors of MBIS and MWIS deem necessary, respective maintenance and repair work shall be carried out by registered contractors who would bid for the contract (BD 2012). The registered maintenance contractors are classified into two categories by the Buildings Department, general building contractors that could undertake all kinds of maintenance work and specialist building contractors that could only undertake one of the sub-registry works, including demolition, foundation, site formation, ventilation and ground investigation. General building contractors account for over half of the market while other contractors under the sub-registry of specialist contractors are scattered as Fig. 31.1 shows.

Since the implementation of these two schemes from June 2012, there has been news reporting that maintenance project price were jet up to three times than usual by collusion of some contractor companies (Oriental Daily 2013). Over 90 % maintenance projects are suspected of being involved in bid-rigging and ultimately the maintenance market are monopolized by only 2–3 big firms (Oriental Daily 2013). Although such cases have been reported to the Independent Commission Against Corruption (ICAC) for several times, people and companies involved could not be convicted for any penalty (Mak 2013). Therefore, the current status of building maintenance market is worth attention.

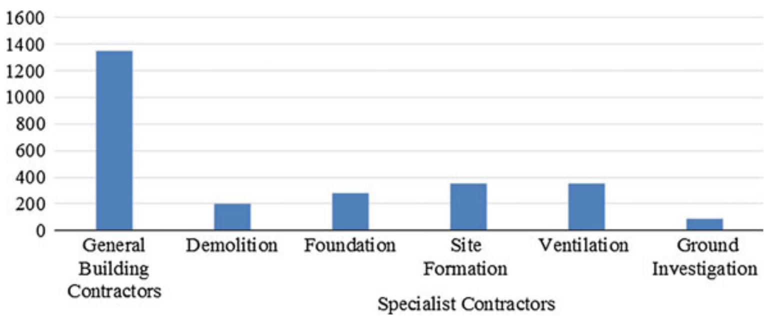

Fig. 31.1 Number of registered maintenance contractor in the buildings department. *Source* provided by the buildings department

Competition among market participants is essential to maintain a healthy market without price distortion (Adelman 1951). High price to marginal cost often signals the use of market power in a market with low competition degree (Shukla and Thampy 2011). Various studies have been conducted to investigate factors to enhance the competitiveness at individual firm level in the construction industry. For example, Yates (1994) reviewed and investigated factors that affect competitiveness of engineering and construction firms in a global context. Tan et al. (2014) found out the key factors for individual firms to achieve success and obtain competitiveness in the maintenance market in Hong Kong. Moreover, competition degree in the construction markets in other regions has also been examined. For example, Bremer and Kok (2000) studied the competition and corporatism of Dutch construction industry by analyzing relationships between different parties involved in the construction process. McCloughan (2004) examined the competition status of the construction industry in British where he mainly focused on the market concentration.

However, few studies have comprehensively investigated the competition degree of the building maintenance market in Hong Kong. Therefore, it remains unknown whether the competition degree of the building maintenance market in Hong Kong is suitable for maintaining a healthy market. One of the possible reasons is a lack of specific action guideline for measuring the competition degree. This study aims to provide a conceptual model to comprehensively examine competition degree of building maintenance market in Hong Kong. The model could be used to guide data collection, data processing and to calculate the competition degree. Measurement outcomes from this model may provide a basis for assisting the enactment of the Competition Ordinance for dealing with the anti-competition malpractices in the market.

31.2 Literature Review

Competition in a market is distorted when the competitive market price cannot be sustained. In perfectly competitive markets, the price is set at which the quantity that consumers demand balances the quantity that firms wish to supply. In such a market, all of the market participants have no market power. Market power refers to the ability of a producer/provider of product to consistently raise prices above the price level established by a competitive market (Alvarado 1998). A firm with market power has the ability to raise price above the competitive level and maintain profitability at the same time (Schmalensee 1982). Market concentration also refers to resource concentration, where few undertakings hold the majority recourse of the market (Alvarado 1998). Consequently, such undertakings would be able to individually affect either price or the quantity in the market. Market share concentration is a fundamental and prevalent method to reflect the inequality of market power distribution and to test the intensity of competition (Adelman 1951; Willekens and Achmadi 2003). Meanwhile, entry barrier of a market assists the incumbents to continuingly sustain their market power (Heflebower 1957). Therefore, it is of importance to examine the market share concentration and entry barrier in order to measure the market share distribution and competition degree.

31.3 Market Share Concentration

The significance of concentration arises from the view that highly concentrated market tends to be dominated by a few large firms, especially where the number of suppliers is limited and barrier to entry is high (McCloughan and Abounoori 2003). In such a concentrated market, the abuse of market power is more likely to occur, and therefore most competition policies intend to restrict high concentration (McCloughan 2004).

The concentration ratio (CRn) is the most widely known and acknowledged measure of industrial concentration, which could represent the top firms' concentration in a market. CRn calculates the percentage of the aggregated share occupied by the largest n firms in a certain industry (Parker 1991). CR4 and CR5 are mostly used to examine market concentration. Baldwin and Gorecki (1994) proposed that CR4 above 75 % indicates a higher probability to have a "competition problem". McCloughan (2004) pinpointed that a CR5 higher than 70 % signals a highly concentrated market while a CR5 less than 10 % signals a highly fragmented market. In Singapore Competition Act 2004 and Laws of Malaysia Act 712 Competition Act 2010, 60 % is the suggested threshold for CR4 signaling high market concentration. According to the Sherman Antitrust Act (1890) in the U.S. and the Competition Act (1998) in the U.K., the threshold of CR4 is 50 %. Although concentration ratio is often praised for its convenience in collection of data, it is also criticized in that CRn only focus on top firms concentration without taking the rest of firms into consideration (Ye et al. 2009).

Hirfindahl-Hirschman index (HHI) is another method to measure concentration, which calculates the sum of the squared market shares of the top 50 firms (or all the firms if they are less than fifty) in a particular sector (Hirschman 1980). HHI demonstrates the weighted total concentration, which weights each firm by its own relative market share and gives more weights to larger firms (Zwanziger et al. 2000). Weighted total concentration could highlight inequality in market share distribution. The HHI of a market where market share are evenly distributed will be extremely lower than that of a market where few firms dominate. HHI is used as an indicator of competition and serves as an efficient screening device for regulator (Rhoades 1993). It has been adopted as a formal numerical index in U.S. Department of Justice Merger Guidelines since 1982. Suggested by the Merger Guidelines of U.S. Department of Justice and the Federal Trade Commission, a HHI below 0.01 indicates a highly competitive degree; a HHI between 0.10 and 0.15 indicates an un-concentrated market; a HHI between 0.15 and 0.25 indicates moderate market concentration; and a HHI above 0.25 indicates high market concentration.

31.4 Entry Barrier

Entry barrier is an advantage of incumbents in a market against potential new entrants (Heflebower 1957). When entry barrier acts like an insulation protecting the incumbents, the existing firms with large market power may strategically manipulate factors that affecting entry barriers to secure their power (Scheffman and Spiller 1992). Since lowering the barriers generally encourages potential competitors to enter the market, it may prevent existing dominant firms from sustaining prices higher than market prices. Consequently, the market power of dominant firms would be attenuated and competition level is likely to rise.

The height of the entry barriers is determined by factors including sunk cost and economies in scale relatively to the market size (Comanor and Wilson 1967). Sunk cost constitutes of the capital required for new entrants to establish a market position in a minimum efficient scale (Comanor and Wilson 1967). It varies between different markets. For building maintenance market where large plants or complex facilities and various materials may be required in some large renovation projects, sunk cost could be considerable. Economy in scale reveals the advantage of large firms to spread cost over more units of output so that less cost are spent per unit (Comanor and Wilson 1967). Comparing to new or potentially new entrants in maintenance market, large incumbents holding more projects could reduce the unit cost by sharing common facilities and plants. For building maintenance market in Hong Kong, other factors may also lift the entry barrier such as certification from government and reputation of contractor firms. Certification from government department is found to be the key factor for maintenance contractor's competitiveness in bidding (Tan et al. 2014). In the MBIS and MWIS programs, the Buildings Department regulates that only registered general building contractors (RGBC) or registered minor works contractors (RMWC) can be appointed for repair and maintenance work. Such requirement rather serves as an entry barrier even for other existing non-registered incumbents, not to mention potential new entrants.

31.5 The Conceptual Model of Measuring Competition Degree

In order to investigate the competition degree of the MBIS and MWIS market, simple additive weighting (SAW) method would be used to calculate the overall competition degree. SAW is one of the commonly used methods to measure the performance of a specific objective when there are multi-criteria involved (Athawale and Chakraborty 2012). To apply SAW method, each factor should be specified first and the weight for each factor should also be determined (Athawale and Chakraborty 2012). Then by multiplying each factor with its corresponding weight, the weighed values can be obtained, which could be subsequently summed

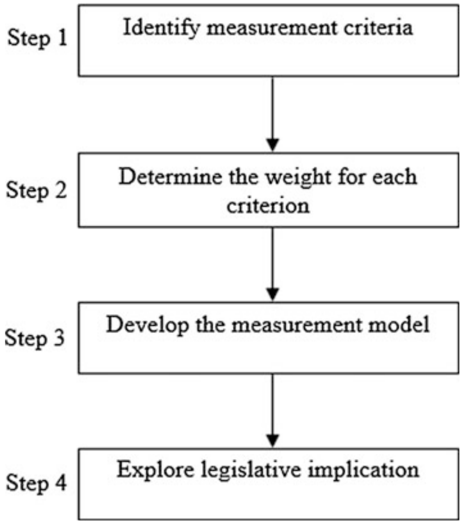

Fig. 31.2 Flow chart of measuring the competition degree in MBIS and MWIS markets

up to get the competition degree in MBIS and MWIS market. A series of analytical processes for the measurement is shown in Fig. 31.2.

Step 1: **Identify the measurement factors**

There are various factors influencing the competition degree in a certain market. Existing studies on competition and building maintenance market as well as anti-trust legislations should be reviewed to identify a list of measurement factors. As indicated in the literature review, a list of factors for measuring competition degree in MBIS and MWIS market is suggested in Table 31.1.

Table 31.1 List of measurement factors

Factors		Reference
Market share concentration	F_1. Top firms concentration	Ye et al. (2009)
	F_2. Weighted total concentration	Ye et al. (2009)
Entry barrier	F_3. Sunk cost	Comanor and Wilson (1967)
	F_4. Economic scale of firm relative to market size	Comanor and Wilson (1967)
	F_5. Limited access to resources	Comanor and Wilson (1967)
	F_6. Certification from government department	Tan et al. (2014)
	F_7. Company reputation	Tan et al. (2014)
Other factors	F_8. Consumer's bargaining right	Singapore Competition Act 2004
	F_9. Economic regulations imposed by government	Laws of Malaysia Act 712 Competition Act 2010
	F_{10}. Project differentiate degree	Australian Competition and Consumer Act 2010

The list of factors is not exhaustive, which are subject to addition, subtraction and amendments by experts and professionals who work in the building maintenance industry. The finalization of factors could be done though surveys by interviews or questionnaires. As a result, finalized measurement factors could be presented as shown in Formula (31.1), where F denotes factors measuring the competition degree in MBIS and MWIS markets and i denotes the sequence of the factors.

$$F = \{F_1, F_2, F_3, \ldots, F_i\} \tag{31.1}$$

Value of each factor could be obtained by data calculation and survey. Top firms concentration could be obtained by using CR4 methods. The type of data for CRn calculation is not fixed, which could be data revealing employment, net output, turnover or work done, and others (Adelman 1951; McCloughan 2004). Transaction price of each maintenance project is suggested for this study due to data availability. Data of transaction price and respective firms for MBIS and MWIS from 2012 to 2014 could be obtained from the Buildings Department of Hong Kong. All the firms that have carried out MBIS and MWIS work could be listed out and ranked by the total incomes for all projects they have undertaken. The percentage of incomes acquired by each firm against the total market volume reflects the market share obtained by each firm. CR4 could be calculated by Formula (31.2). Si denotes percentage of market share acquired by firm i and i denotes the rank of the firm by its total income.

$$\mathrm{F}_1 = \mathrm{CR}_4 = \sum_{i=1}^{4} S_i \tag{31.2}$$

Weighted total concentration could be obtained by HHI methods, which could be calculated by Formula (31.3). Si denotes percentage of market share acquired by firm i and i denotes the rank of firm by its total income. n denotes the number of all firms and the value of n would be 50 if there are more than fifty firms in the market (Hirschman 1980):

$$\mathrm{F}_2 = \mathrm{HHI} = \sum_{i=1}^{n} S_i^2 \tag{31.3}$$

F_1 and F_2 denote the first two measurement factors in the model. The result of F_1 and F_2 will be ranged between 0 and 100 %, where a higher value reflects a higher concentration in the market, suggesting a lower competition degree.

Values of other factors would be obtained by survey among professionals who work in building maintenance field, especially for those who are involved in MBIS and MWIS projects. They will be asked to rate each factor by scale from 1 to 5.

Step 2: **Determine the weight of each factor**

The weight of each factor reveals the relative importance of each factor influencing the competition degree in the MBIS and MWIS markets. Ho et al. (2010) reviewed several methods for the determination of weight. Among those methods, simple multi-attribute rating is a preferred technique for its simplicity and applicability (Peng et al. 2014). On applying the multi-attribute rating technique, rating of each factor would be collected by survey on construction professionals who work in building maintenance market. Each rating of the specific corresponding factor would be summed up together. Then the sum would be divided by the total points of all measurement factors to obtain the weight (Peng et al. 2014).

As a result, a series of weight corresponding to each measurement factor could be obtained as shown in Formula (31.4) where W denotes the weight and i denotes the sequence of each factor.

$$W = \{W_1, W_2, W_3, \ldots, W_i\} \tag{31.4}$$

Step 3: **Develop the measurement model**

Based on step 1 and step 2, the model to measure the competition level of the MBIS and MWIS markets could be established as Formula (31.5).

$$\mathrm{p} = \frac{1}{\sum_{i=1}^{n} W_i \times V(F_i)} \tag{31.5}$$

P denotes the competition degree in the MBIS and/or MWIS market and n denotes the total number of measurement factors. W_i denotes the corresponding weight of measurement factor F_i and V denotes the standardized value of F_i. All of the factors value $V(F_i)$ should be standardized from 0 to 100 % before the calculation of Formula (31.3). The CRn and HHI already exist in the form from 0 to 100 %. Other factors obtained through survey are in the form from scale 1 to 5, which would be converted to 0–100 % to scale. A higher P suggests a higher competition degree in the MBIS and MWIS market.

The developed model can be used to measure the competition degree of MBIS and MWIS market both at an integral market degree and at two sub-markets degree.

Step 4: **Explore legislative implications**

With the enactment of Competition Ordinance in June 2012 in Hong Kong, various means are introduced to promote and maintain competition in Hong Kong. While direct damages or injury-in-fact are difficult to prove for the enforcement of Competition Ordinance, measuring the competition degree of a market could provide basis for enforcing the relative legislative rules. Anti-competition conducts such as collusion and bid-riggings are prone to occur in market with low competition degree. Since the 1st Conduct Rule of Competition Ordinance aims to prevent anti-competition conducts, the Competition Committee should pay due attention to the market with low competition degree. Meanwhile, the 2nd Conduct Rule aims to prevent misuse of dominant market power by major enterprises (Competition Committee 2012). The factors concerning market share concentration in this study could help identify dominant market players in MBIS and MWIS market, and thus provide targets and bases for the enforcement of 2nd Conduct Rule.

31.6 Conclusion

Measuring the competition degree of building maintenance market is of value for better understanding of the market as well as for assisting the enforcement of Competition Ordinance. This study develops a step-by-step working procedure to measure the competition degree in MBIS and MWIS market. It is expected that the model could be carried out at a whole market level for MBIS and MWIS as well as at two sub-market levels to explore the similarities and distinctions between difference levels of market. In addition, further studies could adopt the model for measuring competition degree of other markets. Comparison the competition degrees between different industries may bring more insights into the individual industry status.

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Chapter 32
Country Review on the Main Building Energy-Efficiency Policy Instrument

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Abstract Building energy-efficiency (BEE) is the key to drive the promotion of energy saving in building sector. A large variety of building energy-efficiency policy instrument exist. Some are mandatory, some are soft scheme, and some use economic incentives from country to country. This paper presents the current development of implementing BEE policy instruments by examining the practices of BEE in seven selected countries and regions. In the study, BEE policy instruments are classified into three groups, including mandatory administration control instruments, economic incentive instruments and voluntary scheme instruments. The study shows that different countries have adopted different instruments in their practices for achieving the target of energy-saving and gained various kinds of experiences. It is important to share these experiences gained.

Keywords Building energy-efficiency · Policy instrument · Benchmark framework

32.1 Introduction

There has been a growing appeal globally for improving building energy efficiency in line with the understanding that increasing energy consumption has significant impacts on sustainable development. According to the International Energy Outlook 2013 (U.S. Energy Information Administration 2013), energy consumption will increase globally from 524 quadrillion Btu in 2010 to 630 quadrillion Btu in

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2020, and 820 quadrillion Btu in 2040, which presents a sharp increase of 56 % over 30 years. And it is said that in this report that 85 % of this increase will occur in the developing nations, which is driven by economic growth and expanding populations.

It was estimated in the assessment report by International Panel on Climate Change (IPCC) (2007) that buildings consume as much as half of the primary energy resources and the energy consumption in buildings have contained 35–40 % of all energy-related CO_2 emissions. It is commonly appreciated that building is the biggest single contributor to total energy consumption in most countries (Butler 2008; Saidur 2009). In line with this, governments throughout the world have set up various targets to improve building energy efficiency (BEE) by introducing various types of policy instruments. For example, European Union has defined the target of achieving the reduction of the greenhouse gas emission by 20 %, and the increase of using 20 % renewable energy sources by 20 % by the year of 2020 compared to 1990 (Capros et al. 2011). China has set a target of energy efficiency in its “Twelfth Five-Year Plan” (201) that energy consumption for every 10,000 yuan of GDP will be reduced to 0.869 ton in 2015 from 1.276 tons in 2005, which need a sharp reduction of 32 % in comparing with the energy consumption defined in its “Eleventh Five-Year Plan”. Similarly, other countries have also defined their energy saving target. In pursuing these ambitious targets, governments throughout the world consider BEE policy instruments as important part of policy agenda (Hendrickson and Horvath 2000).

Building products have strong externality characters. In economics, an externality is the cost or benefit that affects a party who did not choose to incur that cost or benefit (Buchanan and Stubblebine 1962). For example, building developers will normally enjoy the economic interests from the development, but the environmental pollution caused by energy consumption on buildings will be borne by the public, and the cost for curing such pollution is usually paid by the concerned government. It is the role of government to protect the public interests. Mahmoudi et al. (2009) opined that government should play a leading role in protecting environment and promoting building energy-efficiency. Government usually plays this leading role through introducing BEE policy instruments.

A policy instrument represents a set of measures which target for a common problem (Bressers 1996). For example, BEE policy instruments include a number of specific measures such as laws, regulations, governmental economic incentives, BEE labelling and certification. Researchers, for example, Peters and Van Nispen (1998) considered that policy instruments give attention to the public interests and present a set of public policy activities for driving social development. They argued further that policy instruments have not only served as major means for the government to guide the development of economy and society, but also as a bridge between policy targets and policy application environment.

Having realized the significance of improving energy efficiency in building sector through policy instruments, there is a pragmatic shift towards the introduction and application of various BEE policy instruments, such as regulations, standards, codes, taxes and governmental incentives in both developed and developing countries. For example, in China, the government has been offering various economic incentives for BEE projects in recent years, such as the "Interim Management Methods on Financial Subsidy for Application of Solar Building Integrated Photovoltaic" issued by the Ministry of Housing and Urban-Rural Development (MOHURD) (2009). United States has issued the Energy Policy Act of 2005 (EPAct 2005), which offers tax incentives in residential and commercial building sectors to encourage the production of energy efficient building products and increase the market share of these products (Meltcalf 2007). However, as different countries have different backgrounds from the perspectives of culture, economy, political systems and environmental conditions the policy instruments for improving building energy efficiency vary between different countries (Pérez-Lombard et al. 2009).

Whilst various BEE policy instruments have been extensively introduced globally, the practices of these instruments in different countries have been encountered with various challenges (Gillingham et al. 2006). The study by Balachandra et al. (2010) suggests that majority of the developing countries, such as India, have not developed effective BEE management instruments, and the implementation of their BEE policy instruments is of limited effectiveness. Li et al. (2009) pointed out that the implementation of BEE policy instruments have encountered with various challenges in practices, such as capital shortage for applying economic incentives and building users lack of efficiency knowledge. Mundaca (2008) echoed that building developer, who usually seeks for short-term benefits, shows less concerns and participations on building energy efficiency. Raut et al. (2011) pointed out that some building users are skeptical about the safety and comfort of new energy efficient materials and technologies, such as brick manufactured by building waste materials. And he further suggested the importance of improving public understanding on BEE policy instruments.

In lines with these challenges, it is considered important to exchange and share the experiences in the process of applying BEE policy instruments between different countries. It is, therefore, the aim of this study to review BEE policy instruments among the main energy-consuming countries.

32.2 Research Methodology

The research starts with understanding the typical BEE policy instruments introduced in a group of selected countries and regions. Progress in implementing BEE policy instruments has been made, especially in Asia, North America, Europe and Oceania. On the other hand, these regions are also the major consumers on primary energy (oil, gas and coal) as shown in Fig. 32.1 (U.S. Energy Information Administration 2013). Therefore these countries and regions are selected for study, including European Union, the United States, Australia, Japan, Singapore, China and India.

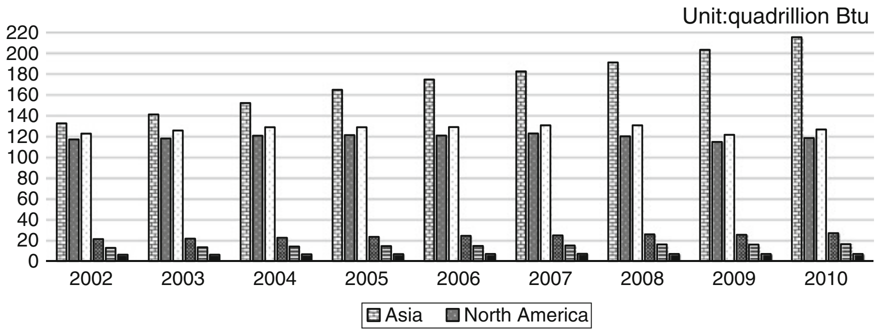

Fig. 32.1 Total primary energy consumption

Table 32.1 Official websites of selected countries

No.	Country	Administration
1	EU	Energy-European Commission (http://ec.europa.eu/energy/index_en.htm)
1.1	UK	Department of Energy and Climate Change (https://www.gov.uk/government/organisations/department-of-energy-climate-change)
1.2	Germany	Umwelt Bundes Amt (http://www.umweltbundesamt.de/)
1.3	France	Department of Energy (http://www.gouvernement.fr/)
2	US	HUD—“Department of Housing and Urban Development” (http://www.huduser.org/portal/home.html)
3	Australia	DOE—“Department of the Environment” (http://www.environment.gov.au/)
4	Japan	METI—“Ministry of Economy, Trade and Industry” (http://www.meti.go.jp/)
5	Singapore	BCA—“Building and Construction Authority”—Ministry of National Development (http://app.mnd.gov.sg/Home.aspx)
6	China	MOHURD—“Ministry of Housing and Urban-Rural Development of the People‘s Republic of China” (http://www.mohurd.gov.cn/)
7	India	MHUPA—Ministry of Housing and Urban Poverty Alleviation (http://www.mhupa.gov.in/)

BEE policy instruments are classified according to the principle of policy instrument into 3 groups of policy instruments, namely, mandatory administration instrument, economic incentive instruments and voluntary scheme instruments. Each group includes various policy measures. By referring this framework of BEE policy instrument classification, the specific BEE policy instruments issued in these surveyed countries are identified.

The primary data needed for identifying these specific policy instruments are gaining from the relevant sources about laws and regulations, administrative rules and governmental plans. These sources are approached by visiting the official websites of these countries, as shown in Table 32.1.

32.3 Identification of Typical BEE Policy Instruments in Selected Countries

32.3.1 Establishment of a Framework of BEE Policy Instruments

In order to identify the typical BEE policy instruments in various countries, a framework of BEE policy instruments is developed. The development of this benchmark framework is based on the principle of policy instrument. Policy instruments are the set of techniques by which governmental authorities wield their power in attempting to ensure support and effect or prevent social change (Bemelmans-Videc et al. 2011). Some policy instruments are mandatory, some are economic incentive and some are voluntary. A few of studies on the classification of policy instruments. Howlett et al. (1995) divided policy instruments into three types: the voluntary instrument, the compulsory instrument and the mixed instrument, but it is appreciated that this classification has limitation for its abstract and vague classification. McDonnell and Lorraine (1987) divided the policy instruments into four categories according to the compulsory degree of governance: the imperative instrument, the constructive instrument, the systematic instrument and the incentive instrument. The downside of this classification is appreciated that the classified elements are not at the same level.

According to the above discussion, BEE policy instruments are classified into 3 groups from the perspective of compulsory degree of instrument: mandatory administration instrument, economic incentive instrument, and voluntary scheme instrument. This classification forms a benchmark framework of BEE policy instruments classification as shown in Fig. 32.2.

By applying the framework for examining the relevant data sources described in methodology section, each group of policy instrument is composed of a number of specific policy measures, which can be summarized as follows:

1. Mandatory administration instrument (I-A), includes the specific policy measures of law, regulation, standard and code.

Fig. 32.2 Benchmark framework of BEE policy instrument classification

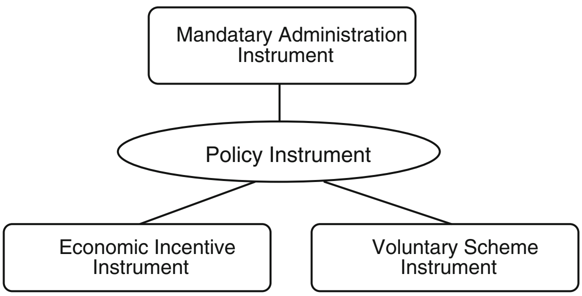

Table 32.2 A detailed framework of BEE policy instrument

	Policy instrument		Policy Measure
I-A	Mandatory administration instrument	I-A1	Law
		I-A2	Regulation
		I-A3	Code and standard
I-B	Economic incentive instrument	I-B1	Subsidy
		I-B2	Tax
		I-B3	Loan Incentive
I-C	Voluntary scheme instrument	I-C1	R&D
		I-C2	Certification and labelling
		I-C3	Governmental service

2. Economic incentive instrument (I-B), consists of subsidy, tax, and loan incentive. Subsidy can be entailed with investment subsidy, production subsidy and consumer subsidy. Tax refers to tax preference (add-value tax, corporate income tax, personal tax, etc.) and mandatory tax (energy tax, carbon tax, fuel oil tax, etc.).
3. Voluntary Scheme instrument (I-C), consists of R&D, certification and labeling, and governmental service. Governmental service includes information service, energy audit, demonstration project, and governmental procurement.

By incorporating these specific policy measures into the benchmark framework, a detailed framework of BEE policy instruments can be produced as shown in Table 32.2.

32.3.2 *Identification of Typical BEE Policy Instruments*

In referring to the framework of Table 32.2, data collection was conducted through the official websites as addressed in methodology. Having examined the collected data, the typical policy instruments in the selected countries are identified, as shown in Tables 32.3, 32.4 and 32.5.

32.4 Discussions on the Experiences and Limits of BEE Policy Instruments

Between the selected groups of countries in this study, they have different experiences and encounter different limits in practicing BEE policy instruments because of their different backgrounds. These experiences and limits can be discussed as follows.

Table 32.3 I-A: mandatory administration instrument

Country		
EU	**I-A$_1$: Law**	**I-A2: Regulation**
	• WSVO (1978, Germany)	• Consultant Service (2000, Germany)
	• Building Codes (2001, UK)	• Live Consultant Program (2005, Germany)
	• "EnEV" 2002 Edition (2002, Germany)	**I-A$_3$: Standard and Code**
	• Air-conditioning Energy Label Regulation 2002/31/EC (2002)	• Residence Heating System Energy-saving Standard in France (1973, France)
	• Building Energy-efficiency Performance 2002/91/EC (2002)	
	• EPBD "Building Energy Performance Directive" (2003, revised 2010, Directive 2010/30/EU)	• Building Research Establishment Environmental Assessment Method (1990)
	• Sustainable and Safe Construction Act (2004, UK)	• UK's BREEAM (Building research establishment environmental assessment method) (1990)
	• Building Energy-saving Regulation (2005, UK)	
	• Energy White Paper (2005, France)	• German Passivhaus Standard
	• Code for Sustainable Homes (2006, UK)	• Minimum Energy Performance Standards (2004)
	• Building Energy-efficiency Regulation (2010, France)	• Energy-using Product Design Standard 2005/32/EC (2005)
	• Energy Efficiency Plan 2011 (2011)	• Energy Performance of Buildings Directive (2010)
US	**I-A$_1$: Law**	**I-A3: Standard and Code**
	• Housing and Community Development Act of 1974 (1974)	• 2009 IECC (International Electrical Certification Centre) (2011)
	• American Homeownership and Economic Opportunity Act of 2000 (2000)	• ASHRAE 90.1-2010 (American Society of Heating Refrigerating and Air Conditioning Engineers) (2011)
	• Community Tax Relief Act (2000)	
	I-A$_2$: Regulation	
	• Helping Families Save Their Homes Act of 2009 (2009)	
Australia	**I-A$_1$: Law**	**I-A2: Regulation**
	• Ozone Protection and Synthetic Greenhouse Gas Management Act (1989)	• Public Building Water Guide (2006)
	• MEPS (Minimum Energy Performance Standards) (1996)	• Green Rent List (2009)
		• Renewable Energy Target Plan (2009.08)
	• Renewable Energy Act (2000)	**I-A3: Standard and Code**
	• National Greenhouse and Energy Reporting Act 2007 (2007)	• 2009 IECC (International Electrical Certification Centre) (2011)

(continued)

Table 32.3 (continued)

Country		
	• Public Law on Building Energy Efficiency (2010.07)	• ASHRAE 90.1-2010 (American Society of Heating Refrigerating and Air Conditioning Engineers) (2011)
Japan	**I-A$_1$: Law**	• Residential Environmental Points System (2009)
	• Energy-saving Law (1979.06,1993,1998,2000,2005 updated)	• Proposal on Zero-Energy-Building Development (2009.11)
	• Law on the Earth Warming Promotion (1998)	• Energy Basic Plan (2010.06)
	• Regulation on Residential Quality Assurance (1999)	• Measures on Promoting Development of Residential and Public Building (2012)
	• Law on Green Procurement (2000)	**I-A3: Standard and Code**
	• Law on Building Materials Recycling (2001)	• Residential Building Performance Certification (1970)
	• EnEG 2008 Version (2008)	• Energy-saving Standard (1980,1992,1999 updated)
	• Energy Saving Act (2013.02)	• Building Energy-saving Design Standard (1980, 1992,1999 updated)
	I-A2: Regulation	• Tax Preference on High Quality Residential Building (2000)
	• SECO Plan (Energy service company) (1996)	• Tax Preference on Building Energy Efficiency (2013)
	• Plan on Green Government Buildings (1998)	• Renewable Energy Standard (2003)
Singapore	**I-A1: Law**	• Government regulation on building recycling economy (2003)
	• Regulatory Requirements for Existing Buildings & Mandatory Submission of Periodic Energy Audits (after 2000)	**I-A3: Standard and Code**
		• Minimum Energy Performance Standards (1999)
		• Retail Green Schedule (after 2000)
	I-A2: Regulation	• Office Green Schedule (after 2000)
	• Government Regulation and Oversight on Construction Debris Market (1999)	• Government Energy Consumption Performance Report (2006)

(continued)

Table 32.3 (continued)

Country		
China	**I-A1: Law**	**I-A3: Standard and Code**
	• Law on Energy Saving (1997.11)	• Regulation on Green Building Labelling (2007.08)
	• Law on Renewable Energy (2005.02)	• JGJ26-95 “Civil Building Energy-saving Design Standard (heating residential building part)” (1995, 2010 updated)
	I-A2: Regulation	
	• MOHURD “Ninth Five-Year Plan” and “2010 Plan” (1995.01, 2002 updated to “Ninth Five-Year Plan” Guideline)	• JGJ 129-2000 “Technical Specification for Energy Conservation Renovation of Existing Heating Residential Building” (2000, 2012 updated)
	• Major Suggestions on Advancing Housing Industry Modernization and Improving Residential Quality (1999.08)	
	• “Eleventh Five-Year” Planning Outline for Urban Green Lighting Project (2006.07)	• JGJ134-2001 “Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone” (2001, 2010 updated)
	• Green Building Act Plan	• JGJ 75-2003 “Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Warm Winter Zone” (2003, 2012 updated)
	• 12th Five-Year Green Building and Ecological City Development Plan (2013.04)	
	• Energy-saving and Low Carbon Emission Development Act Plan (2014–2015)	• Public Building Energy-saving Design Code (2005)
		• JGJ144-2004 “Exterior Insulation Technology Standard” (2005)
	• GB 50176-93 “Civil Building Thermal Design Code” has been abolished (1993)	• GB50411-2007 “Code for Construction Quality Acceptance of Building Energy-saving Project” (2007)
		• Civil Architecture Energy-saving Rules (2008)
		• Rules on Building Energy Conservation Civil Building and Public Building (2008.08)
India	**I-A3: Standard and Code**	• Indian Bureau of Energy Efficiency (2006)
	• National Building Code (2005)	• Energy Conservation Building Code (2007)

32.4.1 Practice of Mandatory Administration Instruments (I-A)

All the countries and regions surveyed in this research have developed direct mandatory administration instruments in previous years. But there are significant differences on the type of BEE policy instruments between the Eastern and Western

Table 32.4 I-B: economic incentive instrument

Country		
EU	**I-B1: Subsidy**	• Public Housing And Low-Rent Housing Energy-Saving Program (2009, France)
	• Low-Rent House Reform Subsidy Project (1978, France)	• "Renewable Thermal Energy Fund" (2009, France)
	• Pah Program (1979, France)	• "Passive On" Special Fund (2009)
	• Building Energy-Efficiency Audit Subsidy (1980, France)	• "CEPHEUS" Fund (Cost-efficient passive houses as European standard) (2011)
	• Solidarity Fund And Structural Fund (1993)	• Green Deal (2012, UK)
	• Kfw Special Fund (1996, Germany)	**I-B2: Tax**
	• Environmental Furniture Subsidy (1997, France)	• Zero Interest Rate Loan (1995, France)
	• 100,000 Daecher Program (1999, Germany)	• A Tax Credit For The Installation Of More Efficient Equipment (1998, France)
	• Solar Equipment Subsidy (2000, France)	• Tax Reform (1999, Germany)
	• "Sun Action" (2000, France)	• Reduced Value-Added Tax Rate (2000, UK)
	• German Kfw (2000, Germany)	• Energy Tax (2004)
	• Dta Bank Financial Subsidy (2001, Germany)	**I-B3: Loan Incentive**
	• The Uk Fuel Poverty Strategy (2001, UK)	• "CO_2 Emission Reduction Program", "CO_2 Building Renovation" (2001, Germany)
	• Community Energy Project (2002, UK)	• "One Hundred Thousand Buildings Solar Power Project" (2003, Germany)
	• Heater Plan (2003, UK)	• Green Loan Project (2011, UK)
	• New Federal State Economic Recovery (2003, Germany)	
	• KfW Energy Efficient Renovation Program (2007, Germany)	
	• 800 Thousand Residential Building Reconstruction (2009, France)	
US	**I-B1: Subsidy**	• Building Performance with ENERGY STAR (BPWES) (2006)
	• Experimental Housing Allowance (1970)	**I-B2: Tax**
	• CDBG (Community Development Block Grants) (1974)	• Energy Policy Act of 2005 (Epact 2005) (2005)
	• HODAG (Rehad Development Grants) (1983)	**I-B3: Loan Incentive**
	• LPAG (Lead Paint Abatement Grants) (1996)	• Green Building Loan Programs (2006)
	• ENERGY STAR-Branded Programs (1998)	

(continued)

Table 32.4 (continued)

Country		
Australia	**I-B1: Subsidy**	• Solar Hot Water Subsidy (2010)
	• Nation Solar Energy School (2008)	**I-B2: Tax**
	• Green Building(Commercial Building) Fund (2009)	• Green Building Tax Cut Project (2011)
Japan	**I-B1: Subsidy**	• Energy-saving Reconstruction on Existing Buildings (2008)
	• Subsidy on LED Chip and Solar Battery (2010)	• Fixed Assets Tax and Income Tax Cut on Building Energy-saving Program (2008)
	I-B2: Tax	
	• Tax Preference on High Quality Residential Building (2000)	• Tax Preference on Building Energy Efficiency (2013)
Singapore	**I-B1: Subsidy**	• Green Mark Incentive Schemes (2009)
	• MND "Research Fund for the Built Environment" (after 2000)	• BGA-SGBC (Green Building Individual Award) (2011)
	• Sustainable Construction Fund (after 2000)	
	• GM-GFA Incentive Scheme "Green Mark Gross Floor Area" (2009)	• BREEF "Build Retrofit Energy Efficiency Financing Scheme" (2011.11)
China	**I-B1: Subsidy**	• National Green Building Innovation Award (2011.01)
	• Interim Administrative Method for Special Fund for Government Office Building and Large-Scale Buildings (2007)	• Financial Incentives for Building Energy End-Use Data Monitoring Platforms for Large Commercial Buildings (2012)
	• Interim Administrative Method for Incentive Funds for Heating Metering and Energy-efficiency Retrofit for Existing Residential Buildings (2007)	• Financial Incentives on Development and Expansion of Green Buildings (2012)
	• Administrative Methods on Financial Subsidy Fund for Promoting High-efficiency Lighting Products (2007)	• Financial Incentives on Green Eco-Cities and Eco-Districts (2012)
	• Special Fund on State Organ Office Buildings and Large Public Buildings (2007.01)	• Special Fund on Existing Residential Building Energy-saving Reconstruction in Hot-summer and Cold-winter Zone (2012.05)
	• Financial Subsidy on Application of Building-integrated Solar Photovoltaic (2009)	• CDMF Special Fund for Green Building (Clean Development Mechanism Fund) (2013.01)
	• Special Fund on Solar PV Building (2009.03)	**I-B2: Tax**
	• Notice of Fiscal Policy for Energy-Efficient and Emission-Reduction Demonstration Provinces and Cities (2011)	• Vat Deduction (2001)
India	**I-B1: Subsidy**	**I-B3: Loan Incentive**
	• MNRE Incentive Program for GRIHA-Rated Buildings (2003)	• Reduced-Interest Loans (2008)
	• Incentives for Integrated Renewable Energy in Buildings (2005)	

countries. The Eastern countries, for example, Japan, Singapore, China and India, have introduced a series of laws, regulations, standards and codes to drive the promotion of BEE development, and standards and codes are often integrated into national laws and regulations. It is only the government who use this enforcement instruments to regulate the practiced of building professionals towards improving building energy efficiency. In particular, Japan and Singapore have built up more mature legal system for enforcing BEE practice than that in China and India. These laws and regulations about on BEE practice, for example, the Japan's "Energy-saving Law", have detailed prescription on the relationships among government departments, enterprises and individuals. China has implemented various codes and standards which are suitable for different regions, climates and types of building, especially in its 11th Five Year Plan produced recently. India is at initial stage on implementing BEE policy. Conversely, the United States and Australia have few mandatory administration instruments for BEE. They focus on establishing optional codes and standards by involving professional organizations.

32.4.2 Practice of Economic Incentive Instruments (I-B)

Economic incentive instruments mainly provides some incentive means in economic terms, but is weak in control in comparing to mandatory administrative instruments (Hillman 2003). It is appreciated that economic incentive mechanism can arouse public and business awareness, and motivate the efforts and enthusiasm of implementing BEE policy in the building sectors (Jin et al. 2010). Incentive programs are also policy deliver mechanisms, which can substantially raise awareness on building energy efficiency opportunities to many stakeholders in building sector. In general, incentive measures are highly acceptable and have better effects in practice, but subject to limitations. For example, economic stimulus will weaken corporate social responsibility and ethics, and cause vicious competition for business interests between corporations (Zhong et al. 2009). Secondly, the implementation of economic incentives needs better monitoring and analysis on market data in order to guide the application of this group instruments (Goodman 2002).

From the examination on the practice of incentive measures in these surveyed countries, incentive schemes mostly come in one of three forms: loans from private and government-associated banks, grants and loans from public utilities and third parties, and tax rebates from government funds. Incentive level funded by governments often rise, and falls as governments change, and falls as public money becomes scarce. For example, Japan and Singapore have encountered the cuts of financing expenditure year by year in recent years, which affect the introduction of diversity of the incentive programs. Furthermore, it normally takes much time for government to introduce and implement incentive distribution plans. However, some of the most successful BEE incentive policies in European Union and the United States does not rely upon governments, but well on regulated non-governmental entities, for instance, investor-owned agencies in United States and

Table 32.5 I-C: voluntary scheme instrument

Country		
EU	**I-C1: R&D**	• European Eco label (2010)
	• Special fund on R&D (1993, Germany)	• BBC-Effinergie Designation (France)
	• IEE Smart Energy Plan (2007)	• Dgnb (2009, Germany)
	• New Energy Technology Development Plan (2008)	**I-C3: Governmental Service**
	I-C2: Certification and Labelling	• Concerted Action EPBD Network (2007)
	• BREEAM (Building Research Establishment Environmental Assessment Method) (1990, UK)	• Zero Carbon Hub (2008, UK)
	• Building Energy-efficiency Label (2007, France)	• Passive House Institute (2011)
US	**I-C2: Certification and Labelling**	• Home Energy Score (2011)
	• Energy Star Portfolio Manager (2000)	**I-C3: Governmental Service**
	• Leadership in Energy and Environmental Design (LEED) (2000)	• Energy Audit Plan (1978)
	• Ashrae Building Energy Quotient (2005)	• Contract Financing Mechanism (1992)
	• Energy Star Buildings (2008)	• Establishment of Renewal Communities (2001)
	• HERS (Home Energy Rating System) (2009)	• Sustainable Communities Initiative (2001)
	• Energy Star for Homes Version 3 (2011)	• EE (Energy-efficiency) Building Program (2004)
Australia	**I-C2: Certification and Labelling**	• EEGO (Government Energy Consumption Performance Report) (2006)
	• ABGRS “Australian Building Greenhouse Rating Scheme” (1999)	• CBD (Commercial Building Information Disclosure) (2010)
	• GSC “Green Star Certification” (2003)	**I-C3: Governmental Service**
	• Green Star (2003)	• Establishment of GBCA “Green Building Council Australia” (2002)
	• NABERS “National Australian Built Environment Rating Scheme” (2005)	• Green Procurement Guide and List (2006)

(continued)

Table 32.5 (continued)

Country		
Japan	**I-C1: R&D**	• Certification on Environment-Symbiotic Residential Buildings (1998)
	• New Sunshine Program (1993)	• CASBEE (Comprehensive assessment system for building environmental efficiency) (2002)
	• Residential Building Performance Evaluation System (2000.01)	
	• ESUM "Energy Specific Unit Management Tool"(2006)	**I-C3: Governmental Service**
	• ECTT "Energy Conservation Target Tool"(2008)	• Association on Environment-Symbiotic Residential Buildings (1990)
	• LCEM "Life Cycle Energy Management"(2008)	• NEDO (New Energy and Industrial Technology Development Organization) (1980)
	• Energy Technology Innovation Plan on Coolling the Earth (2008)	
	• BEST "Building Energy Simulation Tool" (2010)	• Recycling-oriented Residential Building Demonstration Program(2001)
	I-C2: Certification and Labelling	• Japan Sustainable Building Con-sortium (2003.07)
		• Seminar on "the Target of ZEB" (2009.05)
		• Summer and Winter Energy Conservation Measures (2012, 2014 updated)
Singapore	**I-C1: R&D**	**I-C3: Governmental Service**
	• Green Handbook for Photovoltaic Systems (2008.04)	• Sino-Singapore Tianjin Eco-city (2007.01)
	I-C2: Certification and Labelling	• Establishment of CLC "Centre for Liveable Cities" (2008)
	• BCA "Green Mark Scheme" (2005.01)	• Establishment of SGBC (Singapore Green Building Council) (2008)

(continued)

Table 32.5 (continued)

Country		
China	**I-C1: R&D**	• GBEL "Green Building Evaluation and Labeling" (2007)
	• International Smart and Green Building Technology Seminar and Product Exhibition (2004.07)	• Statistical System on Civil Building Energy Consumption (2007.08)
		I-C3: Governmental Service
	• Green Building Certification System (2006)	• Country Residential District Intelligent Technology Demonstration Project (1999.04)
	• "Eleventh Five-Year" International R&D Support Plan—Renewable Energy and Building Integrated Technology Application Demonstration Program (2008.05)	
		• Renewable Energy Architecture Demonstration Program (2006.09)
		• Demonstration Program of Energy-saving Identification on Building Door and Window (2006.12)
	• Establishment of Information Platform on Civil Building Energy Conservation (2008.07)	• Green Building and Low Energy Consumption Demonstration Program (2007.08)
		• Establishment of Industrialization BSE on renewable energy building (2007.08)
	• Establishment of Energy Consumption Monitoring System in Official Buildings and Large Public Buildings (2009.02)	• Solar PV Building Demonstration Program (2009.04)
	• Information Statistical System on Civil Building Energy Consumption and Conservation (2012.05)	• Green Construction Materials Promotion Program (2013.01)
	I-C2: Certification and Labelling	
	• Statement Rule on Energy-saving Chapter of Fixed-asset Investment Project Feasibility Study Report (1997)	
India	**I-C1: R&D**	**I-C2: Certification and Labelling**
	• Leadership in Energy and Environmental Design–India (LEED-India) (After 2003)	• Bee's Star Rating System (2009)
		I-C3: Governmental Service
	• Green Rating for Integrated Habitat Assessment (GRIHA) (2005)	• Eco-Housing India Demonstration Program (2004)

commercial bank in European Union. Financing incentive mechanisms in China and India are more circumscribed than those in the United State, European Union and Australia, although China has been growing quickly in developing economic incentives. For example, recently Chinese government has introduced grants and subsidies, especially full funding for very large-scale retrofit of governmental buildings (MOF 2007).

32.4.3 Practice of Voluntary Scheme Instruments (I-C)

Voluntary scheme instruments have experienced rapid development in all the selected countries in this study. For example, all the countries have set up their own green building assessment system like the UK's BREEAM, American LEED, "Green star" in Australia, the "Green Mark" in Singapore, the "CASBEE" in Japan, the "GBCS" in China and Indian "LEED-India". In the United States and the European Union, label rating and certification system are often tied to financial incentives. This is exemplified in US where the use of the ENERGY STAR commercial building programs is the basis for providing incentives. The increasingly popular ZEB (Zero-energy building) policies introduced in EU rely on the voluntary low-energy labelling programs such as Effinergie and Passive House in assessing the feasibility of BEE. And the rating on building energy performance is the first step to attain a loan or grant from the KfW system in Germany (Tchouvakhina 2004). China have set up various BEE demonstration programs and established collaborations with other developed countries in building energy saving. For instance, the China–Japan Caofeidian program and the China-Singapore Eco-City program are established to promote BEE. In the Western countries like the UK, US and Australia, the governments have outsourced BEE schemes to various private organizations, which could offer better professional services and provide effective BEE information.

32.5 Conclusion

This study suggests that the governments have realized globally the importance of promoting BEE policy instruments. In line with this development Various BEE policy instruments have been introduced by governments from traditionally governmental mandatory controls to public participated schemes. Energy efficiency in building sector has been improved through implementing these BEE policy instruments.

Various BEE policy instruments issued by the seven surveyed countries and regions are identified. All the surveyed countries have been developing good efforts in developing BEE policy instruments of three groups, which is evidenced by the increase in the number of these policy instruments issued particularly in the last ten years. The group "voluntary scheme instrument" has received much better development in comparing to the group of "mandatory administration instrument" and "economic incentive instrument". European Union is more mature in developing these policy instruments, reflected by the largest number of policy instruments introduced. The developed countries such as the United States and Australia have adopted less mandatory administration instruments but more voluntary scheme instruments. Countries like Singapore and Japan have introduced less policy instruments in recent years largely because they have already developed relatively mature BEE policy instrument in early years. Developing countries such as China who used to give little attention on BEE but have given increasing efforts in promoting building energy efficiency in recent years.

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Chapter 33
Ethical Decision-Making of Engineering Based on Sustainability

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Abstract This paper explains the meaning of ethical decision-making of engineering, providing an outline of the ethical decision-making process, in which each part is analyzed in detail. We come to the conclusion that stakeholder is the body of ethical decision-making, including owners, contractors, financing units, quality supervision department and eco-environmental protection department, etc. The ultimate objective is to satisfy the stakeholder and maximize the engineering value. Ethical decision-making process should be democratic, that is, implementing group decision-making method. It's also essential to pinpoint the decision-making content and build a reliable evaluation model, which could help reduce subjective and qualitative decision-making, thus derive more objective and quantitative decisions. This paper offers decision-makers and managers of engineering a theoretical reference for ethical decision-making management.

Keywords Engineering sustainability · Ethical decision-making of engineering · Stakeholder · Implementation evaluation model

33.1 Introduction

The sustainability of engineering includes not only the sustainability of the project itself (such as engineering maintainability, operation safety, renewability, etc.), which ensures the stability, persistence and permanence of engineering products and services, but also the contribution engineering makes to the sustainable development of economy, society and the environment (Chen 2005). However,

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ethical issues in the practices affect the interests of project stakeholders, as well as the sustainable development of the project and the implementation of engineering ethical responsibility. For example, (1) people tend to have contradictions between justice and profit during the actual work of the project. Irrational behavior also happens; (2) Conflicts among each stakeholder appear rather fierce. Participating subjects in the construction project always behave dishonestly and immorally; (3) Nowadays the building products are not ever-lasting, causing huge economic waste and environmental damage. Research on the engineering ethics management, as well as ethics and norms in the whole period of the project, therefore, should become the core of modern engineering management. As the British scientist Robert Heller pointed out, the ethical resurrection of management is a major trend in the future, management ethics demand a in-depth review of the existing management practice (Heller 1991).

While decision-making forms the core of management, ethical decision-making stays the core of ethical management. Yin Ruiyu, a respected academician, made it clear that the accuracy of engineering decision-making affects not only local and regional development, but also the overall situation and the process of social development, even human being’s future and destiny (Yin et al. 2007). Professor Li (2006) further added, ethical study of decision-making will definitely become an important part of engineering ethics research. “Who owns the decision-making authority” and “how to make decisions” are the two key questions.

Ethical decision-making of engineering refers to the decision-making body, according to appropriate ethical standards and systems, tries to regulate emotions and behaviors at all stages of the project life-cycle period, offer alternative solutions to certain ethical issues, which could make compliance with the interests of project stakeholders, balance and coordinate the profit conflicts between each project stakeholder, attempting to realize the engineering ethical responsibility.

The process of ethics decision management of engineering contains the measurement of ethical decision-making with related ethical norms and mathematical model during the whole construction and operation period. This entire process consists of four main components: determining the ethical decision-making body, confirming the ethical decision-making goals and attributes, ensuring contents of various stages of the project and making an estimate of the realization of ethical decision-making. Based on the quantitative analysis method, the process above aims to examine the democracy of ethical decision-making, the realization of ethical responsibility, as well as the degree to which ethical responsibility has been achieved, which offers engineering decision-makers explicit estimates and measurements of the effectiveness of actual work.

33.2 Body of Ethical Decision-Making of Engineering

33.2.1 A Review of the Definition of Engineering Ethics Body

It forms the basis of the study of engineering ethics to define the engineering ethics body. Studies at home and abroad can be divided into two categories: first, technicians should be the engineering ethics body; second, the body should be a group or a community instead of a single individual.

American scholar Mitcham (1999) considers engineering ethics as "vocational engineering ethics"; American philosophy professor Martin (2007) believes that, "engineering ethics refers to the ethical criteria of the current project, including the ethical norm of the engineers and their conduct in the real ethical issues." Yu (2002), a scholar in China defines it as, "engineering ethics, also called as engineers ethics, is the study of ethical principles and conduct norms of the technicians in the process of engineering design, construction, operation and maintenance." Another scholar Xiao (1999) holds that, "engineering ethics means the responsibility of the technicians concerned for the employers, the public, the environment, the society and even the future in the vocational activities." Based on that, some scholars regard the engineering technicians as the main body, believing that engineering ethics is the study of the ethical principles, the ethical norms as well as the conduct of the technicians.

However, when it comes to some other ethicists, they think it still remains questionable to settle down the specific answer. They believe the body should refer to something of a wider meaning. American scholar Devon (2004) holds that, it is actually a methodology of individual ethics study if seen from the perspective of engineers' occupational code, and individual ethics should not be made to constitute the whole picture about ethics. A German-American scholar Hans Jonas (Gan 2002) once gives his point on this issue, which is seen as a further explanation of Devon's idea, "what we have done, once compared to the whole social conduct, is zero. No one can play a really pivotal role in changing things substantially. Technically speaking, the problems the whole modern world should address are beyond the control of individual ethics. 'I' will be taken place by 'We' or the whole thing and the senior codes by the whole. Decision-making and conduct will become 'commune politics thing'." Li (2006), the Chinese scholar, proposes a more specific opinion on the body issue, "we have to confess that the construction activity is more a community activity than an individual activity, and fairly enough we should also confess that in most cases the subject we are facing when it comes to studying engineering ethics and ethics analysis and evaluation is not an individual, but a renewed community." Dr. Liang (2007) expresses a similar viewpoint that, the body mainly involves investors, construction facility managers, operators and others, the dwellers around and the environment changes should also be included.

In one word, most engineering ethics scholars have noticed that if the body is merely restricted to technicians, some ethical problems will be blamed to the engineer's behavior, and then the engineering ethics study will be bound to the individual ethics, ultimately engineering ethics will not be truly set up.

33.2.2 Meaning of Engineering Ethics Body

Based on the analysis above, the definition of engineering ethics body has broadened from the individual technicians to the whole group or community. To be more specific, the group of community is the stakeholders of the whole construction project (which includes the pre-planning stage, the decision-making stage, design and planning stage, construction period and put-in-use phases).

Since the 1960s, there have been more than 27 representative versions of the definitions of the stakeholders both at home and abroad. Among them, Freeman's (Ling 2006) version got universally recognized in 1983: stakeholders are the individuals that certain organization heavily relies on in order to realize certain goals.

This paper holds that, the stakeholders refer to the individuals, groups and organization who have explicit profit demands and will be influenced by each construction phases, in turn, they will also be the key factors in realizing project goals. Stakeholders can be divided into direct and indirect ones, in which the direct stakeholders refer to the individuals who are directly involved in the market relations, including estate-owners, survey and design units, construction units, material manufacturers and suppliers, supervision units, financing units, property service companies; indirect stakeholders refer to those who are indirectly involved in the market relations, including the administrative departments subordinating to the government, construction quality supervision department, inspection department and eco-environmental protection department.

33.2.3 Body of Ethical Decision-Making of Engineering

The engineering ethics body is equal to the body of ethical decision-making of engineering, namely engineering stakeholders.

The engineering organization is mostly makeshift organization constituted by multiple organizations. In the construction and operation process, each participating individual is conflicted with the others in division of interest. Thus, coordination becomes the focus of construction management, which involves the evaluation of various decisions put forward by each decision-maker. When the optimal one is decided, it will be chosen as the unanimous decision for every decision-maker and each one shares the same responsibility for the decision result. Therefore, the engineering stakeholders should take part in the decision-making in an appropriate way, in a way of group decision-making. As Devon (2004) says, "stakeholders play an important and extensive role in decision-making, which not only influences the gaming process of all the participants involved, but also what kind of future which may come by, that is to make the decisions feature-concerned and future-concerned."

Furthermore, what needs to be noted is that, in the whole period of construction project, the participants involved may be different due to different phases of the construction. For example, in the pre-planning stage, contractors are not involved and in the operational phase, the stakeholders begin to concentrate in an extensive way.

33.3 The Objective and Nature of Ethical Decision-Making of Engineering

33.3.1 Objective of Ethical Decision-Making of Engineering

A great number of participants in the construction project pursue eagerly for the maximization of their own interests, ignoring the legitimate interests of other stakeholders. In order to maximize profit, they unscrupulously build low-quality projects, disregarding the protection of labor resources and environment. Moreover, when carrying out the feasibility research, participants are prone to determine the feasibility of a project in terms of economic effects and related techniques, therefore overlooking the consideration for engineering ethical responsibility.

The standard for a successful engineering, however, should not only contain quality, schedule and cost, but also the satisfaction of stakeholders' interests. Only then can we achieve social fairness and justice, ensuring favorable and stable market order and a good ecological environment. Therefore, we set the goals for ethical decision-making of engineering: ethical decision-making body adheres strictly to fair and equitable market trading rules, conducting ethical project management in the whole period of engineering. In addition, the interests of all stakeholders must be involved in the project feasibility research, design as well as the signing of contracts and execution, making efforts to complete the ethical responsibility and maximize the project value.

33.3.2 Nature of Ethical Decision-Making of Engineering

Ethical decision-making of engineering need to involve joint participation of all stakeholders. Thus, democracy should be the nature of engineering ethics decisions.

The engineering project exchanges only for once and has a consortium composed of each stakeholder. It is inevitable to occur conflicts between different stakeholders due to different interest targets and project demands. Encompassing the whole stakeholders in project decision-making, that is, manifesting the democracy of engineering decision-making, makes sense generally in the following three aspects (Wang 2008):

1. We can readily coordinate the whole project organization if requirements of different stakeholders are met;
2. The respective interest request of various stakeholders must be supported by certain sufficient reasons, which could include diverse perspectives and

profound information. This kind of profit competition helps to enhance the theoretical and practical basis for project decision-making, as well as the accuracy of engineering decisions;
3. Stakeholders involved in the decision-making itself reflects the ethics of the project.

33.4 Contents of Ethical Decision-Making of Engineering

The contents of ethical decision-making are somewhat biased at different stages of the project life-cycle phases: Pre-planning stage of the project is the foundation of the whole project, which aims to devise the project outline, set the goals and carry out the feasibility research, impacting greatly even the entire upper system of the project. Design and planning stage of the project needs elaborate plans and arrangements of the implementation of construction project. Project investors, owners, contractors, material and equipment suppliers and other stakeholders are expected to participate and cooperate in the numerous projects. Construction phase of the project is the most active one in the management. The owners become the core body of the project management. Difficulties in operational phase of the project are the conservation and maintenance of the main project structure and public facilities and equipment. Property services companies play an important role in this process.

Taking the pre-planning stage of the project as an example, the contents of the corresponding ethical decision-making in this phase include:

1. The owners should not only represent and reflect the interests and expectations of project investors, but also the interests of those who undertake engineering tasks. What's more, they need to focus on balancing the interests of various stakeholders;
2. During the total pre-planning stage, it's quite partial for us to consider the costs and benefits merely in the construction phase. What we need is to integrate the reliability, maintainability and lower operating costs in the concrete operational phase, implementing the project decision-making from a more comprehensive and mature perspective;
3. The project objective needs to contain the contribution projects could make to social communities. For instance, as the speeding up of urbanization, residential buildings gather in some new city regions, whose corresponding commercial and cultural facilities are not so complete. By setting the construction of commercial and cultural facility goals in these areas, not only can we make profits from the project, but also we can help to promote the regional economic development;
4. Environmental protection is another aspect we need to involve in setting project goals. In the planning stage of the project, owners and other decision-making body should take resource conservation and environmental protection into

consideration. After the entire construction phases, the recycle and utilization of resources still constitutes a significant issue.

33.5 Evaluation of Ethical Decision-Making of Engineering

The evaluation of ethical decision-making of engineering refers to, prior to the economic and technical evaluation, the measurement of the project ethical responsibility with certain procedures and methods, accordingly examining the feasibility of project ethical decision-making.

According to this paper, the ethical decision-making body for the project can be classified into six categories, namely, the supply side of engineering services, the supply side of engineering materials, the demander of the project (the owner), the project authorities, engineering quality supervision and inspection department, eco-environmental protection agencies. The evaluation of ethical decision-making of engineering should be based on the above six decision-making bodies and form an evaluation index system, which includes the index of mutually beneficial competition, the maximization of practical value, the public interests, safety issues, and eco-environmental protection.

The evaluation process mainly adopts the concept and nature of entropy and confirms index weighting coefficients based on the relation of the evaluation index sample itself and the degree of variation, establishing a decision-making evaluation model on the basis of entropy, which could provide foundation for multi-objective group decision-making (Zhu and Chen 2004). With entropy coefficients, we valuate and select various alternative offers, seeing if the scheme corresponds with the engineering ethics. Specific steps are listed as follows:

1. Assuming we confronted a multi-objective ethical decision-making, the matrix corresponding to the original data of ethical evaluation index should manifest as:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} = \left[x_{ij}\right]_{m\times n} \tag{33.1}$$

2. Due to the inconsistency of each index dimension, it's necessary to eliminate the negative impacts of index data dimension and the order of magnitudes with the help of membership functions in fuzzy mathematics, transforming the index value into dimensionless values and regulating the matrix. The formula is:

$$\gamma_{ij} = \begin{cases} \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \\ \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \end{cases} \tag{33.2}$$

In the formula:

① γ_{ij} is the j-th alternative value on the ethical evaluation index i, $\gamma_{ij} \in [0, 1]$;
② $\min x_{ij}$ and $\max x_{ij}$ respectively represent for the most satisfactory and most dissatisfied value of different things under the same ethical evaluation index (the smaller the more satisfaction or the greater the more satisfaction);

3. According to the definition of entropy, entropy of the i-th ethical evaluation index is:

$$e_i = \sum_{j=1}^{n} \left(-\frac{1}{\lg n}\right) p_{ij} \ln p_{ij} \quad \mathrm{i} = 1, 2, \ldots \mathrm{m} \ldots \tag{33.3}$$

$$p_{ij} = \frac{\gamma_{ij}}{\sum_{j=1}^{n} \gamma_{ij}} \tag{33.4}$$

p_{ij} represents the proportion of the j-th alternative indicator under the i-th evaluation index;

4. Calculate the i-th ethical evaluation index weights:

$$\omega_i = \frac{1 - e_i}{\sum_{i=1}^{m} (1 - e_i)} \quad \mathrm{i} = 1, 2, \ldots, \mathrm{m} \tag{33.5}$$

In the formula:

$$0 \leq \omega_i \leq 1, \quad \sum_{i=1}^{m} \omega_i = 1;$$

5. Determine the discriminant value of each alternative: based on the above weighted value and γ_{ij}, γ_j of each alternative can be obtained, accordingly, evaluating and selecting the best option.

$$\gamma_j = \sum_{i=1}^{m} \omega_i \gamma_{ij} \quad \mathrm{j} = 1, 2, \ldots, \mathrm{n} \tag{33.6}$$

To summarize, the evaluation model of ethical decision-making of engineering, based on entropy coefficients, is an efficient tool to examine the realization of ethical responsibility, which offers project decision-makers a theoretical reference and quantitative analysis method for ethical decision-making management, making qualitative analysis quantified.

33.6 Concluding Remarks

Ethical decision-making is the combination of management science and management ethics, as well as the blending of system-oriented rigid management and people-oriented flexible management, which constitutes the essence of engineering ethics. In practice, a considerable number of participants in the construction project pursue eagerly for "profit maximization", concerning more for the economic responsibility rather than the project ethical responsibility. Therefore, it's necessary for us to incorporate ethics into project decision-making and make ethical decisions from the perspective of stakeholders, which would be the key to achieving project "value maximization" and sustainable development. This paper makes a case for the view-point that engineering stakeholders are the main body of ethical decision-making and democratic group decision-making is advocated during this process, which jointly helps form the basis of the implementation evaluation model, measuring the effectiveness of ethical decision-making management and the realization of ethical responsibility. The entire management system above not only enriches the theoretical knowledge of project management, but also becomes an effective tool of the ethical decision-making management in the practices. However, researches on ethical decision-making of engineering are new issues in the field of project management, this paper mainly focuses on the theoretical conceptions and approaches of ethical decision-making management system of engineering, hoping to make more in-depth and complete researches with sufficient data information and concrete cases.

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Chapter 34
Research on the Measurement on Carbon Emissions for Industrialized Buildings

Yingbo Ji, Yiwei Wang and Xiaotong Li

Abstract Construction industrialization is a kind of new method for construction production. Its development experience in developed countries has proved that it is an inevitable direction to realize low energy consumption, low pollution and sustainable development. Researching on carbon emissions on the industrialized buildings will do good to quantitatively analyze the advantages of industrialized buildings in reducing environment pollutions. The current literature on analyzing carbon emissions of traditional buildings and industrialized buildings from the perspective of life cycle as well as identifying the sources of carbon emissions and carbon factors was firstly analyzed. Furthermore a quantitative model based on researching theories and characteristics for industrialized buildings is established. Then Questionnaire survey and case study will be planned to collect data.

34.1 Introduction

The construction environment becomes worse because of accelerating urbanization. According to incomplete estimates, construction attributes to a third of all Chinese carbon emissions (Wei et al. 2011). The sources of greenhouse gas emissions are mainly from construction, industrial and transportation. The carbon emissions from construction aggravate the haze in China since 2003 (Hao 2014). The traditional buildings produce high emissions and high pollutions and it is no longer adapted to the sustainable development of Chinese construction industry. So it is paid more and more attention to find a more environment-friendly construction method (Mohammad 2013). As a new mode of production, the construction industrialization has the advantages of saving energy and protecting environment. And it is conductive to realize sustainable construction (Noguchi 2003; Begum et al. 2010). This paper based on the life cycle theory, combination the production characteristic, analyze the sources of carbon emissions in different stages. Furthermore establish

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carbon emission model, provide theoretical basis for the measurement of industrialized buildings' carbon emission. And then this paper probes into characteristics and advantages of industrialized buildings in protecting environment.

34.2 Reviews

Construction industrialization is characterized by its design standardization, component producing in factory, production and management informationization, component assembling on site (Ji and Fu 2013). It is a sustainable production method which forms complete integrated production technology in research, design, production, construction, operation and so on and realizes maximization in energy-saving, environmental protection life cycle value (Ji et al. 2013). Construction industrialization is a revolution in production mode in construction, and its radical is the prefabrication and industrialization of construction structure and the integration of industrial organization (Liu 2012).

On the basis of reasonable planning, design and management, the promotion of industrialized buildings helps to improve the construction speed, reduce the labor intensity, enhance the construction quality, reduce the resources waste and so on (Xiu et al. 2014). Compared to traditional construction, the industrialized buildings have better performance on decreasing garbage, energy and emission (Li et al. 2014). Study found that an industrialized building resulted in reduced material consumption of up to 66.7 % compared to conventional concrete construction (Lachimpadi et al. 2012). It can reach 65 % of energy saving required by Chinese government and even higher requirements in thermal insulation by increasing the thickness of insulation layer (Wang et al. 2012). Meanwhile, the implementation of industrialized buildings can improve the reuse rates of materials, decrease material loss by about 60 % and save more than 50 % energy (Su 2014). Industrialized buildings' advantages in waste reduction, energy saving and so on can be reflected by carbon emissions.

One of the key indicators of climate change and environment effect is greenhouse gas emission (Omar et al. 2014). And the carbon emission is the main component of greenhouse gas, so the researching on carbon emission of industrialized building can effectively reflect its impact on environment (Han et al. 2012). A number of studies on traditional constructions' carbon emissions have fruitful results and lay the groundwork for further studies. Especially from the perspective of life cycle, the carbon emissions from construction, decoration, maintenance and disassemble are included in the calculations (Chen et al. 2011).

Studies on industrialized buildings' carbon emissions started on 2011. It's the first time to calculate the carbon emissions of construction materials' production and transportation and components' production (Peng and Sui Pheng 2011), then calculate the carbon emissions of components production and usage among prefabricated steel building, prefabricated timber building and conventional concrete construction (Aye et al. 2012). The greenhouse emissions calculation of industrialized buildings started at the same time, the scope is from construction materials production to construction on site, as well as calculating the waste and soil for the first time (Mao et al. 2013). The calculation of industrialized buildings' carbon emissions is always used in the form of partial life cycle assessment (Li et al. 2014). But the carbon emissions from usage and demolition aren't included in the scope. So the scope can't reflect the emissions of industrialized buildings completely. The carbon emissions reduced because of decreased energy use for improving insulation performance in usage and recycle use of materials in demolition aren't reflected in the previous studies.

In the field of construction, the life cycle (LC) perspective is always used to assess the environmental effects of constructions' carbon emissions (Ortiz et al. 2009). The life cycle assessment is an important method (Fava 2006) in construction which can optimize construction environment from raw materials extraction to final waste disposal (Chang et al. 2010). The division of construction life cycle stage is always divided into three stages and five stages, and rarely six stages or seven stages. Three stages include physicochemical phase, operation stage and demolition stage. Compared to three stages, five stages consider more about the mobility among different stages, such as includes the transportation (Yu et al. 2011). The six stages have carried on more detailed classification to the end of life, and specifically divide it into building demolition, waste materials disposal and recycling energy saving (Chen and Luo 2008). Seven stages just split the materials production and transportation on the basis of six stages (Moncaster and Symons 2013). Using the theory of life cycle assessment (LCA) to study the emissions of concrete buildings, steel structure buildings and timber buildings (Aye et al. 2012), compare carbon emissions of different structures or establish carbon footprint models (Harmouche et al. 2012). The application of life cycle thought to calculate construction carbon emissions is scientific, comprehensive and comparable, and it is appropriate used in industrialized buildings.

In recent years, shear wall structure becomes hotspot in researching industrialized building for its suit for residential construction. So this paper establishes assembled concrete shear wall structure's life-cycle carbon emissions model on the bases of the previous studies, measures specific structure carbon levels and furthermore studies the impact extent on environment.

34.3 The Establishment of Life Cycle Carbon Emissions Model

Studies have been taken to research carbon emissions model from stages division and formula establishment of industrialized buildings and traditional buildings. The previous studies on stage division of constructions carbon emissions calculation are shown in Table 34.1.

This paper focus on the energy consumption and conservation for the use of industrialized method compared to traditional method. Through comprehensive analysis the models in Table 34.1, combining the characteristic of design

Table 34.1 Construction carbon emissions calculation stages

Building type	Time	Author	BMP	BMT	CP	CT	WTICS	COS	OM	DD	MR
Industrialized building	2011	Wu Peng	√	√	√						
	2012	Lu Aye	√						√		
	2013	Chao Mao	√	√	√	√	√	√			
	2014	Hong Xian LI	√	√	√	√	√	√			
	2014	Wan Mohd Sabki Wan Omar	√	√	√	√		√			
Traditional building	2011	Chunjing Shang	√					√	√	√	√
	2012	Nicolas Harmouche	√	√				√			
	2013	Ambrose Dodoo	√	√				√	√	√	√
	2013	Christopher R. Iddon	√					√	√		
	2014	Nuri Cihat Onat	√	√				√	√	√	
	2014	Ling Shao	√	√				√	√		

BMP means building materials production. *BMT* means building materials transportation. *CP* means components production. *CT* means components transportation. *WTICS* means waste transportation in component factory and site. *COS* means construction on site. *OM* means operation and maintenance. *DD* means demolition and disposal. *MR* means materials recycling standardization, component producing in factory and assembling on site, this paper divides the calculation into three stages: physicochemical phase, use stage and demolition recycling stage. The physicochemical phase is divided into three parts: building materials production, component production and assemble on site.

In the physicochemical phase, the carbon emissions from materials production and transportation, component production, installation and transportation are primarily taken into consideration, then consider the assemble on site. In the assemblage and construction phase, take the transportation of materials, components and wastes, as well as the water and electricity consumption for machinery and construction workers. In the usage stage, carbon emissions generated by cooling, heating, lighting and other major equipments and replaced materials should be mainly accounted. Carbon emissions in demolition phase contribute little to the total carbon emissions, so the calculation only takes materials recycling into consideration. The reduced carbon emissions are calculated in the materials production stage.

By analyzing the models in Table 34.1, it can be found that the carbon emissions calculations are mainly depend on carbon emissions factors. Firstly it needs to identify the carbon emission sources of different stages. Energy consumptions of different sources multiply corresponding emission factors is the carbon emissions of different carbon emission sources. For involving fuel combustion, chemical reactions, electricity and heat consumptions in the materials production stage, it is more complex to analyze the carbon emission sources in this stage compared to others. Our government has directed the calculations of building materials' carbon emission in its publications, such as cement and steel. According to the documents, we can work out relevant emission factors.

According to the results from previous studies, this paper firstly divides the carbon emissions stages and identifies emission sources of industrialized constructions. The result is shown in Table 34.2.

On the basis of identifying the sources of carbon emissions shown in Table 34.2, carbon emission factors are used to establish prefabricated concrete shear wall lifecycle carbon emission models as in formula (34.1)–(34.3).

$$\text{Total Life Cycle carbon emissions} = TCE = \sum_{i=1}^{4} E \tag{34.1}$$

$$E_i = \sum_{j=1}^{j} M_j \times f_j \times (1 - s) \tag{34.2}$$

where E_i is the carbon emissions of major construction materials; M_j is the total amount of construction material j; f_j is the carbon emission factor of building material j; s is the recycling coefficient of building materials.

Table 34.2 Carbon emission source for each stage of industrialization construction

Process	Carbon emission sources	
Production of building materials E_1	Manufacturing equipments	Cement: cement kilns
		Steel: coke oven, sinter machine, blast furnace, industrial boilers
		Steel processing machinery: bar straightening and cutting machine, steel cutting machine, steel bending machine
Production of components E_2	Transportation of construction materials	Concrete: mixer truck, maneuvering dump truck
		Steel: flat car (20–30 ton load)
	Equipments	Pre-processing machinery: mold desk, sweeping machine, spraying machine, marking machine, the side mode installation, steel mesh installation, embedded part installation, cloth bucket, shaking table, installing insulation board, installing connectors, installing steel cage, car ferry, plastering machine, palletizing machine, maintenance pit, side mold removal, reversing machine
		Material handling equipments
	Transportation within plants	Vehicles for transportation and storage in prefabricated component plants: fixed cranes, mobile cranes, rail-mounted cranes, low-dray, crane goods vehicle forklifts
Assembly and construction on-site E_3	Transportation of components and materials	Prefabricated balcony prefabricated stairs, prefabricated wall panels, etc.
		Transportation equipment: transport equipment in the factory
	Equipments	Cranes, generators, concrete mixers, concrete pumps, welding machines, fork-lift trucks, lifts
	Staff	Water and electricity consumed by construction workers on-site
	Waste transportation	Sediment transported vehicles, other vehicles
Operation and maintenance E_4	Equipments	Heating, cooling, lighting equipments
	Replacing building materials	
Demolition and recovery E_5	Materials recovery	Steel, concrete

$$E_t = \sum_{k=1}^{k} Q_k \times f_k \tag{34.3}$$

where t can be 2, 3, 4; E_2, E_3 and E_4 stand for carbon emissions from fossil fuel in component production stage, assemble and construction on site phase and operational phase; Q_K stands for the total amount consumption of energy k in different stages; f_k is the carbon emission factor of energy k.

Energy includes fossil fuels, electricity and water. Carbon emission factor of electricity can be determined by regional grid baseline released by Chinese Development and Reform Commission every year.

34.3.1 Identify Carbon Emission Factors of Fuels

The latest version of the "IPCC National Greenhouse Gas Inventories" suggests that the fuels' carbon emission factors can be calculated according to Eq. (34.4). According to IPCC, most carbon is oxidized during the combustion process, so the carbon dioxide factors of fuel are assumed to be 1.

$$C = A \times B \times \frac{44}{12} \times 1000 \tag{34.4}$$

where A is carbon content of fuel (kg/GJ); B is factor of fuel carbon oxide; C is carbon dioxide efficient emission factor of fuel (kg/TJ); 44/12 is molecular weight conversion of carbon dioxide and carbon.

Different fossil fuels' unit carbon content and low calorific value used in calculating carbon emissions in construction industry are from "Guidelines for provincial greenhouse gas inventory (Trial)" and "low-carbon development and provincial greenhouse gas inventory preparation of training materials".

Because the carbon oxidation rates of different gas combustion equipments aren't significant, the guidelines suggest the carbon oxidation rates of different devices oil (e.g. crude, fuel oil, diesel et al.) in different sector are 98 %, the carbon oxidation rates of different gas fuel (e.g. coke oven gas, Refinery dry gas, natural gas et al.) are 99 %.

Based on the guidance formula in IPCC and the data released from government, multiply fossil fuels' unit carbon content by low calorific value and carbon oxidation rates are carbon emission factors, as listed in Table 34.3.

Table 34.3 Fossil fuels' carbon emissions in construction industry (kg/TJ)

Coal concentrate	Other coal concentrate	Coke	Coke oven gas	Crude	Fuel oil
91306.6	91306.6	105715.9	48797.5	72154.1	75819.3
Gasoline	Refinery dry gas	Diesel	Other petroleum products	Natural gas	
67914.0	66066.0	72585.3	71866.7	55611.6	

34.3.2 Data Resources

The sources of data for calculating carbon emissions in previous papers are listed in Table 34.3. There are three kinds of sources.

1. Related enterprises, interview relevant personnel or take a look at bill of quantities, project budget book and so on, some data can be acquired by tracing on site. This method is always used to obtain materials consumption, energy consumption of component production and machinery on site.
2. Collect data from related papers or finished buildings. This method is always used when actual data aren't easy to obtain, such as the energy consumption of materials production and operational, materials recycling in the end of buildings.
3. When the data aren't easy to obtain such as transportation distance are assumed based on the distance in the map.

After consulting experts and practical research, the above methods are also applicable in calculating industrialized buildings life cycle carbon emissions and relevant data can also be obtained in the same way.

Table 34.4 Data and sources of data

Data	Population	Attainment method
Building material consumption	Component manufacturers and construction enterprises	Bill of quantities or estimates, balance tickets et al.
Annual component quantities	Component manufacturers	Bill of quantities or balance tickets
Annual energy and power consumption		Accounting records
Monthly energy consumption of machinery	Construction enterprises	Accounting records
Monthly life power and water consumption of constructors		Accounting records
Waste production		Accounting records
Needed component quantities		Bill of quantities
Annual energy consumption of space heating and cooling	Tenement	Accounting records
Materials recovery rate	Enterprises in charge of dismantling and recycling	Accounting records
Energy consumption of transportation	Component manufacturers and construction enterprises	Accounting records

34.4 Questionnaire

The questionnaire is designed to obtain data required in the model, and assigned to materials manufacturers, component manufacturers, construction enterprises, tenement and enterprises in charge of dismantling and recycling based on specific content. The needed data and the sources of data are shown in Table 34.4.

The needed materials carbon emission factors are from the questionnaires assigned to materials manufacturers based on "China cement production enterprises' carbon emission calculation method and reporting guidelines (trial)" and "China steel production enterprises' carbon emission calculation method and reporting guidelines (trial)". And the data about materials recycling is adjusted to adapt industrialization buildings' traits.

After actual research and consulting experts, the above data are accessible and can be used to calculate industrialized buildings' life cycle carbon emissions. So take the data in the Table 34.4 as survey content and assign the questionnaires to the survey subjects.

34.5 Conclusion

This paper firstly establishes industrialized building carbon emission measurement model from materials production to demolition and recycling in the perspective of life cycle, and provides theoretical basis for further study on actual calculation. On the basis of summing up calculation stages divisions and scopes of industrialized constructions and conventional constructions, and combining industrialization buildings' own characteristics, this paper divides calculation stages and identifies sources of carbon emissions of different stages. And then this paper establishes carbon emission measurement model, determines the selection method of carbon emission factors, designs questionnaire, determines survey objects and acquire method based on the needed data for calculating. The established calculate models are theoretical and operable in practical measurement, and it can measure construction life cycle carbon emissions more completely and precisely. The detailed analysis on carbon emission factors and data acquirement ensures the feasibility and accuracy, and guarantees the data collection and analysis in the next step.

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Part III
Urban Construction and Management

Chapter 35
The Spatial Distribution and Utilization Characteristics and Its Driving Mechanism of Urban Office Building in Ningbo City

Yu Cao, Cifang Wu and Yan Zhu

Abstract With the development of urban modern service industry and information economy growing stronger, the development and layout of office industry has gradually become one important symbol of urban economic service and urban functional structure. Objective: In order to analyze the spatial distribution and utilization characteristics in Ningbo and their drive mechanism, to provide scientific guidance for the urban spatial function and structure in Ningbo. Research Methods: On the basis of project team field data, making use of spatial kernel density analysis, local Moran index and location entropy analysis. Findings: (i) spatial distribution of multi-center multi-circle shape began to form in Sanjiangkou, along rivers and transportation to shaft-like spill is evident; (ii) the second level block is in small-scale, the third level block in lags behind as a whole; developed block also has a higher overall service capabilities, while developing block has a single function, uncoordinated with the entire development of the city; (iii) positive correlation exist between the type and level of utilization of office and the space of commercial center, river, main roads; (iv) political, economic and corporate microscopic principal, physical geography, history, culture and other factors are interweave through the combined effect to regulate and guidance the office industry and producer services on the agglomeration and dispersion dynamic evolution in time and space; Conclusions: Offices industrial development should be coupled with the coordinated development of urban services, the fundamental purpose is to create a better life, to meet the diverse needs of the creative community is the city office industry's core value.

Keywords Office building · Spatial · Distribution · Drive mechanism · Ningbo city

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35.1 Introduction

Since the 1950s, world economic structure transition from production manufacturing to service industry, especially the city which main function is productive service do the most dramatic rising (Sassen 2005). Office building as important spatial carrier continuing to emerge in all the city's business center. City turned into a certain place for production, service, marketing and innovation (Gu 1999). With this transition, especially since 1970s, the output value proportion of world's major cities tertiary industry increased dramatically, the manufacturing sector began to gradually move out of the city center, thus contributed to the upgrading and structural adjustment of the internal space of the city (Chu 1992). Western countries have been concerned about the development of the city is the office industry for a long time. During the time 1963–1969, In order to encourage central city (central city) office building evacuation, to alleviate the social problems caused by excessive development office, Location of Office Bureau (LOB) have been set up to management Center City office relocation and re-planning (Fernie 1977). Foreign relative research experienced from theoretical assumption to empirical test, to study the formation process of mechanism: Rent-Transport "compromise" mode in 1920s; discussed the relation of office activities, divided and determined the office activity levels according to production process in 1960s–1970s; built models to predict the spatial distribution number of office activity in 1980s (Li and Lv 2005). In this paper, according to detailed literature review, the research process will be divided into five stages: (1) The embryonic stage (1920s–1950s); (2) The developing stage (1950s–1970s); (3) The high yield and symbol period (1970s–1980s); (4) The mature period (1980s–2000s); (5) The system further period (2000s–). The representative research work as follows: paperwork on the determinations of the physician office building location selection, aroused a heated debate between Hurwitz and Kaplan in 1974 (Kaplan and Leinhardt 1973); Series of books published as follow: The office industry: patterns of growth and location (Armstrong 1972), Office location: an urban and regional study (Daniels 1975), Office location and public policy (Alexander 1979) have played an important role in promoting the research on city office spatial distribution and urban industry structure; research on office spaces and spatial distribution of activity area has made important achievements (Clap 1980; Daniels 1980; Gad 1985); some studies establish spatial econometric models and use space remote sensing technology focus on variables affect the equilibrium structure of office space, such as office occupancy rate, the vacancy rate, the employee growth rate, the real interest rate, the stock price of office property, transport accessibility, public buildings and facilities, architectural aesthetic design, the distance to the Central Business District and so on (Elgar and Miller 2006; Brounen and Jennen 2009; Fu and Jennen 2009; Ozus 2009; Farooq et al. 2010).

In contrast, the domestic research started late, the representative results are as follows: to define the concept the production service and office building, and analysis the relation of production service, office building and the city spatial structure (Hou and Ning 1998); by doing fieldwork of 5 office center in Shanghai, and asset that government policy, city planning, supporting facilities, traffic conditions, historical and other factors are the main factors which influence the office location pattern; by using the kernel density analysis on the database of office location in the range of Beijing city, analysis the existing state of office activities spatial agglomeration, distribution characteristics and formation cause (Zhang et al. 2010); by using the method of the Kriging interpolation to locally spatial estimate of the business office regional variables in Chongqing (Liang 2011); building the integration office model of supply (development site) and demand (enterprise location) on the basis of the related theory of enterprise location and office development site.

In general, the foreign studies have an earlier start and relative abundant and novel direction, research has focused on the impact of corporate office location and microscopic aspects of the community, less involved office location associated with the regional industrial structure; the domestic research is more macroscopic, summarized the office location, spatial distribution and the general rules of urban industrial structure, and even the scenario simulation development of regional office market.

The current domestic study still focus on analysis the phenomena of the office space distribution and factors, less study result about office building specialization degree and space evolution mechanism, and not enough detailed and in-depth, research on urban development and restructuring of the office space is even more rare. This article will try to combine the current domestic and international research different emphases, Summarize the general rules of the structure and use of the feature space office development in Ningbo City from macro perspective, and explore the factors that affect the microstructure of the regional office development from micro perspective.

At present, china is in the transition period of urban development, Market mechanisms play a role in the restructuring of urban space, while the Government is still the economic development policy maker, this may make the internal structure of urban space showing different characteristics with the Western countries.

Based on the above analysis, the purpose of this study are as follows: (1) Through spatial analysis of the project team field research data, explore the spatial distribution characteristics of business building in Ningbo city; (2) On the basis of the history and evolution of spatial analysis, under the two-track system of the market and the government, summarize the formation mechanism of commercial office space in Ningbo pattern; (3) The ultimate aim of this paper is: Based on the conclusions, provide the basis for guiding urban space function and structure, and provide reference for the development of domestic urban services.

35.2 Data Sources and Research Methods

35.2.1 Data Sources and Types

In 2012, from April to December, Research group have done field research work to investigates the office status in the block of Haishu, Jiangdong, Jiangbei, Yinzhou, Zhenhai in Ninbo city, totally collected 340 detailed information of samples office, according to property association statistics, detailed information including office address, office name, function type, occupy area, construction area, building layers, occupancy rates, internal business type, etc., meanwhile obtain services types, transportation data, the sixth census data, the second economic census data, Statistical Yearbook and other data. information collection and spatial analysis based on the bottom picture 1:1000 2012 situation topographic maps of Ningbo, reference 2012 Ningbo traffic maps and Google Maps for office space for sample positioning. Image and data processing using software such ArcGIS9.2 and AutoCAD 2010.

35.2.2 Research Methods

35.2.2.1 Spatial Density Analysis

GIS spatial analysis is used to calculate the density of the whole region gather data, and generating a continuous surface according to the density of the element data, generation mainly based on point data, take each grid point as the center for the circular search area, the more closer to the search point, the much greater the weight value (Bores et al. 2009), thus calculate the density value of each grid point, Density analysis is essentially a discrete sample points with the inner surface interpolation process, the results can be used to Berke (2004). This pare by the means of spatial kernel density analysis, based on the survey to establish a database of office space, and take the office construction area as the weighted variables, Create the space present situation density maps of Ningbo city, research the status of office space layout.

35.2.2.2 Local Moran Index

It is spatial autocorrelation analysis, statistical analysis of spatial autocorrelation of local Moran index I_i, This analysis on the basis of assessment the overall situation, consideration of the potential instability of spatial processes. Using local Moran index can identify similar elements of spatial clustering properties (Xu 2006). Moran index I values generally between −1 and 1, Less than 0 indicates a negative correlation, equal to 0 indicates no correlation, greater than 0 indicates a positive correlation, The more higher the value, the greater the value of the property on behalf of the degree of concentration expressed, Moran index I_i formula is as follows:

$$I_i = \frac{n(x_i - \bar{x}) \sum_j w_{ij}(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} = \frac{nz_i \sum_j w_{ij} z_j}{z^T z} = z_i' \sum_j w_{ij} z_j' \tag{35.1}$$

35.2.2.3 Location Quotient Analysis

Location quotient in the industrial structure is mainly used for the study of regional leading professional situation (Miller and Gibson 1991), the more higher the value, the higher their degree of specialization, Formula is as follows:

$$N_{K-A} = {}^{n_{K-A}}\!/_{n_K} \tag{1.2}$$

N_{K-A} represent the service type A location quotient of regional K; n_{K-A} represent the service type A enterprise number of regional K/the total enterprise number of Ningbo services type, n_K represent the total service enterprise number of regional K/the total service enterprise number in Ningbo.

35.3 Commercial Office Space Distribution Characteristics in Ningbo City

35.3.1 *Present Situation Analysis of the Office Spatial Distribution in Ningbo City*

Figure 35.1 shows the project team surveyed 340 office in Ningbo City nearly 300 offices located in Haishu block, Jiangdong block, Jiangbei block, Yinzhou blocks and Sanjiangkou region, That still highly concentrated area which Yao River, Fenghua River flows into the East China Sea merged into YONGJIANG confluence, however, the majority of the surrounding area, including Zhenhai block and Beilun block only sporadic distribution, In recent years, the distribution of Ningbo City office evolved from "multi-center" to" single-center", Now has shown a "multi-center" prototype, from the "single-center" pattern of the original Haishu district, spread to the surrounding and form the "three centers" State of Haishu District, Jiangdong District, Southern Yinzhou Center District.

35.3.2 *Analysis of the Spatial Density*

This study, using kernel density mapping method, base on the office space data from field survey in Ningbo city, take the office construction area as weighted variables, establish office space density map of Ningbo City, by quartile method divide into five gradient grades. As can be seen from Ningbo spatial density graph (Fig. 35.2), there are three blocks of high density and two medium density blocks, from left to right, top to bottom are: high density area, firstly, the left black center, that Sanjiangkou (Yuyao River, Bay River and Fenghua River) Interchange, is the liberation south road, Zhongshan road, medicine street and spirit bridge constitutes

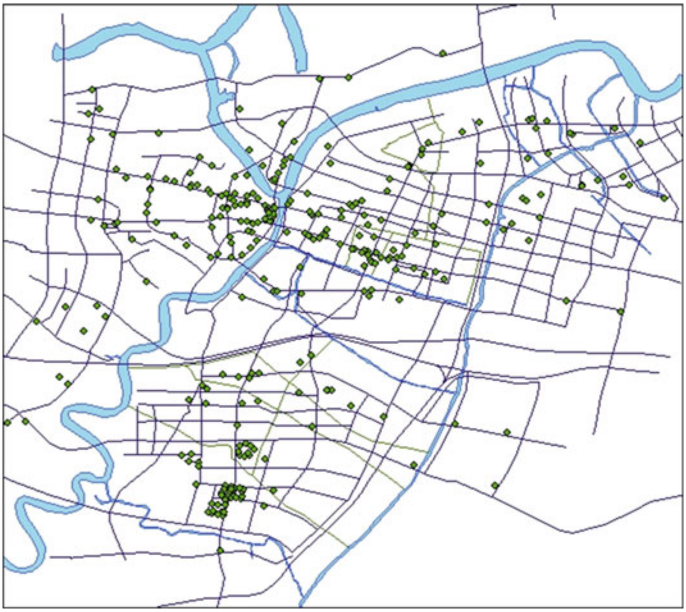

Fig. 35.1 The main block (except Zhenhai, Beilun) office status distribution diagram, Ningbo city

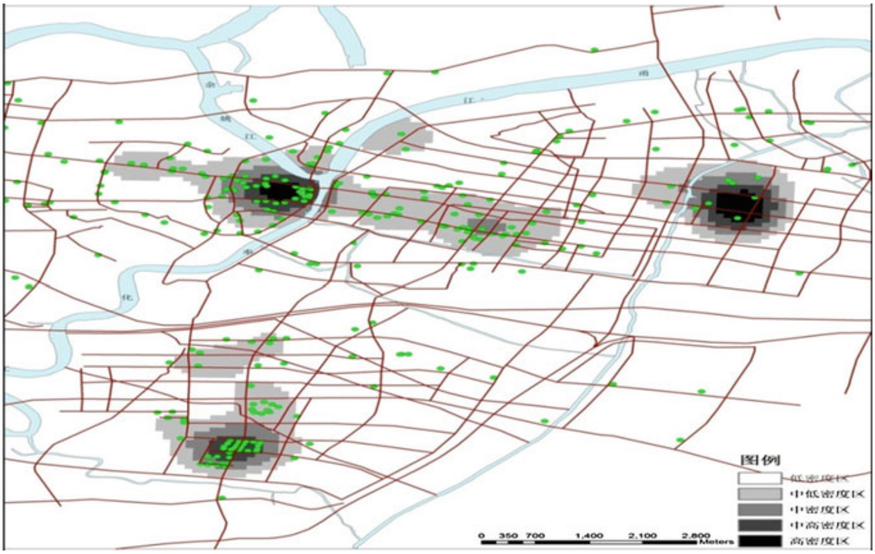

Fig. 35.2 The main block office space density maps, Ningbo city

a ring road bridge, the office layout show core circle style, east side of Zhongshan Road, Zhongxing Road for the intermediate density region; secondly in the right is East Metro, Mingan road, Haiyan Road, Jingjia east road, north the river city road constituting the ring road, also turn out circle layout; in the southern business district of Yinzhou, that view of the lower black area of high-density areas, take the calendar road and Tiantong south road as the center and also turn out circle layout, around the medium density district east to Tiantong road, west to Ninngnan road, south to Siming middle road, north to song river middle road.

35.3.3 Spatial Analysis of Construction Area

Office construction area (employment and use) is the reflect of urban spatial concentration economic implications, from the view of single building construction area (Fig. 35.3), larger offices are located in the peripheral areas of the city, however from the perspective of the whole Ningbo city, the larger single office building distributed more evenly in space, have no some kind of agglomeration; from the view of office building spatial distribution, in space showing a clear pattern of uneven concentration, the most densely region is around Sanjiangkou, presents circle pattern And has a gradient decreasing feature from the center to the periphery, this phenomenon is verified the history inheritance in the process urban

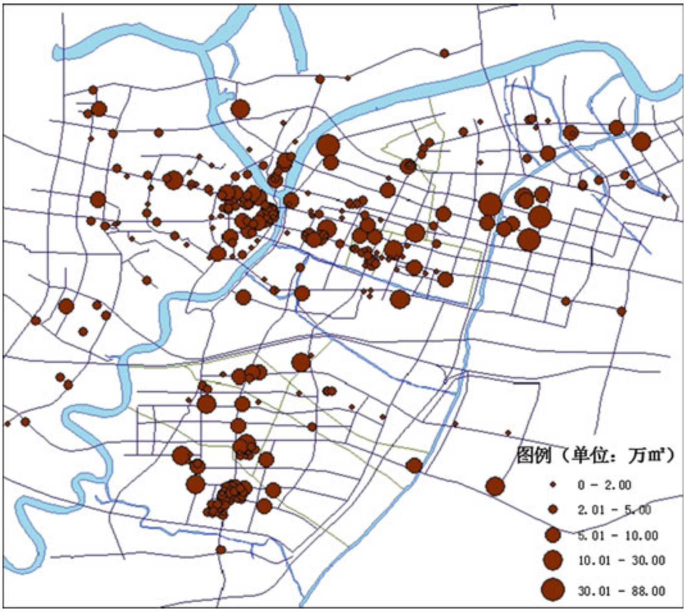

Fig. 35.3 Office construction area spatial distribution maps, Ningbo city

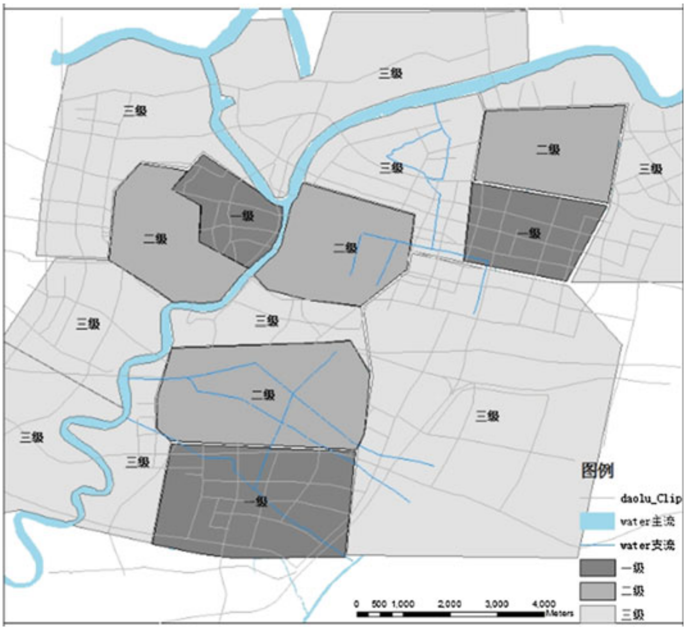

Fig. 35.4 Office building rating distribution maps, Ningbo city

development. Around the Sanjiankou region is the old Ningbo city, as the effect of early urban planning and natural environment, office develop rather earlier, much more lasting, low intensity and larger spatial density. The blocks in the periphery of the old town, most are new office and often carry high government investment and starting point is the planning quality construction, office building density is relatively low, but higher intensity development strength.

Base on the spatial capacity density analysis of office building in Ningbo city (Fig. 35.3), by the mean of K-Means Cluster. according to the principle of minimum Euclidean distance, perform sample clustering analysis of 10 blocks, selected the variables of the number of service enterprises, the floor area, building area simultaneously, using spatial analysis from statistical tools "Cluster and Outlier Analysis", finally get three levels of block size distribution (Fig. 35.4). According to the analysis result, office hierarchical structure is not reasonable in Ningbo city. The second level block small-scale, and uncoordinated with the Ningbo City development, the third level block development lag in a whole, this also shows that the office space distribution is in the evolution form the "single-center" to "multi-centric" stage in Ningbo city. From a simple point accumulation gradually become grid transition, all levels block has appeared basic shape, However, the office functionality and scale is still in formation process, still need to constantly optimize and upgrade.

35.3.4 Analysis of Block Function Feature

Through statistical office internal service type, except the construction of office buildings and abandoned, vacant office, divided according to the blocks, using location quotient to calculate the dominant type of services within each block office, enterprises mainly belong to medium-sized in Ningbo city, enterprises mainly belong to medium-sized in Ningbo city, thus mainly calculation the number of enterprises, Without considering the size and scale, the largest calculations value of service industry type is the dominant service type in the block. Calculated density based on block-level division, Table 35.2 shows the results of the statistical (Table 35.1).

According to the results of location quotient, we can see there is a big difference between the different sectors, much more developed block also has a higher overall service capabilities, the block in the development stage usually only have single function (Table 35.2); In terms of administrative block, the dominant industry is finance and insurance, information, advisory and agency services industry, public administration and social organizations in Sanjingkou, the original three district, The reason may be Sanjiangkou area is the center of Ningbo city construction, and is also the original birthplace of the office development, large residential density and information demand, reflects the city functions historical inheritance in the process of urban development in Ningbo city; Yinzhou southern business district, mostly financial industry, but also reflects the focuses its intent to build a new city center, due to convenient transportation,, blocks away from the city dominant by sparsely populated, the wholesale trade, logistics services, transportation; In terms

Table 35.1 Service types of each grade office building, Ningbo city

Block	Dominant type of office services
First class A	Productive service: a finance, insurance c Information, consulting, agency
First class B	Productive service: e scientific research and comprehensive technical
First class C	Productive service: a finance and insurance industry
Second class A	Distributive services: j wholesale trade
Second class B	Social service: y public administration and social organizations
Second class C	Productive service: c information, advisory and agency services
Second class D	Social service: x public facilities services
Third class A	Distributive services: j wholesale trade—h logistics services
Third class B	Distributive services: j wholesale trade
Third class C	Distributive services: j wholesale trade
Third class D	Distributive services: j wholesale trade
Third class E	Social service: o residents and personal services
Third class F	Productive service: f business services
Third class G	Distributive services: j wholesale trade
Third class H	Consumer services: n entertainment fitness industry
Third class I	Productive service: c information, advisory and agency services

Table 35.2 The location quotient of each grade office buildings, Ningbo city

	First class	A	B	C	Second class	A	B	C	D	Third class	A	B	C	D	E	F	G	H	I
a	1.28	1.65	1.64	4.18	0.91	0	0.97	0.84	1.16	0.92	3.61	0.66	0.44	1.24	0.87	1.31	1.56	0.16	0
b	1.85	0.42	1.88	2.01	0.8	0	0.44	1.3	0.3	0.7	0	0.47	0	0.37	0.92	0.96	0.56	0.28	1.31
c	1.41	7.63	0.52	3.56	0.66	0	0	0.79	2.88	1.01	0	0	0.26	0	1.78	1.55	0	0	0.85
d	3.71	5.82	3.26	3.16	0.42	0	0	0.94	0	0	0	0	0	0	0	0	0	0	0
e	0.71	0.97	4.23	0.58	1.42	0	0.17	2.98	0	0.89	0	0	0	0	0.85	1.47	0	1.3	2.01
f	1.54	1.81	0.38	1.73	0.49	0	0.21	0.88	0	1.05	0	0	1.71	0	0.79	1.38	0.8	0.81	1.25
g	1.06	7.76	0.82	0.31	0.28	0	0	0.21	1.82	1.42	0	0	1.22	0	0.85	2.46	3.44	0.86	0
h	2.57	0	1.66	2.48	0.8	0	0	1.78	0	0.34	6.31	0	1.15	1.08	0	0	1.63	0	1.27
i	1.35	1.53	3.57	0.91	0.67	1.81	0.35	1.08	0	1.03	0	0.29	0.32	6.74	0.78	0.97	0	1.02	0.53
j	0.57	0.53	0	0.68	0.43	0.63	0	0.84	0.38	1.57	5.94	0	3.97	0.16	0.12	2.4	1.66	0.12	0.74
k	0.89	0.89	0.69	0.92	1.04	0.55	1.3	0.88	0.73	1.03	0	1.61	1.2	1.13	0.78	0.98	0.91	1.1	0.97
l	0.69	1.89	0.27	0.64	1.36	2.99	1.58	0.87	2.29	0.93	2.73	0.16	0.71	0.25	1.69	0.5	0.94	2.07	1.75
m	0.87	0.66	0.81	1.04	0.99	0.81	0.83	1.02	1.53	1.02	0	0.61	0.45	0.64	1.46	1	1.36	1.61	1.13
n	1.47	0.71	0.56	1.73	1.15	2.51	0.58	1.41	2.13	0.67	0	0.1	0.28	0.47	1.01	0.72	1.18	0.71	0.74
o	1.2	0.87	1.96	1.09	0.95	0.98	0.7	1.31	0.44	0.93	1.66	0.89	1	1.41	0.96	0.92	0.69	0.46	1.05
p	0.45	0	1.58	0.3	1.94	5.87	3.57	0.67	0	0.68	0	0	0	0.73	1.09	0,95	0	1.11	0
q	0.46	1.68	0.8	0.25	1.26	1.48	1.3	0.95	2.36	1.12	0	1.87	1.05	0	1.46	1.06	0.56	0.84	0.87
r	1.16	5.29	1.34	0.63	0.93	0	1.09	1.03	0	0.97	0	0	0	1.86	1.85	1.07	1.41	0.71	0
s	1.37	2.4	1.52	1.22	0.82	7.25	0.47	0.55	2.17	0.92	3.17	0.38	1.18	0.9	1.34	0.52	0.91	1.14	1.77
t	2.65	3.82	0	2.77	0.85	0	0	0.94	4.1	0.27	0	0	0	0	0	0.74	0	0	0
u	0.25	0	0	0.33	1.2	0	2.35	0	1.93	1.25	0	0	0	0	1.79	2.43	0	0	0
v	0	0	0	0	2.27	0	5.34	0	0	0.71	0	0	0	0	0	1.96	0	0	0
w	0	0	0	0	2.27	27.39	4	0	0	0.71	0	0	0	0	1.69	0.98	0	0	0
x	1.16	4.23	0	1.01	1.39	7.47	1.46	0.34	4.47	0.68	0	0	0.66	1.86	0.92	0.8	0	0	0
y	0.61	0.96	1.52	0.4	1.09	0	1.24	0.54	3.04	1.14	2.91	1.61	1.35	0.84	1.78	0.55	3.19	0	0.99

of class block, the first block mostly is productive service and the third block mostly is distribution service, as the office rental price, the acquired office area is much larger in the second class than in the first at the same price, thus large office area tend to distribute in the third class, technology-intensive services need relatively small office space and usually distribute in the first class.

35.4 The Driving Mechanism of Office Spatial Distribution in Ningbo City

35.4.1 The Relationship of Structure Transformation and Office Distribution Pattern

Urban spatial structure is the reflect of constituent elements overall allocation order and morphology during a certain period, Urban form and structure company with the combination of factors in a variety of variable-based socio-economic factors interact and complex change. Office as the main carrier of urban services, its spatial distribution pattern must have close ties with the urban spatial structure and form. through field surveys for Collecting data and literature data analysis, Ningbo urban spatial structure have taken place many changes from the Opium War (1840s) to the 21st century, 1840s–1970s is a single center aggregate structure and Sanjiangkou as the core area, main function port comprehensive trade, 1970s–1990s urban space structure took place significant changes with "One city, two towns." besides the main central city Sanjiangkou valley, also includes Haishu, Jiangdong and Jiangbei three sub-center, urban main function deviate to industrial production and service; in 1990s–2000s, with great ribbon leap forward development to become the spatial structure characteristics during the period, emergence of a large number of new industrial district and Economic Development Zone, Tianyi Square has become the center of Ningbo city, commercial center, comprehensive industrial base dominated urban functions; from 2000s to now, City Development in Yongjiang line with shape T, emergence a number of central business district, Ningbo Wanda Plaza built as sub-centers in Yinzhou District, function as integrated business services and technology-based information services (Table 35.3).

Evolution of urban spatial structure affects office space layout and function formation in Ningbo city, office buildings gathered in Sangjiangkou valley before 1990s, port trading service as the main function. The current changes in the distribution pattern of the Ningbo city—space is mainly reflected in two aspects: (1) re-adjust—use structure and types of the internal office. By filtering other functions such as processing and manufacturing in the central business district, making more optimized industrial structure, enhance the professional level of the lateral division of extent of the system; (2) by the relocation of processing and manufacturing other functions to achieve structural adjustment and upgrading from a single simple function mix towards multi-center professional, construction and development outside the city's deputy center, will undoubtedly enhance the degree of

Table 35.3 Urban form and central structure evolutionary history, Ningbo city

Historical period	Urban form	Central spatial structure	Central location	Central functions
Opium war 1840s–1970s	Cross Fenghua river and Yuyao river to east river and north river, cluster turn into radial wedge formation in Sanjiangkou valley	Single-center aggregation	Sanjiangkou valley	Political and cultural center port comprehensive downtown
1970s–1990s	Around the old town with the style of "Pie" and "fill the gap" developing, finger-like development along the river of Zhenhai and Beilun region, discontinuities zonal distribution as a whole	"One city, two towns."(old town, Zhenhai, Beilun), old town main center, two peripheral vice city	The old city of Sanjiangkou valley, include Haishu, Jiangdong and Jiangbei three deputy center	Business center, chief business district, cultural commercial district, integrated heavy chemical industry base, port industrial base
1990s–2000s	Take the Sanjiangkou valley as the main center, centrifugal slug development with the three deputy center Beilun, Zhenhai, Yinzhou, ribbon development by leaps and bounds as a whole	"One city, multi-town", three peripheral vice city	The old town, Zhenhai, Beilun, Yongjiang three new district, daxie island, Xiaogang economic development zone, the east new town	Business center, chief business district, cultural commercial district, integrated heavy chemical industry base, science, culture and information center
2000s–	Take Yong river as the axis, cross river, along river network group and cluster	"One city, multi-town", three peripheral vice city, T shape strip distribution along Sanjiang valley	The old town, Zhenhai, Beilun, Yongjiang three new district, daxie development zone, Yinzhou Wanda plaza, century oriental plaza	Administrative center, commercial and cultural tourism service centers, regional business center, a comprehensive industrial city, high-tech integrated metro

competition in the longitudinal vertical division of labor system in the city. For example, the old town Renewal conducted in Sanjiangkou old town; formation suburban office gathering place in the national high-tech park, dominated by one or two level of high-tech manufacturing park, mainly in the form of mostly industrial park, Software Park, aims to attract those computers and software services with a combination of advanced manufacturing, research, and other intermediary services, producer services. In addition, in Beilun district and Zhenhai District area away from the center of these areas, with the rapid development of port construction and port industries, functional of the Central Business District is also gradually improved, in addition, the new eastern Ningbo city in the future as the Chief and business center, a variety of residential, commercial office development, commercial projects are also being expanded.

35.4.2 Drive Mechanism of Office Space Distribution in Ningbo City

Through field research and literature review, this paper based on the analysis of Ningbo City office space distribution characteristics, study the driving mechanism of main factors and the effect path as follows: (1) political factors through public policies, Government guide and control on urban office space distribution and use type. As the government's urban planning adjustment and guidance services in different cities space aggregation of discrete, industrial structure directly affects the type of transition services, and thus determine the main types of urban areas office use; (2) economic factors. urban economic structure adjustment and upgrading, leading the optimization of labor division and industrial structure, thus contributing to the renovation of the old city, the construction of regional production specialization, public transport facilities, bring centrifugation of residential and business office; (3) natural and geographical factors. The survey found that the layout office building near the river is usually turn out banded, and away from the river with "pie" type of "fill in the blank" type with groups aggregation. In addition, natural disasters will have an important impact on the structure of the office building space requirements and style structure. (4) Micro-individual factors. The nature and productivity of enterprises determine the choice of enterprise office address and type, the transformation of urban network structure provides labor guarantee and innovative environment, resulting in agglomeration economies. (5) Spatial location factors. Construction of urban renewal and urban sub-centers to promote the formation of urban multi-center network pattern, center location quality and transportation accessibility provided the impetus and conditions for production services companies central location. Centralized reflect in the following 4 parts (Fig. 35.5):

1. Urban economic transformation and industrial structure adjustment under the market mechanism is the main driving force to promote the evolution of office space. Accordance with the competition theory, city center plots are generally

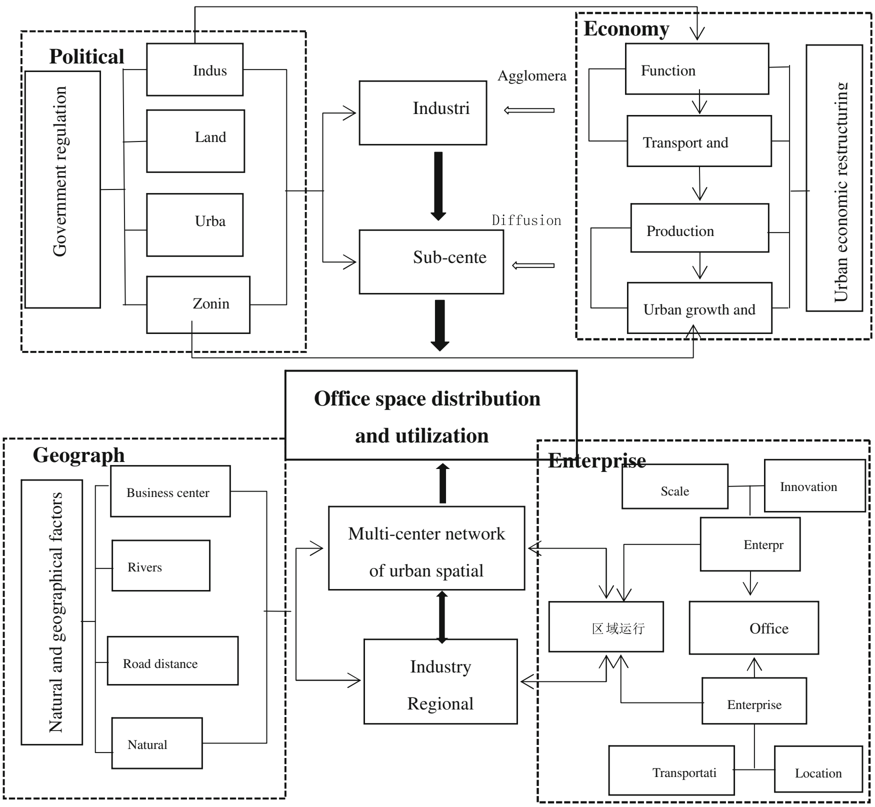

Fig. 35.5 Office space evolutionary mechanism schematic diagram, Ningbo city

occupied by marginal revenue and high rent pay capacity commerce, finance, office industry, and industrial, residential and other industries expand to the outskirts of the city. Urban economic transformation guide urban function space restructuring and optimization, the adjustment of industrial structure promote urban land-use structure with the transformation of urban functions and change accordingly. Such as Ningbo early port traditional processing trade exports gradually moving towards a modern set of financial services, information technology, consulting agency, trade exports and other functions into one integrated service information and knowledge center of the city center, the evolution performance of Ningbo City office space distribution is inner city feature updates and outside new construction. As the former industrial enterprises gradually moving out from Sanjiangkou area or transformed into urban complex, the latter build Yinzhou new business district in the outskirts of city, the eastern city Metro and other high-grade new business center.

2. Government regulation and urban planning policy guidance is the citizenry of office space evolution. Government formulate industrial policies and land policies have a direct impact on the structure and pattern of urban office space, such as of high-tech industrial park, planning and construction of Xiaogang Economic Development Zone, the park is supporting manufacturing and multinational businesses have begun to take a number of new scale research and development, computers and software, intermediary services and other functions for the integrated office area; urban planning because of itself is a regulatory policy of the urban space development, everything is a direct result of the reconstruction of urban space, Ningbo city Planning identified Sanjiangkou region and the eastern town as "dual core" structure of the city center, with the easingland policy and financial support, Yinzhou business district has become a veritable city sub-center.
3. The nature and behavior of enterprise is the catalyst of office space evolution. Enterprise is the cell of city economic activity, the pursuit of profit-oriented enterprises will choose to the location of urban space industrial development correspond with their own ability to pay based on opportunity costs, production costs and transaction costs is the significant cause of industrial agglomeration, intense competition in the market exacerbate the desire for innovative business environment, it is under the combined effect of these factors, enterprises which have similar nature and development stage gathering in the city economic Development Zone and industrial Park, and thus spawned a large number of ancillary office facility needs, such as the city center accelerate eastward, increases the number of business office surrounding the new administrative center of the eastern new city. For example, international financial center, Qiuyi headquarters economy to 2016, at least 980,000 m^2 of office space available for development business office formats.
4. Natural geographical and historical cultural factors play a subtle role in the soft constraints of urban spatial evolution. Human early had the habit of living by the water, the analysis of Ningbo office space showed a very clear law that commercial office morphological shaft-like spillover along traffic axis and rivers, and the use type and level fit business office is very high. Since the Opium War, Ningbo become an open trade port, retains many historic buildings and monuments, Sanjiangkou area because of its architectural style and layout restrictions to protect historical and cultural value of spatial planning, so the layout and development of nearby office buildings is restricted. Evolution of urban spatial pattern is the combined effect of the above factors and following the gradual completion of interpenetration.

35.5 Conclusions and Implications

35.5.1 Conclusions

In this paper, the integrated use of spatial kernel density analysis, local entropy method and regional Moran index, using field research data of Ningbo office project team, from the spatial distribution, building area, and use the block feature, professional level and type of four aspects, study the overall characteristics of Ningbo City office space distribution, and discusses the spatial evolution mechanism. The results show that: (1) the distribution of office space Sanjiangkou oriented multiple spheres centered multi-center network prototype has started to form in Ningbo City, in the old city of Sanjiangkou, the south Yinzhou new city business center and the new eastern city from center to peripheral distribution pattern showing a decreasing gradient layout, turn out discrete peripheral distribution, and the spatial distribution turning point to the ribbon diffusion, multi-center networking trend pattern; (2) spatial analysis of floor area shows relatively small scale of the second blocks uncoordinated with urban development of Ningbo city,, the third blocks as a whole lags behind; (3) location quotient plate analysis showed that there is a big different between differences sectors, more sophisticated block also has a higher overall service capabilities, the developing block which function is relatively single; in terms of level blocks, in the first level block, office mostly occupied by productive service, distribution much more technology-intensive services; in the third level block, office usually occupied by distribution service. From the formation mechanism of Ningbo office spatial pattern evolution, intertwined combined effects of the current political, economic and micro-enterprises body, physical geography, history and culture and other factors to shape the city's industrial structure, economic space, urban function spatial and enterprise distribution, regulation and guidance the dynamic evolution process of the city office and producer services in time and space agglomeration and dispersed, mainly reflect in the following four areas: (1) urban economic transformation and industrial restructuring under the market mechanism is the main driving force to promote the evolution of office space; (2) government regulation and urban planning policies guidance is the weathervane of office spatial evolution; (3) the nature and behavior of enterprise is the catalyst of office spatial evolution; (4) Physical Geography and historical cultural factors play a subtle soft constraints role in the evolution of urban space.

35.5.2 Implications

By the summary the evolution of urban center structure and analysis the status of office spatial distribution characteristic in Ningbo city, can drawn the implications as follows: (1) the evolution of urban spatial structure is respond to the need of industrial structure adjustment and upgrading, and thus the office spatial distribution and use should synergistic coupling with production services development, the guidance and arrangement should much more follow market will; (2) regulation and policy planning of office space should be proportionate and timely. Specifically, land costs, administrative costs, construction costs and profits tax cost are the enterprise concerned but need government policy support, some problem such as business office facilities and market information asymmetry which markets can not solve their own problems, the government should co-ordination arrangements; (3) build a "multi-center, multi-level, network-based" office development framework, establishment a office system of "transverse horizontal labor division" specialized combine with "longitudinal vertical division of labor" competition, which is the important condition to enhance the urban industrial value chain and integrated services capacity, construction of urban sub-center should Comprehensive considering the time cost and distance costs and maintain office space diversity in size, agglomeration degree, function and structure types; (4) the core competitiveness of transformation from "port through the world" to "Port contain the world" is the "creative community", the high-end innovative talent is the most important driving force in knowledge economy era and post-modern society, but also the groups who mainly need business office. According to the scene theory, building municipal facilities which can meet oriented values of outstanding human resource, so that the office facilities combination become the new social consumer sites where can highlight certain values dimension, thus retaining top talent, it has a very important strategic and forward meaning in the development path of innovation of urban and business office in Ningbo city.

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Chapter 36
Project Management of Urban Infrastructure Projects—Indian Scenario

Vanita Ahuja

Abstract Urban Infrastructure Projects comprise new construction as well as urban renewal projects. In India, ownership of these projects is under different government departments. It is observed that these projects, specifically renewal projects are not executed successfully in terms of timely completion, quality of construction, stakeholder management and other related factors of project management. Individually each of these projects may not be of very high financial value, but collectively these projects contribute to high national expenditure. When not executed successfully, these projects are a tremendous strain on the national exchequer. Government of India has initiated a scheme of JNNURM (Jawaharlal Nehru Urban Renewal Mission) under which Project management methodologies and statutory reforms have been specified. This paper discusses these specified parameters and their efficacy.

Keywords Urban infrastructure projects · India · Project management

36.1 Introduction

Urbanization is primarily a result of migration from rural areas as urban areas provide higher productive job opportunities as compared to agriculture. The process facilitates full realization of economic potential of the country. To facilitate this, urban areas need to be ready with physical infrastructure, jobs, and livelihoods. The McKinsey Report (2010) on India's urbanization prospects estimates that over the period 2010–2030, urban India will create 70 % of all new jobs in India and these urban jobs will be twice as productive as equivalent jobs in the rural sector (HPEC 2011). India's urban population is expected to increase from 377 million (31 %) in 2011 to 600 million in 2031 leading to 40 % urbanization. The number of cities

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with a population of 1 million and above is projected to increase from fifty three to eighty seven over this period (Ahluwalia 2014).

Social and urban infrastructure leads to overall development of the state economy. Requirement is not only to have physical infrastructure, but also to have acceptable quality of services which is an important component of stakeholder management. Indian urban areas are deficient in quality of services and need to be effectively managed to sustain and be ready for sustaining the economic productivity. To ensure the contribution of cities to economic growth, Ministry of Urban Development had set out service norms in 2008 (HPEC 2011).

Eight major urban infrastructure sectors are water supply, sewerage, solid waste management, storm water drains, urban roads, urban transport, traffic support infrastructure and street lighting. Apart from creating new physical infrastructure, focus also needs to be on reforming governance for improvement in delivering services and operations and maintenance of existing infrastructure.

In India, an urban area is defined as a statutory place with a Municipality, Corporation, Cantonment Board, or Notified Town Area Committee, and all places satisfying the following three criteria simultaneously (HPEC 2011):

(i) a minimum population of 5000
(ii) at least 75 % of male working population engaged in non-agricultural pursuits
(iii) a population density of at least 400 per km^2 (1000 per mile^2)

Urban agglomeration is defined as an urban spread constituting a city and its adjoining urban outgrowths or two or more physically contiguous cities/towns together and any adjoining urban outgrowth of such cities/towns. Currently the urban population of India occupies only 3 % of the total land area in the country (Ahluwalia 2014). But, situation is changing fast and urban landscape is expanding.

In India, cities are categorized as Class I cities and Class II or smaller towns with population of less than 100,000 (HPEC 2011). Larger cities have Municipal Corporations with elected Councillors as members and smaller cities/towns have Municipalities or Nagarpalikas. Municipal Corporations as well as Municipalities are split into Wards with elected members, usually one for each Ward. Areas in transition from rural to urban areas have Nagar Panchayats which also have elected bodies with a Chairperson. In addition there are Census towns, Cantonment Boards/ Industrial Notified Areas/Estate Offices.

Urban Infrastructure projects fall under two categories.

- Projects planned and executed by Central Government organizations. For example Metro Projects, Airports etc.
- Projects planned and executed by local Municipal Corporations and State Public Works Departments (PWDs) For example road projects, water works etc.

It has been observed that projects falling under the first category are primarily successfully executed. But, projects falling under second category lack in adoption of Project Management methodologies and successful execution and are the area of study for this paper. Individually these projects may be of lesser economic value, but collectively these projects contribute to high national expenditure. When not executed successfully, these projects are a tremendous strain on the national exchequer. Also, these projects affect the day to day lives of public and require high stakeholder management.

36.2 State of Urbanization in India and Its Future Growth

The urban population in India as measured in the census of 2011 was 31 %. But, there is also some unacknowledged urbanization which makes the share of urban population look smaller than what it actually is. This unacknowledged urbanization is due to following factors:

- Restructuring of electoral constituencies is not done at the required periodicity. Last such exercise was conducted in 2008 and next is due in 2026. Thus, increase of urban representation in legislatures would happen by 2030–2031, though urbanization is happening at a fast pace (Ahluwalia 2014).
- There is differential funding structure for rural areas and differential and less favourable urban tax regime. Due to this many gram panchayats (village local governments) resist/refuse to be converted to nagar panchayats or municipalities even when they fulfil the criteria laid down in the census to graduate from a village to a city (Ahluwalia 2014).
- In the outskirts of urban agglomerations, real estate organizations try to delay the conversion from rural to urban.

Due to above factors, though the number of areas defined by the census as 'towns' increased by over 2000 from 1362 in 2001 to 3894 in 2011, the number of towns with statutory urban local bodies increased by less than 250 over the same period. This means that the census of 2011 added more than 2000 'laavaris' (unowned) urban areas to its list of towns; laavaris because they do not have statutory Urban Local Bodies but otherwise fulfill the census definition of urban areas (Ahluwalia 2014). Thus, these areas lack administrative structure to plan for the urban growth that would lead such areas to become economies of agglomeration. Instead such areas experience haphazard growth and have low levels of service delivery. Since many such areas are adjacent to existing urban areas, they attract rural migration and requirement of adding urban infrastructure and its management becomes more important.

During the last decade Government of India has proposed and implemented multiple social welfare schemes that have contributed and would further contribute in providing incentive to rural population to stay back in rural areas. Many such rural areas would further qualify to be categorized as urban areas. As per Census of 2001, there were 18,760 villages with more than 5000 population each in 2001 (HPEC 2011). Such areas also need to have legitimate urban administration so that they do not get categorized as 'laavaris' urban areas, but experience planned urbanization and contribute to the economy of the country.

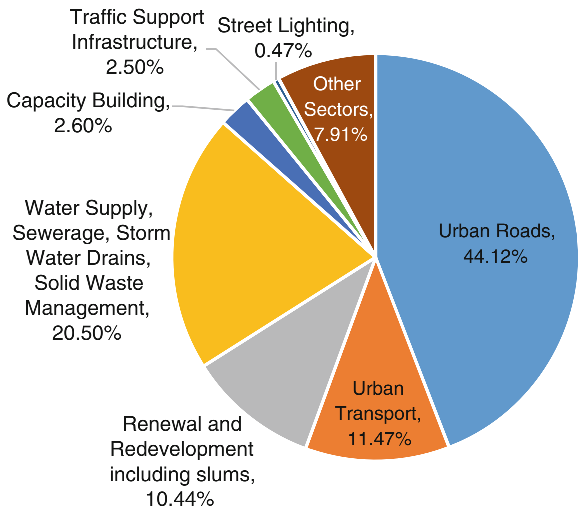

Fig. 36.1 Projections for investment on urban infrastructure from 2012–2031

A High Powered Expert Committee set up by the Government has made projections for investment on urban infrastructure from the Twelfth Five Year Plan to the Fifteenth Five Year Plan, i.e. 2012–2031. Excluding cost of land, the investment for urban infrastructure over the 20-year period is estimated at Rs. 39.2 lakh crore (USD0.65 trillion) at 2009–2010 prices (HPEC 2011). Figure 36.1 shows the breakup for different sectors. Urban roads are assigned the highest share as the backlog for this sector is very large, ranging from 50 to 80 % across the cities of India. 50 % of total estimated investment is towards operations and maintenance requirements for new and old assets (HPEC 2011).

36.3 Issues of Urban Infrastructure Management

Urban Infrastructure effectiveness is defined by the satisfaction of the urban population, which is further defined by the service levels in urban areas. Service is provided by the administrative and political team managing the projects and service standards are defined by the political environment and institutional framework in which our cities function. In India, Urban Management Administrative structure has an issue of multiplicity of organizations with institutional framework being politically weak and administratively cumbersome. Different urban infrastructure components are managed by different ULBs and comprehensive planning and management of urban infrastructure is lacking.

Urban local governments in India are among the weakest in the world both in terms of capacity to raise resources and financial autonomy. ULBs' tax bases are narrow, and inflexible and lack buoyancy, and they have also not been able to levy user charges for the services they deliver to cover Operations and Maintenance (O&M) and depreciation costs (HPEC 2011).

Considering the requirement to upgrade the existing urban infrastructure combined with a structure for reforms in urban infrastructure management, Government of India proposed and implemented a scheme 'Jawaharlal Nehru National Urban Renewal Mission' (JNNURM).

36.4 JNNURM—Phase I and Phase II

JNNURM was launched in December 2005 for a period of seven years and comprised four schemes. Aim of the mission was to encourage reforms and fast track planned development of identified mission cities. Focus was on efficiency in urban infrastructure and service delivery mechanisms, community participation, and accountability of ULBs/Parastatal agencies towards citizens (JNNURM 2014a). Vision of JNNURM was centered around implementation of 74th Constitutional Amendment Act. The Act recognizes ULBs as the third tier of urban government and as per Section 12 of the Act, specific civic functions are assigned to ULBs. As per the Act, State Governments need to look at ULBs as means to strengthen local governance by being empowered with power and authority to function as institutions of self-governance. ULBs are to own the political accountability for the roles assigned to them and share the technical, financial, and administrative accountability with others to whom they may assign their techno-economic roles (JNNURM 2014b).

Two schemes for 65 mission cities were:

- the Scheme for Urban Infrastructure and Governance (UIG)
- the Scheme for Basic Services to the Urban Poor (BSUP).

Two schemes for non-mission cities were:

- the Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT)
- the Integrated Housing and Slum Development Program (IHSDP).

Under JNNURM, Government of India entered into partnership with state governments and ULBs. As a first step, the ULB had to prepare a perspective plan or a City Development Plan (CDP), which was to be followed by a Detailed Project Report (DPR) in line with the priorities laid out in the CDP. The state government and the ULB of a Mission city were required to sign a memorandum of agreement (MoA) with the Government of India, where both the state government and the ULB committed to a set of reforms and agreed to share in the funding of the project. Share of funding for different levels of cities was planned as shown in Table 36.1 (HPEC 2011).

Reforms could be categorized as Mandatory and Optional reforms for State Governments and ULBs. Suggested reforms were in line with 74th Constitutional

Table 36.1 Share of funding for different levels of cities

Categorisation of cities	Funding allocation		
	Government of India (%)	State government (%)	Urban local body (ULB)
Population >4 million	35	15	50 %
Population 1–4 million	50	20	30 %
Other cities	80	10	10 %
Jammu and Kashmir and north eastern states	90	10	–

Amendment Act. Up to December, 2010, total approved project cost was Rs. 109,700 crore (USD18 billion), out of which 26 % funds had been released (HPEC 2011). By the end of the scheme, Rs. 66,000 crore (USD11 billion) had been disbursed (The EuroIndia Letter 2012). Largest share was for water supply and roads and transport projects. Out of 65 identified mission cities, in 3 cities no project was funded, primarily because they could not conduct reforms (HPEC 2011).

JNNURM scheme was extended for two more years as JNNURM Phase II. Phase I projects were completed under Phase II and additional projects were started.

Review

JNNURM scheme has been reviewed by different government agencies. Some of the points are:

- Only 60 % of the funds had been spent and only 18 % of projects taken up under its sub-mission, Urban Infrastructure and Governance (UIG), and 40 % of projects under the other sub-mission, Basic Services to Urban Poor (BSUP), had been completed (The EuroIndia Letter 2012).
- Some states of Central and Southern India had performed better.
- Progress in implementing reforms under the JNNURM had been slow, and it had been difficult to ensure conditionality of overall reforms in a project based financing approach for a variety of reasons. The mission had more generally exposed the lack of capacity at local government level to prepare and implement projects in urban infrastructure (HPEC 2011).
- Mandatory City Development Plan (CDP) under JNNURM was expected to incorporate some basic principles of land use and take an integrated view of public transport and housing. But, the projects that were proposed and approved were standalone projects and not part of a comprehensive plan (HPEC 2011).
- There was 'poor planning' and near absence of people's participation leading to 'lack of ownership' (The EuroIndia Letter 2012).
- There was lack of clarity in the nature of the reforms and inadequate specification of the processes involved. The onus for this lies with Ministries of Urban Development and Housing and Urban Poverty Alleviation in clarifying the

content of reform and on most of the State governments for not taking serious initiatives to implement and sustain the reforms (HPEC 2011).

- State governments and ULBs committed to many ambitious back-loaded reform measures and got approvals and funding for projects. As physical implementation of the asset creation started, the reform commitments were not honored. In this scenario, technically the next instalment of funding for an ongoing urban infrastructure project should have been stopped. But, not releasing the next instalment would mean letting an infrastructure project unfinished. In some projects beneficiaries also contribute partially to the cost of the project. Thus, even with reforms not implemented, the project funding was continued (HPEC 2011).
- There was limited success in promoting PPP in urban infrastructure projects. Such contractual arrangement was largely in the form of outsourcing of services to the private sector. Financing from private partners was not successful mainly because ULBs had not been able to undertake reforms in a convincing manner (HPEC 2011).
- There was 'one-size-fits-all' approach to reforms. Larger and smaller urban areas have different issues, so reforms were to be handled differently (The EuroIndia Letter 2012).

High Powered Expert Committee stressed on the implementation of reforms that were prescribed under JNNURM, and further suggested reforms for improving the administrative system and service delivery. Some of the suggested reforms are shown in Table 36.2 (HPEC 2011).

To counter the issue of multiplicity of organization and provide a radical change, the High Powered Expert Committee suggested institutional linkages that should be fostered for better governance (Fig. 36.2) (HPEC 2011).

Phase I was considered as a large pilot project. After review and some modifications, Phase II was recommended for two more years.

Table 36.2 Suggested reforms

Administrative reforms	Reforms for service delivery
Autonomy in city management	Corporatization of urban services
Empowered mayors with effective devolution	Coming together of different departments or administrative and political nodes to deliver
One ministry for urban affairs and housing	Public private partnership
Convergence of institutional responsibilities	Regulatory regime for urban services
	Accountability and citizen participation
	E-governance

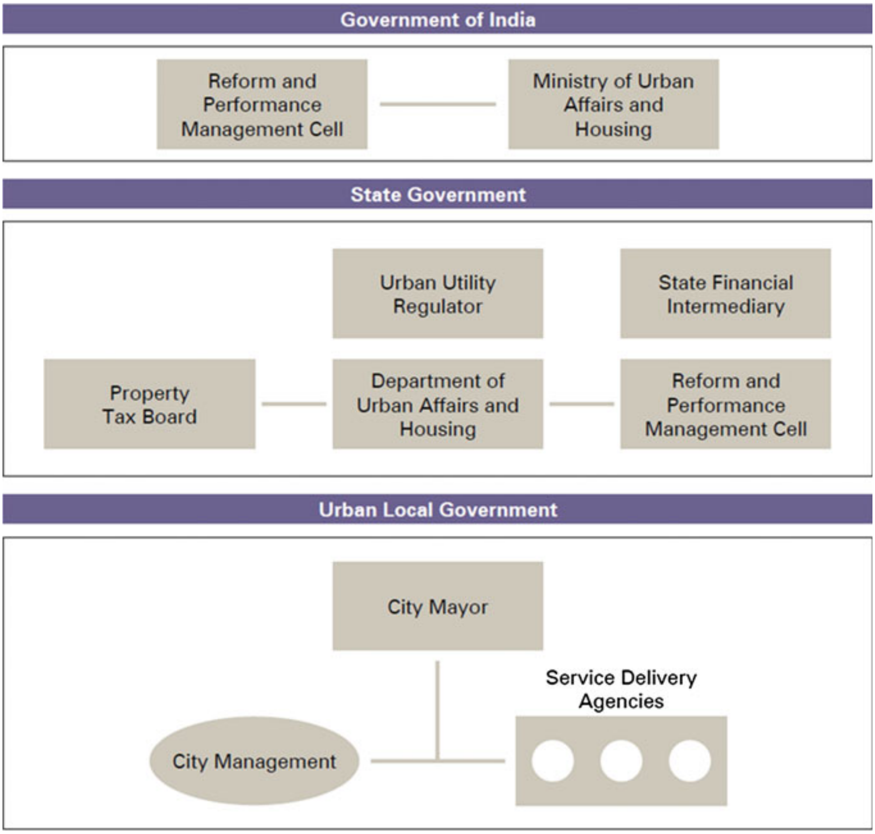

Fig. 36.2 Institutional framework for better governance for service delivery. *Source* Report on urban Indian infrastructure and services. Final report, the high powered expert committee (HPEC) for estimating the investment requirements for urban infrastructure services, New Delhi

Success Cases

The Mission had helped some ULBs to take up projects on a scale they had never attempted earlier, and quite a few successful urban infrastructure projects have resulted from such support. Some examples are given below (HPEC 2011):

- Nagpur had launched a series of initiatives towards an integrated development of its water sector including a continuous water supply project for 10 % of its population. The plan to scale the project to city level was also approved under the JNNURM.
- Navi Mumbai's 100 % city-wide sanitation plan is being funded under the JNNURM.
- The revamp of the solid waste management system in Rajkot was facilitated through JNNURM funds, and it has transformed Rajkot into one of the cleanest cities in the country.

- India's first full BRTS at Ahmedabad, which received many accolades both nationally and internationally, was also funded through the JNNURM.

Failure Case
Ranchi Municipal Corporation (RMC) had a mixed score card. For five years ending at March 2013, it had a 150 % revenue growth, but still poor execution of many multi—crore JNNURM projects (The Telegraph 2013).

- The JNNURM's integrated drainage and sewerage project worth Rs. 1600 crore (USD0.26 billion), envisaged in 2006, got stuck in a series of hurdles, as there was dispute over outsourcing the project to a Singapore-based firm. The matter was sub-judice till 2012, many loopholes were found in the detailed project report prepared by the Singapore firm, and at the end of it all, the first phase of JNNURM had ended. The net result was the state could not collect the Centre's Rs. 1600 crore for the integrated drainage and sewerage project in a capital that sorely needs basic sanitation.
- RMC managed to use only 50 % of Rs. 200 crore meant for the JNNURM's drinking water pipelines laying project, being implemented by Hyderabad-based IVRCL Ltd.
- Low-cost housing under JNNURM's basic services for urban poor (BSUP) worth Rs. 200 crore was executed better, with the state collecting the central funds and the RMC making fair progress.

Residents' feedback was that civic body's performance was affected by the volatile situation of State Government.

36.5 Suggested New Improved JNNURM (NIJNNURM)

High Powered Committee has suggested a New Improved JNNURM (NIJNNURM) for the period of 20 years. Its focus is on capacity building at three levels of governance with a strong but realistic and enforceable component of reform in governance.

The major differences between JNNURM and NIJNNURM are (HPEC 2011):

- The JNNURM was largely directed at a selected few cities as is always the case with a pilot. The NIJNNURM would be open to all.
- The JNNURM was a project-based Mission. The NIJNNURM would have a program approach.
- The JNNURM linked a broad set of reforms to specific projects and was not able to drive reforms through project lending. The NIJNNURM would give funding linked to a set of reforms which would be differentiated across different types of ULBs.
- The JNNURM had a separate funding window (UIDSSMT/IHSDP) for smaller cities and towns. The NIJNNURM would differentiate between smaller cities and towns, on the one hand, and larger cities and metros, on the other, by specifying separate processes of capacity building, reform content and timelines as well.

- Recognising that ULBs needed to be made reform-ready, the NIJNNURM places prime emphasis on capacity building.

Detailed guidelines for the scheme would need to be worked out by Ministries of Urban Development, and Housing and Urban Poverty Alleviation, and other relevant government agencies.

36.6 Conclusions

Study of JNNURM and urban infrastructure management scenario shows that the three tiers of urban governance need to be empowered through administrative structure, funding, revenue generation and capacity building for effective infrastructure creation and management. Requirement is to have more decentralization, where local governments are provided authority and finances to manage local projects. This would bring more accountability into the system.

Infrastructure management includes creation of new infrastructure and Operations and Maintenance and redevelopment of existing infrastructure. Data shows that the second component is a substantial investment. Both components of works require managing projects with Project Management approach and with effective Stakeholder Management or Community Participation at Planning as well as Implementation stage. For redevelopment projects also Community Participation is very important as the existing residents already have a set pattern for the usage of facilities and also the initial promise to these residents needs to be honored.

Indian urban management system lacks substantially in providing quality services. This issue can be dealt by defining an administrative structure for it. In 2008, Government of India had established required service norms. But to implement those regulations, as a capacity building endeavor, staff needs to be provided training not only for technical aspects of Urban Governance, Project Management, Contract Management, Quality Assurance, Stakeholder Management and other related issues, but also in Public Dealing. Service levels would also improve if urban population has required representation in the legislature through inclusion of 'Laavaris' urban areas into the group of urban structure and restructuring of electoral constituencies at the required periodicity.

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Chapter 37
Research on Cost Estimation of Highway Project Based on the GA-BP Algorithm

Yilong Zhang, Yajun Cai and Huanhuan Wu

Abstract In order to make up the inadequacy of cost estimation of traditional highway project, this paper combines BP artificial neural network with genetic algorithm to set up the model GA-BP algorithm, and the artificial intelligence algorithm is led to the cost estimation of highway project. Based on the cost information of existing highway project, the eigenvalues and membership grade are found out. Then, based on the MATLAB platform, through the experimental simulation to compare the results of GA-BP algorithm with BP algorithm. Research finding shows the optimized GA-BP algorithm has calculation simple, fast and high calculation precision. Thus it is concluded that the feasibility and effectiveness of the algorithm.

Keywords Artificial neural network · Genetic algorithm · GA-BP algorithm · Cost estimation

37.1 Introduction

At present, the domestic highway engineering cost estimation is mainly by personnel with bill of quantities valuation method, cost is calculated for each partial quantity multiplied by its comprehensive unit price division component project cost, then calculate measures project, other projects, together with the fees and taxes summary to get unit engineering cost, layer upon layer the summary again eventually get the project total cost. Spend a lot of manpower and material resources, financial resources and a lot of time, and the calculation accuracy to a certain extent, depend on the design depth, the emphasis and difficulty in construction cost estimation is the calculation of quantities, so the calculation error is frequent. In the preparation of cost estimate on the means of main use computer processing.

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Often use some of the budget software also has to do better, Ruth, aspect and so on. Roughly divided into the software engineering project management or the budget, but is not true of the organic integration of both realize the integrated management, the lack of dynamic management software, throughout the entire life cycle and the intellectualized degree is low. Based on the traditional highway engineering cost estimation method, multiple unit using index method. Index method of preparation of investment estimation cost is according to the engineering characteristics, structure and scale, summary for project investment estimation to estimate index calculation. Mainly adopts engineering construction budget estimation and expand estimation indicators. For estimating index is the industry and local unified, did not consider the engineering quality and management level, so it is not suitable for the development of market economy system. And in practice, there are many problems, such as a investment out of control, budget estimate, budget, super budget, settlement over budget, and so on and so forth.

And in foreign countries, started very early on the research of the intelligent construction, was also a very high level now. The intelligent model in abroad can be divided into three categories: computer simulation technology to establish model, artificial intelligence and knowledge base is adopted to establish the engineering cost estimation expert system and fuzzy mathematics model.

37.2 BP Artificial Neural Network Model

The BP artificial neural network algorithm is error back propagation algorithm. It is the most typical artificial neural network algorithm of a multilayer feed forward network with mentor, the multilayer neural network model is proposed on the basis of error back propagation learning algorithm of multilayer neural network model, it is one of the most widely used network. Composed of input layer and output layer and in the middle layer between the input and output layer. Layer has a single layer or multilayer, because they are no direct contact with the outside, also known as the hidden layer. Also known as the hidden layer neurons in the hidden layer units. Although hidden layer and the outside connection, but, their status affects the relationship between the input and output.

As is known to all, the soul of the BP algorithm is through a large number of training samples from the I adjust the connection weights, so the core issue is what kind of learning methods to optimize weights. The basic idea is, the positive learning process by signal transmission with error back propagation of two process. See the following flowchart and the algorithm implementation steps. Neural network model of versatility and adaptability are very strong, not only does not exclude the new sample, and with the increasing improvement of the sample generalization ability and the ability to predict, it just meet the requirements of highway engineering cost estimation system.

Due to the space, the following simple introduced the offline learning process of BP network of the specific steps:

1. Initialize the weights and threshold value;
2. The sample input and output parameters are normalized to the interval [0, 1];
3. The sample p = 1;
4. The sample data is assigned to the network input layer of the corresponding node, and the input sample p;
5. To calculate Network output yp;
6. Calculation sample error $e_p = d_p - y_p$;
7. The sample p = p + 1;
8. Whether p less than or equal to the sample; If so, it returns (4), if not, then turn to the next step;
9. Calculate the total error $E = \sum_{p=1}^{p} e_p$;
10. To determine whether a total error E achieve accuracy; If so, the output directly, if no, then turn to the next step;
11. According to the calculation of each layer in turn reverse adjustment error;
12. Calculate the total error $E = \sum_{p=1}^{p} e_p$;
13. To determine whether a total error E achieve accuracy; If so, the output directly, if no, then return to (3).

37.3 The Basic Theory of Genetic Algorithm

Genetic algorithm (GA) is the general method to solve the problem of the search, it can automatically acquire and accumulate in the process of search about the knowledge of the search space, and the adaptive control of search for optimal solution process, in the process of search is not easy to fall into local minimum, even if the fitness function is discontinuous or without rules, can find the global optimal solution with great probability. After nearly thirty years of research and application of genetic algorithm has showed good ability to solve complex problems., of course, also there are some defects, such as inaccurate coding and non-standard, efficiency of genetic algorithm is less efficient than other traditional algorithms, genetic algorithm time complexity, reliability and precision of algorithm is not effective quantitative analysis method, etc., so in practice should be comprehensive analysis to solve the problem for which algorithm or a variety of complementary advantages of the algorithm, in this way can the most accurate simulation of the best results.

The main steps of genetic algorithm are as follows:

1. To determine the decision variables and constraints, That is, determine the individual phenotypesX and the problem solution space;
2. Optimization model is established, that is, determine the type of the objective function and the mathematical description form or quantitative methods;

3. To determine the feasible solution of chromosome coding method, that is, determine the genotypes of the individual and the searching space of genetic algorithm;
4. Determine the decoding method, Type is determined by individual genes x to Corresponding relation or conversion method of individual phenotypeX;
5. Determine the quantitative evaluation of individual fitness method, namely, determined by the objective function value to the individual fitness transformation rules;
6. Design of genetic operators, namely, determine the selection operation, genetic operators such as crossover operation and mutation operation of specific operation method;
7. Determine the relevant operation parameters of genetic algorithm,The parameters such as M, F, pc, pm.

The general genetic algorithm includes three basic operators: selection, crossover, mutation.

1. Selection: Select individuals from old groups on the basis of a certain probability to the new group, and the probability of the individual is selected based on fitness values. Considering the fitness of the individual is different, so the individual pairs of can be divided into several groups at random, once appear, not to individuals is obsolete.
2. Crossover: Choose two of the individual from individual, generate new individuals, through the combination of chromosome exchange chromosomes randomly select one or more points in position. Set number of crossover probability, crossover, crossover method and so on, depending on the fitness, leave a good individual, eliminate poor individuals.
3. Mutation: Choose an individual from the group, and then select the one in the chromosome variation and produce more excellent individuals, set the mutation rate and variation method, choose variation for each individual position, the first step back.

Mathematic model of genetic algorithm, the basic genetic algorithm (ga) can be defined as a group of 7 power abstract function as shown in formula (37.3.1):

$$GA = (M,\ F, s, c, m, pc, pm) \tag{37.3.1}$$

In the formulas, M—population size; F—Individual fitness evaluation function; s—Select operator; c—Crossover operator; m—Mutation operator; pc—Crossover probability; pm—Mutation probability.

37.4 Algorithm Model of GA-BP

BP algorithm is multilayer error back propagation feed forward network, because of its simple structure, adjustable parameters, training algorithm is also much, and good operability, thus obtained a wide range of application of artificial neural network in the most widely used algorithms, but there are some defects in practice: one is the study of convergence is slow; two it is not guarantee convergence to the global minimum value; Three is a network topology is not easy to determine;

Improved algorithm at present, many scholars put forward some improvement methods in a certain extent, indeed improved BP artificial neural network model of some basic, but in the practical application has shown its short ribs, cannot fundamentally fully overcome the defects of BP algorithm in nature. Considering the practical application of concise, maneuverability, this paper USES genetic algorithm to optimize neural network. Using genetic algorithm to optimize neural network, including network topology optimization, weights and learning rules. Due to space problem, this paper elaborates the value optimization weight, only in the instance analysis also is to use genetic algorithm to optimize the weights of neural network, so below the optimization is a weight optimization. A core part of GA-BP algorithm is optimized by genetic algorithm (BP) neural network training after a local minimum of network weights and threshold, combine GA and BP truly, solving the GA to optimize the BP directly weights and threshold of random values influence on the performance optimization problem. The elements and the GA directly contains five elements as well as the optimized BP initialization of population, fitness function, selection, crossover operation and mutation operation (details below).

Here with the most widely used three layers BP algorithm as an example, expounds the mechanism using genetic algorithm to optimize BP algorithm:

1. The population initialization
   Encoding using real number coding, each individual as real number strings and is composed of four parts, respectively is the connection weights between input and hidden layer, hidden layer threshold, connection weights between hidden layer and output layer and output layer threshold. So, under the condition of the network structure of known, can constitute a weights and thresholds, and structure of neural network. Including the crossover and mutation probability P_c, P_m and the connection weights w_{ih} and Initialization of w_{ho}.
2. Fitness function
   According to population initialization individuals get BP after the initial weights and threshold, the system output after training the BP network training data, the output value and the desired output, it is concluded that error of absolute value and for individual fitness value f, a formula to calculate the following type (37.4.1) shown below:

$$E(i) = \sum_{k=1}^{m} \sum_{o=1}^{q} (d_o - yo_o)^2 \tag{37.4.1}$$

In the formulas,

n The number of species (chromosomes)
i The individuals (chromosome), $i = 1, 2, \ldots, n$
o Individual BP network the first o output node, $0 = 1, 2, \ldots, q$
k The training sample, $k = 1, 2, \ldots, m$
yo BP network forecast output
d The expectation of BP network output

3. Select operation
   Select operation there are many kinds of forms, such as roulette probability choice and championships, this article adopted roulette probability selection method, which is based on fitness ratio method, calculate each individual (chromosome) evaluation function, and sorting them, with the commonly used roulette probability method to select individuals. The choice probability of individuals (chromosomes) I (37.4.2) shown in the following type:
   In the formulas, f_i is individual Fitness function value of i, To measure error sum of squares, that is:

$$P_i = \frac{f}{\sum_{i=1}^{n} f_i} \tag{37.4.2}$$

$$f_i = \frac{1}{E(i)} \tag{37.4.3}$$

4. Crossover operation
   Because individuals using real number coding, crossover operation method, real crossing method is adopted, here USES the genetic algorithm toolbox of the university of Sheffield arithXover. M do crossover operation. Of individual G_i and G_{i+1} by crossover probability P_c crossover operation, and to generate new individual G_i' and $G_{i=1}'$, no individual direct copying for crossover operation.
5. Mutation operation
   Using genetic algorithm toolbox of the University of Sheffield nonUnifMutation mutation. Using the mutation probability P_m mutation generate new individuals G_j' of G_j.
6. Through genetic operators operating to produce new individual (chromosome) is inserted into the population P again, and calculate the new individual evaluation function.
7. Whether algorithm to achieve pre-determined end operation precision. If found the satisfaction of the individual, the end of the operation, otherwise returns (3) into the next round.

When the end of the algorithm, if after reaching preset accuracy, will eventually group of the best individual decoding the optimized network connection weights can be obtained.

37.5 Empirical Study on Optimize Design of the Model and the Result Analysis

1. Select the problem description and characteristic factors
   Use of intelligent algorithm to estimate in highway engineering, the core problem is to find out the characteristics of the decision cost factors, for these factors, the whole task has completed more than half. Due to the diversity and complexity of the project is, of course, there are many factors which can affect cost, can't be all taken into consideration as input feature vectors, and some influencing factors is not universal, so, should choose the appropriate eigenvalue considering all the factors, from design to construction of all factors into consideration, a large number of simulation, universal and typical characteristic value as input vector of the model. In addition, find out the feature vector, the next task is to will be estimated engineering database of comparable. Due to space problem, not fully specify one.
   This paper, taking a established nine highway engineering as the database sample, eight for the training sample, 1 for test samples, for the highway engineering project cost estimates are simulated. As shown in Table 37.1 for a 9 has built the raw data of the highway. First of all make it comparable, divided into several characteristics on the basis of the condition of the project elements (i.e., project) were compared. Should the characteristic elements selection to influence the project cost is larger, can represent the engineering characteristics, and influence the cost of the big structure characteristics as the representative engineering features of elements. All the expenses of highway engineering cost are have direct relationship with the basic characteristics of highway engineering. Whether direct or indirect expenses, they have a connection with the quantities of the project, quantity and dosage of materials and construction of highway engineering solutions related to the specific conditions. But, in estimating stage, only consider the table shown in characteristic factors (Table 37.2).
   This article lists only part of the larger characteristic elements affected the highway engineering cost, for several different project types, respectively summarized, analyzed and choice, to improve the accuracy of the valuations, characteristic value shown in Table 37.3 (Table 37.4).
2. The engineering characteristics of data processing
   In the model input layer contains qualitative factors and quantitative factors, the engineering characteristics as neural network input node, the first thing to initialize it. For quantitative factors, should be normalized processing,

Table 37.1 Has built highway engineering data

Sample	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9
The main line mileage/km	142.03	98.67	98.84	246.2	236.57	117.96	145	53.86	52.79
Year	2005	2005	2005	2004	2007	2005	2007	2008	2005
Design of driving speed/km/h	80	80	80	80	80	80	80	80	80
Width of subgrade/m	23.5	25	25	24	25	25	25	27	27
Earth work amount/m_3/km	182,426.2	77,608.2	38,434	137,023	55,371.6	245,448.2	117,314.2	81,550.5	165,919
The number of bridges/m/km	60.6	73.1	136.3	145.2	34.8	299.4	92.6	103.2	108.1
Channel tao/km	1.5	136.3	0.89	0.61	1.7	1.2	1.7	1.1	1.2
Interchanges place/km	0.07	0.05	0.09	0.08	0.08	0.06	0.04	0.09	0.11
Separation interchange place/km	0.19	0.17	0.12	0.16	0.3	0.25	0.14	0.15	0.19
The tunnel m/km	94.5	0	0	171.7	11.7	117.4	0	0	53
The form of the road	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Topographical features	0.32	0.2	0.2	0.32	0.7	0.5	0.2	0.2	0.2
Area	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total project cost per km	3309.3	3136.43	4487.15	4682.9	2833.13	5745.84	3090.11	4805.29	6870.12

Table 37.2 Major unit engineering cost information

Sample		A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9
X_1	The subgrade engineering (million/km)	370.71	300.96	285.76	257.88	269.1	458.4	363.67	383.78	391.07
X_2	The road engineering (million/km)	228.87	209.49	283.91	218.74	298.33	215.93	195.43	258.28	409.6
X_3	Tunnel engineering (million/km)	290.31	0	0	543.52	33.63	490.6	0	0	276.04
X_4	Bridge engineering (million/km)	297.7	350.03	704.45	678.31	195.33	932.01	413.85	482.76	1156.7
X_5	Cross project (million/km)	318.93	425.98	757.64	458.66	446.35	501.82	286.35	974.96	862.33
X_6	Temporary works (million/km)	7.02	50.92	24.04	15.82	13.28	33.15	48.22	29.08	130.37
X_7	Along the facilities (million/km)	72.08	179.44	67.04	60.73	93.78	128.87	132.2	80.21	88.03

Table 37.3 Highway engineering characteristic values

Indicators	The name of the project	Engineering characteristics
X_1	The subgrade engineering	Subgrade form, fill, height of digging, fill and excavation, soil quality, construction site, the foundation status, the main machinery, transportation distance
X_2	The road engineering	Structure, surface area, the construction way, mainly machinery, transport distance, the construction site
X_3	Tunnel engineering	Form, structural form, length, lining sectional area, the number of pilot tunnel, mainly machinery, transport distance, the construction site
X_4	Bridge engineering	Basic structure, bottom structure form, the upper structure form, the number of concrete, the construction plan, construction method of main machinery, transport distance, the construction site
X_5	Cross project	Cross form, the structure form, concrete quantity, mainly machinery, transport distance, the construction site
X_6	Along the facilities	Green area, highway mileage and number of various facilities, the main machinery, construction site
X_7	Temporary works	All temporary works
Y	The project cost	All the branch of engineering cost summary

Table 37.4 After normalization processing data table

Sample	The input vector							Output item
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	O
A_1	0.99	0.61	0.78	0.8	0.86	0.01	0.18	0.16
A_2	0.71	0.49	0.01	0.82	0.99	0.12	0.42	0.10
A_3	0.38	0.38	0.01	0.93	0.95	0.03	0.09	0.57
A_4	0.37	0.31	0.8	0.99	0.67	0.01	0.07	0.64
A_5	0.59	0.66	0.05	0.42	0.99	0.01	0.19	0.00
A_6	0.47	0.2	0.51	0.99	0.52	0.01	0.11	1.00
A_7	0.88	0.47	0.01	0.99	0.69	0.12	0.32	0.09
A_8	0.39	0.26	0.01	0.5	0.99	0.03	0.08	0.68
A_9	0.28	0.3	0.18	0.99	0.72	0.04	0.01	1.39

formula 37.5.1 general method can be used, put all the samples between the quantitative factors into [0, 1], the purpose is to convert data into a unified dimension, so convenient for computer recognition and neural network to accept; For qualitative factors, according to the principle of similar to quantitative processing, turning it into the amount between [0, 1], here you can first determine a standard factor, its value is 0.5, and other factors, in turn, instead of comparing, the performers the values between 0.5 and 1.0, the LieZhe values between 0 and 0.5.

Table 37.5 Training results

	BP algorithm model	The genetic algorithm to optimize neural network model
The simulation results	1.3265	1.4135
The actual value	1.39	1.39
The relative error (%)	−4.57	1.69

$$y_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}},\ i = 1, 2, \ldots,\ m \tag{37.5.1}$$

3. Network design
   This article neural network with one hidden layer three layer network structure, the engineering characteristics of input layer to select eight representative: subgrade engineering, road engineering, bridge engineering, tunnel engineering, cross, maintenance, and engineering, facilities along the building temporary works, such as the input variables, expressed in the X1–X7, namely input layer 7 nodes; Km cost as the output variable, with O1, said the output layer 1 node; By the Kolmogorov theory N * (2N + 1) * M hidden layer for 15 nodes are obtained.
4. BP network training and testing
   In this paper, with the BP network training by using the Matlab neural network toolbox function programming, to realize the estimation model of building, training and simulation. Select Levenberg—Marquardt optimization method for the network's main training algorithm, in order to achieve the purpose of improve the network generalization ability and convergence speed. Input layer to hidden layer activation function tensing, the activation function of hidden layer to output layer for losing, network training using the default trainlm training algorithm and learngdm learning algorithm, the performance function USES the default mean square error (mse). After repeated experiments, the training of the network parameters as follows (Table 37.5):

   The target error: net. TrainParam. Goal = 0.01;
   Biggest cycles: the.net. TrainParam. Epochs = 100;

5. After using genetic algorithm to optimize network training and testing
   Can be seen from the calculated results, the estimate precision of the evaluation model based on BP neural network reached 95 %. This early in the project, especially the solution phase of the project is the satisfactory results. Because of the feasibility study phase can be used for calculation of cost data is not much, usually there will be a 10 % gap with the final project cost. Here the estimate precision of 95 % is not only accurate, but speed is also very significant. And optimized by genetic algorithm neural network model error smaller than BP algorithm model x.

37.6 Conclusions

In this paper, the model is suitable for ordinary highway, estimate, as long as the early stage of the existing highway engineering related characteristics of the data collected, data processing, model by means of the trained network can be quickly estimate the to-be-built highway engineering cost. The application of neural network with highway engineering valuation, the biggest limit is how to extract the feature vector and the selection of training samples, the accuracy of the cost estimation model is mainly depends on both counts. So requires that we are in the selection of engineering characteristics must be chosen to represent the greatest feature of the highway engineering essence, influence cost factors as the input vector, the selection of training samples and be estimated is similar to highway engineering, only grasp these two points, can ensure that model is not only fast accurate in practical application.

In this article, will also mentioned a combination of genetic algorithm and BP artificial neural network algorithm with highway engineering cost estimation model of application of global search ability of genetic algorithm is good to make up the defects of BP neural network in global search. Advantage of Chongqing local training a large number of sample test proves that this optimized model than the average of the convergence of the BP neural network model, training results of high precision, has certain practicality generally. In fact, in today's intelligent algorithm is widely used, for such prediction problem, there are a lot of application of the depth of the difficulty is not the same, its precision is also each are not identical, due to space problem, here is not to do too much introduction, in the application, should be more training, more inspection, in order to find out a relatively accurate method.

Chapter 38
The Aging Community Management and Service Mode—"AMS" Community Management and Service Mode

Dongmei Huangfu and Wandi Liu

Abstract With the increasing of the aging population in China, the problem of providing for the aged has given rise to a wide attention of the government and society. From the perspective of urban community, this paper aims to advance a new method of the community management and a novel service mode for a predominantly elderly residential community, which will lead to better development and more effective management. Through the analysis of the management and service modes from the existing domestic and foreign elderly community, and with the combination of the characteristics of the elderly community, this paper put forwards the "AMS" Community Management and Service Mode. Further, the relationship of the "AMS" patterning and the organizational structure of the "AMS" mode were also proposed.

Keywords Aging community · Management and service mode · Property management · AMS

38.1 Introduction

As the aging society of China is gradually coming, a huge pension community market is quietly emerging, which indicates the aging real estate development has a great potential. Through analyzing the existing elderly community management and service mode at home and abroad, this article aims to put forward a kind of the community management and service mode for a predominantly elderly residential

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community to manage, which can make the elderly community develop and operate more effectively.

Some of the related literature materials puts forwards the "four one" community management mode and the "five one" as well. However, from the aspect of community and combined with the characteristics of the elderly community based on the analysis and comparison of community management mode of practice at home and abroad, this article proposes a management and service mode which is suitable for the retired living in the community in the future of China, which is named the "AMS" Community Management and Service Mode based on the functional integrated system. Here, "A" (Aging) refers to the aging, "M" (Management) stands for the community management, and "S" (Service) means the community service. This mode proposed can not only increase the confidence of the developers entering into the elderly real estate, but also provide a more suitable management service mode for the future elderly community of China.

38.2 Definition of "AMS" Community Management and Service Mode

In the existing theoretical research and practice, there were two popular contradictory big theories, the "autonomy tendency" and "security administration tendency" (Song 2010). In these two kinds of theoretical research, the first category mainly using the theory of western researchers emphasizes that the government performs the independent social management function in the "small government, big society" mode, and the urban community organization performs the independent exercising autonomy management function. Both are independent of each other. The second category of researchers is from the perspective of strengthening the management of urban community organization, which considers the urban community organization as a kind of alternative tool of strengthening the government's control to the urban grassroots (Song 2010).

From the perspective of urban community, and with the combination of the characteristics of the elderly community, this article puts forward a kind of the community management and service mode named the "AMS" Community Management and Service Mode based on the comparison of domestic and foreign community management and service modes. The "A" stands for the aging, and the "M" stands for the community management, and the "S" is for the community service. What the "AMS" community management and service mode refers to a kind of organizational structure and operation mechanism of the integration of the community management and the community service, on the condition of adapting to the elderly and the market, which is led by the government, sub-district office and the neighborhood residents' committees, meanwhile the property management company takes the responsibility of comprehensive service management, and the elderly participate in the management and service acting as a bridge.

38.3 Relationship of “A”, “M” and “S”

As the aging society of China is gradually coming, a huge pension community market is quietly emerging, which indicates the aging real estate development has a great potential. Under this social situation, some well-known real estate tycoons are preparing to enter into the field of the new aging property, and even some of them set up the professional industry research team. Except that, some pension industry companies are involved in as well. All these have laid a good foundation for the real implementation of the development of the retired community and the management and service mode further.

Firstly, the reason that the AMS mode needs the leading of the government, the sub-district office and the neighborhood committee can be explained simply as what Xie Yifeng said: “Firstly, the policy of the endowment real estate is not quite clear. According to the usual practice, the management the elderly welfare homes belongs to the civil affairs department. So it needs to have a clear policy guidance if the real estate companies prepare to enter into this field and have to cooperate with the government department. Besides, the endowment real estate has certain social welfare nature, so it needs certain preferential policy about the land transfer, bank loads and tax to promote the enthusiasm of the developers to tap.” For this study, it is mainly from the perspective of the community which can be developed and operated. And it also explained it is adaptive to the market. Secondly, the old-age work is not only limited to “enjoying play” and “enjoying music”, but also should with the “six old havings” as the goal (Zhou 2010). In terms of the actual situation of China, part to a great extent, the “Lao You Suo Yang, Lao You Suo Yi” is effected by the national related policy and also needs the introduction of national welfare policy to solve the corresponding. This is not only a personal family issues, which more needs the help and support of the whole state and society.

Although the government participates, it does not mean that the government takes too much interference. In the “AMS” mode, the government mainly plays the role of providing us a platform which can maximize the integration and optimize the allocation of resources.

Due to the particularity of the members of the community residents, the elderly occupies a large proportion. So for the special care of the retired who can take care of themselves, most of them will involve in the management and service as a bridge in the “AMS” mode. Through the formation of “the aging” organization, the retired can participate in the community management and service actually. The organization can adopt the separation mode of two layers’ i.e., the management layer and the operation layer (service layer), and most of the members of the community are the retired of the owner. Besides, the system of card mount guard is necessary because it will make the community management and service more standardized and institutionalized. However, the organization is not existing in isolation but establishing a harmonious and stable relationship with the community property management organization for a long time. In simple terms, it is a kind of complementary and mutual relations between the two. The property company can hire the retired to work for the community management and service through “the aging” organization, meanwhile, the owner of community residents can also supervise the property company through “the aging” organization. While the elderly can get a reward through the form of service in service or rent service in exchange. For example, the community elderly members can have the right to use certain services through their own labor services in exchange. In this way, the property management organization can make efficient utilization of human resources which can also reduce part of the wage bills. So this is a win-win combination. And the bridge bond can not only be the link between the owners of the community and the property management company, but also to achieve the philosophy of “Community is my home, to participate in all”, which breaks the traditional contrary relationship between the two.

To meet the actual demand of market-oriented, it needs to introduce the role of property management service. Nowadays, the modern society changed the living way of life, which gives the real estate a new connotation from the perspective of its function or idea. As followed, a higher requirements for the community property management service was raised. So, this article proposes an integrated organization of management and service with the participation of the retired, which is led by the neighborhood residents’ committees and operated by the professional property management team. It mainly aims to meet the humanized service based on maximizing the interests as much as possible. On the content of property management, from design to the supporting facilities, which need to meet the aging and cultural demand of residential population and culture. Such act according to actual circumstances, personalized, professional service is the basic source of creating value.

Especially for the retired consumer groups, it is important to provide complete hardware, software of the structure and perfect service function, which can combine the building itself and its service function in order to enhance its own value. The humanization of value-added services is closely around the three basis points of different owners’ spending power levels, consumption habits and consumption tendency in order to develop the most suitable service product for the owners, at the same time, to provide new marketing channels for the service and product suppliers, and eventually benefit the owners and suppliers.

38.4 Relationship Pattern of AMS

Figure 38.1 shows that the community is mainly divided into three parts, including the administrative block of government, sub-district office and neighborhood residents’ committees, the market block of community management, and the neighborhood residents’ committees as the administrative block. Each circle represents one “block”, and every two circles intersected forms a small circle. The three newly formed circles stand for the property management, the organization of the elderly and the public service. The organization of the elderly establish contact with property management through leadership and the contact with the public service

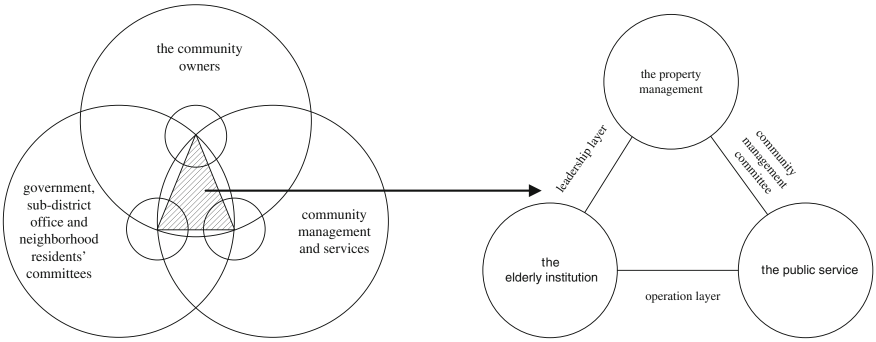

Fig. 38.1 Relationship model of "AMS" (1)

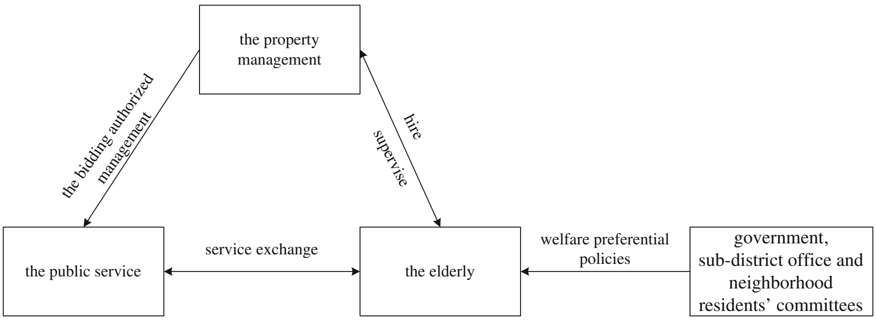

Fig. 38.2 Relationship model of "AMS" (2)

through homework layer, the relationship of the property management and public service is mainly through the community management committee. Figure 38.2 shows the service mode for "AMS" management mode diagram, and the arrows represent the relationship between the two. The above two pictures fully expressed the bridge role of the elderly.

38.5 Organizational Structure of AMS

Through the analysis of the three main bodies of community organization, namely the residents' committee or the owners' committee and the property company, and comparing their respective characteristics, then adding the personality element of the community elderly group, the organization structure of "AMS" is proposed, namely the "triad two melting three" AMS management service organization structure. Here, "Triad of two" means the three main bodies of community (residents committees, industry authority, and property management enterprises) are merged into two big modules (community property management committee and property management enterprise), in combination with the characteristics of AMS living pattern and the main module of the elderly group, which finally comes into the fusion of the three modules (community property management committee, property management enterprises and the elderly group).

In the three modules, the property management enterprise is the key manager and executive of the comprehensive service management of the whole community. Meanwhile, the property management committee and the elderly group will exercise the rights of supervision. The property management committee mainly plays the role of community exercise guidance of voting rights and takes the responsibility of the communication with the administrative department of the government, the streets, nonprofit organizations and so on. Moreover, the elderly group mainly represents the rights and interests of the community core group and help the elderly participate in the community management and service through establishing a win-win relationship of "Service Exchange" in order to play a fully role as the bridge. Figure 38.3 shows the "AMS" community management and service organization structure diagram.

As to the organization forms of the property management company, first of all, from the perspective of the organization form of enterprise management mechanism, it mainly includes four forms, namely the organizational form with linear system, functional structure, line and functional structure, the divisional system organization (Wang 2001). The comprehensive system function (职能综合制) refers to according to the selected function mode contained within the organization characteristics and position requirements, moreover, giving full play to the function to set up the company's internal need of organization and management agencies (Wang 2001). At present, most of the property management company institutions of China take the form of the two level management functions integrated system, and the property management company organization form which the AMS mode adopted is based on the above form. What the Fig. 38.4 shows is the property management company organizational structure of AMS mode.

Among them, the property comprehensive management refers to the whole combination of a series of commercial business, education, health, entertainment, finance and other business services which are provided by the realty management enterprise forming a complete set which matches the normal use of the property and the environment of the daily living and working life of the residential community owners (Wang 2001).

The property management belongs to the service industry, and it has a wide coverage itself, which is commonly divided into the public service and special service (Wang 2001). For the AMS mode, in order to meet the special requirements of the elderly group, the public health in public services, the member venues and cultural entertainment services management etc. should be given more attention, and achieve the implementation of archives management and consume in one card. As to the special services, the staff allocation and the training should be increased in particular, and the contents and quality of the assistant service for the family also should be enhanced. It can be subdivided into two points:

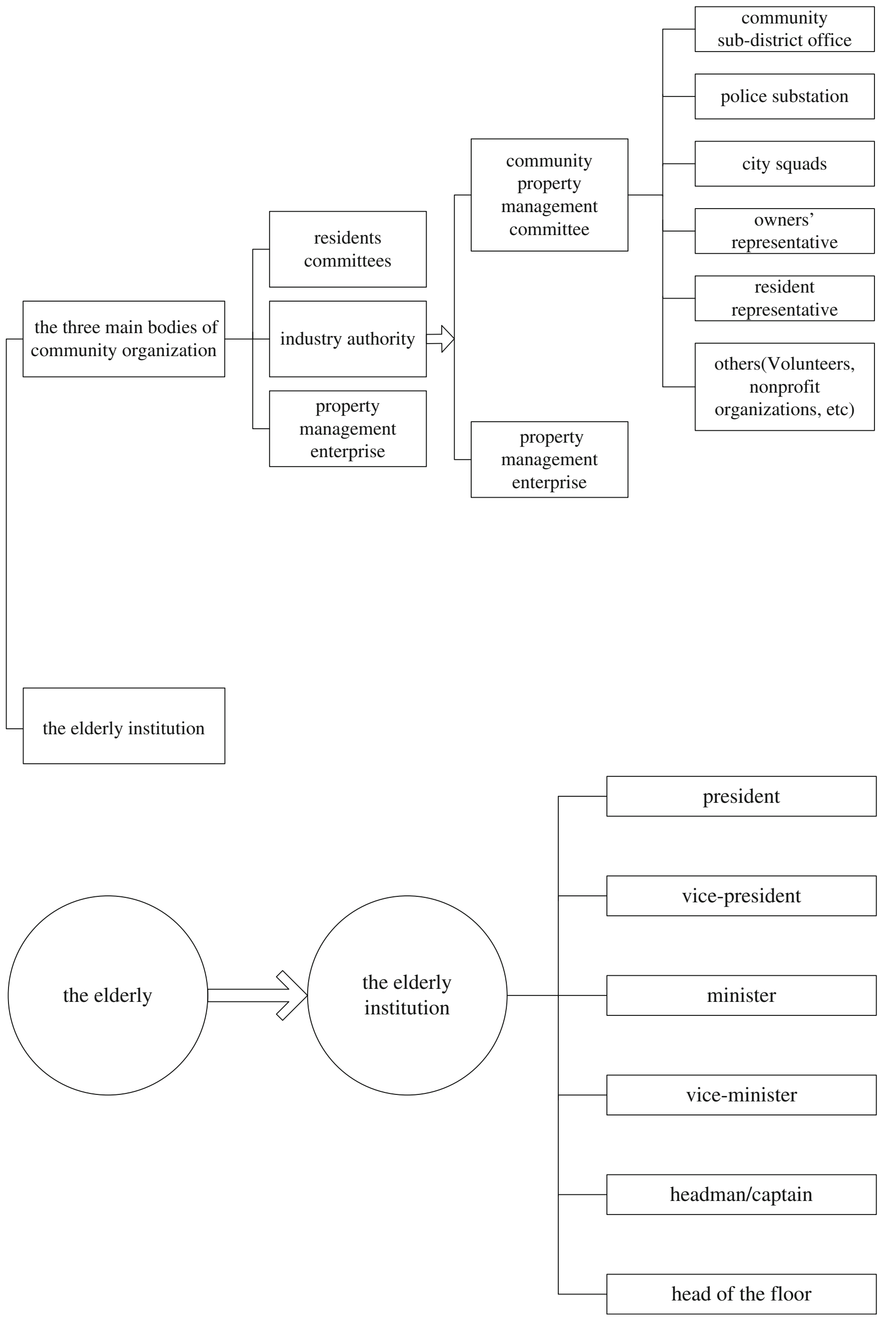

Fig. 38.3 "AMS" community management and service organization structure diagram

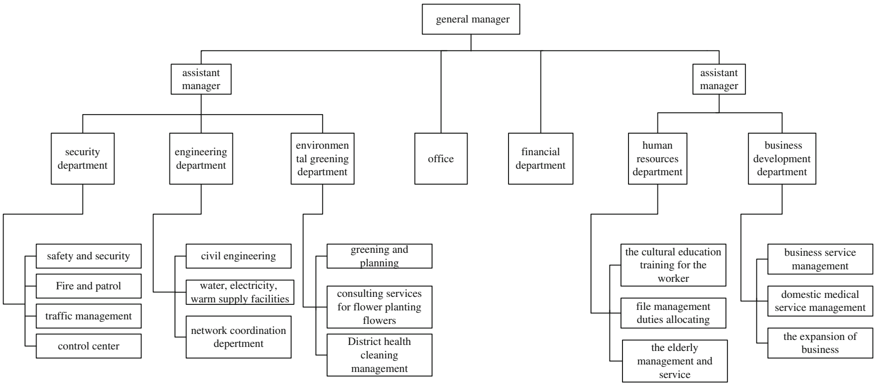

Fig. 38.4 The property management company organization chart of AMS mode

1. home care services, including shopping, laundry, meals, purchasing medicine, such as domestic service, personal care services such as bathing, dressing, and intangible emotional support or comfort services (Nolin et al. 2006).
2. family care services, mainly focused on the illness of the elderly at home health care, generally including prevention, health care management and service (Nolin et al. 2006), etc.

Moreover, the service charge should be adopted hierarchically and classified. And it is necessary to make a detailed reference for the service fee standards in case of unnecessary disputes (Wang 2001).

For participation to community property management of the elderly, it should be more standardized, institutionalized, and the content and scope of the management should be refined and classified. But first of all, the contract should be signed through the elderly group and the property management company. Further, the scope of the service management and the way of "Service Exchange" need to be determined. All in all, the principle is treating the main rights and interests of the elderly as the center. So the government should provide some proper compensation to encourage the initiative of the property management companies.

38.6 Conclusion

As the Development of China's Aging Report (2013), says, China develops communities vigorously for the elderly service and constantly improves the environment of the elderly house (Wu 2013). Besides, providing the needed pension services for different economic conditions and living ability of the elderly. It is not just the responsibility of the government, but that of the society (Nolin et al. 2006; van Bilsen et al. 2008).

In China, the form of the elderly residential real estate development should be given a priority, and on the road of the community elderly service industrialization. Further, the social pension and family-like care combination of the elderly homes should be created. Moreover, the new old residential pattern with a highly qualified integration of the management and service should be developed and perfected actively. The AMS mode can make the community management adapt to the market demand, make services more detailed, improve the service personnel's overall quality of management, and make it more professional. At the same time, it also make most of the elderly (mainly refers to the enjoyment and self-care) participate in the community service and management actively, which makes themselves feel the waste heat they can release and create a healthy and harmonious happy family community.

This article is mainly based on the collecting relevant literatures and news materials, so it still lack a certain practicality. If there is any wrong place, all the experts and scholars' comments are helpful, which can make a meager strength contribution for China's aging cause.

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Chapter 39
Study on Success Factors of Sustainable Urban Renewal

Taozhi Zhuang, Pengpeng Xu and Fan Wang

Abstract In contemporary world, cities are facing the problem of living environment deterioration, urban center decay, city characteristics disappear, city public security disorder and several other adversities, which have restricted urban development. Thus, a clear cognition of what is and how to achieve the goal of success urban renewal in sustainable way are of great significance. This paper examines critical success factors of sustainable urban renewal at the basis of literature review, and then uses Interpretive Structural Modeling (ISM) approach to analyze interactions among success factors identified above to construct an interpretive structure model.

Keywords Urban renewal · Success factors · Sustainability · ISM

39.1 Introduction

In the year 2010, there was a notable watershed in human and urbanization history, with about half of the 7 billion population living in cities, it indicates that cities are carrying larger number than other places (Jim 2013). Thus, urban renewal, as the way to cope with urban problems, plays a more and more significant role in human's life. Such a role is much more crucial, especially in China's rapidly growing transitional economy. While how to tackle urban issues effectively and efficiently has raised a heated debate.

"Sustainability" was first employed at early 1970s to describe an economy "in equilibrium with basic ecological support systems" (Stivers 1976). And about 20 years later, it was commonly applied to cities in the field of urban renewal incorporated into planning and linked with government policy (Conroy and Berke 2004;

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Bromley et al. 2005). Nowadays, sustainability has become a hot research subject in academia, and even a long-term strategy for plenty of countries around the world. Though it is a multi-faceted concept which has plethora of interpretation, there appears to be an emerging agreement that it involves concerns of social, economic and environmental or ecological aspects (Redcliff 2005; Weingaertner and Barber 2010). In the perspective of urban renewal, if it follows the sustainable path and focus on economic regeneration as well as environmental and social regeneration, a series of urban problems can be solved and sustainable urban development can be reached (Zheng et al. 2013). To achieve sustainable urban renewal, not only planning section should be drew attention to, there are also many aspects, such as publics, governments, laws, policies, etc. should be taken into consideration. Thus, the understanding of factors that influence success of sustainable urban renewal and their interactions can contribute to the further urban renewal, thereby resolving urban issues in a better way.

The remainder of the paper is divided to the following sections: (a) literatures will be collected related to sustainable urban renewal, and then the quality research method of content analysis is used to examine factors that influence it; (b) the Interpretive Structural Modeling (ISM) approach will be utilized to analyze interactions among success factors identified above; (c) an interpretive structure model is constructed for success factors of sustainable urban renewal to describe the interrelationship between each factor; (d) conclusions are discussed in the last section.

39.2 Identification of Success Factors of Sustainable Urban Renewal

Urban renewal can be considered as a project, and in project management, activities which restrict ultimate task-performing are called critical activities (Bai and Mao 2011). Thus, in order to identify success factors of sustainable urban renewal, the critical activities ought to be taken account of. This paper intends to identify success factors of sustainable urban renewal by analyzing critical activities, critical problems and risks that effect or restrict urban renewal implementation.

Qualitative research method is the major research method and its main data source is the digital research database. “Sustainable planning”, “sustainable urban renewal”, “sustainable urban regeneration”, “sustainable urban redevelopment” are taken as keywords, searching eligible title of literatures in Web of Science and CNKI database. Ultimately there exists 37 papers after eliminating literatures having similar content with another one or be not related to success of sustainable urban renewal.

In this study, 37 literatures mentioned above are encoded by using coding technology of grounded-theory that is a commonly used method of qualitative research. Each literature is encoded according to their subject concepts of text, mainly adopting segments-based or incidents-based reading mold. Codes with quite similar themes should be merged into one factor. Then 17 critical factors having effect on success of sustainable urban renewal are determined through text coding. All success factors are shown in Table 39.1.

Table 39.1 Success factors of urban renewal

Success factors	Illustration
F_1: Government's support and supervision	As a huge project in a city, sustainable urban renewal must face many barriers without government's leading or participation, and government's supervision pose a guarantee for implementing of urban renewal
F_2: Public awareness and participation	Residents reflect necessity, feasibility and equality in all processes of urban renewal
F_3: Robust legal system	Legal safeguard protect the interests and standardize the behavior of each participant
F_4: Sound financial structure	Three types of investment, including public funds, mutual funds and commercial finance provide great support to sustainable urban renewal
F_5: Effective administrative system	It can resolve the practical predicaments of "the Officials Accountability", and provide a platform to supervise government's efficiency
F_6: Organization model	The corporation way among government, residents and market
F_7: Land requisition	The way and degree of compensation and resettlement for residents
F_8: Utilization of energy conservation technology	The requirement of sustainability and green building
F_9: Qualified urban planers	It is the ones who can definitely understand regenerative sustainable urban planning
F_{10}: Objective of urban renewal	Understanding how the whole system work and realizing the true objective are the methods of sustainable urban renewal
F_{11}: Target control mechanism	It includes quality, process, cost target in operational level and sustainable target, and should be established to control risks in implementation process
F_{12}: Qualified contractors	Completing the construction work with less cost, time and higher quality at the basis of sustainable urban planning
F_{13}: Coordination among participants	Coordination is a must to resolve conflict and raise efficiency
F_{14}: Post-maintenance	Including effect feedback, building maintenance, property management, etc.
F_{15}: Economic development level and marketing environment	Economic condition and demands are one of basic motivations of urban renewal
F_{16}: Physical environment	It contains the situation of buildings, land, site, open space, water source, infrastructure, telecom, environment quality, etc.
F_{17}: Cultural environment	It influences people's mindset and behavior in urban renewal

39.3 Structural Mode of Sustainable Urban Renewal Success Factors Based on ISM

39.3.1 ISM Approach

There are a lot of factors which can affect the success of sustainable urban renewal. And there exist various complex inter-relationships among them. Interpretive Structural Modeling (ISM) is one of the most common used structural modeling tools, which is a method to analyze complex issues about social economic systems. The characteristic of ISM is decomposing complex system into several subsystem factors, utilizing people's experience and knowledge to construct the system as a hierarchical structure model by the assistance of computer. The procedure to develop the ISM model is as follows:

1. Setting key problems.
2. Selecting the factors which constituting the system and affecting key problems.
3. Enumerating the relevance of factors, establishing adjacent matrix on the basis of the relevance.
4. Establishing reachability matrix according to adjacent matrix.

Decomposing reach ability set, antecedent set, region and hierarchy of reachability matrix, drawing hierarchical structure graph, constructing system structural model, and analyzing the key problems based on the model above.

39.3.2 Model Construction

This research focuses on the success factors of sustainable urban renewal. 17 factors have been identified above. In view of relevance of each factor, four experts in the research field of urban renewal in China, coming from Zhangzhou Academy of Urban Planning and Zhangzhou Urban Planning Bureaus were invited to have a round of group discussion. Through the group discussion, the interrelationships between 17 factors are determined and the adjacent.

1. If F_i has a direct effect on F_j, then the entry becomes 1; if F_i has no direct effect on F_j, then the entry becomes 0 (i, j = 0, 1, 2, …, 17);
2. If both factors have a direct effect on each other, then the entry with greater effect becomes 1; the other one with smaller effect becomes 0. Meanwhile, if F_i and F_j have a direct equal effect on each other, then the entries both become 1; if F_i and F_j have no direct effect, then the entries are both 0 (Table 39.2).

Reachability matrix M expresses all direct and indirect structure relationships between each factor. Matrix of reachability M can be obtained by calculating the adjacent matrix A applying operational rule of Boolean algebra.

Table 39.2 Adjacent matrix of success factors of urban renewal

i	j								
	1	2	3	4	5	6	7	8	9
1	0	0	0	0	0	1	1	0	1
2	0	0	0	0	0	1	1	0	1
3	1	1	0	0	0	0	1	0	1
4	1	0	0	0	0	1	1	1	1
5	1	0	0	0	0	0	1	0	1
6	0	0	0	0	0	0	1	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	1	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	1	1	0	1	0	0	0	0	0
16	1	1	0	0	0	0	0	0	0
17	0	1	0	0	0	0	0	0	0

i	j							
	10	11	12	13	14	15	16	17
1	0	0	1	1	1	0	0	0
2	0	0	1	1	1	0	0	0
3	0	0	1	0	1	0	0	0
4	0	0	1	0	1	0	0	0
5	0	0	1	1	1	0	0	0
6	0	0	0	1	0	0	0	0
7	0	0	0	1	0	0	0	0
8	0	0	0	0	0	0	0	0
9	1	1	0	1	1	0	0	0
10	0	1	0	0	0	0	0	0
11	0	0	0	1	1	0	0	0
12	0	0	0	1	1	0	0	0
13	0	0	0	0	1	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0

$$\text{If } (A + I)^m = (A + I)^{m+1}, \quad \text{then } M = (A + I)^m$$

where, A is adjacent matrix, M is Matrix of reachability, I is n order unit matrix, m is times of calculation.

Reachability matrix is calculated by the help of Matlab2010b (shown in Table 39.3).

Reachability matrix can be decomposed into two sets, including reachability set $R(F_i)$ and antecedent set $A(F_i)$. Reachability set $R(F_i)$ of each factor F_i indicates that it is the set of all factors which F_i can reach, while antecedent sets $A(F_i)$ are the sets that F_i can be reached. $R(F_i)$ and $A(F_i)$ reflect all interrelationships between each factor, including direct and indirect relation (shown in Table 39.4).

Divisions of factors hierarchy level: factor F_i is lying at the top level of the system if equality holds $R(F_i) \cap A(F_i) = R(F_i)$. Removing the top factor and repeating steps above, factors lying at the second level, the third level…and the bottom level can be determined. According to the method above, this study conclude the factors from the top level to the sixth level (shown in Table 39.5).

On account of the level order of factors above, factors can be layered. After that, factors are expected to be connected by vector line on the basis of interconnection of structure matrix factors, to draw the hierarchical structure graph of success factors of sustainable urban renewal. Finally, ISM model of sustainable urban renewal success factors are capable to be acquired (shown in Fig. 39.1).

In ISM model, the lower level the factor is in, the more basic the factor is and the more effect it has on other factors. The factors in top level are directly or indirectly influenced by factors in lower level. Figure 39.1 shows that the effect degree and scope of various factors are quite different, and they are divided into 8 levels. Economic development level and marketing environment (F_{15}) are lying at the bottom level of ISM model, which are the most basic and fundamental success factor of sustainable urban renewal. It has great impact on sound financial structure (F_4) and raise public awareness and participation (F_2). Robust legal system (F_3), sound financial structure (F_4), effective administrative system (F_5), physical environment (F_{16}) and cultural environment (F_{17}) are all lying at the seventh level of ISM model. Except cultural environment, other four factors have synergy effect on government's support and supervision (F_1). And robust legal system, physical environment and cultural environment influence public awareness and participation with economic development level and marketing environment at the bottom level. In sixth level, government's support and supervision and public awareness and participation have combined influences on qualified urban planers (F_9), organization model (F_6) and qualified contractors (F_{12}). In fifth level, there is only one factor, qualified urban planers, having a mature idea of sustainable urban renewal that is conductive to define objective of urban renewal (F_{10}) in a sustainable way. Organization model is in the fourth level, it affect land requisition (F_7) in a certain degree. Objective of urban renewal is also in this level, it determines the effectiveness of target control mechanism (F_{11}), besides, it has an effect on utilization of energy conservation technology (F_8) in the first level with the synergy of qualified

Table 39.3 Matrix of reachability of success factors of sustainable urban renewal

i	j								
	1	2	3	4	5	6	7	8	9
1	1	0	0	0	0	1	1	1	1
2	0	1	0	0	0	1	1	1	1
3	1	1	1	0	0	1	1	1	1
4	1	0	0	1	0	1	1	1	1
5	1	0	0	0	1	1	1	1	1
6	0	0	0	0	0	1	1	0	0
7	0	0	0	0	0	0	1	0	0
8	0	0	0	0	0	0	0	1	0
9	0	0	0	0	0	0	0	1	1
10	0	0	0	0	0	0	0	1	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	1	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	1	1	0	1	0	1	1	1	1
16	1	1	0	0	0	1	1	1	1
17	0	1	0	0	0	1	1	1	1
	6	5	1	2	1	9	10	12	9

i	j								
	10	11	12	13	14	15	16	17	Driving power
1	1	1	1	1	1	0	0	0	10
2	1	1	1	1	1	0	0	0	10
3	1	1	1	1	1	0	0	0	12
4	1	1	1	1	1	0	0	0	11
5	1	1	1	1	1	0	0	0	11
6	0	0	0	1	1	0	0	0	4
7	0	0	0	1	1	0	0	0	3
8	0	0	0	0	0	0	0	0	1
9	1	1	0	1	1	0	0	0	6
10	1	1	0	1	1	0	0	0	5
11	0	1	0	1	1	0	0	0	3
12	0	0	1	1	1	0	0	0	4
13	0	0	0	1	1	0	0	0	2
14	0	0	0	0	1	0	0	0	1
15	1	1	1	1	1	1	0	0	13
16	1	1	1	1	1	0	1	0	12
17	1	1	1	1	1	0	0	1	11
	10	11	9	15	16	1	1	1	–

Table 39.4 Interaction between success factors of sustainable urban renewal

Factor (F_i)	Reachability set R (F_i)	Antecedent set A (F_i)	Intersection set C (F_i)
F_1	F_1, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}	F_1, F_3, F_4, F_5, F_{15}, F_{16}	F_1
F_2	F_2, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}	F_2, F_3, F_{15}, F_{16}, F_{17}	F_2
F_3	F_1, F_2, F_3, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}	F_3	F_3
F_4	F_1, F_4, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}	F_4, F_{15}	F_4
F_5	F_1, F_5, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}	F_5	F_5
F_6	F_6, F_7, F_{13}, F_{14}	F_1, F_2, F_3, F_4, F_5, F_6, F_{15}, F_{16}, F_{17}	F_6
F_7	F_7, F_{13}, F_{14}	F_1, F_2, F_3, F_4, F_5, F_6, F_7, F_{15}, F_{16}, F_{17}	F_7
F_8	F_8	F_1, F_2, F_3, F_4, F_5, F_8, F_9, F_{10}, F_{12}, F_{15}, F_{16}, F_{17}	F_8
F_9	F_8, F_9, F_{10}, F_{11}, F_{13}, F_{14}	F_1, F_2, F_3, F_4, F_5, F_9, F_{15}, F_{16}, F_{17}	F_9
F_{10}	F_8, F_{10}, F_{11}, F_{13}, F_{14}	F_1, F_2, F_3, F_4, F_5, F_9, F_{10}, F_{15}, F_{16}, F_{17}	F_{10}
F_{11}	F_{11}, F_{13}, F_{14}	F_1, F_2, F_3, F_4, F_5, F_9, F_{10}, F_{11}, F_{15}, F_{16}, F_{17}	F_{11}
F_{12}	F_8, F_{12}, F_{13}, F_{14}	F_1, F_2, F_3, F_4, F_5, F_{12}, F_{15}, F_{16}, F_{17}	F_{12}
F_{13}	F_{13}, F_{14}	F_1, F_2, F_3, F_4, F_5, F_6, F_7, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{15}, F_{16}, F_{17}	F_{13}
F_{14}	F_{14}	F_1, F_2, F_3, F_4, F_5, F_6, F_7, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}, F_{15}, F_{16}, F_{17}	F_{14}
F_{15}	F_1, F_2, F_4, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}, F_{15}	F_{15}	F_{15}
F_{16}	F_1, F_2, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}, F_{16}	F_{16}	F_{16}
F_{17}	F_2, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}, F_{17}	F_{17}	F_{17}

Table 39.5 Level of success factors of sustainable urban renewal

Level	Factors
1	F_8, F_{14}
2	F_{13}
3	F_7, F_{11}, F_{12}
4	F_6, F_{10}
5	F_9
6	F_1, F_2
7	F_3, F_4, F_5, F_{16}, F_{17}
8	F_{15}

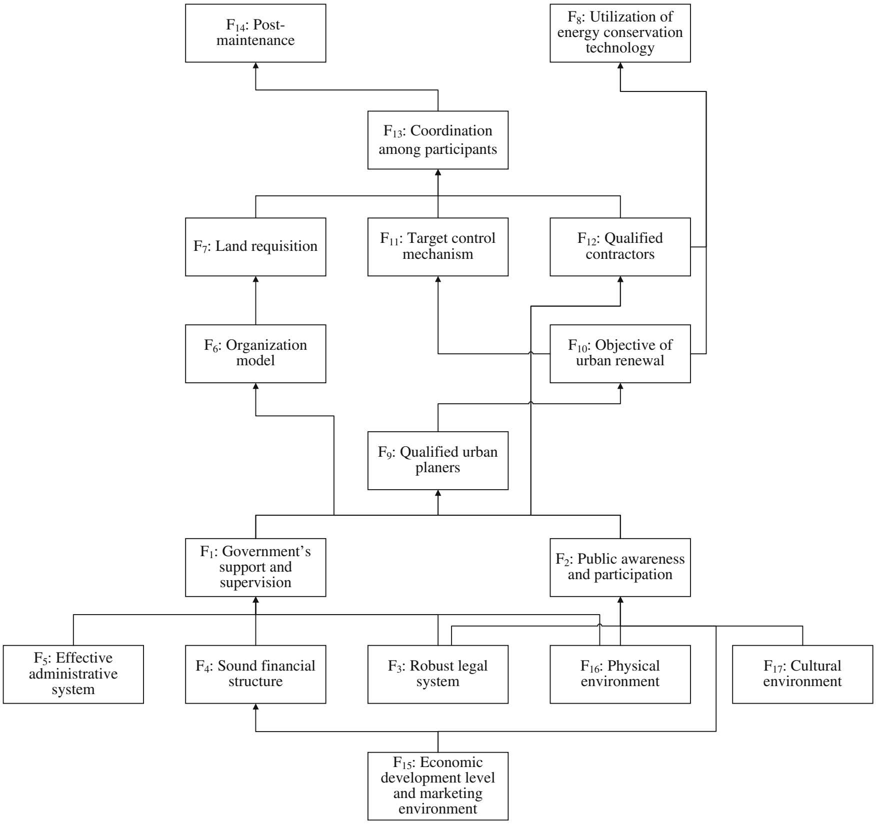

Fig. 39.1 ISM model of success factors of sustainable urban renewal

contractors in third level. Also, there are another two factors, land requisition and target control mechanism, in this level. All three directly impact the situation of coordination among participants (F_{13}). The first level consists of utilization of energy conservation technology and post-maintenance (F_{14}), and the latter is affected by coordination among participants.

39.4 Conclusion

Because of the particularity of sustainable urban renewal itself, the factors influencing its success are quite complex. This paper defines success of urban renewal in the perspective of sustainability, and systematically examines 17 success factors using grounded-theory based on previous literatures. In order to recognize the interactional relationships among success factors of sustainable urban renewal, Interpretive Structural Modeling (ISM) approach is used to construct an interpretive structural model. Based on ISM model, 17 success factors are divided into 8 levels. The economic development level and marketing environment lying at the bottom level is the most basic success factor, while the direct factors in top level are utilization of energy conservation technology and post-maintenance.

Through this study, the understanding of factors influencing success of sustainable urban renewal is a way for authorities, publics, planners and other relevant parties to take as a basic to make contribution to cope with urban problems. Of course, there still exist some limitations. Data collection in the first step of research for identifying factors comes from desk work of literatures review, which lacks of practical cases study. In addition, because of high generalization of its success factors, each factor can be further studied as a subclass in future study.

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Chapter 40
Study on the Correlation Between Urbanization and Economic Development, Real Estate Market in Xi'an

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Abstract This paper is based on the urbanization, economic development and real estate market data in Xi'an city using the analysis model of Econometrics includes entropy, stability testing, Johansen Cointegration and Granger causality test to explore the interactions and relationships among economic development, urbanization and the real estate market. The results show that: the level of economic development, urbanization and the development of the real estate market since 2001 in Xi'an have steadily improved overall; there is a long-term equilibrium relationship among the economic development, urbanization and the real estate market; In the 5 % level of significance, for each Granger causality between economic development and urbanization; Urbanization is the Granger cause of the real estate market development, but lack empirical support for the inverse relationship; Economic development is not the Granger cause of the real estate market development, but also the development of the real estate market is not the Granger cause of the economic development. Based on the results of this study, this paper presents the corresponding policy suggestions.

Keywords Urbanization · Economic development · Real estate market · Granger test

40.1 Introduction

Since 2001, Xi'an city's economy has been growing at a more rapid pace of development, and the level of urbanization is also rising. At the same time, the real estate market closely linked to the urbanization and economic development is also booming. At present, the research literature on economic development, urbanization, the real

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estate market is more, but the relation between the three has fewer discussions. Therefore, this article discussed the interactions among the economic development, urbanization and the real estate market of Xi'an, committed to a clear understanding of the mechanism among the three, in order to develop urban development guidelines and policies on science, and to promote the healthy and sustainable development of society.

40.2 Index System and Methods

40.2.1 Indicators Constructed

This article was based on 2001–2012 data authority in "Xi'an Economic and Social Development Statistical Yearbook", the comprehensive formulation factor indicators build Xi'an's urbanization, economic development, real estate market relations quantitative indicator system (Table 40.1).

Table 40.1 Build relationships Indicators among economic development, urbanization, and the real estate market in Xi'an

Target	Interpretation layer	Classification layer	Index layer
Research on the relationship between urbanization, economic development and real estate market	Urbanization	Demographic indicators	Population urbanization rate
			The proportion of non-farm payrolls of the population
			The urban proportion of the population
		Industry Indicators	Secondary industry GDP
			Gross production of tertiary industry
	Economic development	Economies of scale	GDP
			Total fixed asset investment
			Revenue
		Economic level	Per capita household disposable income
			Total wages of employees
	Real estate market	Development index	Investment in real estate development
			Housing area
		Output indicators	The average price of commercial housing
			Real estate sales

1. The level of urbanization. Urbanization is mainly reflected in the development and expansion of urban population by the progress of the social process of rural to urban concentration, including the increase in urban population and rural population relative reduction, the increase in the number of towns and the expansion of urban scale, economic relationship between the town and the popularity of the mode of production and expand and so on (Yu 2005). Thus, the level of urbanization in this study uses population index and industrial index to represent. Specific indicators include population urbanization rate, the proportion of non-farm payrolls, the urban proportion of the population, secondary industry GDP, the total value of the tertiary industry production.
2. The level of economic development. According to the connotation and influencing factors of economic development, follow the indicators selected scientific, systematic, comparability and accessibility principles, drawing on existing achievements, construction of evaluation index system of the level of economic development from two aspects economics scale and economic level. Specific indicators including GDP, fixed asset investment, financial income, per capita household disposable income, total wages of employees (Zhu et al. 2009).
3. Level of the real estate market. According to the connotation and influencing factors of real estate market development, follow the indicators selected scientific, systematic, comparability and accessibility principles, drawing on existing achievements, construction of the real estate market development level evaluation system from the real estate development indicators and output indicators. Specific indicators include investment in real estate development, housing area, the average price of real estate, real estate sales.

40.2.2 Research Methods

This paper uses the entropy method, ADF test, co-integration analysis, analysis method of Grainger causality test econometric, through analysis and Research on the dynamic relationship among the urbanization, economic development and the development of the real estate market in Xi'an. Of which: ① using ADF test inspection urbanization, economic development, real estate market timing stability of three series; ② in three sequences having the same order single whole premise to establish vector autoregression (VAR) model, using Johansen test method to verify the existence of cointegration relationship among the variables that examine the long-term equilibrium relationship; ③ Granger causality test carried out on the basis of co-integration equation, contacts and visits between the three intrinsic role.

40.3 Data Processing

In information theory, entropy:

$$H(x) = -\sum_{i=1}^{n} p(x_i) \ln p(x_i)$$

Information entropy is used to measure the uncertainty of the system, or is used to measure the degree of disorder of the system. Information is a measure of degree of order system.

Object hypothesis in comprehensive evaluation system set M = (M1, M2, …, Mm), evaluation index system for the D = (D1, D2, …, Dn), evaluation object Mi on the index of Dj value is denoted as X = (Xij) m × n, X then the decision matrix:

$$X = \begin{bmatrix} & D_1 & D_2 & \cdots & D_n \\ M_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ M_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ M_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Through every index quantification of same, using P_{ij} to calculate the P_{ij} proportion in the j index index scheme for I

$$p_{ij} = \frac{X_{ij}}{\sum\limits_{i=1}^{n} X_{ij}}, \quad (i = 1, 2\ldots, n, j = 1, 2\ldots, m)$$

The index is calculated on the J its entropy value e_j, which is calculated as:

$$e_j = -k \sum\nolimits_{i=1}^{n} p_{ij} \ln(p_{ij})$$

Among them $k > 0$, $k = 1/\ln(n)$, $e_j \geq 0$.

The calculation formula of entropy, for a target Dj, difference X_{ij} smaller, E_J is bigger; if all of the above X_{ij} are equal, so when e_j = emax = 1, in comparison of scheme, index X_j will not have the slightest effect; so when the index value the greater difference between each program, the amount of information will be reflected by the larger, while E_J will be smaller. To determine the entropy weight of every index is:

$$W_j = \frac{1 + \frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \ln(p_{ij})}{\sum_{k=1}^{n} 1 + \frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \ln(p_{ij})}$$

The entropy weight by calculating substitution the different index can be calculated score index of each layer of concrete:

$$s_i = \sum_{j=1}^{m} w_j \cdot p_{ij} \quad (i = 1, 2, \ldots, n)$$

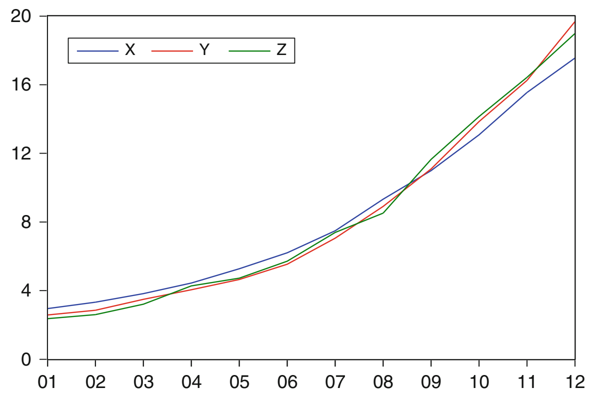

Fig. 40.1 Urbanization, economic development, the real estate market development level index in Xi'an

Calculated based on the entropy method to determine the weight of, the source data of Xi'an's economic development, urbanization, the real estate market-related data into a comprehensive evaluation, then get the 2001–2012 level of urbanization index, the level of economic development index and the level of development of the real estate market index in Xi'an, which was a chart showing (Fig. 40.1):

Urbanization, economic development, the real estate market development level index.

40.4 Data Test

40.4.1 Stationary Test

In order to ensure the unbiasedness, effectiveness and best guarantee of the regression results, before the cointegration analysis of the level of urbanization, economic development and the development of the real estate market, must be stationary test to the test, namely the presence of unit roots.

If a time series X_t is stable, then:

1. the mean E (X_t) and independent of the time t;
2. Variance Var (X_t) is limited, is not generated with the passage of time t changes in the system.

Then, the time series X_t will tend to return to its average, in a relatively constant amplitude fluctuations around the mean.

If a time series X_t is non-stable, then the mean and variance will change with t. For example, the sequence of random walks

$$x_t = x_{t-1} + \varepsilon_t;\ \varepsilon_t \sim (0, \delta^2)$$

If $X_0 = 0$ then

$$x_t = \sum_{i=1}^{t} \varepsilon_i Var(x_t) = t\delta^2$$

when $t \to \infty$, $Var(x_t) \to \infty$, the mean is without meaning, X_t sequence has actually reached the return point of a desired time is infinite.

A stable sequence can generally use an autoregressive moving average expression ARMA (P, q) said:

$$x_t = \varphi_1 x_{t-1} + \cdots + \varphi_p x_{t-p} + \xi_t + \theta\xi_{t-1} + \cdots + \theta_q \xi_{t-q}$$

Using ADF test time series urbanization level (x), the level of economic development (y) and the development of the real estate market level (z) stability. The test results are given in Table 40.2.

Because each variable test results show there are unit root, which are non-stationary series, Therefore, the unit root test must be carried out on its first difference. Based on the variable first-order differential trends can be preliminary judgement, can be seen from Fig. 40.2, the level of urbanization (x), the level of economic development (y) and the development of the real estate market level (z) of the first-order differential dx, dy, dz still has the upward trend.

From the test results, the ADF test value of the original sequence 6.748457, 9.580192, 4.038408 respectively greater than the corresponding critical values, and thus can not reject the null hypothesis (the existence of a unit root), showed that x, y, Z are non-stationary series; on three sequences of first-order difference, respectively, to the Δx, Δy, Δz, then use the ADF test, ADF test value −0.997090, 0.682309, −1.468331 were greater than the corresponding critical values, show that the three sequence of first-order differential are non-stationary series. On three sequences of two order difference, ΔΔx, ΔΔy, ΔΔz were obtained respectively, and then were analyzed by ADF test, ADF test value −4.097047, −4.155463, 4.918437 were less than 5 % significance level critical value, show that the two order three sequence difference are stationary series.

40.4.2 Johansen Cointegration Test

Cointegration means that if the sequence X_{1t}, X_{2t}, …, X_{kt} are d-order single whole, there is a vector:

Table 40.2 Results of unit root test

Sequence	Variable name	ADF test value	1 % level	5 % level	10 % level	Probability	Conclusion
The original sequence	x	6.748457	−4.200056	−3.175352	−2.728985	0.9999	Non stationary
	y	9.580192	−4.200056	−3.175352	−2.728985	0.9999	Non stationary
	z	4.038408	−4.200056	−3.175352	−2.728985	1.0000	Non stationary
The first order difference sequence	Δx	−0.997090	−4.297073	−3.212696	−2.747676	0.7095	Non stationary
	Δy	0.682309	−4.420595	−3.259808	−2.771129	0.9825	Non stationary
	Δz	−1.468331	−4.297073	−3.212696	−2.747676	0.5072	Non stationary
Two order differential sequence	ΔΔx	−4.097047	−4.582648	−3.320969	−2.801384	0.0183	stable
	ΔΔy	−4.155463	−4.420595	−3.259808	−2.771129	0.0143	stable
	ΔΔz	−4.918437	−4.420595	−3.259808	−2.771129	0.0052	stable

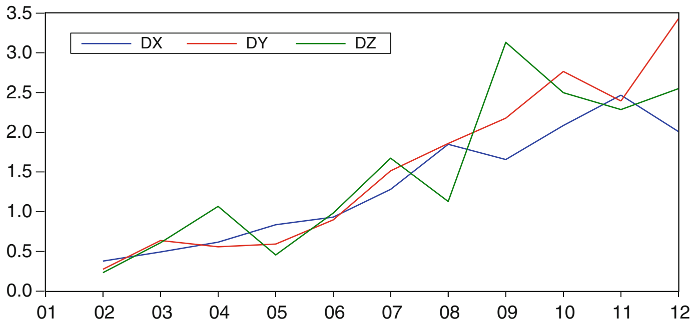

Fig. 40.2 First-order differential trend graph

$$\alpha = (\alpha_1, \alpha_2, \ldots, \alpha_k)$$

Make:

$$Z_t = \alpha X_t^{'} \sim I(a - b)$$

Among them, $b > 0$, $Xt = (X_{1t}, X_{2t}, \ldots, X_{kt})$ That sequence $X_{1t}, X_{2t}, \ldots, X_{kt}$ is (d, b) Order cointegration, denoted as

$$X_t \sim CI(d, b)$$

α is a cointegration vector.

If two variables are single integer variable, and only when their single whole order is the same, it may co-integration, a single whole order if they are not the same, it is impossible cointegration. In the stationary test results can be learned, the level of urbanization, economic development level and the level of development of the real estate market is second-order single whole, and conduct Johansen cointegration premise for the series are integrated of the same order, so x, y, z three sequences cointegration test conditions are met.

In this study, use the method of Johansen cointegration test to test cointegration of the three variables. First constructed vector autoregression model (VAR), select "sequence has the certainty of a linear trend, cointegration equation only intercept" has been co-integration test results (Table 40.3).

Test results table is based on the largest eigenvalues (Maximum Eigenvalue) that Max-Eigen statistic test results table, It is a test of the null hypothesis that there are r cointegration contrary, there are r + 1 cointegration relationships.

Johansen cointegration test results shows that when the critical value of trace test statistics regression equation is greater than the 5 % confidence level, reject its assumptions; otherwise accept his assumptions. The relationship between these four variables cointegration test results show that, at the 5 % level, the existence of a long-run equilibrium relationship between variables, which implies the existence of

Table 40.3 Johansen cointegration test results (1), results (2)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical value	Probability
Result 1				
None*	0.999165	111.0980	29.79707	0.0000
At most 1	0.974442	40.22160	15.49471	0.0000
At most 2	0.299080	3.553608	3.841466	0.0594
Result 2				
None*	0.999165	70.87638	21.13162	0.0000
At most 1	0.974442	36.66799	14.26460	0.0000
At most 2	0.299080	3.553608	3.841466	0.0594

interactions between the long-term development of urbanization, economic development and real estate market.

40.4.3 Granger Causality Test

Cointegration analysis can reveal whether there is a long-term equilibrium relationship between variables, but the equilibrium relationship is a causal relationship, you need to verify through the Granger causality test (Sun 2009). Granger believes that the variable cointegration relationship exists between these variables case, there exists at least one direction of Granger causality. Therefore, to further explore the causal relationship between the various time series (Zhou and Li 2004).

Under the 5 % significance level, "Y (Economic Development) is not X (urbanization) rejected Grainger reason", and "X (urbanization) is not Y (Economic Development) Grainger reason" can not be refused show that for each Granger causality between economic development and urbanization. Under the 5 % significance level, "Z (real estate market) is not X (urbanization) Granger cause" was rejected, and "X (urbanization) is not Z (real estate market) Granger cause" can not be rejected, indicating that urbanization is the Granger cause of the development of the real estate market, but lack of empirical support for the inverse relationship; at

Table 40.4 The Granger causality test results

Lag	Null hypothesis	F-statistic	Probability	Result
1	Y does not Granger Cause X	10.7504	0.0155	reject
	X does not Granger Cause Y	8.50514	0.0246	reject
2	Z does not Granger Cause X	5.18661	0.0603	accept
	X does not Granger Cause Z	10.3136	0.0168	reject
3	Z does not Granger Cause Y	0.17641	0.8433	accept
	Y does not Granger Cause Z	2.70129	0.1602	accept

the 5 % significance level, "Z (real estate market) is not Y (economic development) Granger cause", and "Y (economic development) is not Z (real estate market) Granger cause" not to be rejected, indicating that economic development is not the Granger cause of the real estate market development, while the real estate market is not the Granger cause of economic development.

Thus, the development of urbanization and economic reinforce each other in Xi'an, that economic development to some extent, contributed to the process of urbanization in Xi'an, while urbanization also makes more rapid economic development and improvement; orderly urbanization is an important factor in promoting the booming real estate market, while economic development is not the main factor in promoting the development of the real estate market, but that does not mean that economic development will not have an impact on the real estate market, but the impact is relatively weak; the real estate market development is not the reasons of economic development and urbanization. This means that in the analysis of the relations between the three, the development of this market is only the result and not as a cause to promote the economic development and urbanization (Table 40.4).

The results show that: the economic development has attracted Xi'an surrounding agricultural population and non-urban population into the cities, to promote the city's industrial structure optimization and value increase, making the process of urbanization in Xi'an significantly accelerated, at the same time, the promotion of the urbanization process promote the optimization of industrial structure, increase the supply of labor force, directly or indirectly to meet a variety of conditions in the city in the process of economic development required. In addition, urbanization leads to the change of the land use structure and the way so as to improve the efficiency of the allocation and utilization benefit, which directly promote the development of the real estate market (Wu 2006); However, the real estate market does not promote economic development, improve the level of urbanization, because of the level of economic development, improving the process of urbanization is largely dependent on various elements of the input increases, the relationship between the different elements are cumbersome and complex, One aspect of the real estate market as one of the impact, the promotion of relations between the two can not be fully reflected.

40.5 Conclusions and Recommendations

40.5.1 The Main Conclusions

By entropy method, cointegration test and Granger causality test, perform a quantitative analysis to the urbanization, economic development and the development of the real estate market, draw the following conclusions:

First, by entropy method to calculate the level of urbanization and level of economic development, the level of development of the real estate market in Xi'an each year, you can find a comprehensive evaluation of the three scores were rising over time, and the three score's rises are very close, up speed faster. This shows that since the beginning of the 21st century with the process of urbanization in Xi'an urban development continues to accelerate economic development is accelerating, the real estate market is also expanding.

Second, urbanization and economic development, the development of the real estate market cointegration relationship exists between various indexes. It is said that in the short term, urbanization and economic development, the development of the real estate market may fluctuate relationship, but in the long run, there is a long-term stable equilibrium relationship between urbanization, economic development and the development of the real estate market.

Third, by Granger test, found in the 5 % significance level, mutual Granger causality between economic development and urbanization. The town is the Granger cause of the real estate market development, but the real estate market is not the Granger cause of urbanization. Economic development is not the Granger cause of real estate market development, while the real estate market is not the Granger cause of economic development. This suggests that the development of the real estate industry, urbanization and economic development is still in uncoordinated stage.

Fourth, the economic development by increasing the total GDP, increase revenue, increase income, create a favorable macroeconomic environment for urbanization; by providing a large number of employment opportunities, solve the problem of new urban population, create a favorable economic environment for the urbanization of onlookers. Urbanization provides the necessary space for the city's economic development through financial contributions and taxes for the government as well as to attract capital and labor, in order to accumulate funds for construction of urbanization. Economic development and urbanization both reinforce each other, complementary and mutually promote the development of each other. Urbanization makes the demand for urban housing supply increases, making the real estate industry to integrate more funds for construction, thus urbanization is the Granger cause of the real estate market.

The conclusion can help us better understanding the relations between urbanization, economic development, and the real estate market development. About urbanization and economic development, the real estate market, existing research mainly uses regression analysis, correlation analysis to reveal the relationship between the three, did not solve the problem of the interaction and mutual influence mechanism between the variables. In this study, economic analysis of measurement explore the dynamic relationship between urbanization and economic development, the development of the real estate market, analyzes the trend between the urbanization and economic development, the development of the real estate market and the interaction between the urbanization and economic development, the development of the real estate market.

40.5.2 Policy Recommendations

First, Xi'an should be explored new urbanization patterns in the current pattern of urbanization, set the urbanization development planning through scientific, a reasonable measure of the size of a standard all types of land, reasonably determine the land policy, careful planning town, district and so on, to keep real estate industry reasonable pace, in order to effectively control the real estate market, and promote the stable development of the real estate market.

Second, the scale and speed of real estate development should be coordinated with the process of urbanization, adapt to the economic development level of Xi'an city and affordability, government in the real estate market regulator housing total also should construct multi residential supply channels. Building a new population of housing security system covering the urbanization of the city.

Third, Xi'an should be further transformation of economic development mode, optimizing the layout of industrial upgrading, increased capital investment and technological innovation, continue to strengthen business investment, economic development more dependent on technological advances rather than the allocation of resources, reducing the economic development's dependence on the land resources. By properly regulate the mode of economic development, in order to optimize the allocation of resources in the urbanization and promote healthy development of urbanization. In the process of transformation of the economic development and the urbanization, let them combined with each other and promote each other, not at the expense of agriculture and food, ecology and the environment at the expense of economic development and to balance urban and rural development, urban and rural integration, the city in interactive, intensive, ecological and livable, harmonious development of the new town is the core of the defense transformation.

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Chapter 41
A Quantitative Approach for Identifying Adaptive Reuse Option for Industrial Buildings

Yongtao Tan, Liyin Shen and Craig Langston

Abstract With rapid economic development and restructuring, there are an increasing number of aged or obsolete buildings in large cities, such as Hong Kong. Adaptive reuse of these buildings provides an alternative for property stakeholders towards more sustainable practices instead of redevelopment or destruction. Adaptive reuse can also make great contributions to sustainable development by reducing construction waste and saving natural resources. As a result of industrial restructuring, manufacturing plants were migrated from Hong Kong to Mainland China during the 1980s and 1990s. Many industrial buildings then became vacant or under-utilized. Adaptive reuse of these industrial buildings is considered a viable way forward for all parties, including government, property stakeholders and the community. However, the problem is how to deal with multiple criteria to assess how these buildings can be reused for residential living, retail, training centers, or other purposes. Adaptive reuse of industrial buildings is discussed in this paper, and a fuzzy adaptive reuse selection model is developed for decision-making. A hypothetical example is used to demonstrate the application of the method and show its effectiveness.

Keywords Adaptive reuse · Fuzzy approach · Industrial building · Decision making · Multiple selection criteria

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41.1 Introduction

As one of the most densely populated places in the world, Hong Kong has a well developed property market. The property market comprises four sectors, including residential, office, commercial and industrial space (private flatted factories, industrial/office, specialised factories and storage). As a result of industrial restructuring during the 1980s and 1990s, financial services, trading and logistics, tourism, and producer and professional services became emerging industries for the Hong Kong economy. Most manufacturing plants were moved to mainland China and there was little need for significant manufacturing factories in Hong Kong. Some buildings became obsolete. In 2009, the vacancy of private flatted factories exceeded 1.3 million square metres, or 8 % of the total stock (Rating and Valuation Department 2010).

Furthermore, the built environment is responsible for 40 % of world materials usage, a third of energy consumed by the world economy and 40 % of greenhouse gas emissions (Worldwatch Institute 1995). New construction adds less than 2 % per annum to the built environment stock in Hong Kong (Langston et al. 2008). Greenhouse gas emissions (GGE) in Hong Kong are nearing 50 million tonnes (CO_2 equivalent) per annum (http://www.epd.gov.hk/). Adaptive reuse of industrial buildings can decrease new building construction with faster project delivery time and make corresponding contributions to GGE reduction, and the need for building adaptation is increasing with relevant policy drivers, such as the '1200 building program' developed by the City of Melbourne (Wilkinson and Reed 2011), and 'Wholesale Conversion of Industrial Buildings' scheme in Hong Kong (HKSAR 2009). Therefore, it is an opportunity for stakeholders to think about how to reuse their buildings to meet economical, environmental and social needs. The paper aims to: (1) examine the adaptive reuse potential of industrial buildings in Hong Kong; (2) develop a fuzzy decision making method for adaptive reuse of industrial buildings, and (3) demonstrate its application in practice via a hypothetical case study.

41.2 Literature Review

41.2.1 Adaptive Reuse

With economic and social development, existing buildings may be obsolete or rapidly approach disuse and potential demolition. These buildings can be considered as raw materials for new projects, a concept described by Chusid (1993) as 'urban ore'. A more effective method is to leave the basic structure and fabric of the building intact, and change its use, rather than extracting these raw materials during demolition or deconstruction. This approach is called 'adaptive reuse'. Adaptive reuse is a special form of refurbishment that poses quite difficult challenges for designers. Changing the functional classification of a building will introduce new regulatory conditions and perhaps require zoning consent. In some cases, increases in floor space ratios can be obtained and concessions received for pursuing government policy directions by regenerating derelict public assets. There are clear economic, environmental and social benefits that can make this option attractive to developers (Langston et al. 2008). In recent years, redundant city office buildings have been converted into high quality residential apartments, bringing people back to cities and in the process revitalizing them. In Hong Kong, the Urban Renewal Authority plays an important role in overseeing such projects (http://www.ura.org.hk).

Adaptive reuse has been successfully applied in many types of facilities, including defence estates (e.g. Doak 1999; van Driesche and Lane 2002), airfields (e.g. Gallent et al. 2000), government buildings (e.g. Abbotts et al. 2003), and industrial buildings (e.g. Ball 1999; Cantell 2005; Wilson 2010). Adaptive reuse of buildings is seen as fundamental to sound government policy and sustainable development, e.g. in Atlanta, USA (Newman 2001), Canada (Brandt 2006), Hong Kong (Poon 2001), and Australia (McLaren 1996; Maggs 1999).

Morrissey et al. (2012) argued that decision-makers in the built environment were increasingly considering environmental and social issues alongside functional and economic aspects of development projects. Infrastructure projects in particular represent major investment and construction initiatives with attendant environmental, economic and societal impacts across multiple scales. For this reason, unmasking costs can provide strong incentives for a transition to more sustainable energy practices, less profligate use of new materials, and greater utilisation of existing building stock. Refurbishment is also a better employment generator than new construction due to the labour intensive nature of adaptation (Kincaid 2002).

Much research has been done on how existing buildings can be adapted from different stakeholder perspectives, such as developer, designer, planner, and government. Government plays an active role in building adaptive reuse, not only in regulation, but also in expanding knowledge of the sustainable development of cities (Kincaid 2000). Adaptive reuse of existing buildings, especially older buildings, attracts those creative and risk-taking investors who can make higher returns by innovative building renovation (Shipley et al. 2006). For developers, adaptive reuse of redundant structures also provides a quick solution when they are searching space for a project (Henehan et al. 2004). The concept of sustainability should be integrated into the adaptive reuse of buildings with innovative green designs (Fournier and Zimnicki 2004).

The selection of adaptive reuse opportunities is a difficult task for decision-makers, including government, owners, investors, developers or consultants, as they have different objectives. For an optimal selection, multiple criteria should be used and decision-makers should consider different interest groups. Wang and Zeng (2010) proposed a method for reuse selection of historic buildings using two steps: initial screening and final selection by an ANP-based approach. Pair-wise comparison is used in the ANP model, which is generally time-consuming. Moreover, it may be confusing for even professionals to compare the importance of different criteria. Highest and best use method is also frequently used for real estate appraisal. However, this method is normally used to maximize the productive use for generating the highest profit. For adaptive reuse, the economic factor may not be the first. In some cases, the environmental and social factors are more important. There is a need to develop a new method to incorporate stakeholders' opinion by considering multiple selection criteria.

41.2.2 Adaptive Reuse Potential of Industrial Buildings in Hong Kong

With the relocation of traditional manufacturing activities to the Mainland, an amount of industrial floor space in Hong Kong has been converted to office and storage uses. However, there are still many private flatted industrial buildings under-utilised. At the end of 2010, the total stock of private flatted factories in Hong Kong was around 17.2 million square metres with a vacancy rate of 6.7 %. Furthermore, 70 % of existing industrial buildings are now situated in non-industrial zones, mainly in the "Other Specified Uses (Business)" zone (Development Bureau 2011). Most of the vacant industrial buildings are relatively young, located in urban areas with good and improving access and connectivity, and furnished with large floor plates, high ceilings, strong floor loadings, wide corridors and large lifts (Legislative Council 2011). With the increasing demand for non-industrial spaces, adaptive reuse of industrial building can help meet the needs in short term, the image and economy of the district can be improved (Yap 2013). Therefore, there is great potential for adaptive reuse of industrial buildings in Hong Kong.

However, the conversion of existing industrial buildings for other uses remains slow. There were only 37 cases in OU(B) zone that completed lease modifications for change of use of industrial buildings between 2001 and 2009, and only three cases involved wholesale conversion, so detailed case studies in Hong Kong are rare. The key difficulties are lack of adequate government initiatives and incentives (Yap 2013). Non-compliant uses of industrial buildings are widespread (Development Bureau 2011) with mixed usage of buildings due to increased rental and purchase office and residential property prices. The conversion of existing industrial buildings is an immediate solution to the problem, and there are many successful cases overseas which could be good references for Hong Kong. Furthermore, the concept of sustainability can be extended to innovative adaption of industrial buildings with creative solutions in line with current building legislation (RICS 2009). The key issues for adaptive reuse of industrial buildings include health & safety, multi-ownership, deeds of mutual covenant, fire safety, environmental challenges, planning interface, sustainability, financial viability, building regulations, parking, district-wide implications, and enforcement (RICS 2009).

Table 41.1 Selection criteria of adaptive reuse industrial building

Criteria	Description
C1: Architectural	Physical condition, architectural evaluation; structural analysis; functional changeability, technological difficulties; material and decoration; refurbishment feasibility; functional performance
C2: Economic	Potential market; benefit-cost ratio; life-cycle cost; financial sources; subsidize; exemption
C3: Environmental	Site layout; environmental impact; environmental quality of surroundings; energy usage
C4: Social	Compatibility with existing; public interest and support; social value; enhancing community; loss of habitat
C5: Legal	Outline Zoning Plan (OZP); Development Permission Area (DPA) Plans; new policy measures to revitalizing industrial buildings; Wholesale Conversion of Industrial Buildings

41.2.3 Adaptive Reuse Selection Criteria

For adaptive reuse decision-making for buildings, multiple criteria are necessary for the assessment, including economic, social and environmental attributes. Murtagh (2006) suggested the following factors for adaptive reuse selection: potential market, location, physical analysis, architectural and historical evaluation. Obsolescence of existing buildings can be assessed using seven aspects, including physical, economic, functional, technological, social, legal and political (Langston 2008). Wang and Zeng (2010) identified six criteria for reuse selection of historic buildings based on fuzzy Delphi method, including cultural, economic, architectural, environmental, social aspect and continuity. Langston and Smith (2012) developed a decision-making cube called iconCUR for making decisions about existing buildings, including applicability and prioritization for adaptive reuse. Based on the above and related literature, multiple selection criteria for industrial building adaptive reuse are summarized in Table 41.1. Changes could be made to the criteria for specific building types.

41.3 Methodology

41.3.1 Fuzzy Set Theory

Generally, decision-making problems are made under uncertainty, vagueness, fuzziness, risk, time pressure, and some information is either incomplete or missing. Decision makers prefer to describe their feeling in the fuzzy terms of "good", "fair", "poor", etc. These fuzzy terms can be expressed by fuzzy sets or fuzzy numbers. A fuzzy set is characterized by its membership function (Zadeh 1965).

Table 41.2 Linguistic terms describing attribute weightings and ratings

Linguistic terms for weightings	Fuzzy numbers	Linguistic terms for ratings	Fuzzy numbers
Very low (VL)	(0, 0, 0.1)	Very poor (VP)	(0, 0, 1)
Low (L)	(0, 0.1, 0.3)	Poor (P)	(0, 1, 3)
Medium low (ML)	(0.1, 0.3, 0.5)	Medium poor (MP)	(1, 3, 5)
Medium (M)	(0.3, 0.5, 0.7)	Fair (F)	(3, 5, 7)
Medium high (MH)	(0.5, 0.7, 0.9)	Medium good (MG)	(5, 7, 9)
High (H)	(0.7, 0.9, 1.0)	Good (G)	(7, 9, 10)
Very high (VH)	(0.9, 1.0, 1.0)	Very good (VG)	(9, 10, 10)

An appropriate linguistic variable set can help decision-makers make correct judgments concerning options. The linguistic terms and corresponding membership functions can be elicited from expert assessment and past data, and can be modified to incorporate individual situations. The triangular fuzzy number is the simplest fuzzy number and is used most frequently for expressing the linguistic terms in research (Chen 2000; Deng 2006). In this study, the linguistic terms are defined for a demonstration based on previous studies (Lin and Chen 2004; Li et al. 2007), as shown in Table 41.2.

41.3.2 Fuzzy Adaptive Reuse Selection Model

There are various options for adaptive reuse of industrial buildings, and these can be denoted as $X = \{x_1, x_2, \ldots, x_n\}$. Each alternative can be assessed by the identified selection criterion $G = \{G_1, G_2, \ldots, G_s\}$. Then a decision-making committee is formed, denoted as $D = \{d_1, d_2, \ldots, d_t\}$. The committee normally should comprise key project stakeholders including appropriate community representation. According to Table 41.2, the importance of the criteria and rating of alternatives with respect to each attribute are assessed by committee members. $\tilde{A}^{(k)} = (\tilde{a}_{ij}^{(k)})_{s \times n}$ is a fuzzy decision matrix describing the rating of alternatives, where $(\tilde{a}_{ij}^{k})_{s \times n} = [a_{lij}^{k}, a_{mij}^{k}, a_{uij}^{k}]$ is an attribute value given by decision maker $d_k \in D$, for alternative $x_j \in X$ with respect to attribute $G_i \in G$, and $w = (w_1, w_2, \ldots, w_s)^T$ is the weight vector of attributes, where $w_i \geq 0, i = 1, 2, \ldots, s$. Then, the decision makers' assessments can be aggregated by an operator and the fuzzy adaptive reuse value (FARV) of each alternative can be denoted as:

$$FARV_j = \sum_{i=1}^{s} \tilde{w}_i \otimes \tilde{r}_{ij} \tag{41.1}$$

$\tilde{r}_{ij}$ is the normalized fuzzy rating of alternative $x_j \in X$ with respect to attribute $G_i \in G$. The calculation of $\tilde{r}_{ij}$ will be introduced in the next section. Then, the FARV of each alternative can be ranked.

41.4 Application of Fuzzy Adaptive Reuse Selection Model

Adaptive reuse decision-making is more complex than expected by considering multi-criteria. The fuzzy approach provides a solution to integrate opinions from various parties. Here is an example for demonstrating the application of the fuzzy adaptive reuse selection model. A private 15-storey industrial building, completed in the 1980s and located in the waterfront Yau Tong Bay of Hong Kong, is selected as a hypothetical case study[1] to illustrate the proposed model. The building is a reinforced concrete frame structure with windows on only two opposite faces, one facing the bay. The total floor area of the building is 50,000 m^2, and the ceiling height of a typical floor is 3095 mm. There are 2 passenger lifts and 5 service lifts, and a central air conditioning system. This building is used for small offices and storage areas (mainly timber and other construction materials). The vacancy of the building is 70 % at present. The building is representative as there are many similar buildings in Hong Kong. In order to reduce the environmental and social impact, the owner is considering adaptive reuse of the building instead of demolishing it for a new building. The decision process is as follows:

Step 1: Forming decision making committee and initial screening In this case, a committee was formed comprising six members, including owner of the building, investor, government department, architect, surveyor and structural engineer. Committee members are to be involved in the whole decision-making process. Normally, the decision-making process takes several weeks. According to Legislative Council Brief (2011), the permitted non-industrial uses in buildings within the "Commercial" Zone include office, commercial uses (including hotel, shop and services), recreation and leisure uses, educational and religious uses, Government, Institution or Community (GI/C) uses, and residential uses (subject to planning permission from town planning boards). With initial screening by the committee, the possible options for the adaptive reuse of this industrial building are defined, including fashion design industrial centre (A1), luxury serviced apartment (A2), a 4-star hotel and retail centre (retail centre on lower floors) (A3), prestige office and shopping centre (shops on lower floors) (A4), or vocational education and training centre (A5). These options are based on the highest and best use for the site within the context of retaining a significant amount of the existing structure.

[1]A hypothetical scenario is used as the case study, and although based on an actual site, is not an active adaptive reuse project. It is nevertheless representative of typical industrialised building reuse opportunities in Hong Kong.

Step 2: Assessing each alternative Before assessment, a comprehensive survey should be conducted, including as-built survey of the site, building context, structural and environmental components of the building, mechanical systems, safety and accessibility, and energy savings (Brownfield News 2007). The committee members should undertake a site visit. Then, the committee members assess each alternative using the criteria defined in Table 41.1. In some cases, the importance of decision-makers should be considered.

Step 3: Aggregating weightings and ratings Aggregate the fuzzy decision matrices $\tilde{A}^{(k)} = (\tilde{a}_{ij}^{(k)})_{s \times n}$ into a complex fuzzy decision matrix $\tilde{A} = (\tilde{a}_{ij})_{s \times n} = [a_{lij}, a_{mij}, a_{uij}]_{s \times n}$, and aggregate the attribute weights $\tilde{w}_i^k = [w_{li}^k, w_{mi}^k, w_{ui}^k]$ into the complex attribute weights $\tilde{w}_i = [w_{li}, w_{mi}, w_{ui}]$. The mean operator is normally used for aggregating decision-makers' opinion on attribute ratings and weightings (Chen 2000).

Step 4: Normalizing the complex fuzzy decision matrix To ensure compatibility between averaged ratings, the complex fuzzy decision matrix $\tilde{A} = (\tilde{a}_{ij})_{s \times n} = [a_{lij}, a_{mij}, a_{uij}]_{s \times n}$ is normalized into a corresponding matrix $\tilde{R}^{(k)} = (\tilde{r}_{ij}^{(k)})_{s \times n}$.

Step 5: Calculate the FARV and NFARV for each alternative The FARV for each alternative is calculated using formula (41.1). For compatibility, the normalized FARV (NFARV) is used to keep the fuzzy value in the range of [0, 1].

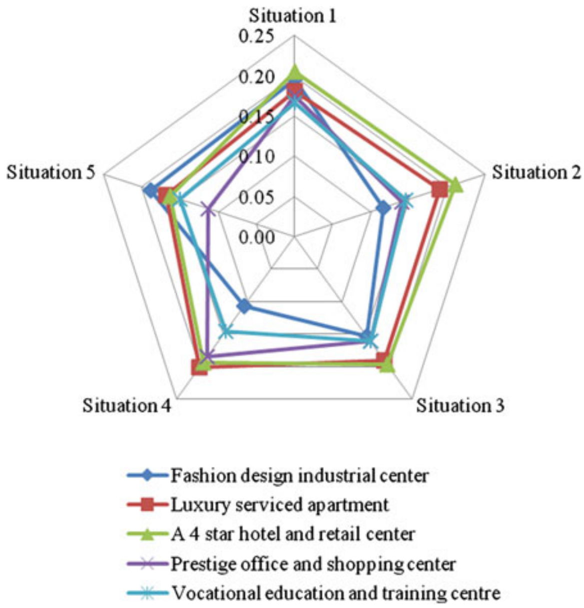
Step 6: Ranking NFAVRj There are different approaches for ranking fuzzy numbers, such as weight center, fuzzy number recognition, fuzzy TOPSIS, and simple defuzzification method (Li et al. 2007). In this study, the simple defuzzification method is used for a demonstration purpose.

According to the closeness coefficient, the ranking of the five alternatives is A3, A2; A5; A4 and A1. The best choice is A3, (i.e. adaptive reuse for a 4-star hotel and retail centre), while adaptive reuse to a luxury serviced apartment is also under consideration as its coefficient is very close to A1. Given the 'Economic' criterion has a higher weighting than other selection criteria, a 4-star hotel or a luxury serviced apartment are more attractive with higher economic benefits. The ranking will be different if the weightings are changed.

41.5 Sensitivity Analysis and Discussion

Sensitivity analysis will be used when the decision-makers have different preferences on the five criteria. In this example case, the extreme states will be examined by assuming that only one criterion has the maximum possible weight whereas the others have the minimum possible weights. For each state, the closeness coefficient

Fig. 41.1 Closeness coefficients of each alternative under five extreme situations



of each alternative is calculated and the results are graphically represented in Fig. 41.1.

Under situation 1, when 'Architectural' is considered as the most important criterion, the conversion choice could be fashion design industrial centre (A1) or a 4-star hotel (A3). Under situation 2, 'Economic', the best choice is hotel (A3). Under situation 3, 'Environmental', it will be luxury serviced apartment (A2) or hotel (A3). Under situation 4, 'Social', luxury serviced apartment (A2) is the best one. Under situation 5, 'Legal', the best choice is the fashion design industrial centre (A1). It can be seen that conversion to a 4-star hotel has the best economic performance that explains why the optimal choice is hotel in the case study. When environmental and social criteria are considered more important, conversion to serviced apartment could be a better choice. Therefore, this model provides decision-makers multiple options according to their different preferences on the criteria. The results form a valuable reference for them to make better decisions.

41.6 Conclusions

With industrial transformation, there are many private industrial buildings vacant or under-utilised in Hong Kong. Adaptive reuse or revitalisation of these obsolete industrial buildings not only extends their life but also has great economic, social and environmental benefits if they are properly assessed. The industrial buildings in Hong Kong have a high potential for adaptive reuse with innovative sustainable designs. These buildings could be converted to residential, hotel, office, retail shops, sports centres, etc., or otherwise demolished and a new development constructed in its place. The deployment of a fuzzy approach for decision-makers in order to make better choices about reusing existing buildings will need to consider the characteristics of the building and integrate stakeholder opinions. The results provide decision-makers with valuable insight into the adaptive reuse selection problem.

In practice, however, adaptive reuse of existing industrial buildings may not reflect the highest and best use for a site. There may be social and environmental arguments for why an economic focus may be inappropriate. Where reuse is the chosen strategy, the selection process for a new functional purpose can be assisted by the approach outlined in this paper.

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Chapter 42
Transformation of Urban Villages in Nanjing Based on Urban Spatial Structure

Yang Xiao, Ma Xin and Yang Jun

Abstract With China's accelerated urbanization process, urban villages have affected the regular operation of cities. The transformation of urban villages has gradually been put on the agenda and it has been experiencing a booming stage. This article presents the reasons and influence of urban villages through literature review from the perspective of urban spatial structure. Data of urban villages in Nanjing were collected and Google Earth was to adopted to analyze its spatial structure features and reveal the influence of urban spatial structure on the formation of the urban village. Recommendations on the transformation of the urban village are addressed.

Keywords Urban village Nanjing · Spatial structure · Transformation

42.1 Introduction

In the process of rapid urbanization, "urban village" has become a huge obstacle which hinders city development. Both domestic and foreign scholars have expressed their close attention to the concept, the transformation and life cycle of urban villages. In the perspective of concept, Pryor (1968), Andrews (1942), Zheng et al. (2007), Lan (2008), Li (2003) and other scholars have researched. Li Junfu thinks that "urban villages" are those rural villages that belong to the scope of urban planning zone or the rural and urban fringe area are surrounded by city proper land with no or only a small

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amount of agricultural land. In terms of life cycle, the urban sociologist Park (1960) who explored the urban community found that along with the constant transformation and change of urban space, urban community also produced phenomenon of forming or fading. According to this principle, urban villages were divided into four lifecycle stages of forming, friction, conflict, and phase.

Guldin (2001) and Hsing (2010) have researched that rapid village transformation has emerged as a widely-recognized facet of settlement transition in China. Under the background of the plan of transformation of Nanjing's urban villages and dilapidated houses, starting from the urban space structure, this article presents on the spatial structure features of "urban village" and raises some suggestions for transformation in order to promote urban villages after reconstruction to be in the direction of harmonious, healthy and orderly development.

42.2 Related Problems of Urban Villages in Nanjing

42.2.1 Reasons of Emerging Urban Villages in Nanjing

With the rapid expansion of Nanjing city scale, some rural areas in the past have been gradually into the city. But in terms of land ownership, management system, they still remain to be a rural model, which is not harmonious with the overall development of the city. There is a widespread environmental sanitation in these urban villages, such as the chaotic property of building layout, large building density, which caused destruction of ecological environment and serious waste of land resources. What's more, sprawling urban villages also result in some gambling, crime and other social problems, seriously influencing the quality and image of city. To sum up, the serious situation of Nanjing urban villages is a cancer of development of economy in Nanjing, which severely restricts the development of urbanization in Nanjing.

42.2.1.1 The Primary Cause of the Urban and Rural Dual System

The land management system of urban and rural dual system is the main cause of emerging urban villages. The urban and rural dual system refers to that the rural society is a part and urban society is a separate part. Between urban and rural areas, there are a lot of different aspects such as household registration, social security and economic system that can result in many conflicts.

42.2.1.2 The External Reason of Social Transformation

Transformation of urban villages is an inevitable stage of social transformation of China's urbanization process. In Nanjing, a series of urban changes happen due to the rapid growth of urban economy. For example, in terms of population and industry, some people migrate outside to meet their own needs and gain more profits because of differential rents. In addition, the establishment of lands using fee system can reflect the high price of city centre, and only those groups or enterprises with high added value stay in the town centre. The space within the proper city can't meet the needs of urban development, and the city needs to form a wider range of urban development zones, industrial clusters, a new center and a establishment of new population.

42.2.1.3 The Internal Reason of Farmers's Profit Tendency

Villagers' income of urban villages mainly comes from self-built rental income and village collective bonus. The rural collective economy is built on the village land for development, the land expropriation compensation and the establishment of rental property relying on land expropriation compensation. With the rapid development of urban economy, under the premise of slam shut and investment weakness in employment, villagers who privately build houses to have more rental income became their main way of investment, resulting in the chaos of the construction and management of urban villages.

42.2.1.4 The Reason of Spatial Structure Evolution

Nanjing is located in the subtropical Yangtze River delta with soil fertility, pleasant climate, developed agriculture, many villages. With the expansion of urban land, rural land, fish ponds, orchards and other agricultural lands were gradually taken over to develop urban residential area and industrial area. Infrastructures such as roads, water supply, power supply encroached upon the countryside. Lands' change and urban expansion had brought the evolution of urban spatial structure, which had influenced the formation and distribution of urban villages.

42.2.2 The Impact of Urban Villages in Nanjing on Urban Development

42.2.2.1 The Negative Impact of Urban Villages in Nanjing

1. Land planning and utilization
   In terms of Nanjing, illegally building a large number of urban villages increased the investment of development of urban construction; Huge loss of urban land's income seriously influenced structural optimization of urban land-use; Differences between cities and villages of land system caused earthy land

ownership and use of urban villages in chaos, out of control and dysfunction. Internal close construction and lack of necessary infrastructure highly didn't harmonize with the urban landscape.

2. Policing management in community
After the birth of urban villages, it has become a mixed residential area of the floating population, urban residents and villagers. All kinds of entertainment lives in such an environment conflict, communicate and intellect with each other. Because of lack of the management of social order, so it leads the urban village to become a serious problem of urban security administration. In addition, the urban villages produced some pronouns such as yellow, poison, bet dirty and difference. It's more seriously that some people compared the urban village to super living guerrilla base, safe haven and big warehouse and workshop of counterfeit goods.

3. Spirit culture in community
Urban villages relying on superior geographical location get the land requisition compensation and benefits of renting land, leading the villagers' material wealth to increase rapidly in the short term. But it does not bring the improvement of villagers' quality, and young and middle-aged villager's urban and rural duality and the social borderline is obvious; Middle-aged and young villagers become social "rentier class"; The low quality of the villagers' culture, decline of the moral quality and indifferent legal consciousness make the urban villages become a main obstacle of urbanization.

42.2.2.2 The Positive Impact of Urban Villages in Nanjing

In recent years, the phenomenon of "urban village" has gradually obtained our approval in the process of the urbanization in our country. It has played an important and irreplaceable role in support of the rapid and extensive urbanization and alleviating these problems such as a lack of physical materials and social structural problems.

1. Low cost of operation of urban system and creating opportunities for the villagers
The urban village could reduce the operation cost of urban social economy and the production cost of enterprises, alleviate the urban traffic pressure, reduce the urban total commuting costs and total commuting distance. It has played a important role as a "relief valve" in space and social conflicts to support the high-speed process of urbanization.

2. Improvement of the urban housing system
The urban village could meet the requirements of urban low income earners. And this king of living pattern is permanent, which is a more appropriate living mode for urban low-income people, making up the housing structural

imbalances in short of cheap housing. The urban village has become the main force of urban housing supply. To a certain extent, it could alleviate the social living contradiction, make the housing economic policy stable.

3. Social security and creating jobs
   The measure of regularized employment in the urban village has an irreplaceable role to made for solving large employment problem; The informal economy produced by the urban village in the system of the urbanization provides the social material guarantee for farmers lack of lands and provides employment opportunity with low threshold for migrant workers again obtain.
4. Temporarily maintaining social stability
   A survey about culture quality of urban villagers in Nanjing has shown that most of the villagers' cultural degree is elementary school or junior high school, whose ability of re-employment is low and income almost comes from the rental after losing land. In fact, village lands and things immovably attached to the land building are very important for urban villagers to maintain social stability. Especially during the period of the rapid expansion of urbanization, the rural stability and the stability of the villagers are very important for the rapid expansion of urbanization.

42.3 Spatial Evolution of Urban Villages in Nanjing

42.3.1 The Concept of the Urban Space Structure

The concept of urban space structure is that how to arrange urban public space reasonably. In addition, the methods of planning urban public space will affect many functions of the city, which can reflect the sustainability, accessibility, social fairness, security, cultural innovation, social capital and economic conditions of the environment of the city. The explanation in the economic geography is that the urban space structure is formed in a certain condition and development period, and a joint result of combination and distribution of all economic organization inside the city space.

42.3.2 The Spatial Structure Distribution of Urban Villages and Dilapidated Houses in Nanjing

42.3.2.1 Research Area

According to the statistical caliber, Nanjing is divided into two parts which is the city proper and the suburbs. And the suburbs includes five area of Yu Huatai, Qixia, Liuhe, Jiangning and Pukou, then the city proper includes six areas of Jianye, Baixia, Xiaguan, Qinhuai, Gulou and Xuanwu, a total of 39 townships and 75 street agencies, which has a total area of 4723 km^2. In the process of urbanization in Nanjing, there appears a large number of urban villages and dilapidated houses, both of which are decline and old corners of the urban development with bad landscape and rugged environment, bringing serious obstacles to local economic development. Therefore the research area of this paper is mainly urban villages and dilapidated houses of eight districts in Jiangnan of Nanjing.

42.3.2.2 Distribution of Urban Villages and Dilapidated Houses of Eight Districts in Jiangnan

According to the statistical data in 2012 of the comprehensive environmental control headquarters in Nanjing given in Fig. 42.1, urban villages and dilapidated houses of eight districts in Jiangnan have 45 urban villages and 133 dilapidated houses, which amount to 178. According to the chart, it can be concluded that Baixia area has the most of urban villages and dilapidated houses, and Xiaguan area takes second place of them, but Jianye area has the least of them. Apart from this, it can be seen from Fig. 42.1 that areas of dilapidated houses cover the most of the total area of Baixia area with the highest density, and Xiaguan area takes second

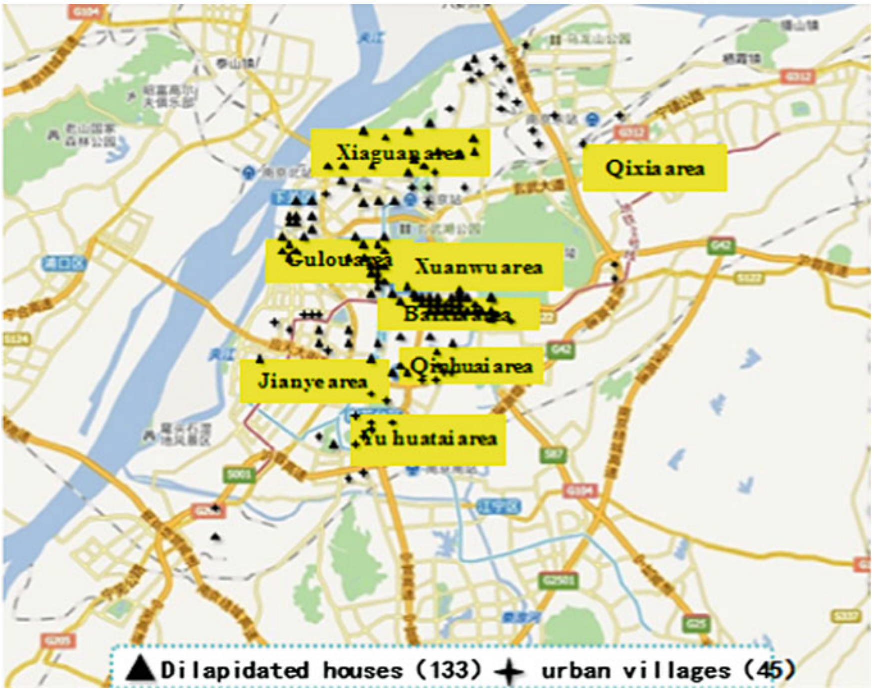

Fig. 42.1 Summary of dilapidated houses and urban villages of Nanjing

place. However, the areas of urban villages cover the most of the total area of Qixia area with the highest density, and Yu Huatai area takes second place.

In order to further analyse the distribution of the spatial structure of urban villages and dilapidated houses, this paper uses a type research methods of layers. But given the limitations of traditional methods, Nanjing could be divided into five layers:

Centered on Xin Jiekou, taking north-south direction for longitudinal axis and east-west direction for the horizontal axis, 178 urban villages and dilapidated houses are mapped in Google Earth villages and distribution, as shown in Fig. 42.2. Based on it, it is divided into I, II, III, IV four areas, each of which is divided into five layers of A, B, C, D, E. Circle A indicates the scope of less than 1 km from Xin Jiekou; Circle B indicates the scope of less than 3 km and more than 1 km from Xin Jiekou; Circle C indicates the scope of less than 6 km and more than 3 km from Xin Jiekou; Circle D indicates the scope of less than 9 km and more than 6 km from Xin Jiekou; Circle E indicates the scope of more than 9 km from Xin Jiekou. Shown in Fig. 42.3, the shadows stand for the density of urban villages. If the shadow is deeper, it means that the density of urban villages greater. According to Fig. 42.2, the number of urban villages and dilapidated houses of every region is counted up in Table 42.1.

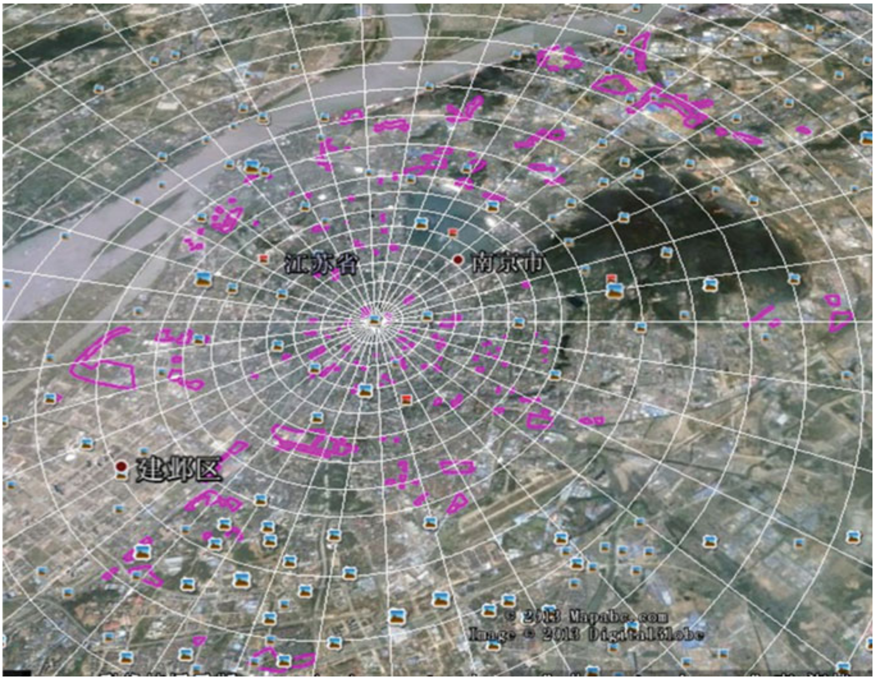

Fig. 42.2 A map of dilapidated houses and urban villages

Fig. 42.3 Geographic division of Nanjing

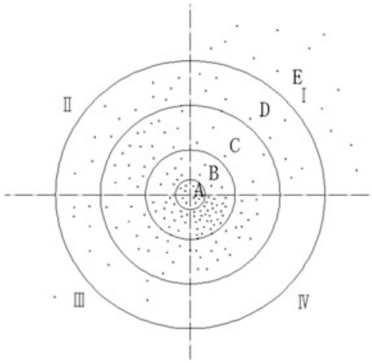

Table 42.1 Numbers of dilapidated houses and urban villages of every ring

	I	II	III	IV	Total
A (<1 km)	2	3	2	3	10
B (1–3 km)	4	7	15	32	58
C (3–6 km)	5	21	16	22	64
D (6–9 km)	12	12	8	0	32
E (>9 km)	13	0	1	0	14
Total	36	43	42	57	178

42.3.2.3 The Spatial Structure Distribution of Urban Villages and Dilapidated Houses of Eight Districts in Jiangnan

According to the number of urban villages and dilapidated houses for each circle of the Table 42.1, Figs. 42.2 and 42.3 above, all the eight districts in Jiangnan have a total of 178 urban villages and dilapidated houses. Among them, areas in the southeast for transformation cover the most number that is 57, which mainly are distributed within the scope of 1–6 km away from Xin Jiekou, relatively densely distributed in Baixia area; There are also more reconstructed areas in the northwest with a total of 43, which are distributed within the scope of 3–6 km away from Xin Jiekou, relatively in scattered distribution, mainly distributed in Xiaguan area; In addition, the number of urban villages and dilapidated houses in the southwest is total 42, which mainly are distributed within the scope of 1–6 km with scattered distribution, namely as Jianye area; A small number of plot is in the northeast is a total of 36 within far scope, mainly distributed in the northwest and north direction of Mount Zijin. In lateral view, most of urban villages and dilapidated houses are located in the scope of 1–6 km away from Xin Jiekou.

From the perspective of the distribution of spatial structure of urban villages and dilapidated houses, on the one hand, urban villages and dilapidated houses are far from Xin Jiekou as a bustling business quarter; On the other hand, they also are’t out of the city, which locate at the edge of urban and rural, showing cricoid intensive distribution in the sphere. But because of the terrain, such as Mount Zijin

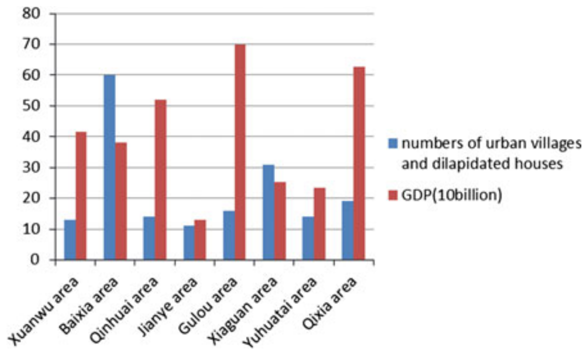

Fig. 42.4 Comparison between numbers and GDP of Nanjing in 2012

and Xuanwu Lake are distributed in the first area that cannot be used for residential land. Also urban villages will not be too close from the center because of factors such as land price. Therefore, most of urban villages and dilapidated houses are extended outward along the direction of Xin Jiekou—Mount Zijin and Xin Jiekou - Xuanwu Lake extend. In addition, the Yangtse River divides the second area into two parts in the northwest direction. Because of the terrain, more low-rent houses are distributed in the southeast of the Yangtse River rather than far suburbs.

From the point of the entire distribution, on the one hand, the distribution of the spatial structure of urban villages has close relation with the natural terrain; On the one hand, the distribution is related to the economic development of the city. Xin Jiekou is the most prosperous business district in Nanjing city, in which life, finance, insurance, intermediary and other modern service industry have developed fastly. While the employment structure of central area has changed gradually, it is hard for low-income people squeezed out with lack of specialized vocational skills and training to find a job in the center of the city area, which makes the center of the city area gradually become the exclusive area of white-collar workers. In addition, the transformation of function of urban structure makes the phenomenon of stratification of urban residential. What's more, the central business district (CBD) with comfortable and convenient living conditions attracted white-collar employees. However migrant workers' income is quite low and they can only choose the place far away from the center to live. So in a certain range, the farther away from the downtown, and the more the number of urban villages and dilapidated houses. Although the rent of further suburbs is cheap, there are fewer low-rent houses for the reason that traffic is not convenient.

From the point of development of Nanjing city, there is an obvious phenomenon of "strong center, the weak edge" in the long term. Shown in Fig. 42.4, urban villages and dilapidated houses are distributed in all eight districts in Jiangnan. And the number of Baixia area and Xiaguan area is in the majority. GDP data in eight districts in Jiangnan in 2012 showed that the annual gross domestic product of Gulou area is the highest of them. It shows that economic development level of the Gulou area is higher, Qixia area takes the second place. From the Fig. 42.4, it can be concluded that the higher is the economic development level, the fewer is the number of urban villages and dilapidated houses. The reason for this phenomenon is mainly related to the level of urbanization and economic development, and an enormous gap between the central gap and edge zone.

42.4 Conclusions and Recommendation

42.4.1 The Impact of Spatial Structure of Urban Villages and Dilapidated Houses on the Development of Nanjing City

42.4.1.1 The Impact on the Urban Economic and Cultural Development

Economic development depends on the labor force, and a large number of urban villages provide a stable home for migrant workers. Urban villages are distributed inside the ring far from the center, which not only have certain distance from the prosperous business circle, but also are not out of the city. It has both promoted the economic income of local residents and has brought more jobs for migrant workers. With the development of urbanization and diversified industry, while there exits a phenomenon of "strong center, the weak edge", but the existence of urban village has alleviated the severe form. On the aspect of culture, the distribution characteristics of urban villages and dilapidated houses result in collision and communion between the city and foreign culture, which will bring challenges to the inheritance of local culture. At the same time, It also can inject fresh blood into a drab urban culture.

42.4.1.2 The Impact on the Urban Morphology

Although space and urban form influences with each other, but in general, spatial pattern of urban village has more influence on the overall urban spatial pattern. On the contrary, the influence itself is smaller. From the perspective of the indicators of urban form, the impact of urban morphology on the urban village mainly reflects that urban villages have a lot of vitality and diversity which other urban communities do not have. It has put a certain pressure on the suitability of the city, which can effectively use lands and can guarantee a certain living condition to keep a relatively balanced living form where the distribution of internal interest is relatively fair. However the worse living environment is caused by reducing the cost of urbanization and neglected management, which actually shows the unfairness of urban form. It is a fatal problem to be solved, otherwise urban form will be affected, which is unfavourable for the sustainable development of city.

42.4.2 Suggestions on the Transformation of Urban Villages

Transformation of urban villages is a long process. In this long process, the main parts participating in the transformation of urban villages need to determine the function orientation in city space structure and formulate reasonable steady transformation strategy based on the actual situation of the urban villages and its urban geographical characteristics. In the period of function orientation of each urban villages, there are many factors needed to be taken account of such as the city spatial structure, the space distribution of the urban village, the situation of village economic structure, architectural landscape, traditional culture and so on. In conclusion, making a reasonable plan for transformation should take into account the actual situation of each urban villages.

Combined with the actual situation of Nanjing, it takes urban villages and dilapidated houses into the project of transformation. In the process of transformation, it especially is needed to consider the problem of historical and cultural relics based on the characteristics of the spatial structure distribution. For those urban villages in the scope of the ancient city ruins, the problem of the inheritance of traditional culture should be considered. After reconstruction of urban village, it couldn't make the Nanjing city architectural style in which the spatial pattern is not harmonious, thus losing the unique style of Nanjing city. The fundamental direction of development of urban village is the real urbanization. At the same time, it is important to plan the layout of urban spatial structure.

The problem of "Urban village" let us know that the reconstruction of urban village is an indispensable part in the process of urbanization in our country. In addition to considering the distribution of the characteristics of the urban space structure, in the process of transformation, we need to follow the principle of gradual improvement, pay attention to improving the quality of villagers and cultural construction, implement compensation and resettlement, and properly handle all aspects of interest relationship.

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Part IV
Affordable Housing

Chapter 43
Jobs-Housing Spatial Mismatch Condition in Public Rental Housing in Chongqing, China

Lizi Luo and Deheng Zeng

Abstract Public rental housing (PRH) is a significant new type of affordable housing in China. The government provides PRH to solve the housing problems of low- and moderate-income households. Jobs-housing spatial mismatch exists in PRH neighborhoods because of the spatial segregation of residential areas in the urban–rural fringes and jobs in the main urban area. This type of spatial imbalance has increased commuting costs, lengthened commuting distance, worsened traffic jams, and generated other problems. This study adopts a combined method of content analysis on literature, questionnaire survey, and face-to-face interviews to measure the extent of the spatial mismatch in PRH neighborhoods. Results indicate that public transport, especially rail transit, has obvious effects on the housing affordability and job accessibility of tenants. Moreover, a close spatial interaction between housing cost and transportation cost of PRH is lacking. This study provides valuable references to the policy-making process to reduce the effects of jobs-housing spatial mismatch on the tenants. The study likewise adds to the understanding of the spatial mismatch hypothesis in Chinese urban space.

Keywords Jobs-housing spatial mismatch · Public rental housing · Commuting · China

43.1 Introduction

Kain (1968) first formulated the spatial mismatch hypothesis (SMH). He argued that the spatial segregation between employment opportunities in the suburbs and low-skilled black residents in inner cities would hinder blacks from finding and

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retaining well-paid jobs (Kain 1968). His argument inspired abundant studies on the SMH. Most of these studies focused on the problem of the adverse labor market for blacks in U.S. cities (Jencks and Mayer 1990; Stoll 2006; Weinberg 2000). The spatial disconnection was considered the main cause of high unemployment, low wages, more poverty, and other social problems (Holzer 1991; Wheeler 1993; Gobillon et al. 2007). Moreover, the concept of spatial mismatch has been applied in the policy-making process of federal and local governments. These policies consequently improved the spatial mismatch condition through a series of urban development strategies.

While spatial mismatch has been extensively studied in western cities, this phenomenon is relatively new in China. The rising jobs-housing mismatch in Chinese cities has received growing attention in recent years. Zhou (2004) first pointed out the necessity of research on the SMH in China. Subsequently, Li and Wu (2006), Zheng et al. (2007), Liu and Luan (2005), and Ma and Yuan (2011) stated the feasibility of applying the SMH in urban planning, the affordable housing system, urban economics, and other fields. Liu and Weng (2008) indicated that the government should closely focus on low-rent housing tenants and other disadvantaged groups in the course of formulating welfare policies.

Few existing studies focused on the spatial mismatch of PRH program. Little is known about how and to what extent the spatial mismatch will influence the PRH residents. PRH is a new type of affordable housing initiated in 2009 to solve the housing problems of low- and moderate-income households. The 12th Five-year Plan declared that 36 million affordable housing units would be completed from 2011 to 2015. A series of policies have stimulated the large-scale construction of PRH neighborhoods. For instance, the Chongqing municipal government has planned 21 PRH residential districts (Shi and Meng 2013), with a total of 20 million square meters. By the end of 2012, 80,000 households had moved to PRH in Chongqing.

However, while numerous PRH projects are located in urban–rural fringes, most of the jobs remain in the main urban area, causing the spatial segregation of jobs and residence. This phenomenon appears in major cities of China. Wang et al. (2011) assessed the changing jobs-housing relationship in Beijing based on three years of statistical data. Zhou et al. (2013) investigated two typical low-income housing neighborhoods in Guangzhou and analyzed the impact of spatial mismatch on local residents. However, little theoretical or practical attention has been given to the spatial mismatch of this new type of affordable housing.

The current paper aims to fill this knowledge gap by measuring the extent of the spatial mismatch in PRH neighborhoods. It also adds to the understanding of the SMH in Chinese urban space. Policy suggestions are proposed from the perspective of reducing the effects of spatial mismatch in PRH neighborhoods.

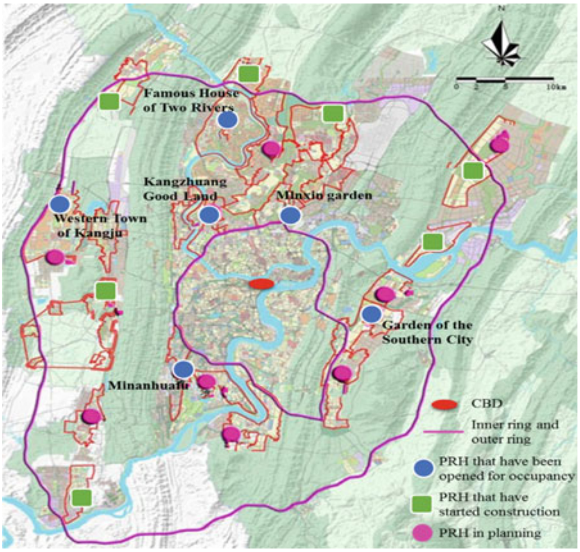

Fig. 43.1 Spatial layout of PRH neighborhoods in Chongqing

43.2 Spatial Layout of PRH Neighborhoods in Chongqing

Chongqing, one of the four municipalities in China, has incorporated 21 districts in the PRH construction. Of the 21 districts, 14 have been constructed. Among the 14 districts, six PRH neighborhoods have been opened for occupancy, including Minxin Garden, Kangzhuang Good Land, Minanhuafu, Famous House of Two Rivers, Western Town of Kangju, and Garden of the Southern City. PRH neighborhoods in Chongqing are located between the inner and outer rings, with a few communities lying on the edge of inner ring (see Fig. 43.1). The overall layout of PRH is remote from the central city.

The six neighborhoods that have been opened for occupancy are all near the inner ring (see Table 43.1).

43.3 Research Methods and Data

This study adopted a combined method of content analysis on literature, questionnaire survey, and face-to-face interviews.

Table 43.1 Traffic conditions of PRH neighborhoods that have been opened for occupancy

	Number of bus lines	Rail transit	The distance from the nearest rail transit station (m)	The distance from mail urban area (km)	The distance from the nearest deputy city center (km)
Minxin garden	8	Opened up	600	14.5	11.4
Kangzhuang good land	6	Opened up	120	16.5	7.0
Minanhuafu	5	2016	400	26.5	15.2
famous house of two rivers	3	2013	1100	33.6	26
Western town of Kangju	5	2013	3500	40	12.1
Garden of the southern city	4	2013	500	16.7	4.3

43.4 Spatial Mismatch Measurement: Affordability Index

In 2008, the Center for Transit Oriented Development of the United States proposed the affordability index as a tool for measuring the true affordability of a housing choice. The affordability index (AI) is calculated as the sum of average housing costs plus the average transportation costs for a neighborhood, divided by average neighborhood income (Center for Transit Oriented Development 2008). The calculated results are divided into four levels, namely, less than 35 %, 35–50 %, 50–65 %, and above 65 %, which imply good, general, poor, and very poor, respectively.

The current study mainly used HAI and THAI combined with commuting distance and commuting time to measure the extent of the spatial mismatch of the surveyed neighborhoods. The basic calculation formulas are as follows:

$$\mathrm{HAI} = \mathrm{HC}/\mathrm{INC}$$
$$\mathrm{THAI} = (\mathrm{HC} + \mathrm{TC})/\mathrm{INC},$$

where HC denotes the housing costs, TC denotes the transportation costs, and INC denotes household disposable income. High HAI and THAI indicated that the housing choice is less affordable.

43.5 Data Collection

Basic data in this study were collected from the questionnaire survey conducted from May 2012 to August 2012. Only three PRH neighborhoods of Chongqing (i.e., Minxin Garden, Western Town of Kangju, and Garden of the Southern City) that had been opened for occupancy were selected to complete the research due to limited time and data accessibility. 481 households that were selected randomly from the three neighborhoods completed the questionnaires. Data content included personal and family attributes, cost of living, commuting time and costs, etc. GIS technology and SPSS were used in the statistical analysis process.

43.6 Respondent Introduction

Minxin Garden is located in Yubei District. As the nearest PRH neighborhood to the main urban area as well as the first PRH project in Chongqing, Minxin Garden is adjacent to the airport highway and Yuyi expressway. The station is 600 m away from the west of Minxin Garden. A total of 16,000 households have moved into Minxin Garden until the survey. Western Town of Kangju is located in Xiyong Area in Shapingba District, close to the university town and Xiyong microelectronics industrial park. Rail Transit Line 1 station is located 3500 m away on the south side of Western Town. Rail Transit Line 13 station is planned at the gate of the neighborhood. A total of 2060 households have moved to Western Town of Kangju. Garden of the Southern City is the largest PRH neighborhood of Chongqing. The PRH is located in Chayuan Area in Nanan District. Two stations of Rail Transit Line 6500 and 700 m away will be built in the area. A total of 5958 households have signed contracts to live in the Garden of the Southern City. The proportion of surveyed households from these three PRH neighborhoods is 279:93:90.

Population structure of residents in PRH neighborhood.

The questionnaire involves three kinds of background information of surveyed residents, including age, level of education, and monthly family income (see Table 43.2).

43.7 Living Cost

The rent per square meter of PRH varies from RMB 8 to RMB 11 per month. The interval of the construction area mainly ranges from 30 to 50 m^2. Only a few housing types have areas of more than 60 m^2. Most of the tenants have a lower living cost than before (see Table 43.3). The living cost mainly decreased from 10 to 20 %, followed by 0–10 %.

Table 43.2 Background information of surveyed residents

		Minxin garden	Western town of Kangju	Garden of the southern city
Average age		38	33	34
Level of education		Mainly high school, college and university oriented	Mainly college and university oriented	Mainly college and university oriented
Income structure	Per capita monthly income(RMB)	2056	1933	1824
	Total family income (RMB)	4531	4256	4375

Table 43.3 Basic information about the living cost of the surveyed residents

		Minxin garden	Western town of Kangju	Garden of the southern city
Average cost of living of the family (rent) (yuan per month)		413	395	386
Proportion of cost of living to monthly family income after moving in PRH	Rise	12 %	5 %	8 %
	Fair	25 %	18 %	16 %
	Fall	63 %	77 %	74 %

43.8 Commuting Condition

In the face-to-face interviews with the respondents of PRH, several tenants reflected that they relied on buses except for Minxin Garden, which has a rail transit (see Table 43.4) (The rail transit near West Town of Kangju and Garden of the Southern City had not been completed at the time of the survey in 2012. The expected completion was in 2013.) The residents generally complained that their commuting costs and commuting time have increased considerably after moving into PRH communities. The commuting cost growth varied from 30 to 40 %. Commuting cost decreased from 50 to 30 % compared with the time of the survey because of the implementation of one hour free and transfer benefits in January 2013.

Table 43.4 shows that the cost of living of PRH tenants has decreased slightly, but the commuting cost has increased. Although PRH has no obvious advantage compared with the market rental room, people still choose to move to PRH. The reasons mainly include (1) the instability of the leases of market rental housing, and the number of houses is less than PRH; (2) the living cost does not increase significantly, but the living environment can improve substantially; (3) according to the related policies, the PRH units can be sold to the tenants after a five-year occupancy, and the rent paid previously can be used to offset the housing price.

Table 43.4 Basic information on the commuting condition of surveyed residents

		Minxin garden (%)	Western town of Kangju (%)	Garden of the southern city (%)
Commuting distance	0–5 km	3	2	5
	5–20 km	83	65	72
	>20 km	14	33	22
Commuting time	0–1 h	36	11	10
	1–2 h	45	58	62
	>2 h	18	31	28
Commuting tools	Walk	–	–	–
	Bus	46	92	90
	Rail transit	48	–	–
	Others	6	8	10
Commuting cost	RMB 100–RMB 200 per month	6	4	4
	RMB 200–RMB 500 per month	68	57	54
	RMB 500–RMB 1000 per month	26	39	42

43.9 Survey Results and Analysis

The calculated results indicated that THAI of Minxin Garden, Western Town of Kangju, and Garden of the Southern City are 22, 27, and 26 % respectively (see Fig. 43.2).

The average THAI of urban households in Chongqing from 2002 to 2010 ranged from 30 to 40 %. Within this period, the THAI level of Chongqing is significantly higher than that of the PRH neighborhood. This phenomenon indicated that PRH neighborhoods can effectively reduce the transportation and housing cost of tenants.

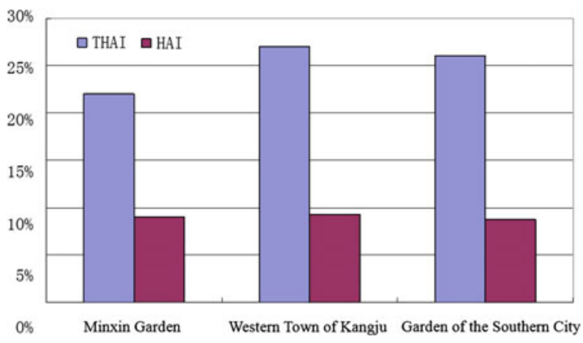

Fig. 43.2 HAI and THAI of PRH neighborhoods

In terms of HAI, none of the three calculated results exceeded 10 %. An allocation of 25 % of household disposable income per month for cost of living is acceptable. Therefore, the living cost of PRH districts is attractive for the tenants.

The distance between residence and employment increased significantly after moving into PRH neighborhoods. The distance of the PRH from the city center, such as Minxin Garden increased from 9.6 to 11.5 km, Western Town of Kangju increased from 8.6 to 12.3 km, and Garden of the Southern City increased from 8.4 to 14.5 km, suggesting that the majority of the inhabitants in the current neighborhoods increased their commuting distance and most remained at the current levels of long commutes. Only a few tenants shortened the distance through changing jobs. Compared with the average commute distance of 10.5 km in the urban area of Chongqing, the commuting distance of PRH is basically within the psychologically acceptable range of most respondents, but obviously higher than the average level in the main area. Viewed from the commuting time, the average commuting time increases as a result of increasing commuting distance. The commuting time of Minxin Garden increased from 56 to 70 min, Western Town of Kangju increased from 61 to 83 min, and Garden of the Southern City increased from 64 to 92 min. The commuting time of Western Town of Kangju and Garden of the Southern City was definitely higher compared with the 60–70 min in the urban area of Chongqing.

In sum, Minxin Garden is located beside the rail transit station. This convenient location results in the shortest commuting distance and commuting time among the surveyed neighborhoods. The other two neighborhoods are farther from the rail transit station, and their dwellers have to take bus transfer in daily travel, thus increasing the commuting costs and commuting time. Moreover, THAI and the spatial mismatch condition of Minxin Garden are at a better level than other two neighbourhoods. Similar living cost and different locations are considered the main cause of differences in THAI and spatial mismatch conditions of the three neighborhoods.

43.10 Conclusion and Discussion

The rising jobs-housing mismatch has adversely influenced Chinese urban development and urban life, including long commuting distance to jobs, increased commuting time, as well as worsened traffic jam and pollution. This type of spatial mismatch is similar to that found in western cities.

This study applied the concept of spatial mismatch in PRH neighborhoods in Chongqing. The findings suggested that public transport, especially rail transit, has an obvious effect on the housing affordability and job accessibility of PRH tenants. Moreover, a close spatial interaction between housing cost and transportation cost of PRH is lacking.

This study provides valuable references for the policy-making process to reduce the effects of jobs-housing spatial mismatch on PRH tenants. First, determining whether the rail transit station should be adjacent or not should be significantly considered in the site selection of PRH neighborhoods. Second, reducing transportation cost and providing sufficient jobs nearby for the residents should be considered during PRH construction. Third, THAI of PRH program is a reference indicator for policymakers to regularly adjust the rents.

Although this study focused on Chongqing, it can provide insights into the large-scale construction of PRH districts in China because PRH neighborhoods are constructed in a similar pattern. This study likewise adds to the understanding of the spatial mismatch hypothesis in Chinese urban space. Further research can investigate more practical cases for a more detailed analysis of the jobs-housing spatial mismatch in Chinese neighborhoods.

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Chapter 44
Qualitative Effect Analysis of Chinese and South Korean Housing Policies: Taking the Policy on Stimulating Market, Stabilizing Price and Refraining Speculation as Examples

Hyungu G. Roh and Cifang F. Wu

Abstract The aim of this study is to numeralize and calculate indicators of stimulating market and stabilizing housing price, refraining speculation policies issued between 1998 to 2009 in China and Korea, and then to compare and determine implementation effects of these two housing policies based on the change of indicators. Qualitative research method, comparative analysis and descriptive statistic method were employed and the following main conclusions were obtained: (1) before 2008, the stimulating housing market policies of Chinese and Korean had effects on completed housing area, traded area and completed home unit rate; (2) from 2005 to 2006, in order to stabilize housing price and refrain speculation, the housing policy adopted by China government had effects on the housing trading price and selling price of residential land of Shanghai, subsequently, policy effect gradually disappeared; (3) from 2002 to 2004 and after 2007, the housing policy adopted by Korea government had effects on the housing trading price and selling price of residential land of Seoul as well; (4) during the same period, Chinese and Korean government used different policy means to cope with problems.

Keywords Land economy · Housing policy · Qualitative analysis · Effectiveness evaluation

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44.1 Introduction

Chinese economy is developing rapidly. With fast urbanization process, urban population boom, and changes in family structure, it is urgent to resolve housing problem in the city. In recent years, China's commercialized housing market has changed greatly under influence of the market environment and many government housing policies, and external environment risks showed increasing trend.

China and Korea are neighboring countries. They have some similar culture and traditions. However, because of different social system, their housing policies were very different in the past. China started commercialized housing system in 1998 and the housing marketization degree has been increasing, causing more and more attention to the housing problem and related housing policy. Meanwhile, Korea experienced the similar problem in its housing market as that in China after the Asian financial crisis in 1997. Comparative study on the differences and similarities of housing policy between these two countries and learn from each other, is beneficial to solve the housing problem, and to promote development of national housing policy.

Huang argued that, since the housing system reform in 1998, China had launched a series of policies to regulate financial credit of the housing market. Lifting the restriction on financial credit boosted investment in the real estate market, pushing housing price and economy up constantly. Among them, interest rate and macro-economy had significant influences on the housing price in Shanghai (Huang 2009). Pan studied the influence of housing policy on controlling housing price from three aspects, including real estate financial policy, administrative policy and fiscal policy, and gave some advices on formulation of the policy in China (Pang 2008). Thus, previous researches in China mainly focus on the influences of land policy, financial policy and macro-economic policy on housing price.

Kwak pointed out that, from January 1987 to July 2004, the housing price in Korea had four intensifying change stages and six decreasing change stages. He also compared periods of the housing price fluctuation and implementation of the real estate policy (Kwak and Lee 2006). The study on the effect analysis system of real estate policy (Lee 2005) and the influence of real estate policy on national economy (Kim 2007), are both studies on spread effect of formulating and abolishing the real estate policy. While the study on the influence of real estate policy on housing price centered on real estate policy itself (Oh 2006). Previous researches in Korea paid more attention to the influence of housing policy on the housing market and the housing policy itself. Meanwhile, they integrated qualitative and empirical research methods to discuss mechanism of the influence of housing policy on the housing market.

Therefore, this study selected two metropolises, Shanghai, China and Seoul, Korea. By qualitative analyzing the housing policies that have been released in China and Korea, clarifying the differences and similarities, and offering advice on formulating and optimizing the housing policies in the future.

44.2 Effect Analysis Framework of Housing Policy

According to the research of Dunleavy and O'Leary (1987) classifying housing policy to category 1 and category 2[1], this study classified housing policy to two categories as stimulating policy and stabilizing housing price, refraining speculation policy. Housing market stimulation policy refers to the policy that will increase market demand and supply. Generally, policy increasing market demand is mainly tax policy and credit, loan adjusting policy. Due to difficult to directly assess its effect on goal realization, this study adopted ROC (rate of change) of completed housing area, which indicates the changes in the supply and demand of the housing market, as the indicator of housing market stimulation policy (Weimer and Vining 1992). Meanwhile, to further specify the possible influence of increasing market supply on the demand of the housing market, ROC of traded area and completed home unit rate were adopted as the impact indicators assessing the goal realization of the housing market stimulation policy.

Housing price stabilizing and speculation refraining policy refers to the policy that stabilizes housing market price by refraining unnecessary demand. Therefore, this study adopted ROC of housing trading price as the indicator assessing the goal realization. Meanwhile, to further specify the possible influence of refraining demand on the supply of the housing market, the study adopted ROC of selling price of residential land and ROC of trade volume of residential land as the impact indicators assessing the influence of the housing price stabilizing and speculation refraining policy on the goal realization (see Table 44.1).

Therefore, the housing policy assessment indicators in this study were based on efficiency criteria. Calculated the effect indicators of the housing policies issued by Chinese and Korean. government to obtain general data, and then judged the effect of housing policy according to changes of the effect indicators in a certain period of time (Lee 2004).

Table 44.1 Indicator and impact indicator on the goal realization of assessing the influence of housing policy

Policy	Indicator and impact indicator on the goal realization	
	Indicator	Impact indicator
Stimulation policy	ROC of completed housing area	– ROC of traded area
		– Completed home unit rate
Stabilizing housing price and refraining speculation policy	ROC of housing trading price	– ROC of trade volume of residential land
		– ROC of selling price of residential land

[1]Category 1: The laws and regulations made by the legislation for the development and stability of society, which play the role of maintaining the stability and the traditional ethics and value of the nation. Category 2: By intervening the economy system, the policy plays a role of providing assets to citizens by means of regulating production, limiting private assets and redistributing income that are different from market economy.

44.3 Goal Realization Assessment Method and Data Collation

Judgment on the goal realization of housing market usually depends on comparing the indicators before and after implementation of the policy, i.e., assessing the difference of the indicator before and after the day of releasing or implementing policy. If there is any difference, it is deemed that the policy is effective. Under the circumstances of adopting comprehensive policies, it is unable to control the mutual influences completely. Different indicators assess the goal realization of different policies and the meaning of each indicator is different, therefore, these assessment indicators are independent from each other to some degree. Data sources for effect analysis showed in Table 44.2.

44.4 Results

44.4.1 Housing Policy Effect Analysis of Shanghai, China

44.4.1.1 Housing Market Stimulation Policy of Shanghai

From 1998 to 2009, affected by Asian financial crisis in 1997 and by American subprime mortgage crisis in 2008, Chinese government released housing market

Table 44.2 Date sources for effect analysis

Indicator	Unit	Time period of time	Sources
ROC of completed housing area	10,000 m^2	1998–2009	Statistical annual of Shanghai
	Household	1998–2009	Ministry of Land and Marine, Korea
ROC of traded area	10,000 m^2	1998–2009	Statistical annual of Shanghai
	Household	1998–2009	Ministry of Land and Marine, Korea
Completed home unit rate	%	1998–2009	China Statistical Bureau
	%	1995–2010	Korea Statistical Bureau
ROC of housing trading price	RMB/m^2	1998–2009	Statistical annual of Shanghai
	RMB/m^2	1998–2009	Statistical annual of Seoul
ROC of trade volume of residential land	10,000 m^2	1998–2009	www.soshoo.com
	10,000 m^2	1998–2009	Ministry of Land and Marine, Korea
ROC of selling price of residential land	RMB	1998–2009	www.soshoo.com
	WUAN	1998–2009	Ministry of Land and Marine, Korea

simulation policy twice. To conquer the crisis and maintain the continuous development of national economy, the housing market stimulation policy of Chinese government became an important approach to simulate national economic development.

From 1998 to 2001, both the completed housing area and the traded area of Shanghai showed rising tendency. Thus, it can be deduced that the housing policy stimulating the market during this period had influence on the indicators. Affected by American subprime mortgage crisis in 2008, the completed housing area and the traded area of Shanghai reduced by 33.21 and 40.05 % respectively compared with that in previous year. The completed housing area kept decreasing in 2009, but the traded area kept increasing. The traded area was about twice higher than the completed housing area in 2009. Therefore, the policy did not impose any influence on the completed housing area, but increased traded area. Both the two housing market stimulation policies were targeted to home buyers and the housing market changed correspondingly.

The completed home unit rate of Shanghai increased from 65.4 % in 1998 to 87.4 % in 2002, increasing by 22 % in five years, which was resulted from huge housing supply, active trade of the actual housing owners, and housing reform policy that had been implemented by the government of Shanghai. Then the completed housing area grew rapidly from 2003 to 2004, and the completed home unit rate increased from 92.3 to 92.5 %. By the end of 2009, this figure only increased by 3.1 % in five years, which was not only because the housing supply kept reducing from 2008 to 2009, but also because more immigrants entered Shanghai, causing the number of households to increase.

The implement of stimulation policy on housing market of Shanghai, China and the assessment results of the goal realization from 1998 to 2009[2] showed in Table 44.3.

44.4.1.2 Stabilizing Price and Speculation Refraining Policy of Shanghai

With fast increasing of the price, housing problem has gradually become a social problem. Against the background, Chinese government started releasing housing policy that stabilized housing price and refrained speculation in 2001. To assess the effects of such policy, this study analyzed ROC of housing trading price, ROC of selling price of residential land and ROC of trade volume of residential land in Shanghai before and after implementation of the policy. Since the municipal government of Shanghai controlled selling residential land volume and time, it is difficult to assess effect of the policy by comparing the related indicators before and

[2]Hyungu Roh. A Comparative Research on Chinese and Korean Housing Policy and Their Influence on Housing Price—Taking Shanghai, China and Seoul, Korea as Examples [D]. Dissertation for Doctoral Degree of Zhejiang University, 2012, Chapter III.

Table 44.3 The implement of stimulation policy on housing market of Shanghai and assessment results of its goal realization

Year	Month	Stimulation Policy										Indicator		Impact indicator			
		Policy means										Completed housing Area (10,000 m^2)		Traded Area (10,000 m^2)		Completed home unit rate (%)	
		A	B	C	D	E	F	G	H	I	J	Pre	Post	Pre	Post	Pre	Post
98	4		1			1						1963.51	1731.55	1056.77	1243.30	65.4	69.7
	5	1										–	–	–	–	–	–
	7									1		–	–	–	–	–	–
99		1										1731.55	1724.02	1243.30	1445.87	69.7	74.0
	12				1							–	–	–	–	–	–
00	1					1						1724.02	1743.90	1445.87	1681.47	74.0	85.7
01	2				1							1743.90	1880.50	1681.47	1846.38	85.7	87.4
08	10			1	1							1899.40	1522.07	1965.86	2928.04	95.2	95.6
	10	1										–	–	–	–	–	–
	12				1							–	–	–	–	–	–
09	5					1						1522.07	–	2928.04	–	95.6	–

Note Policy means A, B, C refer to financial policy, including housing loans, finance support, down-payment; D, E, F, G, H, I, J refer to administrative policy, including tax, building housing, land, reconstruction of old area, vacant housing, trade term and comprehensive means. See detail information at Hyungu Roh. A Comparative Research on Chinese and Korean Housing Policy and Their Influence on Housing Price—Taking Shanghai, China and Seoul, Korea as Examples [D]. Dissertation for Doctoral Degree of Zhejiang University, 2012, Chapter III. Same in Tables 44.4–44.6

after implement of the policy. While land selling price is related to the selling behavior, so the study compared residential land selling prices of different years to assess the goal realization of such policy. The results showed that ROC of housing trading price of Shanghai had little influence on the ROC of residential land selling price while had certain influence on the ROC of trade volume of residential land.

In addition, comparing the ROC of housing trading price and ROC of selling price of residential land from 2002 to the first half of 2008, it can be found that both the ROCs in 2002 and 2004 went up, which may be because housing price stabilizing and speculation refraining policy failed to affect housing trading price and residential land selling price of Shanghai. However, in the following 2005 to 2006, both the ROCs went down, inferring that the related policy did not play the expected role. In 2007, the two ROCs went up again, inferring that it was caused by gradually fading effect of the policy carried out before. In 2008, ROC of housing trading price went down again, which may be resulted from stagnation of the real estate economy caused by the financial crisis in the U.S. and other reasons. However, the residential land selling price went up, which may be resulted from reduced land supply. The trade volume of residential land in 2007 decreased by 53.93 % compared with that in previous year which may be triggered price going up.

The ROC of trade volume of residential land kept going down from 2002 to 2007, which may be because the housing price stabilizing and speculation refraining policy implemented during this period imposed influence on the change of trade volume of residential land. Meanwhile, rise of the trade volume of residential land in 2008 might be a bounce resulted from constant decrease of the trade residential land volume in the past six years.

The implement of stabilizing housing price and speculation refraining policy of Shanghai, China and the assessment results of the goal realization showed in Table 44.4.

44.4.2 Housing Policy Effect Analysis of Seoul, Korea

44.4.2.1 Housing Market Stimulation Policy of Seoul

From 1998 to 2009, affected by Asian financial crisis in 1997 and American subprime mortgage crisis in 2008, Korean government also released housing market simulation policy to conquer the crisis and maintain the continuous development of national economy. To assess the effect of policy, this study analyzed the changing trend of completed housing area, traded area and completed home unit rate in Seoul during this period. However, there had no data of the traded housing area before 2006 in Korea, but only data of the traded area of residential land. Therefore, the data of traded housing area before 2006 in Korea was actually the data of traded residential land area. Meanwhile, there had no term of completed home unit in Korea. This study analyzed the home ownership rate in Korea, which is similar to

Table 44.4 The implement of stabilizing housing price and speculation refraining policy on housing market of Shanghai and assessment results of its goal realization

Year	Month	Stabilizing price and speculation refraining policy										Indicator		Impact indicator			
		Policy means										Housing price (RMB/m^2)		ROC of selling residential land price (%)		ROC of trade volume of residential land (%)	
		A	B	C	D	E	F	G	H	I	J	Pre	Post	Pre	Post	Pre	Post
01	3						1					671	676	−7.8	11.0	3728.89	3393.05
	4									1		676	687	–	–	–	–
02	7						1					782	794	11.0	22.2	3393.05	3149.21
	8						1					794	807	–	–	–	–
03	6	1		1								953	996	22.2	29.4	3149.21	2888.28
	7				1							996	1013	–	–	–	–
	8					1						1013	1038	–	–	–	–
	9						1					1038	1058	–	–	–	–
04	3						1					1162	1184	29.4	5.4	2888.28	2640.94
	4			1								1184	1201	–	–	–	–
	7									1		1219	1233	–	–	–	–
05	3	1								1		1412	1440	5.4	-0.5	2640.94	1987.06
	3										1	–	–	–	–	–	–
	4										1	1440	1456	–	–	–	–
	5					1				1		1456	1456	–	–	–	–
	5				1							–	–	–	–	–	–
	10				1							1341	1311	–	–	–	–
06	5										1	1276	1290	−0.5	4.4	1987.06	915.42

(continued)

Table 44.4 (continued)

Year	Month	Stabilizing price and speculation refraining policy										Indicator		Impact indicator			
		Policy means										Housing price (RMB/m^2)		ROC of selling residential land price (%)		ROC of trade volume of residential land (%)	
		A	B	C	D	E	F	G	H	I	J	Pre	Post	Pre	Post	Pre	Post
	5											–	–	–	–	–	–
	7									1		1288	1295	–	–	–	–
	7				1							–	–	–	–	–	–
	8						1					1295	1300	–	–	–	–
	12						1					1306	1305	–	–	–	–
07	6									1		1340	1495	4.4	6.9	915.42	952.66
	9			1								1577	1696	–	–	–	–
	12	1										1847	1878	–	–	–	–
08	1						1					1878	1885	6.9	2.9	952.66	866.99
	2									1		1885	1899	–	–	–	–
	4			1								1923	1947	–	–	–	–
09	6			1								3041	3195	2.9	–	866.99	–
	11						1					3963	4184	–	–	–	–
	12				1							4184	4200	–	–	–	–

the completed home unit rate in China. In order to make the concept unified, traded area and completed home unit rate were actually used in article.

From 1999 to 2001, both the completed housing area and the traded area rose significantly. However, both figures went down from 2008 to 2009, in which completed housing area decreased by 223 and 25.6 %, while traded area decreased by 5.89 and 9.76 % respectively. The housing market stimulation policy carried out by Korean government made the completed housing area and the traded area change during Asian financial crisis in 1998 as the government wished. However, the policy failed in 2008.

The completed home unit rate of Korea increased from 70.8 % in 1998 to 72.9 % in 2001, increasing by 2.1 % in four year, the yearly increase rate was only 0.5 %. Afterwards, the government built a large amount of houses from 2000 to 2001, making the completed home unit rate increase from 72.9 % in 2001 to 82.4 % in 2002, increasing by about 10 % in one year. It indicated that the housing market stimulation policy carried out by Korean government during this period played its expected role. After then, the completed home unit rate reached its peak to 94.7 % in 2006 and then went down to 93.6 % in 2008 and 93.1 % in 2009, which may be related to constant decrease of completed housing area during the period and increase of the households that only had 1 or 2 persons in Seoul.

The implement of stimulation policy on housing market of Seoul, Korea and the assessment results of the goal realization from 1998 to 2009 showed in Table 44.5.

44.4.2.2 Stabilizing Price and Speculation Refraining Policy of Seoul

Comparing the ROC of housing trading price and selling price of residential land from 2002 to 2007, it can be found that both the ROCs from 2002 to 2004 went down, which may be because the housing price stabilizing and speculation refraining policy carried out during this period played its expected role. However, from 2005 to 2006, both the ROCs went up, inferring that it was caused by gradually fading effect of the policy carried out before. From 2007 to 2008, both the ROCs went down again, which may be resulted from poor national economy of Korea and sluggish caused by American financial crisis then. From 2002 to 2008, the ROC of selling price of residential land was relatively stable compared to the ROC of housing trading price, which infers that the speculative force influencing the housing price in Seoul did not impose significant influence on land market.

From 2002 to 2007, the ROC of trade volume of residential land in Seoul went up and down repeatedly. While the ROC of housing trading price and the ROC of selling price of residential land kept similar fluctuation level from 2000 to 2009, which infers that housing price stabilizing and speculation refraining policy implemented during this period imposed influence on both impact indicators. The housing price and the land supply amount in Seoul were also closely related.

The implement of stabilizing housing price and speculation refraining policy of Seoul, Korea and the assessment results of the goal realization showed in Table 44.6.

Table 44.5 The implement of stimulation policy on housing market of Seoul and assessment results of its goal realization

Year	Month	Stimulation Policy										Indicator		Impact indicator			
		Policy means										Completed housing Area (10.000 m²)		Traded area (10,000 m²)		Completed home Unit Rate (%)	
		A	B	C	D	E	F	G	H	I	J	Pre	Post	Pre	Post	Pre	Post
98	5				1		1			2		2159	2149	10,587	10,327	–	–
	6		1					1				2149	935	10,327	12,682	–	–
	9		1									1772	3190	16,335	12,326	–	–
	12				1							4874	4739	30,719	11,768	–	–
99	3		1									1657	6916	19,958	18,096	70.8	71.5
	8		1									4044	5145	18,413	16,629	–	–
	10									1		2836	9865	19,194	19,002	–	–
00	1	1										2563	3339	14,596	17,064	71.5	72.0
	7		1									9714	8281	15,307	16,183	–	–
	8				1							8281	18,588	16,183	15,408	–	–
	11				2	1						5959	8649	20,828	16,424	–	–
08	6	1										5053	4388	22,396	18,273	93.6	93.1
	8				1				1			2409	1522	11,324	9553	–	–
	10		1						1			1521	1603	9991	6236	–	–
	11							1		1		1603	6022	6236	7621	–	–
09	1						1					764	1852	6293	8617	93.1	–
	2				1							1852	1256	8671	11,023	–	–
	3				1							1256	1812	11,023	14,018	–	–
	4				1							1812	3359	14,018	14,925	–	–

Table 44.6 The implement of stabilizing housing price and speculation refraining policy on housing market of Seoul and assessment results of its goal realization

Year	Month	Stabilizing price and speculation refraining policy										Indicator		Impact indicator			
		Policy means										Housing trading price (RMB/m^2)		ROC of selling price residential land (%)		ROC of trade volume of residential land (%)	
		A	B	C	D	E	F	G	H	I	J	Pre	Post	Pre	Post	Pre	Post
01	5				2							1.1	1.3	3.150	2.420	2782	2971
02	1				1							3.7	3.3	3.150	2.420	2782	2971
	3									1		2.7	1.2	3.150	2.420	3750	3811
	8				1			1				2.6	3.3	5.440	4.400	2733	3580
	9					1						3.3	0.4	5.440	4.400	3530	3468
	10				1							0.4	−0.2	4.400	0.290	3468	3098
03	1					1				1		−0.7	0.4	0.290	0.450	1622	2538
	5	1								1		1.6	0.6	0.450	1.880	3251	4637
	9				1			1				1.5	1.5	1.880	2.310	2843	3513
	10	1			1							1.5	−0.6	2.310	2.010	3513	4312
04	1									1		−0.2	0.5	2.010	0.910	1735	2487
05	2							1				0.6	0.3	0.117	0.375	2578	2268
	5				2			1				0.6	1.4	0.549	1.234	2578	2268
	6	1										1.4	1.4	1.234	0.445	2268	2105
	8										1	0.4	0.4	0.733	0.194	3070	2285
06	3	1				1		1				1.2	1.5	0.829	0.761	2639	2642
	11	2										4.8	3.0	0.893	0.822	3930	3557
07	1	1								2		1.5	0.4	0.523	0.479	2183	1502
	9	1			1	1						0.4	0.4	0.491	0.568	1532	2014

44.5 Conclusion

44.5.1 Housing Policy Effect Analysis of Shanghai and Seoul

44.5.1.1 Similarities of the Housing Market Stimulation Policy of Shanghai and Seoul

In the early years, both housing market stimulation policies of Chinese and Korean government imposed influence on the completed home unit rate of Shanghai and Seoul. Nevertheless, the policy with the same goal implemented in 2008 did not impose the expected influence.

44.5.1.2 Differences of the Housing Market Simulation Policy of Shanghai and Seoul

In the early years, the housing market stimulation policy carried out by the government of two countries imposed influence on the completed housing area and traded area of Shanghai and Seoul.

Affected by the financial crisis in 2008, both the completed housing area and traded area in Shanghai and Seoul went down. Except for traded housing area in 2009 of Shanghai, the completed housing area of two cities showed a decreasing tendency from 2008 to 2009. That is to say, the housing market stimulation policy implemented by the government of two countries did not impose influence.

44.5.1.3 Similarities of the Housing Price Stabilizing and Speculation Refraining Policy of Shanghai and Seoul

Comparing the changes in the traded volume of residential land before and after the implementation of policy, it can be found that both the housing price stabilizing and speculation refraining policies of two countries imposed their expected influence on the traded volume of residential land from 2002 to 2007 for Shanghai and Seoul.

44.5.1.4 Differences of the Housing Price Stabilizing and Speculation Refraining Policy of Shanghai and Seoul

Comparing ROC of housing trading price and selling price of residential land of Shanghai and Seoul from 1998 to 2009, it can be found that both the ROCs of Shanghai went up from 2002 to 2004 and then went down in 2006, inferring that housing price stabilizing and speculation refraining policy of Chinese government did not impose any influence on impact indicators of Shanghai from 2002 to 2004, but played its expected role from 2005 to 2006. In 2007, both the ROCs of

Shanghai went up and then went down again, inferring effect of the policy was fading.

Both the ROCs of Seoul went down and then went up in 2006, which was different from that in Shanghai, inferring that the housing price stabilizing and speculation refraining policy of Korean government imposed influence from 2002 to 2004, but did not play its expected role from 2005 to 2006. The national economy of Korea has been stagnating since 2007, which affected the housing market of Seoul.

44.5.2 Different Policy Means Application Between China and Korea

According to housing policy effect analysis of two countries, both housing market stimulation policy and housing price stabilizing and speculation refraining policy had some effects. When further comparing and analyzing the detail characteristics of different policy means and goals, it can be found that: (1) to activate the housing market of Shanghai, the government mainly applied housing loan (A), tax (D) and house building (E) policy means to impose influence on the traded area and the completed home unit rate; comparing to Seoul, Korea government mainly used financial support (B) and tax (D) policy means; (2) to stabilize housing price in Shanghai and refrain speculation, the government used land (F), trade term (I) and comprehensive (J) policy means to affect trade volume of residential land, but failed to play their expected role in controlling selling price of residential land; comparing to Seoul, Korean government used loan (A), tax (D) and trade term (I) policy means; (3) to stabilize housing price and refrain speculation, Chinese government mainly used land supply regulation policy (F) while Korean government mainly used old town rebuilding policy (G), which is a difference between China and Korea. These policies could impose great influence on trade volume of residential land, but would not play its expected role in controlling selling price of residential land.

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Chapter 45
Housing Affordability Among Potential Buyers in the City of Kuala Lumpur, Malaysia

Aminah Md Yusof, Chang Saar Chai and Julaida Johan

Abstract This paper investigates housing affordability problem in Malaysia. It reveals the state of income, purchase and repayment affordability for home ownership in the City of Kuala Lumpur. The study shows that the potential house buyers are severely affected by the affordability problem. Low income (individual and household) has been the most significant cause of affordability problem. The finding suggests that the potential buyers afford houses which are lower than published eligible amount. The problem is further exacerbated by lack of active government's interventions in the provision of affordable houses and the reluctance of financiers in providing loans to some house buyers. The research anticipates that housing affordability problem will escalates further and most of the respondents which represent the most susceptible group to poor are at the higher risk of being excluded from the opportunity to own a house.

Keywords Housing affordability · Potential buyers · Kuala Lumpur

45.1 Introduction

The need to provide appropriate and affordable houses to different groups of urban dwellers introduces a new dilemma especially in developing countries such as Malaysia. Yusof and Chai (2012) explore and relate urban poor to housing

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affordability problem and show that the price escalation of houses causes a new dilemma in home ownership as house prices are too high and are beyond reachable among certain income groups. It is not the only low income group hit by the housing affordability problem but the middle class is also affected. The middle class makes up the majority of Malaysians, are salaried workers who have their money deducted monthly and still have to pay more at the end of the year. Those from middle class are neither rich nor poor but with the continuous price hike in the essentials of living, many are drifting towards the poor category. Even worse, they are not qualified for most of the financial aids. One typical example is the starting salary of graduate, which is around MYR1800 to MYR2000. The young generation is struggling to start their life in the city of Kuala Lumpur. The increased in cost of living is a real case as JobStreet (2014) shows that in Malaysia, a majority of fresh graduates were struggling to make ends meet. The survey shows that approximately 77 % of the fresh graduate said that their salary does not leave them with any savings after spending on essentials such as car and study loans. The average pay across industries in Malaysia for fresh grads appear to be MYR2100 per month, but 60 % of the respondents said that they have to ask for higher-than-average salaries of at least MYR3500 (30 % even expected to be paid as high as MYR6500) in order to cope with the increased cost of living.

Housing affordability is one of the controversial issues in the developing and developed countries such as Malaysia. It is important to realize that the complexities of the affordability problem vary from one locality to another and affordability housing scenario in Malaysia signifies there is a lack of affordable housing especially for the middle income group. As the public housing programmes intended to cater the low-income group, the free market is gradually skewed towards high-priced properties. As a result the middle income group is trap in the between what available and qualified for. Although various efforts to overcome affordability problem in Malaysia, the nation is facing a dilemma of affordable housing that is unaffordable. The affordable housing scheme, which is an addition to the My First Home Scheme for units costing between MYR100000 and MYR220000, will see stratified units priced between MYR220000 and MYR300000 being built for those with a household income of less than MYR6000 a month and who do not yet own a house. But the scheme failed as very little applicants has successfully gained an access to financing.

This paper analyses housing affordability dilemma among middle to low income group in the city of Kuala Lumpur, Malaysia. This group represents the potential house buyers. Kuala Lumpur, the capital city of Malaysia attracted influx of rural migrants which contributed to affordability problem as house price rising beyond reachable. The paper reveals the root of housing affordability from the potential house buyers'. An analysis of income, purchase and repayment affordability is undertaken to explore in-depth the affordability dilemma among respondents in the City of Kuala Lumpur.

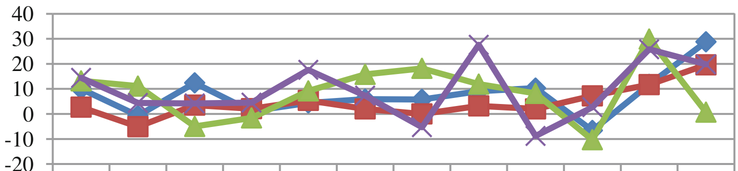
45.2 Housing Affordability

Affordability is referring to the ability of a person in providing something, which is usually referred to his ability in financial terms. Affordable housing is used to illustrate residential units that total housing costs are deemed affordable to those with median income. Anirban et al. (2006) mentioned that house affordability is a condition when people have the potential to save certain portion of their income to buy a house, as well as to pay for other expenditures in their working period.

The statistic by Department of Statistic, Economic Planning Unit, Malaysia (2008), shows the average monthly household income is MYR3686. 57.8 % of the families are members of this group and 29.3 % are above average. Malaysia is classified as an upper middle income group ($3976–$12,275) by World Bank Country Income Classification. The City Hall of Kuala Lumpur uses MYR3000 per month as poverty line; hence those who earn less than MYR3000 per month in Kuala Lumpur are considered poor. In 2009 Malaysia was also signified by the World Bank as low income increment country whereby an average annual increment of salary in Malaysia is merely 2.6 % for the past ten years.

An analysis by Yusof and Chai (2012) indicates that the most frequently transacted house prior to 2008 was priced between MYR150000 to MYR200000. However after 2008, the most affordable price is between MYR 200000 and MYR250000. The price of houses (for all type in the City of Kuala Lumpur) increased gradually as observed from 2000 and recorded double digit growth as depicted in Fig. 45.1. The worst hit is terrace housing which is highly demanded and most affordable amongst Malaysian. Current Kuala Lumpur residential property is about MYR485000 which is roughly 9 times the average household annual income of MYR54000.

To some buying a house becomes unaffordable. The concern over housing affordability problem is also highlighted in the Malaysia National Housing Policy which aimed to provide a direction and basis for the planning and development of



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Terrace	10	-0.7	12.4	1.1	4.4	5.9	5.8	9.1	10.3	-6.6	11.8	28.8
High Rise	2.7	-5.1	3.5	2.1	5.4	2	0	3.2	2	7.2	11.7	19.6
Detach	13.2	11.1	-5	-1.6	9.2	15.8	18.2	11.9	8.2	-10.3	29.9	0.7
Semi Detach	14.4	4.4	4.2	4.5	17.6	7.3	-5.3	27.6	-8.8	2.7	25.8	19.8

Fig. 45.1 Growth in house price: The city of Kuala Lumpur

housing development and to provide affordable and accessible house for the people to own or rent a house.

In relation to affordability, Gan and Hill (2009) distinguish the concept of purchase affordability, repayment affordability and income affordability. While the purchase affordability considers whether a household is able to borrow enough funds to purchase a house, the repayment affordability considers the burden imposed on a household of repaying the mortgage. Income affordability simply measures the ratio of house prices to income (in many cases used median house price and median income). The general rule of allocating only one third of monthly income to pay for housing seems to be less applicable in Malaysia. In 2000, on average Malaysians used only 21.7 % of the income for housing and the slice is even smaller in 2009 as an average Malaysia spent only 16.7 % of their income on housing due to higher consumption on other basic needs such as food, transportation and accommodation (Malaysia Economy Report 2010).

Yusof and Chai (2012) recognise several ways of determining affordability amongst potential buyers. The median multiple can be used to indicate the income affordability based on the scale adopted. One of the typical examples is Demographia International Housing Affordability Survey. The backward calculation is used to determine the affordable houses for respondents. However, the best indicator to affordability is to ask the potential buyers, the price afforded by them. This will provide the accurate indicator for the most affordable houses by the respondents and pursued in this research.

45.3 Data Collection

This research utilizes secondary data that revolves around macro-economic and housing. A review on housing industry in Malaysia and the concept of affordability forms the essential part of the research. A questionnaire survey on the targeted group was carried out in Kuala Lumpur area. The questionnaire designed to capture socio-economic aspect of respondents on income (individual and household, spending pattern, future housing plan and views on current housing situations). A total of 939 respondents aged between 21 and 35 years old involved in the survey. The 21 and 35 year cohort is expected to face housing dilemma especially in the City of Kuala Lumpur. 49 % respondents are within 21–25 years old, 31 % are 26–30 years old and 20 % 31–35 years old which comprises of 54.1 % male and 45.9 % female.

The median income used to compute the median multiple for the respondents. Median multiple (median house price divided by gross before tax annual median household income) is used to rate housing affordability. The Median Multiple is widely used for evaluating urban markets, recommended by the World Bank and the United Nations and is used by the Harvard University Joint Centre on Housing. The following Table 45.1 illustrates the use and scale recommended for affordability index.

45.4 Analysis and Discussion

The survey reveals that more than 50 % of the respondents are earning below RM3000 per month. Majority of the respondents in the City of Kuala Lumpur are within poor category as defined by the City Hall of Kuala Lumpur. The average for the respondents is around MYR2500 which more or less confirmed the finding by BBC News Magazine that average monthly income for Malaysian is MYR2888 in 2012. The state of income is expected to influence the affordability which is discussed in the subsequent sub sections.

As profound earlier, Malaysian spend less than 20 % of their income for housing. An analysis shows that the most frequently transacted houses is less than MYR200000. An analysis is focus on income, purchase and repayment affordability among respondents. From the median extracted, median multiple is calculated. The backward calculation performed to derive the affordable house price for each group of respondents. This is compared to the eligible amount published by the government on the entitlement for the housing loan as visualized in Table 45.2.

Based on the above table, affordability in relation to income, purchase and repayment is discussed below;

45.4.1 Income Affordability

The income affordability is measured through median multiple using formula (1). Median income of respondents (individual and household) and the median house price in the City of Kuala Lumpur are used. The HAI is

$$\text{Affordability Index (HAI)} = \frac{\text{Median House Price}}{\text{Annual Median Income}} \tag{45.1}$$

As shown in Table 45.2, the median multiple or affordability index for the sample is greater than 5.0 which indicate with income gathered, the respondents are in the state of severely unaffordable. All groups are significantly affected by housing affordability. The extreme median multiple for group 21–25 years old (9.97) shows that affordability is the worst among others. The table indicates that in either segmented by individual or household income, the respondents are trapped in the situation of severely unaffordable. It is clear that the young generation: 21–25 years is mostly affected. Although the index is improved for 26–30 years, they are still facing the affordability dilemma. As compared to other groups 31–35 years old is within seriously affordable to buy median price houses.

The calculation of HAI based on household income also exhibits similar pattern but with some improvement in the value of HAI. The median household income for all is MYR2750, MYR2750 and MYR5250 for group 21–25, 26–30 and 31–35 years old respectively. This slight improvement has not change the ‘severely unaffordable' situation among respondents except for 31–35 years old. This signals that affordability is serious among younger household compared to others. As youngsters are working and live up the city, their need and problem require serious attention. From the market analysis, the reluctance of private developers to come up with the lower price housing schemes implies that government must interfere in housing affordable provision.

45.4.2 *Purchase Affordability*

Table 45.1 illustrates median multiple 3.0 and below indicates affordable state. Median house price in the City of Kuala Lumpur is RM239397 which leaves the respondents in the severely unaffordable state. Backward calculation is performed to explore the price affordable by respondents. In order to achieve the affordable index of 3.0 (affordable), the affordable prices are computed and shown in Table 45.2. The affordable houses under the individual income segment range from MYR81000 to RM135000. With the median of individual income, the most affordable house is MYR81000. The 20–25 years old group affords a house of MYR72000, 25–30 years old (MYR99000) and 30–35 years old (MYR135000). This is contrast with the eligible amount for loan of between MYR200000 and MYR380000 as illustrated in Table 45.2.

Based on household income, the affordable houses are MYR99000 for all respondents. The affordable house for 20–25, 26–30 and 31–35 years old is

Table 45.1 Demographia international housing affordability survey housing affordability rating categories

Rating	Median multiple
Severely unaffordable	5.1 and over
Seriously unaffordable	4.1–5.0
Moderately unaffordable	3.1–4.0
Affordable	3.0 and under

(*Source* The World Bank, United Nations, Harvard University Joint Centre on Housing, 2012)

Table 45.2 The median income, median multiple, entitlement and affordable amount

Group (years)	Individual				Household			
	Med	HAI	Eligibility	AH	Med	HAI	Eligibility	AH
All	2250	8.87	255,000	81,000	2751	7.25	280,000	99,000
21–25	2001	9.97	205,000	72,000	2557	7.80	280,000	92,000
26–30	2751	7.25	280,000	99,000	2751	7.25	280,000	99,000
31–35	3750	5.32	380,000	135,000	5250	3.80	400,000	190,000

Med Median; *HAI* Housing Affordability Index; *AH* Affordable Houses (in MYR)

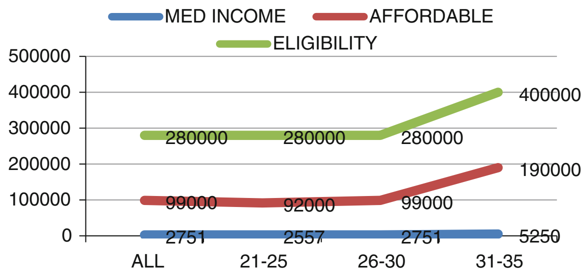


Fig. 45.2 Eligibility and affordability

MYR92000, MYR 99000 and MYR190000 accordingly. This is far less than the published loan entitlements that are MYR280000 and MYR400000 as indicated in Table 45.2. As a result of this constraint, the respondents inclined to choose condominium, apartment and terrace houses as the price of these are lower than detached units. The deviation between published eligible loan and affordable price is shown in Fig. 45.2.

45.4.3 Repayment Affordability

The research explores the repayment affordability among respondents. The following repayment schedule is developed to gain an insight into the matter. The table is based the survey indicates that Malaysians are willing to pay about 20–30 % of their monthly income for the housing installment.

The table shows that if someone is intended to borrow MYR80000 for 20 years loan he will have to pay MYR510 per month. If he chooses to allocate 20 % of his income, he needs to have a household income of MR2250 or alternatively he opts to allocate 30 % of his income, household income should be MYR1700. In an extreme case if one with an income of RM3000 wishes to buy a house of RM200 000, the repayment will be MYR1556 per month for 15 years tenure, MYR1292 for 20 years, RM1140 for 25 years and RM1043 for 30 years. This will consume about 34 % to 38 % of the gross monthly income. This high proportion will certainly cause problems in financing approval as financier will normally or may consider net income. High commitments are normally leading to unsuccessful loan application.

The respondents are asked about the amount that they are willing to pay for their monthly installments as this would be the best affordability indicator. The most affordable amount to be paid is skewed under RM2500 per month. The lower income group comprises those earn less than RM2500, indicated their affordability of less than MYR1000 amounts of installment per month. The highest percentage is for MYR1001 to MYR1500. Next is between MYR1501 to MYR2 000. However as shown earlier, based on HAI and purchase affordability, the reality of repayment affordability is tabulated in Table 45.3. As expenses on food and transportation tend to rise and be prioritised by Malaysians, the expenses on housing has to be reduced.

Table 45.3 Backward calculation on housing repayment

		Term of repayment (years)				
Amount of loan	Allocation (%)	10	15	20	25	30
70,000	Monthly Installment	**729**	**540**	**447**	**393**	**359**
	20	3645	2700	2235	1965	1795
	30	2430	1800	1490	1310	1197
80,000	Monthly Installment	**833**	**616**	**510**	**450**	**410**
	20	4165	3080	2550	2250	2050
	30	2777	2053	1700	1500	1367
100,000	Monthly Installment	**1048**	**778**	**646**	**570**	**522**
	20	5240	3890	3230	2850	2610
	30	3495	2593	2153	1900	1720
150,000	Monthly Installment	**1573**	**1167**	**967**	**855**	**782**
	20	7865	5835	4845	4275	3910
	30	5243	3890	3230	2850	2607
200,000	Monthly Installment	**2097**	**1556**	**1292**	**1140**	**1043**
	20	10,485	7530	6460	5700	5215
	30	6990	5186	4300	3800	3476

42.5 % of the respondents are willing to allocate between 11 and 20 % of their current income for future housing installment. In general about 80 % of respondents are willing to allocate less than 30 % of their income for future housing installment.

45.4.4 General Remark

The above discussion suggests the fact that the level of affordability amongst average Malaysian in the City of Kuala Lumpur is a house of less than MYR300, 000 or to be more accurate is MYR200000. As shown in Tables 5.14 and 5.15, the respondents prefer houses between MYR100000 to MYR200000. The most frequently transacted residential units are housed between MYR25000 to MYR100000 per unit. The share of more than 40 % for each year indicates that this range of price is the most affordable and sought after by the buyers. This is followed by the house of MYR100000 to MYR250000 which captured more than 30 % of the volume of residential transaction. Unfortunately, the supply of such units is very limited especially in the city centre due to high land cost and low profit margin in such development. This creates housing stress in the city which calls for government's direct intervention to take leading role to control price and exercise proper measure to avoid unhealthy and unsustainable increase in property price. The move to curb house price increase (between 10 and 20 % per annum) which is not corresponding to salary increment (less than 10 % per annum) requires serious address by the government. The respondents call for government involvement in financing issue especially in relation to credit deregulation in Malaysia.

45.5 Conclusion

The research investigates the severity of housing affordability problem among respondents in the City of Kuala Lumpur. The young generation is seriously affected despite educated and work to live up the city due to low income. Although the older seems to better, they are still seriously affected by housing affordability problem. To address this, the provision of houses in the City must consider the units that demanded and afforded by each group. The short term solution will be to provide more renting units as transited before the income is sufficient to buy the houses. Research should be undertaken to identify what is needed so that the right house are afforded by right citizen.

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Chapter 46
Sustainable Supply Model Design of Public Rental Housing—Case Study of Chongqing

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Abstract Public rental housing is an important governmental live hood project. Within three years, the Chongqing municipal government proposed building 40 million square meters of public rental housing to solve housing problem of 2 million people. As many problems of unsustainability that has happened in the long-term large-scale construction, including gradually-slow renting progress, the shortage of funds, the facilities of public rental housing community are backwards, the sites are selected on the edge of city, this paper analyzed the situation of Chongqing public rental housing from the perspective of sustainable public rental housing supply, put forward the sustainable supply model that is suitable for Chongqing, and then Calculate their proportionate.

Keywords Public rental housing · Sustainability · Supply model · Filtering theory

46.1 Introduction

In 2013, China plans to start the construction of 6.3 million suites of new affordable housing, including 4.7 million suites to be completed basically. By the end of September this year, 6.2 million suites of the affordable housing has been launched nation-widely and 4.1 million suites that have been completed basically, reaching the annual goals' 98 and 87 % respectively, with the investment of 820 billion. But from current implementation throughout the country, China' construction and promotion of affordable housing are still in the exploring stage. There are still some contradiction and problems, including project quality and the distribution supervision (Yang 2012).

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Chongqing has started over 36 million square meters public rental housing construction with the goal of 40 million square, and 120 thousand households have moved in. Through on-spot investigation and literature research. Problems like huge funds lacking, remote site selection, poor quality, not full-finished equipment, part-interruption of housing marketization have been found during the implementation of public rental housing.

As the center of West China and a hot area for industry transferring, the construction of public rental housing in Chongqing develops rapidly with a large scale. Problems arising in Chongqing are relatively typical. At the same time, 40–50 % of the tenants are migrant workers, 15–20 % are new generation of college students, and the other 30–35 % are original residents. However, the 'sandwich class", which takes the college graduates as the mainstay, creates an increased employment group of 237 thousand people every year. It is investigated that college students and original residents are not pleased to rent public rentals considering issues like living safety, transportation and facilities. Meanwhile, college graduates have different choices when it comes to the living: 26.6 % of them turn to house agencies or rent private housing; 26.6 % of them live in staff dormitories; 14.1 % of them lodge with their relatives or friends; 30.4 % of them choose to purchase a new house or live in their own houses (Zeng et al. 2012); only 2.4 % choose the public rental housing. So it's quite necessary to explore and solve the sustainable supply model of public rental housing in Chongqing.

46.2 Sustainable Supply of Public Rental Housing

Sustainability is the ability to maintain a stable process or status, which is often used to study the relationship between ecology, economy and society. On the sustainable economic theory, the non-declining consumption put forward by John Hartvik, and managing resources to maintain production opportunities put forward by Luthroll, fully embody what the sustainability represent is an acceptable status that human benefit can maintain in an infinite period. So we define the sustainability of public rental housing's supply as: not only to satisfy current high-unity supply, which means the sustainability supply of financial resources and physical housing, the sustainability of site selection, layout and healthy orderly life of district residents, the stability of the supplier and operation system, the sustainability of the whole housing market operation; but also to build a supply system to manage resources so that the distribution of public rental housing between two generations could be achieved (Merliwot 2013).

1. The sustainable of public rental housing supply

The supply of public rental housing not only need reasonable operation costs and maintenance costs, but also need inflation-proof and reused ability. It can achieve a better combination between the government and the market in public rental housing supply (Li et al. 2012).

2. The sustainable optimization of the site selection of public rental housing

Considering that the local government's game over land interest resulting in that public rental housing's sites are reliable to be the edge of the city, which is related to high trip cost and slums. So it will make site selection more sustainable, if we make bull calculation between the tenants' traffic accessibility of the newly-built public rental housing site selection and government's income area, or purchase vacant housing (commodity houses that the estate developers fail to sell out) to supply public rental housing (Wang et al. 2012).

3. The sustainable stability of the supplier and operation system of the public rental housing

At present, public rental housing is in the sole supply and management by the government, but there also exits problems like low equipment efficiency of the government, the shortage of the funds. Property Right Theory insists that owner of property in Private agencies takes the occupancy right for surplus profit and has powerful incentive motivation to increase enterprises' profits. Therefore, it is necessary for us to introduce private agencies which are high-efficient and own large amount of private capital to form a sustainable supply and operation system of the public rental housing (Yang 2011).

46.3 The Current Supply of Chongqing's Public Rental Housing

The capital of Chongqing's public rental housing is funded by the government. In the past ten years, Chongqing Land Group which is responsible for the land reserve work has stored a reservation of over 100 thousand mu (Zhang 2011). The land for construction of public rental housing is directly allocated by the government, while the construction of public rental is also designated by the government to state-owned enterprises "City Investment Group" and "Real Estate Group" and other companies (Zhili and Limei 2012).

46.3.1 Renting Progress and Construction Fund

In 2010, there were seven projects starting in downtown area, which can provide 9.88 million square meters' public rentals and solve 162.217 thousand households' living problem. In 2011, there were nine projects starting in downtown area, which can provide with 11.081 million square meters' public rentals and solve 168.1 thousand households' living problem. In 2012, there were thirteen projects starting in downtown area, which can provide with 4.41 million square meters' public rentals and solve 80 thousand households' living problem (Li et al. 2011).

Table 46.1 The investment of Chongqing's public rental housing

	Total investment			Costs	
	Fiscal investment	Accumulation fund	Loan from commercial bank	Financing cost	Housing management fees
Min Xin Jia Yuan	960 million	800 million	1440 million	10.86 million	90 thousand per months
In total	3200 million			10.95 million	
Beautiful Land	1065 million	500 million	1985 million	12.71 million	100 thousand per month
In total	3550 million			12.81 million	

Table 46.2 The income per month of Chongqing's public rental housing

	Housing rents	Commercial rents	Garage rents	In total
Min Xin Jia Yuan	10.07 million	1.72 million	0.83 million	12.62 million
Beautiful land	10.26 million	3.23 million	0.77 million	14.26 million

Since the implementation of public rental housing in 2010, there have been seven times renting by lotting. In 2011, there were 4 times with the renting rate of 59.69 %. In 2012, there were 2 times with the renting rate of 64.88 %. In 2013, there were only one time with the renting rate of 50.22 %. From the renting process from 2011 to 2013, it can be found that 80 thousand suites public rentals were rented by 4 lots, but the second year and the third year's volume take up the former year's 50 % year by year. The general renting process is slowing year on year.

The total investment of 40 million square meters of public rental housing in Chongqing is about 12 billion, and it consists of fiscal investment and financing loan with the ratio of 3:7. Fiscal investment is mainly collected by the 30 thousand square meters national stored land, the center government specialty fund, the local government fiscal budget, a reduction of or exemption from fees and taxes. Financing part is mainly collected by bank loan, non-bank financial agencies, housing accumulated fund loan, marketing channels like issue bonds (Chen 2012) (Tables 46.1 and 46.2).

There is only about 1 million left every month provided by the two early public rental housing on the circumstance that it is saturated check and only interest is paid. Besides, large amounts of subsequent running costs and housing maintenance costs are increasing year by year. Comparing to each project's loan of over 2 billion, public rentals are only to be rent not for sale in the first five years, and it is estimated that the payback period will be as long as 15.98 years and the internal rate of return is only 8.14 %, which will be a huge financial pressure for the government without a doubt. The sustainable supply of public rental housing is hard to achieve.

Table 46.3 Tenants' working area distribution in Min Xin Jia Yuan

Working areas	Shapingba	Yuzhong	Jiangbei	Yubei
Percentage	10.84	14.46	36.14	18.07
Working areas	Jiulongpo	Dadukou	Nanan	Beibei
Percentage	7.23	3.61	7.23	1.20

46.3.2 Site Selection and Environment Layout

We conducted a survey on 30 environment factors of public rental housing, and received 136 effective questionnaires from residence in public rental communities, residence in surrounding communities and government administrators. They a list of five environment factors which drew people's attention most are obtained. These five factors are exactly the problems exist in public rentals housing recently (Lv 2013).

1. Inconvenient transportation and high transportation costs

Public rental housing projects are all at the edge of Chongqing downtown areas at present, relatively far from the main business circles. But most of 83 tenants in Min Xin Jia Yuan, which is the most mature community of public rental housing, work at commercially developed area of Chongqing downtown area. As is shown in Table 46.3.

What's more, only Metro Line 3 has stops around the Min Xin Jia Yuan, and people's transportation relies mainly on bus. Over 49 % residents spend more than one hour on the commute, which decreases the middle-and low-income groups' living convenience and raises tenants' living cost. Besides, there exists very few bus lines that are linked to other commercial circles and districts in public rental housing community. Many Rail transit lines are not open, and intensive communities can led to crowded traffic and affect the smooth of the traffic flow in commuting time.

2. Isolation from mature areas, incomprehensive facilities and chaotic environment

These public rental housing projects' sites are selected together, and the site selection strategy can easily result in the public rental housing communities' separation from mature communities, they enlarge the gap between different social classes, which is bad for public rental housing's sustainable operation in the long term and brings great security hidden dangers. Many breaking-door murder incidences has happened in Min Xin Jia Yuan (Zhang 2010). Facilities in public rental housing can far more meet tenants' demand. Through site investigation, phenomenon that lack of important educational and medical facilities still exit in those four relatively mature public rental communities. The main reason is that the poor sites led to difficulties in attracting investment and the owner didn't paid enough attention to commercial facility management.

Under the circumstance that residents are not so satisfied with the surrounding facilities, many residents in public rental housing communities do not have steady jobs and live a hard life. Most of groups start taking self-employment and pitching on the street, resulting in the rapid increasing number of illegal pitching, flowing sewage around the community, deteriorating environment. Combined with water leakage caused by the poor quality of the public rental housing itself, further lower community residents' satisfaction happen and problems arouse like that property management fee cannot be collected punctually(Hu 2013).

In conclusion, such problems of public rental housing supply in Chongqing are summarized in the following: slow renting progress, huge shortage of funds, site selection and environment layout are unreasonable. Centralized construction in large scale is source of problems, and only multiple supply model can benefit the sustainability of public rental housing.

46.4 Design of Public Rental Housing Supply Model

In the midterm of 2012, the Chongqing municipal government proposed to build 13.5 million square meters of public rental housing on the basis of over 28 million square meters of construction. It is fundamental to choose sustainable supply model to solve a series of problems. Different supply models should be adopted according to different people. For workers in relatively centralized industrial park and industrial base, we can supply with newly-built and intensively-built public rental housing. But for new graduates and indigenous people, we can purchase vacant houses to meet their need on the basis of filtering theory (Song et al. 2000).

46.4.1 Necessity of the Supply of Public Rental Housing

Since Chongqing's development can be achieved without outer workers, centralized construction of public rental housing can be constructed around the industrialization park and development zones. From the perspective of enterprises and the government, building public rental housing around work areas make difference. Firstly, it can attract more workers and provide labors that enterprises around the industrialization park and development zones need. Secondly, it can benefit the labor stability and increase economic profits so that outer workers don't need to worry about housing if they have stable housing. Thirdly, more enterprises gather here which will benefit pushing on city's economic development and urbanization process. From the perspective of outer workers, firstly, they are beyond the urban housing security system and don't have the right to enjoy housing security policies. Secondly, current policies for enterprises' land use limit the construction of outer workers' apartments or dormitories. According to rules for the urban planning management, constructing supporting facilities that are not for production is prohibited in the industrial zones including residential sets, hotels, expert buildings, rest houses, training center and so on. The land area for administration and office and living facilities can't exceed 7 % the total land area for industrial projects in national or provincial industrial park and development zones. In industrial park and development zones of other levels, the rate can't exceed 10 %. And construction area can't exceed 10 % the total land area for industrial projects. But labor-intensive enterprises holds a large number of staff, and 10 % limits the construction of enterprises' apartments or dormitories seriously. So it's quite necessary to conduct centralized construction of public rental housing in industrial park, development zones and industrial base (Wang et al. 2011).

Statistics from the Chongqing statistical bureau in 2012 indicate commercial housing vacancy in Chongqing downtown area reached 6.0736 million square meters, including 3.0405 million-square-meter commercial housing which have been vacant for one to three years and 1.0709 million-square-meter commercial housing which have been vacant for over three years. If government can take in the housing stock, it will relieve shortage of the public rental housing and make resource configuration best by lowing the vacancy rate of commercial housing.

46.4.2 Supply Model Selection Based on the Filtering Theory

The value of housing are falling by depreciation as time went on, so there are housing stock of different grades. On the basis of filtering theory, in case the demands are unchanged, rents will rise with the decreasing supply of middle-and-low class housing. When the rents rise to the level of upper-class housing, the downward filtration of old housing of relevant grades will accelerate. Then it will lead to a small number of housing stock of upper class and the increase of housing stock of middle-and-low class, which will provide abundantly available housing for the government' s purchase of second-hand houses to supply public rental housing. Meanwhile, the decrease of upper-class housing stock is a direct incentive for the developers to develop products of upper class, which are in the line with government's policy that "market for upper-class housing, security for low-class housing". So the government of Chongqing should establish the supply model of purchasing second-hand houses to promote the sustainable supply of the public rental housing.

In the long term, it is not consistent with filtering theory that constructing a lot of new houses for the middle and low income families. On one hand, the newly-built housing of low grade cannot keep the pace of the social demands, which will cause new waste. On the other hand, it will break the succession of supply chains of housing and deprive developers' enthusiasm for developing housing of middle and upper class, then the market stagnated, and the operating efficiency will be compromised as result. As small and medium-housing take the majority of the rigid demands for housing in Chongqing housing market, and phenomenon still exits that the demands for small and medium-housing exceed the supply. From the perspective of demand and supply, it seems obviously that we should increase the housing supply of middle-and-low class, but from the filtering effect of housing market, low-class housing can be supplied by the middle-class housing through filtering. So government of Chongqing should consider to lower the limits of the construction area, which will accumulate the download filtering of middle-class

Table 46.4 Calculating table of the increase rate of the new commercial housing and second-hand housing's price in Chongqing downtown area

Year	Average price of new commercial housing (yuan per square meter) gross floor area	R_1 (%)	Average price of second-hand housing (yuan per square meter) gross floor area	R_2 (%)
2006	2697		3976	
2007	3155	16.98	4094	2.97
2008	3998	19.80	4515	10.28
2009	4310	7.80	4655	3.10
2010	5994	39.10	5173	11.13
2011	6792	13.31	7561	46.16
2012	6775	−0.25	7464	−1.28

housing then make public rental housing more available. To speed filtering, the government should also control the development scale of public rental housing. All of these measures will contribute to the whole housing market's development.

46.4.3 *Proportion Analysis of the Supply Model of Public Rental Housing Based on Housing Filtering Theory*

To achieve sustainable supply of the public rental housing, it is of great need to focus on how to allocate the proportion between the supply model of new housing and the supply model of purchasing second-hand houses to realize the welfare maximization for middle and-low income families, the same meaning as realizing the maximum number of the tenants. We can discuss the topic on the basis of some consumption and Chongqing's supply plan of the public rental housing (Jian 2005). Through analyzing the price changes of commercial housing and second-hand housing in the recent years in Chongqing, R_1 (the increased ratio of commercial housing's price) and R_2 (the increased ratio of second-hand housing's price) can be calculated (Table 46.4).

$$R1 = (16.98\,\% + 19.8\,\% + 7.8\,\% + 39.1\,\% + 13.31\,\% - 0.23\,\%)/6 = 16.12\,\%$$
$$R2 = (2.97\,\% + 10.28\,\% + 3.1\,\% + 11.13\,\% + 46.16\,\% - 1.28\,\%)/6 = 12.06\,\%$$

By December 2012, the scale of Chongqing's public rental housing has reached 36.6162 million square meters, 580.7 thousand suites in total. Among that, the construction that have been finished reached 6.5954 million square meters, 112.9 thousand suites in total. Take the construction which has not start for example, the number of suites to be constructed will reach 49.7 thousand in proportion to the area of 3.3838 million square meters. Comparing with the Min Xin Jia Yuan, whose total investment is 3.2 billion, with the scale of 1.08 million square meters, the government have to finance 10.026 billion for the public rental housing to be

Table 46.5 Calculating table of proportion of multiple supply model of Chongqing's public rental housing

	Formula	The meanings of functions		Values
Funds planned to be injected by the government	$I = I_1 + I_2$			6.016 billion
Funds need to be injected under the supply model of constructing public rental housing	$I_1 = P_1(1 - K)(1 + R_1) * S * N * X_1$	P_1	The average price of newly-built public rental housing per gross floor area	3150
		K	The ratio of land cost and tax to the housing price	40 %
		R_1	The ratio of incremental price of newly-built commercial housing	16.12 %
		S	Average rental area (of public rental housing)	40
		X_1	The ratio of the supply model of constructing new public rental housing to the total supply	X_1
		N	The number of tenants of public rental housing	49.7 thousand
Be injected under the supply model of purchasing housing	$I_2 = P_2(1 + R_2) * S * N * X_2$	P_2	The average price of purchased second-hand housing per gross floor area	7464
		R_2	The ratio of incremental price of second-hand housing	12.06 %
		X_2	The ratio of the supply model of purchasing second-hand housing to the total supply	X_2

constructed at the same market price, and it have to inject 6.016 billion after taking away the land cost and tax which take up 40 % totally (Table 46.5).

List the equation set:

Table 46.6 Calculating table of distribution proportion of multiple supply model of Chongqing's public rental housing

	Distribution proportion of extremes		Judgment for i	Evaluation
Supposing 1	$X_1 = 0$	$X_2 = 1$	I = 1937139 > 601,600	Coincident with filtering theory
				Welfare level comes to maximization but limited by funds
				Not practical
Supposing 2	$X_2 = 0$	$X_1 = 1$	I = 508,285 < 601,600	Not coincident with filtering theory
				Welfare level is relatively high but limited by funds
				Not practical
Solutions	$X_1 = 93.47\ \%$	$X_2 = 6.53\ \%$	601,600	Coincident with filtering theory
				Integrated welfare level comes to maximization

$$
\begin{aligned}
&508285X_1 + 1937139X_2 \leq 601{,}600 \\
&X_1 + X_2 = 1
\end{aligned}
$$

Solutions to the equation set are as follows:

Considering the development of the whole real estate market based on the filtering model, and focusing on maximizing the welfare level of public rental housing, the optimal proportion distribution is: the supply model of constricting new public rental housing provide 93.47 % for the housing market, while the supply model of purchasing housing provide 6.53 %. Then the two models provide the rest public rental housing of 3.3838 million square meters together (Table 46.6).

46.5 Conclusion

This paper from the perspective of economics, make a selection of supply model based on housing filtering theory and current situation of Chongqing's public rental housing and housing market, further work out the proportions of different models, and conclusions are as follows. Problems are arousing frequently on the supplied public rental housing projects by government of Chongqing, and it brings great danger to the sustainable supply of public rental housing. Meanwhile, combined with the supply failing to meet the demands in current housing market in

Chongqing and unbalanced structure of supply and demand, contractions between supply and demand are sharpening with the accelerated urbanization and increasing housing price. However, the vacancy rate is high, and second-hand house market are undeveloped. So taking effective supply model of public housing can accelerate the filtering of the housing market, and help the implementation of the public rental housing. By calculating the proportion of the supply model, we make it sure that the optimal proportion distribution combination, the supply model of constructing new public rental housing make up the model of market housing 93.47 %, and the supply model of purchasing housing provide 6.53 %.

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Chapter 47
Theoretical Analysis in Supply System of Public Rental Housing

Yue Teng, Xiao Li, Ling Li, Xiazhi Fang and Bo Xu

Abstract Public rental housing (PRH) is provided for urban low-income hierarchy and is an important part of affordable housing system. Based on the theory of public goods, both government and private enterprises have advantages and disadvantages in supplying PRH respectively. In order to optimize the present supply system of PRH, this article introduced the delivery pattern of Public & Private Partnership (PPP) into the government allocation system, and further improved it into Public-Intermediary-Private- Partnerships (PIPP), a new supply system through the cooperation of government, private enterprises and intermediary organizations. It helps to better achieve the security role of PRH in our society.

Keywords Public rental housing, government supply · Public and private partnership (PPP; PIPP)

47.1 Introduction

As one of indemnificatory housing, public rental housing means the indemnification housing that invested by the government. They provide policy support and offer specific person with preferential rental price. The third plenary session of the 18 "decision" points out that the system of affordable housing allocation need be optimized and the construction of low-rent public housing and public rentals will be gradually merged. So it can be seem that the importance of the Public rental

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housing has increased rapidly. At present, public rental housing is provided and managed by the government, which is quite different from the private project. But as a matter of fact, the present supply system has caused several issues, such as the financial problems, potential quality issues and unreasonable management mechanism. So it is urgent to explore an efficient supply system of PRH to make the public rental housing more sustainable.

As the non-excludability and non-competiveness of public rental housing, it has the characteristic of public goods. In the past, many discussions existed about who should be responsible for the supply of public goods. According to Welfare economics, Samuelson believed that government allocation would be more effective than market mechanism. (Xiaoan 2001) According to Public Choice Theory, it was almost impossible for the private enterprises to take in them if there is no other benefits as the little revenue of public goods. So the government took the responsibility to provide the public goods. But since 60s and 70s of 20 century, crises in welfare states broken out (Broadcom and Yu-Xiang 2000). A group of economists who claimed economic freedom, like Goldin, Brubaker, Schmidts, Demsetz and Coase, doubted about if it is reasonable for the government to be the supplier of public goods as the low-efficiency and non-flexibility of the government (Bingheng and Kun-hui 2011). Simis also demonstrated that the as the unbalanced interests in government, it may lead to a conflict between the interest participants and causes a waste of social resources. (Simis 2002) believed that it would be more efficiency and fair if the public goods were provided by the government and market at the same time (Coase 1974).

According to the exist research on public goods, this article analyzed both the advantages and disadvantages of government and private enterprises in supplying the public rental housing. Furthermore, it put forward a new supply system through cooperation of government, private enterprises and intermediary organizations. This will help to better achieve the sustainability of public rental housing and form a reasonable supply and operation mechanism.

47.2 Property Analysis of PRH

According to economics theory, the public goods are usually divided into three categories: purely public goods, purely private goods and quasi-public goods. Purely Public goods means the one person's consumption of them will not lead to a decrease on consumption for other people. So there are three main features of purely public good:

(1) Non-competitive consumption
    It means that the increase of people who consume the same goods will not cause any decrease of utility enjoyed by the previous consumers;

(2) Non-excludability
It means consumers cannot be stopped to benefit from the provided public good as the technical or economic obstacles.
(3) External economies
It means the influence on others in producing and consumption.

Compared to purely public good, purely private good is both competitive and exclusively (Goldin 1977). Moreover, as the consumption independence of purely private goods, they can be separated among consumers, which make purely private goods have no external effects. However, most goods in real life are ranging from purely public good on the one hand to purely private good on the other. Then quasi-public good, with incomplete competitiveness and excludability, has been proposed by Buchanan (1965) to fill the Samuelson gap between the purely public good and purely private good (Demsetz 1970).

In terms of consumption feature, PRH can be defined as quasi-public good due to its limited competitiveness and partial excludability. And a theory of clubs or consumption ownership-membership arrangement can be applied to explain it (Shu-qian 2007). The corresponding cases are those goods, the consumption of which involves some finite "publicness", where the optimal sharing group is more than one person or family but smaller than an infinitely large number (Buchanan 1965). Actually, PRH exactly has specific qualification restriction to its available applicants, which results in finite consumers. As Goldin (1977) put it, no goods or services which are inherently public goods or externalities; that there is always a choice between equal and selective access (Shu-qian 2007). Consequently, PRH indeed has selective access to consumption. Under certain consumption capacity, qualified consumer of PRH will not affect or decrease consumption availability of other individuals, the same with purely public goods; but when the certain capacity is surpassed, supply falls short of demand and non-competitiveness gradually disappear, and congestion will naturally appear, which is called limited competitiveness (Goldin 1977). Moreover, PRH has strong externality, like relieving the rigid demand of housing market, stimulate domestic demand, improve the investment climate, and raise the level of the overall social welfare, etc. Therefore, it is reasonable to adopt the theory of public goods to solve the problems within PRH supply since PRH has fundamental characteristics of public goods, though limitedly or partially

47.3 Necessity of Government Supply

47.3.1 Market Failure of Public Rental Housing

In the early time, A Smith, J S Mill, and P A Samuelson all considered public goods to be allocated by government as the market failure. When idealized competitive market cannot achieve the equilibrium configuration of resources, namely the market in the allocation of resources is of low efficiency, then market failure emerged. Specifically, market failure of PRH has the following aspects:

(1) Market directs the operation of economy by Law of Value based on the Principle of Voluntariness and it do not has the compelling force. However, PRH is not for all the residents, which means it unable to define its beneficiaries through spontaneous adjustment of market.
(2) Market reflects the strength of individual preference according to the prices, but since PRH is exclusive to its beneficiaries, consumers tends to send out misleading signal for his/her own interest, pretending that she/he has lower interest in these collective consumption activities. Thus dispersion of price mechanism is unable to determine optimum of collective consumption, even causing the phenomenon of "free ride" (Samuelson 1954).
(3) Owing to the strong externality of PRH, it is difficult for suppliers to recover their investment. If suppliers raised the rents to protect their revenue, it would lead to failure of housing security function of PRH (Shu-qian 2007).

47.3.2 Government Advantages

Due to the above market failure, it is necessary for the government to intervene in the supply process of PRH. Different from ordinary economic organizations, government is an administrative machinery and has strong power to restrain each member in society. This characterastic makes government has an obvious advantage of resource allocation than the market:

(1) Government can determine the application requirements of PRH, which can exclude the middle-income and high-income consumers by administrative measures. In this part, it defines the beneficiaries.
(2) PRH is a hypothetic project, and it has to keep a lower rent level so that the low-income families can really afford it. Under the market mechanism, the lack of profits will lead to cause invalid supply for private enterprises, while government can use strong force to keep it operate well, although there are no profits.
(3) Adjustment ability of market usually lags, which causes the housing demand of the low-income families cannot be covered. In contrast, government can conduct productions in a short time with administrative force.
(4) The auto-adjustment of market easily accelerates the polarization between the rich and the poor, thus making it more difficult for the low-income to afford a house while housing price soars. Society would even lose stabilization (Xiaochun 2010).

47.4 Necessity of Private-Enterprises Supply

In Private Production of Public Goods, Demsetz (1970) said "Given the ability to exclude non purchasers, private producers can produce public goods efficiently." And Brubaker (1975) argued about the dominant position occupied by the free-rider hypothesis and regarded it as lacking of empirical scientific basis. Coase (1974) used a case study of lighthouses to support the idea that public goods can as well supplied by private enterprises. Though, PRH is defined as quasi-public goods, the theory of public goods still can be applied with necessary changes. In all, combined with these empirical analyses, though government is proved to necessity and advantages in supplying PRH, insurmountable latent defects and external restraints make it is possible for PRH supplied by private enterprise.

47.4.1 Latent Defect

(1) Invalid supervision of resources
To be specific, government management is seen as lacking of effective entrusted agency-supervision mechanism and incentive mechanism. With the assumption of "economic man", problems like cutting corners and transmitting cost will also appear in the construction process of PRH, which usually result in bad-quality PRH.
(2) Ineffective mechanism of cost control
Government is in charge of PRH construction but not in pursuit of economic profit maximization. This will cause inefficiency in cost control and the fund cannot be used to achieve maximize utility.

47.4.2 External Restraints

(1) Construction cost
Government needs to invest a large amount of money in the construction of PRH. However, the present financing pattern—government investment + bank loan + housing provident fund loans—caused a large burden of the government and cannot be sustainable.
(2) Management cost
In each phase of the operation and construction phase of PRH, government has to set up a organization to manage it, which will bring huge operation fees.
(3) Opportunity cost
On one hand, government's domination on the supply of PRH is of lower efficiency than private enterprises; on the other hand, lots of vacant houses cannot get effective use in the market at the same time.

(4) Local government interest
Since PRH is mainly provided by central government, local governments can response differently toward this policy due to their inconformity of interest.

47.5 Improvement of PPP

47.5.1 Introduction of PPP

Public-private-partnership (PPP) is the pattern that public department cooperates with private enterprises in public projects. In this pattern, both sides can play their respective advantages in providing public service, sharing risks, responsibilities and interests. Specific application of PPP in supplying PRH can not only improve the efficiency of resource allocation, but also relieve the capital pressure of government in large-scale construction.

1. Improvement of resource allocation efficiency
   In the original supplied-by-government pattern, PRH is provided for the beneficiaries without entering the market. In this way, it is difficult to do precise cost-benefit analysis, and as a consequence easily cover the low-efficiency of government. In addition, government has relatively higher external cost and management cost since it is less flexible than private enterprises facing the market change.
   After applying PPP, government can make use of the appeals of enterprises for profits to save the construction cost. Meanwhile, good knowledge of market information of enterprises can help government avoid the blind spots of investment, further improving its lower utilization rate of fund. For instance, the price of construction materials changes with the fluctuation of the market, while the enterprises are able to choose a better time to conduct proper procurement. What is more, private enterprises can improve the utilization of fund by weakening government's blindness of investment and dominance of performance (Yilin 2008).
2. Encouragement for private investment
   In the case of Chongqing's PRH project, in 2010, Chongqing planned to build 600,000 sets of PRH in 3 years with a required investment of 75 billion yuan. An estimation of 1/3 of investment would be provided directly by government, and the rest will rely on finance. But both the direct investment of 25 billion yuan and large interest for the loan bring heavy pressure to the government. At the same time, saving deposits balance of local residents experiences continual rise. By the end of August 2012, Chongqing resident deposit balance had reached 805.077 billion yuan, achieving a 21.64 billion yuan increase. If the government takes use of policy guidance and tax preference to encourage the private investment in PRH, idle funds of society can be better utilized. This

solution not only provides more opportunities for private investment, but largely eases the government's financial pressure. With investment diversification, government also disperses risk to better guarantee the financial investment. All these are good examples of PRH's externality (Da-sheng 2004).

3. Speed up the change of government function
PRH supplied by private enterprises does not mean entirely away from government. On the contrary, government still plays a significant role in this process (Xiaochun 2010). The main construction of PRH by government includes financing, site selection, construction and maintenance, etc. Regardless of the ability of government to undertake such professional real estate development and operation work, such much work will inevitably impose much pressure to the government and throw it into thinking of micro decision-making frequently. This will lead to dysfunction in its macro decision-making and management. When private enterprises and government have joint investment in PRH, government can stay out of heavy work above and concentrate more on how PRH can better satisfy the public demand. So it can achieve the harmonious development of economy and society (Huan-liang 2001).

47.5.2 The Existing Limitations of PPP

To allow private enterprises' involvement, we employ PPP to illustrate the supply system of PRH. But further discussion shows that even though PPP has the advantage of both market supply and government supply, some limitations still exist (Table 47.1).

Table 47.1 Contrastive analysis of PPP

<table>
<tr><th>PPP pattern</th><th>Type</th><th>Advantages</th><th>Disadvantages</th></tr>
<tr><td rowspan="6">Newly-built projects</td><td>BOT</td><td rowspan="10">1. It can reduce investment of public department and increase the efficiency, thus rationalizing resource configuration
2. In the process of biding, it can attract more private enterprises to participate so that they can put forward more advanced technology and management experience
3. Reduce the risk of the government</td><td rowspan="10">1. It is difficult to find private enterprises and may cause Rent-Seeking behaviors
2. Laws and regulations are not perfect
3. It require for high level of government management
4. It requires frequent communication and coordination to set the rate of return on the project</td></tr>
<tr><td>BOOT</td></tr>
<tr><td>BTO</td></tr>
<tr><td>BOO</td></tr>
<tr><td>BT</td></tr>
<tr><td>BOST</td></tr>
<tr><td rowspan="2">Expansion project</td><td>LBO</td></tr>
<tr><td>BBO</td></tr>
<tr><td rowspan="2">Existing projects</td><td>Service Agreement</td></tr>
<tr><td>Operate and maintenance contract</td></tr>
</table>

47.5.3 Introduction of PIPP

According to the above analysis, it is quite necessary to optimize the present PPP model. One of the solution is to add intermediary organizations into the cooperation between government and private enterprises, acting as a coordinator in PPP pattern. It can accelerate information transform, take responsibility for the jobs that are not suitable for the government nowadays, and help to reduce the failure of market and government. This optimized pattern can be called Public-Intermediary-Private-Partnerships (PIPP). Specific supply system is as follows (Fig. 47.1).

As the supplier of PRH in PIPP, private enterprises have comparable advantages in capital and efficiency. At the same time, private enterprises prefer to do a project which is in low risk but in high profits, namely realizing a balance return of its own funds and extra profits. This is exactly why PRH can attract interest of private investors, with stable rent income and sales of commercial part, as well as compensation and incentive in policy and good reputation as involving in livelihood projects. In China, the policy gives great impetus to PRH, the local government will provide preferential policies to attract private investment to solve the fund problems.

With the changed role of the government, an independent space forms based on the market. In this space, an intermediary organization is needed to connect government and private enterprises. And it can help to diversify social economy and offset the deficiency of the market and the government. At present, chamber of commerce and industry associations are the most representative intermediary organizations. They rely on trust, cooperation, self-discipline and social punishment among members to reduce the opportunistic behaviors. It can also avoid market failure and government failure, resulting in smoother transactions.

In terms of transactions involved with complexity, uncertainty and strong externality, the chamber of commerce can act more effectively than market

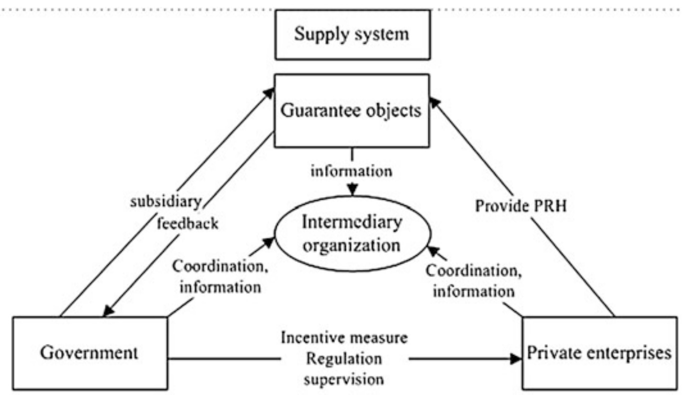

Fig. 47.1 Supply system of PRH based on PIP

mechanism. In fact, market failure and government failure is a quite common phenomenon in a developing country as the underdeveloped system of law. What is more, it will bring high transaction cost to these owners through applying law since most transactions is small, even though there is already an exist law. Differently, intermediary organizations are able to focus on lowing the costs of these small-scale transactions through cooperation, self-discipline and negotiation in PRH. Therefore under the cooperation of government, market and intermediary organizations, developing countries are able to better promoting the balance of economy and society.

Due to the existence of market failure, such as monopoly, information asymmetry, externality and unfair distribution, it is necessary for government to intervene the situation. After applying PIPP pattern, government acts as a manager rather than an executer in the supply of PRH. It takes charge of controlling the whole housing market, focuses on the approval of private enterprises' admittance, supervision of the implementation process, and ex-post evaluation. The specific work of PRH will be left to intermediary organizations and private enterprises. It is helpful to achieve better PRH allocation operation (Rifen 2012).

47.6 Empirical Research

In order to identify the utility of the system of PIPP, the paper take an empirical research in Chongqing. "Min Xin Jia Yuan" is the first project of public rental housing which was constructed in Chongqing and now it has been completed. The project is located in Chongqing northern New Area. The project takes an area of 41 hectares and the construction area is about 1,080,000 m^2. The total investment of this project is 3.402 billion, which conclude 30 % of financial fund, 23.8 % of housing provident fund loans and 46.2 % of bank loans. The cost of per square meter of the public rental housing is 3150 yuan.

47.6.1 The Main Cost of the Public Rental Housing

1. The overhaul, renew, replace fees in public areas
   According to a questionnaire research, the overhaul, renew, replace fees is about 0.432 million every month.
2. Interior decoration Maintenance fees
   Expose that the Interior decoration will be maintain every ten years. So the maintenance will happen 4 times during the existence of the Public Rental Housing. The average fees of maintains is 300 yuan per m^2. So the whole fees is 1.84 million per month.

Table 47.2 Operation fees in details

	Fees (million yuan per month)
The overhaul, renew, replace fees in public areas	0.432
Interior decoration maintenance fees	1.84
Administrative expenses of staff	0.0842
Total	2.3562

3. Administrative expenses of staff
   According to the standard, every 800 residents should be guarantee a management. So the whole demand for the staff are 23 in "Min Xin Jia Yuan". If the wage is 3660 yuan per staff, the total fees will be 84.2 thousand.
   The detail is on the Table 47.2.

47.6.2 The Interest of the Public Rental Housing

As the total investment of this project is 3.402 billion, and the 30 % comes from financial fund. So the government need to finance 2.38 billion (Including 0.8 billion housing provident fund loans and 1.58 bank loans). So the average interest is $(0.8 \times 0.045 + 1.58 \times 0.0655)/12 = 11.62$ million yuan per month.

So the total costs are $11.62 + 2.3562 = 13.9762$ million yuan per month.

47.6.3 The Rent of the Public Rental Housing

The project takes an area of 41 hectares and the construction area is about 1,080,000 m^2, which covers 920,000 m^2 (17,836 sets) residence, 43,000 m^2 commercial façade and 83,222 m^2 (3327) garage. According to the survey, the rent of each project is in the Table 47.3.

So it can be seen that the total revenue is 12.84 million, lower than the total cost 13.9762 million every month. So if government take the responsibility to build the Public Rental Housing, they still have to invest funds to this projects every months.

Moreover, in the construction period, there is a huge risk as the projects borrowed so much money is from the banks and the housing provident fund. If we do

Table 47.3 The average of PRH

Parts	Rent
Residence	11 (yuan per month per square)
Commercial façade	40 (yuan per month per square)
Garage	300 each
Total	12.84 million

not adopt the PIPP system to supply the Public Rental Housing, that is mean all the risks are undertook by the government. It is not good for the development and sustainability of Public Rental Housing.

47.7 Conclusion

Public rental housing is an important part of security housing. But at present the supply of government has brought serious problems to the sustainability of the Public rental housing. After analyzing the property of PRH, this paper compared the advantages of government's involvement in allocation of public good, but also put forward a series of limitations to its sustainable allocation. In order to optimize system, the paper introduced public and private partnership, and developed a new pattern named PIPP by adding an intermediary organization into the original PPP mechanism. At the end of the paper, a case study was put forward to test and verify the utility of the PIPP system by using the data of "Min Xin Jia Yuan", a project in Chongqing. And the result shows that the system is indeed helpful. It helps to improve resources allocation efficiency, assuage capital pressure of government in providing PRH, as well as optimize function of government in this process.

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Chapter 48
A Model for Replacing Public Rental Housing Based on the Extension Theory

Li Yan, Kunhui Ye and Lili Wang

Abstract In order to find a solution to the problems about long waiting time and tedious process in replacing public rental housing in China, extension strategy generating system in extension theory is proposed in this paper. This paper describes a model that can be used to lessen the waiting time in the process of housing replacement, and improve the satisfaction of housing rent. Taking Chongqing city as an example, the proposed model is simulated and demonstrated applicable. The results show that the model is able to reduce unexpected subjective intervention, improve decision efficiency.

Keywords Public rental housing · Replacing house · Extension theory · Extension strategy generating

48.1 Introduction

Since the Housing Reform in 1988, indemnification housing construction in our country has been an important part of government housing policies. Due to the increasing of indemnification housing construction strength of affordable housing, low-rent housing, and capped-price housing, the housing conditions of many families in low-income over a lot of cities have been improved. Recent years, with the rapid rise of public housing in our country, the living pressure of middle-income and low-income people has been greatly reduced.

As public rental housing gradually built and put into use, people's focus has shifted from the initial planning and construction processes to the final management of usage (Chen and Wu 2012), especially for the research of administrative management, access qualification review, and exit mechanism. However, demands of

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replacing public rental housing because of job-housing balance have not been put enough attention.

48.2 Reasons of the Replacing House Demands

48.2.1 Job-Housing Balance

The accepted meaning of "Job-housing Balance" is: within a given region, the number of labors and the number of jobs is roughly equal, and most residents can work nearby. Commuted vehicle can be walking, bike or other non-motor vehicles, even if using motor vehicles, travel distance and commuted time is shorter in a reasonable range. It is helpful to reduce the use of motor vehicles, and reduce traffic congestion and air pollution (Cervero 1992; Giuliano 1991).

Since the 1990s, major cities in our country begin to expand to suburbs, which speeding up the urban development and urban housing reform, fundamentally change the space relationship between job and living place (Wang et al. 2011). More over the development of real estate and the suburbs of large factories drive the flows of population. The separation of work place and living space causes serious traffic problems, and also increases commuting time and cost of residents, which present a lot of inconvenience. As the result, "Job-housing Balance" begins to be concerned and accepted by setters and renters.

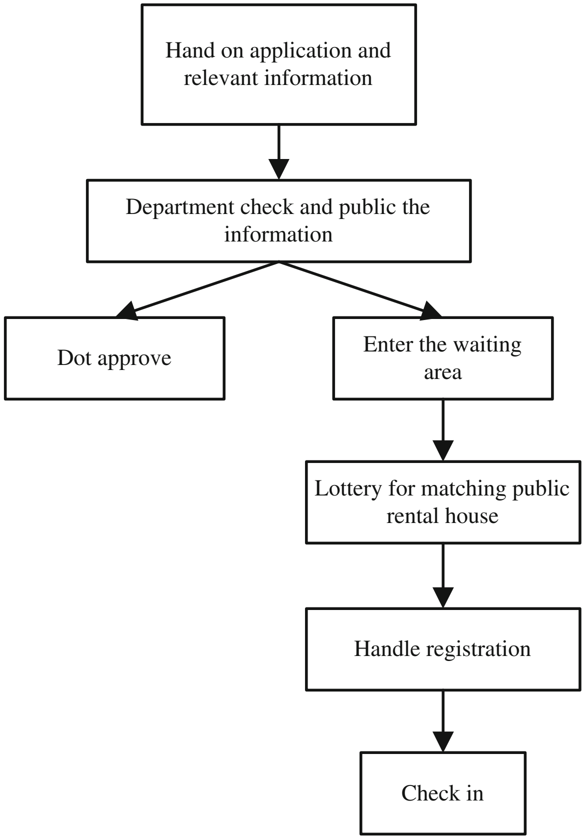
48.2.2 The Replacing House Demands of Public Renters

The target group of public rental housing includes migrant workers, new graduates, and other middle-income or low-income people (Ma and Zhu 2013). These people's most notable characteristic is they change their work frequently. It is indicative from relevant data statistics that the job-hopping rate of college graduates as high as 70 % in three years (Chen 2009), and after entering urban, migrant workers also experience a process of changing work frequently (Huang 2010). Job changing, but housing address remaining the same will cause increased commuting cost and time, and aggravate the low-income people's life pressure. Therefore, the renters who live in public rental house will have to replace house demands as their work places are changed.

48.3 The Replacing House Management Process of Public Rental House

At present, replacing public rental house policy in our country has been implemented in Chongqing and Tianjin. The replacing house process is illustrated in Figs. 48.1 and 48.2. Two replacing house methods both carry out the process of "Check-Match-Exchange", which turn out to be practical. However, the two methods also have some shortcomings. Chongqing public rental housing administration only accepts applications of replacing the house inside the same community, and renters must wait for the government to arrange a lottery for rental house after handing on their applications. This method will take a long time of renters who want replace their public rental housing as the job issue, and it is unable to solve their difficult effectively. Tianjin public rental housing exchange platform is established, in which the renters can release their house information and seek their satisfying public rental house at the same time. Only when the tenants in the two houses all agree to exchange their house, the replacing house action can be

Fig. 48.1 The replacing rent process of public housing in Chongqing



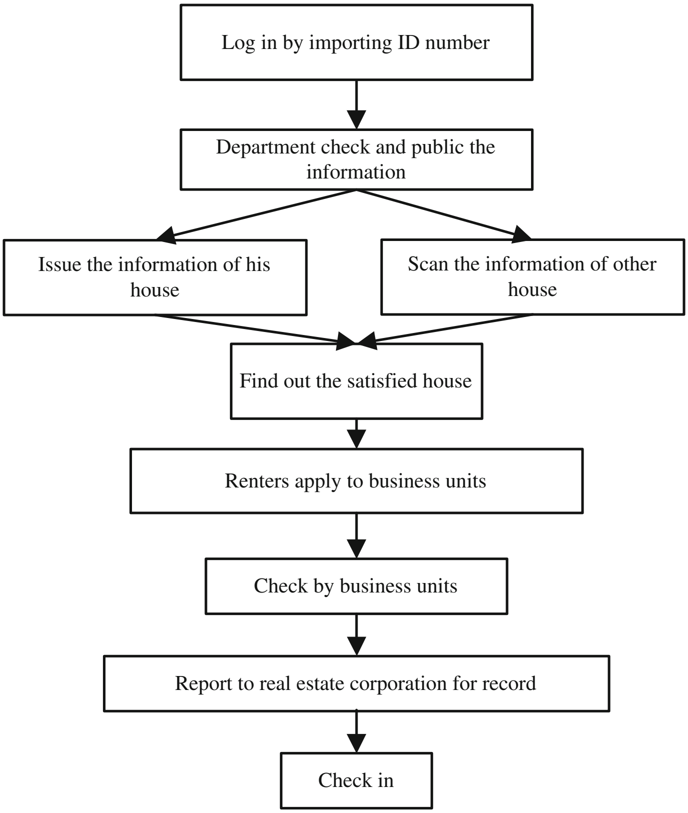


Fig. 48.2 The replacing rent process of public housing in Tianjin

implemented. This method has problems such as it is difficult to find out the exchanged house, and the replacing house process is complex.

48.4 Improvement Program of Replacing Public Rental House

The current exchange pattern and procedure of public rental house reflect that management system of public rental house is not perfect in a way. Two aspects measures can be done in a time of regimes and procedures to reduce commuting pressure and protect the housing interests of rental tenants.

On one hand, take measures to do the work of replacing rental housing between the two communities. Job-housing unbalance is one of the main reasons for replacing rental housing. Not only the application of exchanging rental houses within the same community, but also the applications between different communities are important problems that the government must solve. The government should establish a unified replacing house system for all the public rental houses so as to implement exchange between different communities. Applicants can fill their demands of location and others in application forms, in order to find out the public rental house which meets the requirements easily.

On the other hand, it is important to establish an intelligent matching system of replacing rental house, improving the program of replacing public rental house. Facing a large number of public rental housing information, tenants may not take out the optimal decisions as they will consider a lot of factors. It will exit incompatible problems because it may not have satisfied public rental housing in the real life. Therefore, it can utilize the theory of extension strategy generation to establish the matching model of replacing rental housing.

48.5 Extension Strategy Generating Model

48.5.1 Set up the Extension Model of Problem

This research focuses on the problem of replacing rental housing, so that the goal and conditions of this problem are required house and available house (Yang and Wen 2007; Ye and Wang 2010). Then choose those follow factors as characteristic parameters to set up extension model (Zhang 2001; Li et al. 2013).

- Location of apply house
- House type
- Area
- Commuting time
- Commuting cost
- Rent

$$P = G * L = \begin{bmatrix} \text{Renter,} & \text{Control object,} & W \\ & \text{Agent object,} & \text{Renter} \end{bmatrix} * \begin{bmatrix} \text{Public rental housing A,} & \text{Location,} & d_1 \\ & \text{House type,} & h_1 \\ & \text{Area,} & a_1 \\ & \text{Commuting time,} & t_1 \\ & \text{Commuting cost,} & c_1 \\ & \text{Rent,} & r_1 \end{bmatrix}$$

Among them

$$W = \begin{bmatrix} \text{Objective house M}, & \text{Location}, & d_0 \\ & \text{House style}, & h_0 \\ & \text{Area}, & [a_0, b_0] \\ & \text{Commuting time}, & t_0 \\ & \text{Commuting cost}, & c_0 \\ & \text{Rent} & r_0 \end{bmatrix}$$

In the definition of the core issue, the positive domain interval of target primaries g_0 is the interval in which value of target primaries g_0 can satisfy all requirements. So the minimum values of the positive domain of commuting time and cost are zero, and maximum values are the request values of the tenants. The minimum value of rent is the lowest price in public rental housing price, while the maximum value is the maximum rent price tenant can be acceptable. Therefore, the extension model of the core issue can be set up as follow

$$P_0 = g_0 * l_0 = \begin{bmatrix} \text{Objective house M}, & \text{Location}, & d_0 \\ & \text{House style}, & h_0 \\ & \text{Area}, & [a_0, b_0] \\ & \text{Commuting time}, & t_0 \\ & \text{Commuting cost}, & c_0 \\ & \text{Rent}, & r_0 \end{bmatrix}$$
$$* \begin{bmatrix} \text{Public rental housing A}, & \text{Location}, & d_1 \\ & \text{House type}, & h_1 \\ & \text{Area}, & a_1 \\ & \text{Commuting time}, & t_1 \\ & \text{Commuting cost}, & c_1 \\ & \text{Rent}, & r_1 \end{bmatrix}$$

48.5.2 Compatibility Analysis

(a) To establish the location linked function

If there is no matched house in replacing rental housing data can meet tenant's request for location, but some similar houses nearby may be accepted, then the distance between the two sites dAB can be used to describe the connection degree of condition and target. Besides, the condition and target are better as close as possible. That is, dAB is as small as possible. So, this study need to build the elementary linked function which the optimum point is the left point of an interval.

There are two necessary intervals of distance factor: the interval of target X_0 = <0, d>, and the interval of condition X = <0, d_{max}>. Among them, d is the ideal distance tenants want, d_{max} is the maximum distance, and $x_0 \in X_0$, $X_0 \subset X$.

$$k_1 = \begin{cases} \frac{\rho(x,x_0,X_0)}{D(x,x_0,X)}, & \text{else} \\ \frac{\rho(x,x_0,X_0)}{D(x,x_0,X)} - 1, & \rho(x,X) = \rho(x,X_0) \text{ and } x \notin X_0 \end{cases}$$

According to the book Extension Engineering, because xo = 0, so has

$$\rho_1(x,0,X_0) = \begin{cases} -x, & x<0 \\ az, & x=0 \\ x-d, & x>0 \end{cases} \text{ and } az = \rho_l(0,0,X_0) = 0 - d = -d, 0 \in X_0$$

$$D(x,X_0,X) = \begin{cases} \rho(x,X) - \rho(x,X_0), & \rho(x,X) \neq \rho(x,X_0) \text{ and } x \notin X_0 \\ \rho(x,X) - \rho(x,X_0) + a - b, & \rho(x,X) \neq \rho(x,X_0) \text{ and } x \in X_0 \\ a-b, & \rho(x,X) = \rho(x,X_0) \end{cases}$$

(b) To establish the house style linked function

Public rental housing style includes single room, one bedroom, two bedrooms with one living room, and three bedrooms with one living room. This if a collection of discrete data, so it needs to choose discrete linked function.

$$k_2 = \begin{cases} 1, & \text{x} \in \left\{ \begin{array}{l} \text{(single room, single room), (one bedroom, one bedroom)} \\ \text{(two bedrooms with one living room, two bedrooms with one living room)} \\ \text{(three bedrooms with one living room, three bedrooms with one living room)} \end{array} \right\} \\ 0.5, & \text{x} \in \{\text{(single room, one bedroom), (one bedroom, single room)}\} \\ -1, & \text{x} \in \text{else} \end{cases}$$

(single room, one bedroom) means tenant's demand of the target house is one bedroom, while the available house in public rental housing data is single room. Others are similar.

(c) To establish the area linked function

Tenant's demand of house area can be expressed as [a_0, b_0], and the middle point is the best. So the interval is X_0 = <a_0, b_0>, M $\in X_0$, and $M = \frac{a_0+b_0}{2}$. The area linked function is

$$k_3 = \begin{cases} \frac{2(x-a_0)}{b_0-a_0}, & x \leq \frac{b_0+a_0}{2} \\ \frac{2(b_0-x)}{b_0-a_0}, & x \geq \frac{b0+a_0}{2} \end{cases}$$

$k_3(x)$ gets the maximum value when $M = \frac{a_0+b_0}{2}$, x stands for the real area of the available house.

(d) To establish the commuting time and cost linked functions

The maximum commuting time and cost should be given by tenant as t_0 and c_0, so intervals are X_0 = <0, t_0> and X_0 = <0, c_0>, when a = 0, k(a) = 1.

So the commuting time linked function is

$$k_4(x) = \begin{cases} \frac{x}{t_0}, & x<0 \\ k(a) = 1, & x = 0 \\ \frac{t_0 - x}{t_0}, & x > 0 \end{cases}$$

And the commuting cost linked function is

$$k_5(x) = \begin{cases} \frac{x}{c_0}, & x \leq 0 \\ k(a) = 1, & x = 0 \\ \frac{c_0 - x}{c_0}, & x \geq 0 \end{cases}$$

(e) To establish the rent linked functions

Tenants can give the maximum rent r_0 they can afford, the minimum price is r′, so the rent linked functions can be described as follow

$$k_6(x) = \begin{cases} \frac{x - r'}{r_0 - r'}, & x<r' \\ k(r') = 1, & x = r' \\ \frac{r_0 - x}{r_0 - r'}, & x > r' \end{cases}$$

Integrating all the linked functions above can get the compatibility of this issue

$$\mathrm{K(P)} = \mathrm{k_1(v_1) \wedge k_2(v_2) \wedge k_3(v_3) \wedge k_4(v_4) \wedge k_5(v_5) \wedge k_6(v_6)}$$

It is indicated that the available house meet the requirement of tenants when K (P) > 0, and tenants can replacing their rental housing. Otherwise, extensive analysis and extension transformation methods should be done according to the specific situation.

48.5.3 *Extensive Analysis and Extension Transformation Methods*

48.5.3.1 Contains Analysis About Target Matter Elements

When the available house cannot meet the requirement of tenants, the replacing rental housing system can take contains analysis to expand the scope of tenants' demands. Analysis process is showed by Fig. 48.3.

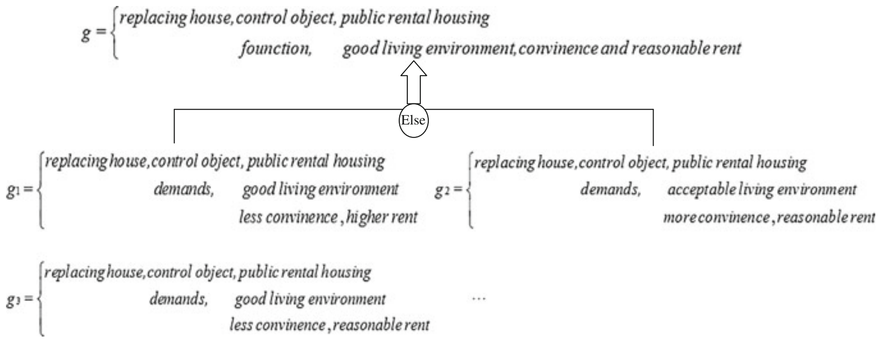


Fig. 48.3 Contains analysis about target matter elements

According to the principle of contains analysis, the target come to realize if anyone of gi comes true (Wen and Yang 2013).

48.5.3.2 Divergence Analysis and Extension Transformation

The result of contains analysis indicates that tenants may choose the house which most approaches their ideal public rental housing when there is no matched available house. So through divergence analysis and extension transformation of the six characteristic parameters of applied public rental housing to transform them into acceptable targets.

The first step. Divergence analysis of location.

$$\text{(Location } d_0\text{, the distance between and work place, near)} \dashv \begin{cases} location\ d_{11},\ c_0,\ near \\ location\ d_{12},\ c_0,\ near \\ \vdots \\ location\ d_{1n},\ c_0,\ near \end{cases}$$

And do replace: $T_{11i}W = W_{11i}$ $(i = 1, 2, \ldots)$

The second step. *Divergence analysis of* house style.

(single room, bedroom, one) $\dashv$ (one bedroom with one living room, bedroom, one)

And do replace: $T_{2i}\ W = W_{2i}$ $(i = 1, 2)$

The third step. Divergence analysis of area.

Choosing a coefficient to enlarge or shrink the area of tenant’s demand in order to find out the most suitable house.

T_3 (required house M, area, $[a_0, b_0]$) = (required house M_1, area, $[\alpha a_0, \alpha b_0]$)

Then undertake the similar method above to enlarge or shrink the commuting time, commuting cost, and rent.

T_4 (required house M, commuting time, t_0) = (required house M_2, commuting time, $\beta\ t_0$)

T_5 (required house M, commuting cost, c_0) = (required house M_3, commuting cos, $\gamma\ c_0$)

T_6 (required house M, rent, r_0) = (required house M_4, rent, λr_0)

48.5.4 Optimal Evaluation

In this part, tenants should give their weighting coefficients to the six characteristic parameters, expressed as α_1, α_2, α_3, α_4, α_5, α_6($0 \leq \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6 \leq 1$). Then counting out the specification correlation [expressed as K(Zj)] of each available house in public rental housing system. Finally, the result of optimal evaluation of each available house can be described as follow:

$$C(Z_j) = (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6)K(Z_j) = \sum_{i=1}^{6} \alpha_i k_{ij}, \quad j = 1, 2, \ldots, n$$

The maximum one is the most suitable house.

48.6 Simulation Test

Choosing replacing house system of Chongqing public rental housing as the example simulation test, in order to put the extension strategy generating model in replacing rental house decision-making system into practice.

48.6.1 Establish Extension Model of Replacing Rental Housing

A family with three members lived in Minan Huafu Rental Housing Community in HuaYan region, but one member of this family exchanged his work place near Xiexin Centre in JangBei region. The quickest method from his home to his work place needs one hour and 20 min and 7 yuan in total, while the cheapest method needs more than one and half hour and 4 yuan in total. It can be observed that the tenant suffer long commuting time and high commuting cost after he changed this job. This family can apply to Chongqing public rental housing department to replace their house. Their demands are

$$W = \begin{bmatrix} \text{Objective house M,} & \text{Location,} & \text{Minxin gardon} \\ & \text{House style,} & \text{one bedroom} \\ & \text{Area,} & [48, 55] \\ & \text{Commuting time,} & 55\,\text{min} \\ & \text{Commuting cost,} & 4\,\text{yuan} \\ & \text{Rent,} & 10.5\,\text{yuan/m}^2 \end{bmatrix}$$

There is no suitable available house in public rental housing system which meets all the demands of the tenant, so should take some measures to find out the closest house form available houses A, B, C, and D.

Among them, A can be described by extension model as

$$L = \begin{bmatrix} \text{Available house A,} & \text{Location,} & \text{Minxin gardon} \\ & \text{House style,} & \text{one bedroom} \\ & \text{Area,} & 47.37 \\ & \text{Commuting time,} & 55\,\text{min} \\ & \text{Commuting cost,} & 2\,\text{yuan} \\ & \text{Rent,} & 11\,\text{yuan/m}^2 \end{bmatrix}$$

The extension model of this incompatible problem is

$$P = G * L = \begin{bmatrix} \text{Renter,} & \text{Control object,} & W \\ & \text{Agent object,} & \text{Renter} \end{bmatrix} * \begin{bmatrix} \text{Available house A,} & \text{Location,} & \text{Minxin gardon} \\ & \text{House style,} & \text{one bedroom} \\ & \text{Area,} & 47.37 \\ & \text{Commuting time,} & 55\,\text{min} \\ & \text{Commuting cost,} & 2\,\text{yuan} \\ & \text{Rent} & 11\,\text{yuan/m}^2 \end{bmatrix}$$

48.6.2 Compatibility Analysis

The location linked function: because x = 0, so $k_1(x) = 1$.

The house style linked function: $k_2(x) = 1$.

The area linked function: tenant's demand of house area is [48, 55], M = 51.5, while the area of available house is x = 47.37, and x < 48, so

$$k_3(x) = \frac{2(47.37 - 48)}{55 - 48} = -0.18$$

The commuting time linked functions: $k_4(x) = 0.09$

The commuting cost linked functions: $k_5(x) = 0.5$
The rent linked functions:

$$k_6(x) = \frac{10.5 - 11}{10.5 - 9} = -0.33$$

Then it can get the integrated linked function: $KA(P) = k_1(v_1) \wedge k_2(v_2) \wedge k_3(v_3) \wedge k_4(v_4) \wedge k_5(v_5) \wedge k_6(v_6) = 1 \wedge 1 \wedge (-0.18) \wedge 0.09 \wedge 0.5 \wedge (-0.33) < 0$.

48.6.3 Extension Transformation

The area and rent of available house do not meet tenant's demands, so choosing coefficient 0.9 to shrink the area of objective house and choosing coefficient 1.1 to enlarge the rent.

T_3 (required house M, area, [48, 55]) = (required house M_1, area, [43.2, 49.5])

T_6(required house M, rent, 10.5) = (required house M_4, rent, 11.55)

Then count the linked function again: $k_3'(x) = 0.68$; $k_6'(x) = 0.22$.

$KA'(P) = 1 \wedge 1 \wedge 0.68 \wedge 0.09 \wedge 0.5 \wedge 0.22 > 0$, so that available house A becomes the one which close to the tenant's demands.

Use the same method above to analysis and calculate rest available public rental housing B, C, and D.

$$L = \begin{bmatrix} \text{Available house B,} & \text{Location,} & \text{Kangzhuang Meidi} \\ & \text{House style,} & \text{one bedroom} \\ & \text{Area,} & 49.5 \\ & \text{Commuting time,} & 40\,\text{min} \\ & \text{Commuting cost,} & 2\,\text{yuan} \\ & \text{Rent,} & 10\,\text{yuan/m}^2 \end{bmatrix}$$

$$L = \begin{bmatrix} \text{Available house C,} & \text{Location,} & \text{Kangzhuang Meidi} \\ & \text{House style,} & \text{one bedroom} \\ & \text{Area,} & 48.7 \\ & \text{Commuting time,} & 40\,\text{min} \\ & \text{Commuting cost,} & 2\,\text{yuan} \\ & \text{Rent,} & 10\,\text{yuan/m}^2 \end{bmatrix}$$

$$L = \begin{bmatrix} \text{Available house D,} & \text{Location,} & \text{Kangzhuang Meidi} \\ & \text{House style,} & \text{Single room} \\ & \text{Area,} & 45.04 \\ & \text{Commuting time,} & 40\,\text{min} \\ & \text{Commuting cost,} & 2\,\text{yuan} \\ & \text{Rent,} & 10\,\text{yuan/m}^2 \end{bmatrix}$$

48.6.4 Optimal Evaluate

This family gives their weighting coefficients of the six characteristic parameters as (0.10, 0.25, 0.15, 0.15, 0.20, 0.15).

The linked degrees of six characteristic parameters of public rental housing A, B, C, and D are:

$K_1 = (1,1,1,1)$

$K_2 = (1,1,1,0.5)$

$K_3 = (0.68,0.43,0.76,0.58)$

$K_4 = (0.09,0.27,0.27,0.27)$

$K_5 = (0.5,0.5,0.5,0.5)$

$K_6 = (0.22,0.33,0.33,0.33)$

The maximum values of each available house about suitable degree are:

$\max|K_1(x)| = 1$, $\max|K_2(x)| = 1$, $\max|K_3(x)| = 0.76$, $\max|K_4(x)| = 0.27$, $\max|K_5(x)| = 0.5$, $\max|K_6(x)| = 0.33$

Specification correlation degrees are:

$$\begin{aligned} K(A) &= (1,1,\ 0.89,\ 0.33,1,\ 0.67) \\ K(B) &= (1,1,\ 0.57,\ 1,1,1) \\ K(C) &= (1,1,1,1,\ 0.74,1) \\ K(D) &= (1,\ 0.5,\ 0.76,1,1,1) \end{aligned}$$

Optimal evaluate of A is:

$$C(A) = \alpha K(A) = \begin{bmatrix} 0.10 \\ 0.25 \\ 0.15 \\ 0.15 \\ 0.20 \\ 0.15 \end{bmatrix} (\ 1,\ 1,\ 0.89,\ 0.33,\ 1,\ 0.6) = 0.83$$

Others are: $C(B) = 0.94$, $C(C) = 0.96$, $C(D) = 0.84$

$C(C) > C(B) > C(D) > C(A)$

From what has been discussed above, it can be seen that public rental housing C is the best house in replacing rental housing system which meets the needs of tenants in the greatest degree.

48.7 Conclusion

The extension strategy generating method can transform unmatched house in public rental housing system into alternative proposal so as to expand the scope of tenant selection and reduce waiting time of tenants. Because using extension model in replacing rental housing system, the tenants only need to hand on their demands of target public rental housing and their weighting coefficients of the six characteristic parameters in one time. As the simulation test above, if searching for available house in public rental housing system according to initial demands of tenant, it may be unable find out the suitable house. However, extension strategy generating method can find out several houses which close to the requirements of the target house. The most usable point is the replacing house decision-making system based on extension model will make an optimal evaluation on each available house, and the system will eventually output results according to conform degree to tenant's demands, for tenants to choose from.

The extension model is implemented to improve replacing house process of public rental housing. It not only accelerates the speed and improves the accuracy of replacing house decision-making, but also reduces human intervention to ensure that the justice in the decision-making process. At the same time, the model can offer reference for public rental housing management operation.

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Chapter 49
Temporal and Spatial Variation of Housing Affordability in China

Huachao Qian, Xin Ma, Qi Wang and Chen Liu

Abstract This paper analysis the PIR index changes in 35 cities from 1991 to 2012. The results show that the housing affordability of urban residents appears to enhance at first and then becomes weak. In generally, the overall housing affordability is low and always fluctuating. In addition, the differences of the spatial distribution are significant. The PIR in developed areas are high while in underdeveloped areas are low. People's income in developed areas is higher than those in underdeveloped areas, and this leading to a more comfortable life. But the increasing rate of the housing price is faster than that of the income, so it increases the cost of housing payments.

Keywords PIR · Historical changes · Regional differences

49.1 Introduction

Housing prices is the most important factor that leading to the housing problem, and the housing problem is deeply connected to everybody's benefit and social stability. In order to solve the housing problem of the residents, complete the housing structure, ensure that the real estate can developed healthily and steadily, it's necessary to have a good command of the housing affordability of urban residents in our country. The unreasonable PIR and the low housing affordability are the inherent problems that implies in the housing problem and high housing price. A comprehensive and systematic research about the housing affordability of urban

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residents in our country can contribute to master the overall change rule and housing affordability, and then providing basis for housing policy makers.

Currently, there are a large number of academic studies on the problem of housing affordability, Ka Man Lau (2006) used the PIR to analysis the housing affordability of Beijing resident between the year 1992 and 2002 and had the in-depth discussion on how the high housing price caused the low housing Affordability. In order to take the expected growth of income into account, Chen Jie (2008) for the first time to use a numerical model to calculate the "dynamic price earnings ratio" indicator in Shanghai, at the same time, he pointed out that stable and rapid growth of revenue is the fundamental way to solve the problem of housing affordability. Scholars above just analyzed the PIR of part of the cities, however, the level of economic development in all regions of China are very different. At the same time, Zhang (2007) calculated the PIR between year 1991 and 2005, he found that the PIR has obvious regional differences. The truth was that few people combined time with space in their studies. This paper selected index of PIR to analysis the changes of the PIR from time and space. Grasping its distribution had important policy and practical significance on improving housing standards and people's livelihood.

49.2 Data Sources and Index Selection

49.2.1 Data Sources

In this paper, by using the data from "China Statistics Yearbook 2012", "China statistical abstract 2012" and fine news database. Among them, the average sales price of residential from 1991 to 2006 was calculated according to the table in the Yearbook "commodity housing sales" data. The data comes from the Yearbook "according to the average sales price of the commodity housing" use table from 2007 to 2012. Urban per person's housing area from 1991 to 2005 data from the years of the "Chinese calendar year of urban and rural residents per person's household consumption expenditure and housing statistics", and other years from data published by the Ministry of construction. Average household sized from JX database "statistics Chinese in Main Years basic situation of Urban Households". Per resident's disposable income in 1991 to 2011 data from the Yearbook "families of urban and rural per resident's income and the Engel coefficient" table. In addition, the data in 2012 comes from the database Chinese JX "over the years in various regions of per urban resident's disposable income statistics". You can see the data in Table 49.1.

The data of per person's disposable income in 35 cities came from Fine news database and each city's Statistical Bulletin. Among them, the data between 2007 and 2010 came from the Fine news database taken from the calendar year, "Beijing Statistical Yearbook" while 2011 and 2012 data were from 35 cities in the

Table 49.1 1991–2012 years of housing price and income situation

Years	Average household population (N)	Construction area of per capita housing (AH)	The average sales price of residential (AP)	The capita disposable income (AV)	Household disposable income (TY)	Household housing price (TP)
	People per household	Square meters per person	Yuan per square metre	Yuan per person	Yuan per household	Yuan per household
1991	3.43	14.2	756	1700.6	5833.058	36,817.2
1992	3.37	14.8	996	2026.6	6829.642	49,700.4
1993	3.31	15.2	1280	2577.4	8531.194	60,762.4
1994	3.28	15.7	1194	3496.2	11,467.54	61,491
1995	3.23	16.3	1509	4283	13,834.09	79,373.4
1996	3.2	17	1605	4838.9	15,484.48	87,312
1997	3.19	17.8	1790	5160.3	16,461.36	101,639.8
1998	3.16	18.7	1854	5425.1	17,143.32	109,556.6
1999	3.14	19.4	1857	5854	18,381.62	11,312.1
2000	3.13	20.3	1948	6280	19,656.4	123,774
2001	3.1	20.8	201.7	6859.6	21,264.76	130,056.2
2002	3.04	24.5	2092	7702.8	23,416.51	155,812.2
2003	3.01	25.3	2197	8472.2	25,501.32	167,308.1
2004	2.98	26.4	2608	9421.6	28,076.37	205,176.6
2005	2.96	27.8	2937	10,493	31,059.28	241,676.8
2006	2.95	28.5	3119	11,759.5	34,690.53	262,251
2007	2.91	30.1	3645	13,785.8	40,116.68	319,285.2
2008	2.91	30.6	3576	15,780.8	45,922.01	318,428.5
2009	2.89	31.3	4459	17,174.7	49,634.74	403,347.8
2010	2.88	31.6	4725	19,109.4	55,035.19	430,012.8
2011	2.87	32.7	4993	21,809.8	62,594.07	468,604.4
2012	2.86	32.9	5430	24,564.7	70,255.1	510,923.9

"Economic and Social Development Statistics Bulletin". The average selling price of residential in 35 cities came from "China Real Estate Statistics Yearbook" over these years. In the absence of per family population in 35 cities from year 2007 to 2012, this paper use provincial data instead. By compared per family population in some cities with provincial data, we can see that the city's population is slightly less than the average provincial data. However, due to the use of the household disposable income, the substitution effect on the total revenue will be very small.

49.2.2 Index Selection

CICC Research report using each residential floor area of 90 m^2 to calculate PIR, Jie Chen, Qianjin Hao using 80 m^2 standard, Qingyong Zhang use was 80 m^2.

There is still no uniform standard. Both sets of residential area were a dynamic variable and will change over time, so the best selection of new residential units is an area over the years. But the absence of the full data of the 35 new residential units, the article select an area of 90 m^2 each for calculation. With economic development, the house type of 60–70 m^2 which people liked in nineties did not apply, while the government ruled that more than 70 % of new residential must be under 90 m^2 house, you can see 90 square feet of residential did not belong to the market the public side, so I put the area to 80 m^2.

The selection of capacity to pay has lots of indexes, It also has lots of other indexes effected of various factors such as the economic situation, income, price level, supply, financial support. The characteristics of PIR is simple and practical, at the same time, the data were easier to obtain, so the paper choose this method. It shows that it is appropriate to select PIR to analysis historical change trend of housing affordability. Although there are differences of many scholars in the index of some component factors of selection, most of them hold a positive attitude on using the housing price to income ratio to analysis the capacity to pay of historical changes. They think it is feasible to analysis the change trend of history based on the data of the homologous. Therefore this paper select PIR to analysis the change trend of housing payment ability for China's urban residents in 1991–2012.

In this paper, the housing price to income ratio (PIR) is calculated by the following formula:

$$PIR = \frac{TP}{TY} = \frac{AP \times AH \times N}{AY \times N}$$

Among them, TP refers to the new housing market price, which residential average sales price (AP) and the per person's housing construction area (AH) and the average number of population (N) product. TY refers to the household disposable income, which is the per person's disposable income (AY) and the average number of population (N) product.

49.2.3 Data Processing and Variable Description

Table 49.1 describes our 1991–2012 Annual average residential sales price (AP), Per capita housing area (AH), The average number of people per household (N) and Per capita disposable income (AY).

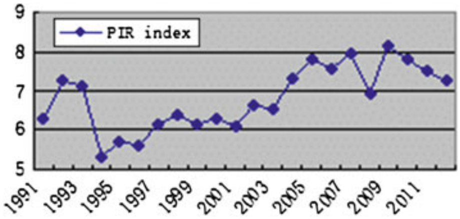


Fig. 49.1 The trends of the PIR from year 1991 to 2012

49.3 Analysis of Historical Change of the Ability of Payment

According to Fig. 49.1, we can divide our house price income ratio variation into the following five stages:

The first stage (1991–1993), the PIR of our country at this stage was in a relatively high level, of which the PIR in 1992 is 7.28, the highest in three years. This was because the rise of house prices during 1991–1993 was faster than income growth. During this period, with the support of Banks and local governments, there was the real estate development boom in China, investment hot spots were mainly concentrated in southeast coastal area, the second was in northeast. Mainland funds flock into the coastal areas of the real estate market, which contributes to the boom of the housing and land prices and the decrease of the housing affordable ability. In this stage, of course, the contradiction between housing supply and demand was not particularly outstanding, because the composition of urban residents housing main body or predominantly unit was still welfare housing which lasting for a long time. So even though the PIR was high, but it did not create a larger burden on people's lives.

The second phase (1994–1998), in 1994 the government took the tightening monetary policy on real estate market to carry on macroeconomic regulation and control, cooling the property market, and the average housing sales price appeared a negative growth. Sharp decline happened in PIR from 7.12 in 1993 to 5.36 in 1994. After this years, while the growth of home sales prices was declining, the growth rate of people's income was slower comparing with it, thus a steady rise was reflected on the PIR. Since 1994, the ability of people's housing affordability was abate on the housing market, but in the absolute quantity, average housing burden of urban residents was not heavy, most of people have the ability to pay house prices.

The third stage (1999–2003), the volatility of PIR in China was very small during this period, except the slight increase in 2000, the other few years maintain the same basic level. House prices had a certain pressure on household incomes in recent years. However, in contrast, the degree of the pressure was not too heavy.

The fourth stage (2004–2007), China's PIR showed rapid upward trend firstly, and then fell back, but on the whole is still at a relatively high level, among them, the PIR reached the highest value 7.31 in 2005. As we can see from the Fig. 49.1, the housing price rose faster in 2004 and 2005, considerably faster than the income growth of urban residents, which caused the decline of urban residents housing affordability, aggravated the housing burden of residents. The government strengthened the regulation of real estate in view of the situation of continuing high real estate prices rose. Through regulation, residential sales price growth slowed in 2006, however the price continued growing in 2007. On the whole, in this stage, the housing affordability of urban residents was in a decline, it aggravated the burden of obtaining housing from the market.

The fifth stage (2008–2012), the PIR was still at a high level, the housing price was greatly fluctuating in these few years. The real estate market also received a certain impact because of the global economic crisis, the PIR was only 6.93. But the PIR reached an all-time high level 8.13 because of a series of policy carried out by government to rescue the market. The Housing price was steady state after year 2010.

It can be seen from Fig. 49.1, the PIR changes mainly ranging from 5.36 to 8.13 since 1991.

Among them, the PIR was Significantly higher in year 2005, 2006, 2007, 2010 and 2011, it indicated that the resident's housing payment ability was weak in these years and had burden on purchasing.

On the whole, the housing affordability of urban residents was firstly increased and then decreased, but finally it still increased since 1991–2012. The resident's housing affordability was not good in most of these years and only a few years the housing affordability was better.

49.4 Analysis of the Regional Differences in the Ability to Pay

The primary feature of the real estate is in touch with the land, with immovable property, and thus the real estate market is a typical feature of a regional market. Due to natural conditions, the existence of differences in social and economic conditions and the level of economic and social development, there must also be regional differences in China's real estate market. The level of development of China's housing market presence in eastern, central and western regions the level of development of China's housing market showed large differences, changes in housing prices also showed a large regional differences. Therefore, China's urban residents in housing affordability on regional differences can make analysis of the housing situation of urban residents the ability to pay more accurate. Here we will use the price earnings ratio (PIR) and housing payment capability index (HAI) to comprehensively analyze the ability to pay for housing of 35 cities residents to explore China's urban residents in housing affordability features of inter-regional and regional differences.

49.4.1 Analysis of the PIR of 35 Large and Medium-Sized Cities: 2007–2012

See Table 4.2.

Table 49.2 PIR of the 35 large and medium-sized cities: 2007–2012

PIR	2007	2008	2009	2010	2011	2012	Average	Standard deviation
Beijing	12.47	11.24	10.54	9.79	11.64	12.58	11.38	1.09
Tianjin	7.29	7.58	6.78	7.47	9.72	9.9	8.12	1.34
Shijiazhuang	7.23	5.49	5.28	4.58	4.6	4.69	5.31	1.01
Taiyuan	7.6	6.42	6.54	6.2	7.38	7.05	6.87	0.56
Huhehaote	6.05	4.92	4.39	4.04	3.85	4.62	4.65	0.79
Shenyang	11.62	10.57	10.04	9.19	9.24	8.37	9.84	1.16
Dalian	10.29	9.33	8.61	8.24	9.2	9.78	9.24	0.75
Changchun	9.33	8.11	6.87	6.61	6.47	6.27	7.28	1.2
Ha'erbin	9.22	8.61	7.91	7.1	7.18	6.71	7.79	0.97
Shanghai	8.97	9.42	10.75	10.87	12.2	11.57	10.63	1.24
Nanjing	8.37	8.67	8.02	7.7	7.94	7.34	8.01	0.47
Hangzhou	7.48	8.59	8.74	8.09	10.83	9.94	8.95	1.23
Ningbo	4.74	5058	5.43	5.77	8.55	8.21	6.38	1.59
Hefei	5.91	5.84	6.46	7.07	8.61	7.65	6.93	1.07
Fuzhoy	6.07	5.96	5.9	6.05	7.09	8.05	6.52	0.87
Xiamen	6.18	6.16	4.93	7.38	8.71	10.25	7.27	1.94
Nanchang	6.16	5.6	6.98	7.14	6.7	7.25	6.64	0.64
Jinan	6.59	5.91	6.12	6.98	6.84	6.51	6.49	0.41
Qingdao	6.03	6.83	5.18	7.34	8.63	8.01	7.01	1.27
Zhengzhou	6.4	6.16	5.78	5.41	5.9	6.05	5.95	0.34
Wuhan	6.23	6.73	6.52	6.9	8.04	8.36	7.13	0.86
Changsha	5.17	4.86	4.77	4.26	4.82	5.05	4.82	0.31
Guangzhou	6.67	7.37	6.26	6.11	7.3	8.18	6.98	0.78
Shenzhou	5.77	5.93	5.69	5.85	8.58	10.33	7.03	1.96
Nanning	6.06	6.01	5.74	6.15	6.91	6.67	6.26	0.44
Haikou	5.24	5.45	5.39	5.34	6.09	5.71	5.54	0.31
Chongqing	3.76	4.74	4.29	5.26	5.9	5.4	4.89	0.78
Chengdu	6.67	5.95	5.86	5.77	7.71	8.14	6.68	1.02
Guiyang	4.73	4.95	5.35	4.51	4.73	4.73	4.83	0.29
Kuming	7.5	6.84	6.1	6.46	6.55	6.28	6.62	0.5
Xi'an	6.88	6.84	6.27	7.01	7.7	7.83	7.05	0.61
Lanzhou	5.78	5.12	5.33	6.21	6.73	6.46	5.94	0.64
Xining	4.57	4.43	4.9	4.67	5.04	5.1	4.79	0.27
Yinchuan	5.91	6.61	5.74	5.91	5.77	5.48	5.9	0.38
Wulumuqi	5.47	5.81	5.63	5.18	5.18	4.74	5.34	0.38
Standard deviation	1.92	1.68	1.64	1.52	1.95	2.04	–	–

49.4.2 The Result Analysis

1. Most of the eastern cities of housing affordability are reduced, and poor housing affordability can be seen from Table 49.2. The cities whose standard deviation of PIR are more than 1.2 include Shenzhen (1.96), Ningbo (1.59), Xiamen (1.94), Tianjin (1.34), Qingdao (1.27), Shanghai (1.24), Hangzhou (1.23). That means those cities' housing price to income ratio fluctuates greatly. From 2007 to 2012, the PIR of the cities in general were on the rise, especially in Shenzhen and Xiamen, these cities of PIR respectively increased from 5.77 and 6.18 in 2007 to 10.33 and 10.25 in 2012, indicating that in Shenzhen and Xiamen city from 2007 to 2012, there was a sharp drop in affordability obtaining house from the housing market. This may be related to the rapid rise of these two cities' housing prices. From the eastern, central and western point of view, all cities whose standard deviations above 1.2 and PIR showing an increasing trend distributed in our country in the eastern region, besides the two cities of Shijiazhuang, Nanjing PIR falling slightly, with all the other cities in eastern PIR rising slightly. It showed that most of the residents of the city in East China housing afford ability including Shenzhen Xiamen and other cities of the large reduced.
2. Although most of the western cities of housing affordability are less volatile, part of the cities have good ability to pay. According to the calculation results of Table 49.2, Xining, Guiyang, Yinchuan and Urumqi PIR standard deviation of these western cities was less than 0.4, and the PIR average was less than 6, which suggested that the PIR was less volatile, housing prices of these cities was in residents' affordable range. It is worth noting that since 2009 PIR value of the three cities of Chengdu, Chongqing and Xi'an have been increasing year by year, indicating that the cities' residents had a drop in housing affordability. These three cities were more developed in the western region, with the development of the western development strategy, some real estate developers entering into the west, and preempting potential market. These cities' real estate market increased actively, and house price rose faster, thus PIR value began to decrease.
3. The changes of the central cities of PIR varied, and housing affordability of most of the central cities was weak from Table 49.2. PIR value of the two cities of Changchun, Harbin appeared a decreasing trend year by year, from 9.33 and 9.22 in 2007, dropped to 7.28 and 7.79 in 2012. This showed that the residents housing affordability of the two cities has increased, but on the whole, the two cities' housing affordability was relatively weaker. PIR value of Wuhan, Nanchang, Hefei rose slightly, and Wuhan is the largest city in the central parts and had the value of 8.36 in 2012. It showed that the housing affordability of the three cities declined, while Wuhan becomes the city of the worst housing affordability in central China. PIR value standard deviation of Zhengzhou and Changsha were 0.34 and 0.31, respectively, showed that housing payments of the two cities were less volatile. In recent years, housing affordability of

Zhengzhou and Changsha is better, but it was noting that the two cities of PIR since 2010 have had smaller value rise year by year, which meant that the two cities housing affordability was on the decline.

4. By Calculating different cities' PIR standard deviation of each year between 2007 and 2012, find that firstly the standard deviation is decreasing year by year, reduced from 1.92 in 2007 to 1.52 in 2010, and then increasing year by year, rose from 1.52 in 2010 to 2.04 in 2012. The difference before 2010 has shortened probably due to the increases of social fluidity, housing mercerization and the regional residential market linkage strengthened; but in recent years, housing payment capacity among 35 large and medium-sized cities shows a trend of increase, it may caused by huge rising speed difference of housing price among several main cities.

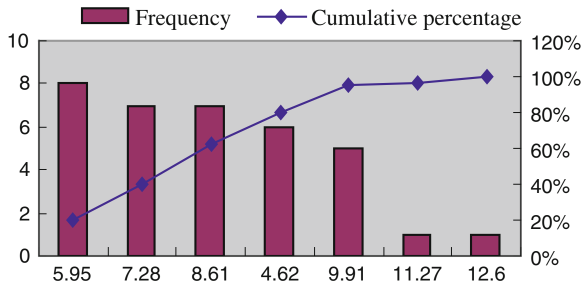
According to the above data, we can get some conclusions: People in economically developed areas get higher income. In economically developed areas, people's income is relatively high with the standard of living is relatively high, they should be able to enjoy a higher quality of life. But comparatively speaking, the housing price is increasing faster than people's income. Overall, it increases people's housing payment cost instead.

49.4.3 Analysis of 5 Large and Medium-Sized Cities' PIR Histogram

Though the PIR has none judgment, it may due to differences in the statistical caliber and the actual situation in various countries, PIR cannot be measured with a unified standard determined by the residents of housing payment capacity. Therefore, our country scholars discuss lots about the reasonable standard of PIR, in general there are two kinds of thought. One is through modifying the data used for calculation of PIR, to reduce as far as possible the deviation caused by the inaccuracy of data, such as when using people's income data, considering the gray income and catch the last adjustment coefficient, then almost using the range no more than 6 in international to measure people's housing payment capability. The second is inclined to explore a suitable PIR range on base of China's special national conditions. The paper will use the histogram method below analyzing the PIR of 35 large and medium-sized cities in 2012 to explore its "normal" range in our country.

Call the "Normal P-P" process in SPSS16.0 to draw the normal probability distribution map by using the PIR data of 35 large and medium-sized cities in 2012, we can find that the normal probability distribution map drawn form an almost vertical axis line from point to the upper right corner, this suggesting that these values are almost in the basic normal distribution. So we can use the histogram analysis method to draw the Pareto diagram of PIR of 35 large and medium-sized cities in 2012. As shown in Fig. 49.2:

Fig. 49.2 35 cities PIR pare to in 2012



Based on histogram and frequency distribution table to select a normal proportion, we can obtain the “normal” distribution interval of Chinese housing-price-to-income ratio.

It can be seen from the 3.2 that if select 80 % and no lower limit, the PIR’s “normal” interval of newly built house will be (4.62, 4.62), which means the housing affordability of Beijing, Shanghai, Shenzhen, Xiamen, Hangzhou, Tianjin and Dalian are poorer; If select 65 % and a lower limit, the PIR’s “normal” interval of newly built house will be (5.95, 5.95), which means the housing affordability of Hohhot, Shijiazhuang, Wulumuqi, Guiyang and other cities is better whose PIR is less than 5.95; If select 60 % and a lower limit, the “normal” interval of our country’s PIR is (5.95, 5.95). There is a certain gap with the usual boundaries of “6”, but the gap is not too big. Above is analyzed from the angle of statistics for the “normal” distribution range of Chinese housing-price-to-income ratio, in fact that is the median level of urban housing-price-to-income ratio of our country. It use of the same indicators, but due to the change of the object of study, there are differences between the choice of the indicators used in the factors, which may cause a certain influence on reasonable scope of the measure. Therefore, this analysis is only a simple and plain attempt for reasonable housing-price-to-income ratio, whether the attempt is reasonable or not remains to be further discussed.

49.5 Conclusions

1. Generally speaking, the PIR was at a relatively high state from the year 1991. It showed that people’s housing affordability was relatively weak and had relatively heavy burden of buyers. The housing affordability of urban residents appeared to enhance at first and then weakened. We can see that people’s housing affordability was not very good in most of the years.
2. By comparing the change of the PIR in 35 large and medium-sized cities, we can see that may be due to enhanced staff mobility between cities and residential market, in recent years, housing affordability differences in 35 cities showed a tendency to increase. People’s income in economically developed regions were

relatively higher, so people can enjoy higher life. Relatively speaking, the rate of increase of the housing price was more than the rate of increase of the income, which increased the cost of housing payments (Xia et al. 2008).

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Chapter 50
A Panel Data Analysis on the Relationship Between Supply of Affordable Housing and Housing Prices

Pu Xiaotian and Yang Jun

Abstract Although there is the development of affordable housing construction in China, it is still failed to curb the housing price and improve the supply and demand contradiction. Therefore, we need to understand the mechanism of the interaction between them. In this paper, we use the panel data over the period of 2002–2012 from 29 provinces in China to test the impacts of affordable housing market to housing price. The result shows that the price of affordable housing has a positive effect on housing price, but the area has a bidirectional effect on housing price and there are strong regional differences in the strength of influence. And the authors put forward policy recommendations according to the empirical results.

Keywords Housing price · Panel · Data analysis · Affordable housing

50.1 Introduction

The government has always been committed to inhibiting the excessive growth of house prices, achieving market supply and demand balance and solving the housing problem of vulnerable groups. In spite of the several rounds of regulation, the government and resident are still not satisfied with the trend of housing price which is maintained at a reasonable price with steady growth. At present, low-income groups have quite little possibility to afford housing with such high housing price. Government has re-recognized that the construction of affordable housing can not be slackened through these failed policies. In recent years, the government

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promulgates large number of policies to build affordable housing aimed at clear the debt of neglecting the construction of it. In the capital of the central government on protection of housing construction funds investing, we can see that 2008 was 36.866 billion yuan, 55.056 billion yuan in 2009, 2010 was 63.2 billion yuan and 2011 central government subsidied to fund investment reached 152.2 billion yuan, 2012 was even reached 233.261 billion yuan.

Although the construction of is increasing, whether we can see the effect of this policy rapidly or witness little consequent of it as the policy can not take the pulse of quasi-market? The authors think that it lies on correct understanding to the interaction mechanism between affordable housing and housing market. Therefore the empirical study of relationship between supply of affordable housing and housing prices and correct understanding on the interaction mechanism between them and make affordable housing and housing interact positively in a rational framework. As a result, the two accelerate each other, interact better, and develop harmoniously, maximize the effectiveness of the common market and the government. The above-mentioned is quite urgent.

50.2 Literature Review

What does affordable housing price affect have on housing price? Whether it promotes or restrains housing price, or maybe there is little connection between them? There has been debate in academic theory circle.

At present, domestic scholars mainly has the following several kinds of understanding: (1) Promotion theory. In this view, affordable housing and commercial housing alternative is not strong, depending on demand for different groups respectively, analyzing from the supply side, that the supply of affordable housing will be reduced commodity residential land, thereby reducing the number of housing supply (Assaf et al. 2010; Aimin and Zhenglong 2012). (2) Reduction theory. In this view, affordable housing supply will ease the population living difficulties, and solve the housing problem, thereby reducing the price of commercial housing (Moulton 2014; Ryan and Enderle 2012). (3) Limitation theory. In this view, there is no clear correlation between the two, affordable housing is not valid for Home Basic. Wang Xianzhu views that effect is present, but is limited. He chooses Hong Kong's public housing as a control to explain the mainland by the fitness room some negative impact on the market, come to the protection of housing market adjustment is insufficient to have an enormous impact on substantive conclusions. As can be seen from different angles scholars' departure, the conclusion is also quite different (Xianzhu 2009; Youyi 2009).

The purpose of the present study is to answer two questions: Firstly, what would affordable housing have affect on commodity prices? Whether it is raised or decreased commodity prices. Secondly, how much is the extent of this influence? Only through scientific analysis of the quantitative relation, can we get rigorous conclusion.

50.3 Data Selection and Model Building

50.3.1 Panel Data

Panel data refers to the multidimensional data set which consists of a variable's value of the individual (personal, family, enterprise or country) in a period. Such data can be tracked to obtain through a few individuals. From the cross section, panel data is composed of several individual section observation forms at some point value and each individual is a time series.

50.3.2 Data Selection

In this paper, we select the following data: (1) Supply of affordable housing. It mainly affects housing prices through price and availability. We use affordable housing sales area of application (AHA) to represent the supply of affordable housing. Although affordable housing includes low-rent housing and public rental, it is generally agreed that affordable housing is the main supply of affordable housing. And when it comes to quantity, it is accounted for the vast majority of affordable housing constitutes. The reason that we choose affordable housing sales area but not construction area is that we mainly aimed at revealing its affect on current housing price; (2) affordable housing price (AHP), We use affordable housing price to represent affordable housing price based on a same reason; (3) We use the average prices for sales of commercial housing (HP) to present commodity residential house price. As Shanghai and Tibet statistical data are missing and affordable housing system in the actual situation, the data object to 29 provinces, municipalities and autonomous regions of the real estate market development sample data span the period 2002–2012, a total sample of 319. Data comes from "China Statistical Yearbook".

50.3.3 Model Building

50.3.3.1 Unit Root Test

At the 1 % significance level, affordable housing prices, the supply of affordable housing area and its price and housing price data are non-stationary time series data. There are unit root, so the order of the original sequence of a stationary test results show the affordable housing prices, supply area and the real estate prices exist an order one, consistent cointegration relationship between variables basis, and the test results are shown in Table 50.1.

Table 50.1 Three variable order 1 unit root test results

Test methods	Commercial housing sales price		Affordable housing sales price		Affordable housing sales area	
	Statistics	P-statistics	Statistics	P-statistics	Statistics	P-statistics
LLC	−9.78987	0.0000**	−12.1345	0.0000	−23.2154	0.0000
IPS	−5.88586	0.0000	−5.4654	0.0000	−13.6464	0.0000
ADF	144.947	0.0000	132.365	0.0000	235.078	0.0000
PP	284.545	0.0000	211.678	0.0000	276.667	0.0000

** Their confidence levels all reach to 99 %

50.3.3.2 Cointegration Test

By Counteraction test, indicators basically conform to several methods, such as Panel rho, Panel V test, data basically conform to the cointegration test, we can conclusion that the three have a long-term equilibrium relationship. Test indicators are shown in Table 50.2.

50.3.3.3 The Choice of Panel Model

In order to define the variables form, we build the influence of random effect model and fixed effect model.

$$HP_{it} = c + \alpha_i + \beta_{0i} * AHP_{it} + \beta_{1i} * AHA_{it} + u_{it}$$
$$HP_{it} = \alpha_i + \beta_{0i} * AHP_{it} + \beta_{1i} * AHA_{it} + u_{it}$$

Then we set out to Hausman test and likelihood ratio test (LR) to judge the influence form. The test results are shown in Table 50.3.

Table 50.2 Three variables cointegration test

Test methods	Statistics	P-statistics	Test methods	Statistics	P-statistics
Panel v-statistic	1.921394	0.0815	Group rho-statistic	4.6434348	0.0345
Panel rho-statistic	1.185838	0.8827	Group PP-statistic	−3.646447	0.0001
Panel PP-statistic	−4.303449	0.0000	Group ADF-statistic	2.022354	0.0397

Table 50.3 Hausman and LR test result

	Type	chi-sq.statistic	chi-sq.df	P-statistic
Hauseman test	Cross-section random effects	20.033300	2	0.0430
LR test	Cross-section chi-sq.	171.721812	28	0.0000
	Cross-section F	7.659509	(28, 228)	0.0000

Table 50.4 The established regression results

	Fixed effects model	Mixed model	Variable coefficient model
Adjusted R-squared	0.826615	0.700324	0.875357
sum squared resid	1.02E + 08	1.97E + 08	55,097,437
prob.	0.000000	0.000000	0.000000

Hausman test and LR test results show that we can build individual fixed model, rather than the mixed model and the individual random model. In addition, by establishing the variable coefficient model, the fixed effects model, and the constant parameter model and set out to do F value test to determine the model forms.

$$HP_{it} = \alpha_i + \beta_{0i} * AHP_{it} + \beta_{1i} * AHA_{it} + u_i$$
$$HP_{it} = \alpha_i + \alpha_i * + \beta_{0i} * AHP_{it} + \beta_{1i} * AHA_{it} + u$$
$$HP_i = \alpha + \beta_0 * AHP_i + \beta_1 * AHA_i + u_i$$

Calculated according to the results of the regression, F2 = 5.33, F1 = 2.65, in a given significance level of 5 % F1 and F2 are greater than threshold, it refused to H1, H2, respectively, model with variable coefficients form should be adopted Table 50.4.

50.4 Empirical Tests

50.4.1 Cointegration Test Results

We build a fixed effects model with variable coefficients, affordable housing and commercial housing price volatility analysis of the relationship between the established model is as the following form:

$$HP_i = \alpha_i + \beta_{0i} * AHP_i + \beta_{1i} * AHA_{it} + u_i$$

The test result of the model as shown in Table 50.5, the price changes of affordable housing and commercial housing in 29 provinces are homodromous, e.g. the price of affordable housing has a long-term positive effect on the price of commercial housing. With every percentage of the price of affordable housing changed, the price of commercial housing increased by 1.845278233 at national level. As for the coefficient, there are differences among different provinces. Beijing has the highest influence degree whose coefficient is 4.282268, while Yunnan's influence degree is the lowest and this coefficient is just 0.714382. As can be seen from the data, the coefficient of the eastern region with mature developed market is larger than the western region.

Table 50.5 Fixed effects model with variable coefficients test results

Area	AHP	AHA	α	Area	AHP	AHA	α
Beijing	4.282268	−16.20072	−1884.247	Hunan	1.843993	−0.566221	74.13975
Tianjin	2.151302	0.052448	−1977.543	Guangdong	1.62997	−10.50244	2556.143
Hebei	1.565074	−2.962621	726.9153	Guangxi	1.237137	3.793544	404.7979
Shanxi	1.769502	−0.608752	116.9103	Hainan	1.584218	71.13363	33.65919
Neimengu	1.267083	1.150323	131.271	Chongqing	1.270195	2.216704	220.9888
Liaoning	1.568297	0.402477	−38.21791	Sichuan	1.583537	−4.5906	1399.71
Jilin	1.983489	3.578221	−1377.03	Guizhou	1.127476	5.210155	−29.66093
Helongjiang	2.884492	0.345612	−2203.299	Yunan	0.714382	−3.631719	2027.714
Jiangsu	3.199016	−0.939663	−1457.777	Tibet	1.34179	−0.185189	117.8393
Zhejiang	2.981729	−10.62511	−804.6125	Shanaxi	1.495467	−1.370673	699.8258
Anhui	2.646793	−5.292882	−320.9352	Gansu	2.301554	−3.256628	−166.8776
Fujian	1.968641	4.183635	177.0566	Qinghai	0.983972	−9.907651	1245.683
Jiangxi	2.406324	−0.570904	−26.86989	Ningxia	1.25215	0.666496	686.5737
Shandong	1.944141	5.577302	−1996.015	Xinjiang	1.261232	−3.268593	1040.568
Henan	1.425574	0.834647	293.1594	Mean value	1.845278233	0.8065181	
Hubei	1.687549	−0.469285	379.5349				

Table 50.6 Error correction model test results

Area	Hp(−1)	ahp	aha	ecm(−1)	α
Beijing	0.899	3.193	15.633	−1.638	−64.660
Tianjin	0.032	0.575	2.420	−0.963	200.304
Hebei	0.668	1.517	−0.528	−1.055	−212.687
Shanxi	−0.852	2.600	1.996	−1.303	−17.858
Neimeng	0.272	0.793	1.790	−1.739	−27.681
Liaoning	−0.958	0.804	0.060	0.428	370.461
Jilin	−0.126	1.480	4.089	−0.949	−28.602
Heilongj	0.125	3.614	−1.430	−1.733	−214.612
Jiangsu	0.323	2.815	−0.040	−0.467	−102.225
Zhejiang	−0.039	0.229	−3.217	−2.057	−181.565
Anhui	0.393	2.285	−7.691	−0.732	−76.820
Fujian	0.191	0.792	5.102	−0.453	192.241
Jiangxi	0.371	1.670	1.444	−0.643	−32.111
Shandong	0.034	1.358	5.657	−0.965	29.146
Henan	−0.398	2.477	1.735	−6.667	−37.483
Hubei	0.375	1.399	0.587	−0.895	−49.530
Hunan	−0.034	1.466	0.810	−0.918	−26.715
Guangdong	0.024	0.175	3.347	−1.078	326.397
Guangxi	0.004	1.449	−1.368	0.011	−2.008
Hainan	−2.137	1.501	24.246	−3.604	190.744
Chongqing	0.019	0.967	2.893	−1.606	−62.696
Sichuan	−0.472	1.412	−1.140	−0.453	196.926
Guizhou	0.295	1.469	4.639	−2.705	−309.962
Yunnnan	−0.302	0.530	−2.218	−0.908	12.320
Shaanxi	−0.022	2.655	3.756	−2.782	−118.378
Gansu	0.589	2.318	0.878	−0.598	−71.005
Qinghai	−0.847	0.274	0.191	0.068	220.977
Ningxia	1.212	1.007	5.714	−1.500	−184.133
Xinjiang	−0.468	0.339	−0.509	0.428	97.754
Mean value	−0.029	1.488	2.374	−1.292	0.570

The area of affordable housing also has effect on the housing price, but the extent of the impact is smaller than the influence of the price. On a purely national level, a 1 % change in the area of affordable housing is associated with a 0.8065181 % increase in commercial housing price. The area of affordable housing has different impacts on the long-term price of commercial housing in different places and the impacts can be positive or negative. There are 13 provinces having been influenced positively while 16 provinces have been influenced negatively among 29 provinces. The correlation between the two-way effects and the market development is not obvious. Both the provinces with mature market and the provinces with less-developed one are under the two-side effects.

By synthesizing both the function characteristics, It can also illustrate that the affordable housing market substitution effect is less than the income effect of commercial housing in developed areas, the provinces where the real estate market is mature, so what the data embodies is the income effect, the rising of the price of the affordable houses brings about the price rising of the commercial houses. While in economically under-developed areas, the substitution effect is much more clear, the effect of which surpasses the income effect, so the overall presentation is the substitution effect, the affordable housing market can effectively influence the demand of the commercial housing market and alleviate the contradiction of tight supply.

50.4.2 The Test Result of Error Correction Model

Due to there is a cointegration relationship between the three variables, then when we next, establish panel error correction model, firstly, gain the residual term using the model of long-term relationship, then establish the dynamic panel error correction model.

Error correction model combined the short-term undulation with long-term equilibrium in a model which reflects free adjustment process of the system when the equilibrium appeared deviating. This paper establishes error correction model based on the panel data (Table 50.6), the model estimates R2 = 0.89, DW = 2.38 and the equation of fitting performance is good.

The price of short-term affordable housing has a positive impact on the price of commercial housing and the average elastic coefficient is 1.488364 which is smaller than the long-term one 1.845278233 at national level. Additionally, the size of the affordable housing also have positive impact on the price of commercial housing and its average coefficient is 2.374034 which is higher than the long-term average elastic coefficient 0.8065181. This also reflects the influence of the supply of affordable housing in the area is higher than the one which the price of commercial housing in the short term.

From the point of the error correction system, the average of error correction coefficient is −1.29223 which shows that when the short-term fluctuations deviated from its long-term equilibrium, and it will be adjust unbalanced state back to equilibrium with −1.29223.

50.5 Discussion and Conclusions

In this paper, we use the panel data from 2002 to 2010 of 29 provinces, municipalities and autonomous regions to test the relationship between affordable housing market and housing price empirically and we have reached the following main conclusions and recommendations.

We can see that affordable housing market has different impacts on commercial housing market when studying from different angles. Looking from the price and area, the development of affordable housing market in the developed provinces, not only the housing price decreases as the policy expected, but also raises the commercial house price further. However, in less developed provinces, the development of affordable housing market has negative impact on the commercial house price. In the long term, the change of affordable housing market price has greater effect on commercial housing market than the change of supply area.

The short-term price of affordable housing has a positive impact on the price of commercial housing and the average elastic coefficient is 1.488364 which is smaller than the long-term one 1.845278233 at national level. Additionally, the size of the affordable housing also have positive impact on the price of commercial housing and its average coefficient is 2.374034 which is higher than the long-term average elastic coefficient 0.8065181. This also reflects the influence of the supply area of affordable housing is higher than the one which the price of commercial housing in the short term. What has great influence on the commercial housing market is the change of the supply area of the affordable housing, thus influencing supply and requisitioning government's judgment about market movements and changing the expectations of both sides.

It also shows that in the short term non-market housing substitution effect is obvious, while the income effect is obvious in the long term. From the point of the error correction system, the average of error correction coefficient is −1. This shows that when the short-term fluctuations deviated from its long-term equilibrium, and it will be adjust unbalanced state back to equilibrium with −1.29223.

It can be seen from the empirical results that its impact on the real estate is positive whether it is from the price or the area of the affordable housing, namely, with the rising of the price of the affordable housing, the price of commodities will also rise, the number of the affordable housing will rise, and the price of the commercial houses will rise. Implications of this conclusion is that if policy control is only aimed at adjusting commercial housing price, the construction of the s affordable housing's crowing out" effect is greater than its "substitution effect", in case of the price falling. On the other hand, the construction of the affordable housing itself makes diversion only for a small part of the market, therefore, the substitution effect is not obvious, however, the security room solves the housing needs of those people who can't get satisfy in real estate but really have living difficulties, this is its positive role.

As affordable housing market's impact on the housing price fluctuations has regional differences, therefore, the national housing security policy which is to regulate the real estate market should take the differences into consideration as well. The same policy will make different results in the provinces where the market is developed and different provinces, in the economically underdeveloped regions, the construction of the affordable housing can well solve the housing shortage while with little success in economically developed areas, so the government should give policy measures separately for different regions in order to produce better policy results.

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Chapter 51
Analysis of Housing Price Factors Based on the Market Players' Behavior—Taking Beijing as an Example

Xiao Li

Abstract To research the real estate market of our country in depth, this paper uses SPSS to make a multiple linear regression, and select factors from the aspects of consumers, property developers and the government, which are closely related to the price of the house, and finally find the most important factors that influence the real estate market. The paper focuses on the analysis of the relationship between the expectation and the income level and the housing price, proving the effect of the market players' action on the real estate market.

Keywords Housing price · Market players · Income level · Rational expectation

51.1 Introduction

Since the reform and opening up, the real estate industry has gradually become the pillar industry of our country with the rapid development of the market. Real estate development is closely related to the lifeline of the national economy, and also has enormous influence on social fairness and stability. Recent years, the housing prices in Beijing rose rapidly, resulting in part of the town family having difficulties affording it. This phenomenon has aroused the attention and concern from all circles of the society, and the government introduced a number of policies to curb prices, but the prices are still unexpectedly high. This let us think: what is the main factor that affect prices? Only understand this fundamental question, will it be possible to improve the prices soaring situation.

There are plenty of studies concerning the question abroad, which are always quantitative research. In recent years, with the rise of the "irrational" prices, the domestic research on prices has increased, and quantitative research is also more and more. But the study on influencing factors of housing prices has not formed a

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system, and there are many questions: There is little study involving government, property developers, consumers and other market behavior, and quantitative analysis is relatively little.

Real estate is some special commodity, it has not only residential function, but also the function of investment, therefore the analysis of prices can't simply consider the supply and demand balance, it should also consider a number of other factors. The following paper select some prices related factors from the three aspects of consumers, property developers and the government.

51.2 The Mechanism of Changes of Housing Price

In the early 1990s, the establishment of a socialist market economy with Chinese characteristics provides an institutional guarantee for the formation of the liberal land market. The abolition of welfare housing in 1998 create the conditions for the establishment of commodity housing market, leading the urban housing prices keeping rising. As the process of economic reform and institutional reforms, economic factors and historical information can not be used to explain the growth of housing prices. Academic research about the dynamic mechanism focused on the following three areas: supply and demand theory, system economics theory and cost theory (Wu et al. 2012).

51.2.1 Supply and Demand Theory

The theory claims that the real reason of the continuing rising house prices is supply constraints and strong demand. The strong demand mainly comes from increasing income level and rapid urbanization, which are effective demand. On the other hand, there is also speculative demand that effect the housing price significantly; Supply constraints is partly because there is limited land which is non-renewable resource, while strategy choice of the government also have a significant impact (Cui 2011).

51.2.2 System Economics Theory

The theory hold that the increasing housing prices are mainly due to institutional change or system defects. System reform theorists believe that the mismatch of assets in housing reform at the end of the 1990s is an important cause of the rising house prices; Chen et al. point out the abolition of the welfare housing in 1998 spawn a large number of rigid demand which leads to residential prices rise; Ye and Liao (2007) notes that the implementation of the land "auction" in 2003 boost the premium. Defects commentators focus on tax reform and land finance (Gong Yu Kai et al. 2012), the land transfer system (Zhang Hongxia, etc., 2010), tax system (Wang et al. 2012) and other perspectives. Some scholars believe policy adjustments can always cause housing price volatility, such as the relevant policy research since 2007, which have a significant impact on the price volatility.

51.2.3 Cost Theory

The rising cost is a key cause of house prices. On one hand, rising cost is the result of the increase in cost, with which most scholars agree; On the other hand, the increasing price is attributed to the push-pull relationship between the land price and housing price, but there are disputes about this. The author argues that, regardless of the relationship between them, it is undeniable that, the real estate developers act as the housing prices beneficiary while the local government as the land prices gainers, and there is a long-term equilibrium between them, so that both sides take the initiative to raise real estate prices (Zhou 2006).

51.3 Analysis of House Price Factors and Formula Selection

51.3.1 Analysis of the Influence Factors

51.3.1.1 The Factors Selection for the Consumer Behavior

With the enhancement of comprehensive national strength, the income level of residents has also been greatly improved. Revenue increase so that people have more disposable income to purchase, which means the rigid demand for house is released. This will also improve the hierarchy of needs, resulting in improved demand. From the perspective of supply and demand analysis, the increasing income will increase the demand, eventually causing prices to rise. Based on the analysis above, the per capita income is selected as one of the important factors affecting prices.

Housing is commodity in essence and has the same attributes as general merchandise: the higher the price, the smaller the demand. Taking the expectation factor into account, when consumers expect prices will rise in the future, they will increase the current demand for the product, whereas reducing the demand for the commodities. This can be used to explain people's purchase behavior for housing: The higher the prices go, the more people queuing to buy, the reason is that consumers expect prices will rise further; During downturn in the real estate industry, consumers will have the opposite expectations, resulting in reduction in the demand. In order to analyze the rational expectations of consumers, we use the average price of the previous year as the independent and analyze its influence for the prices of the year.

51.3.1.2 The Factors Selection for the Real Estate Developer Behavior

The purchase price of the land accounts for the biggest cost during real estate development. With the development of the national economy and the rapid urbanization, prices rise due to differential rent, especially when there is increasing demand for land and limited land resources in China's urbanization process. In recent years, land prices also show a rising trend just as the housing price. Secondly, some cities follow the route of international development since China's accession to WTO, thus urban planning and other policy factors trigger a regional land prices increasing significantly. In this paper, two indicators—land acquisition costs of a real estate company, and land area—are used to analyze the impact of land prices for housing prices.

Commodity cost determines its value, and the real estate is no exception. From this point of view, the price will naturally grow higher when the construction cost is higher, and it is more prominent for greater investment in the real estate industry. As the construction cost involves construction details, this paper should not analysis in detail (Huang and Hou 2011).

51.3.1.3 The Factors Selection for the Government Behavior

Real estate development involves land allocation, while land belongs to the state in our country, so the impact of government on housing prices can not be ignored besides consumers and real estate agency. The most important factors for the development of real estate from the government is financial support, which is the credit policy (Wu et al. 2013).

In the boom time, each subject will expect the real estate industry to have a high rate of return, so the demand for real estate loans will rise, and banks will increase their lending to the real estate to occupy a favorable position in the market, which further improves the enthusiasm of the investor. On the other side, because of the limited supply of real estate, housing prices rise sharply. At the same time, the rise in house prices also increased the asset value of the house owners, so they will further expand their investment, and the bank will further increase the real estate investment, finally leading prices rising again and again, and prices will keep rising in Circulation (Liu 2010).

Builders' financing costs depends on the level of bank lending rates: When lending rates get lower, the cost of real estate agency to obtain funds get lower, too. Therefore, revenue will be higher. Impact of bank interest rates on housing prices is mainly due to the characteristics of real estate decisions, as the industry's high debt, builders need to get most of the funds through debt financing, so prices are sensitive to changes in interest rates. In addition to the impact of lending rates on house prices, deposit rates will also affect homebuyers through which affects housing prices, because when interest rates on deposits is low, people have a tendency to hedge funds for the purchase of houses, whereas people are more inclined to save up money (Xiao et al. 2011).

Since the credit policy is difficult to quantify, this paper use lending rates to analyzes the influence of government on prices.

51.3.2 Formula Selection

In the analysis of the factors affecting housing prices, the linear form is the most commonly used models. In addition to basic linear form, there are also other form, such as logarithmic function, semi-logarithmic function, and logarithmic linear function. In the real socio-economic activities, the relationship between the dependencies is more complex, but this article focuses on the comparison of the effects of different actors in the real estate market, and does not involve quantitative characteristics of the price, so linear function is able to explain the sample differences and fit the sample data. In a nutshell, we uses SPSS linear regression and the function is as follows:

$$P = \sum \alpha_i Z_i + \varepsilon$$

where: P represents housing prices, α_i is the variable regression coefficients for the price, Z_i represents factors selected, and ε is for the error term. The independent variables and the dependent variable are in linear form, and the regression coefficient corresponds to the degree of influence of the variable.

51.4 Housing Price Factors in Beijing

51.4.1 Multiple Linear Regression Based on SPSS

Based on the analysis above, we get date from statistical databases of China's economic and social development and China Real Estate Statistics Yearbook, and collect the date of the residential average price during 2001–2012, per capita income level, the average price of residential last year, land acquisition costs, State-owned

Table 51.1 Model statistics

Model	R	R Square	Adjusted R square	Std. error of the estimate	Durbin-Watson
1	0.962(a)	0.925	0.878	0.34935	1.124

Source Author Self-painted

Table 51.2 Coefficient list

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	Correlations			Collinearity statistics	
	B	Std. error	Beta			Zero-order	Partial	Part	Tolerance	VIF
The average residential price	0.287858	0.62416		0.461193	0.65694					
Land acquisition costs	0.192047	0.134815	0.188585	1.424521	0.192114	0.708386	0.449816	0.138026	0.535679	1.866789
Per capita income levels	0.687776	0.370064	0.687776	1.858532	0.100156	0.946469	0.549147	0.180078	0.068553	14.58721
The average price of residential last year	0.242989	0.673875	0.140607	0.360584	0.727746	0.932332	0.126462	0.034938	0.061742	16.19649
The annual interest rate	0.04863	0.103822	0.04863	0.468393	0.652001	0.043502	0.163377	0.045384	0.870964	1.148153
State-owned land area data	0.109999	0.215197	0.052842	0.511152	0.623049	0.135053	0.177839	0.049527	0.878477	1.138334

Source Author Self-painted

land area data, the annual interest rate. We choose the average residential price as the dependent variable, with the rest of the data as the independent variable, using SPSS software for multiple linear regression. The regression results are as follows Tables 51.1 and 51.2:

We can obtain the regression equation from the Table 51.2:

$$y = 0.192x1 + 0.688x2 + 0.243x3 + 0.049x4 + 0.11x5 + 0.288$$

where x1 is on behalf of land acquisition costs, x2 on behalf of per capita income levels, x3 on behalf of the average selling price of residential last year, that is the rational expectations of consumers, x4 means the lending rate, while x5 on behalf of the state-owned land area.

We can learn from Table 51.2 that the coefficient of per capita income is 0.688, which is much higher than other independent variables, and means a large degree of influence on prices; The coefficient of average selling price of previous year exceed 0.2, the degree of which is the second among all five factors, the coefficient for corporate land acquisition costs is 0.192, the third place at five factors, and the coefficient of other factors is not higher than 0.2.

Thus, at the time for residents to expect price movements, they tend to refer to the early date, however, the impact of the per capita income levels is greater than the early price, indicating the important role of market stability. The coefficient of price of the land, the annual interest rate and other factors are not high, but the authors believe they have small direct impact on prices, but ultimately act on rational expectations, indirectly affecting people's purchasing behavior.

51.4.2 Interpretation of the Results

51.4.2.1 Rational Expectation

Rational expectations is to make the most accurate expectations in the long run under the premise of using of all the information effective, which is also consistent with the economic theory. Rational expectations were originally proposed by American economist John Moose in <Reasonable Expectations and Price Change Theory> in 1961. He believes: Expectation is the same as the economic predict theory in nature, because they are accepted predictions of future events. Malpezzi and Watcher's study (2005) also pointed out that when the real estate market was in inelastic supply, speculative demand based on the expected appreciation will have an impact on the price changes. Through the above analysis can we see that the rational expectations has a significant impact on price fluctuations, "The ratchet effect" of prices soaring or plummeting can not be reversed in the short term, and this may be one of the root causes of prices volatility in recent years.

Based on the existing market, people tend to be too optimistic, and this may be expected to produce different effects. Glaeser et al.' recent studies have shown that if housing supply continues stay inelastic, the optimistic about the future appreciation is likely to persist in the market for a long time. Any increase in demand—regardless of whether it is reasonable—and inelastic supply will cause prices to grow more rapidly. As the prices go higher, over-optimistic expectations are verified, so they feel there is no need to adjust their expectations. As shown from the United States data, excessive optimism in such a model will continue to persist.

From the perspective of real estate developers, in the case of asymmetric information—developers do not know how much land will be sold in the future and what the position of it, developers expect the price will increases strongly in the future. The government control the number and the structure of land transfer, which affects the land market obviously, and the special land system allows developers to expect land prices will continue to rise very strongly, and thus form their judgment on the future of real estate prices.

From the buyer's perspective, due to the traditional concept of "buy a house to get married," and the serious deficiencies in supply of affordable housing for low-income groups, there is a rigid demand for house in the market. Consumers regard themselves as passive recipients of the prices rose, so they can only expect they will be forced to accept the premium increase and the rising housing costs.

51.4.2.2 Price-Income Ratio

From Table 51.2 can we learn, the coefficient of residents income levels that is 0.688 is far higher than the other independent variables, and has a great influence on housing prices. This paper uses the price-income ratio to analysis the relationship between the per capita income and the rising housing prices. Price-income ratio is a traditional method from international real estate research, and it is used to represent the affordability in the estate market. The standard formula is as follows:

$$\text{Price-income ratio} = \text{average house price}/\text{average house hold income}$$

But neither the average house price index nor the average house hold income indicators are readily available in China, therefore we redefine the formula:

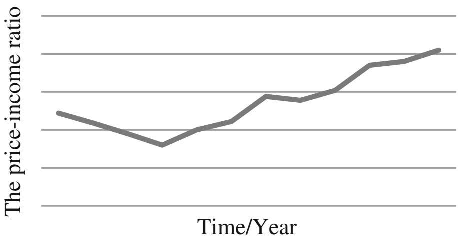
$$\begin{aligned}\text{Price-income ratio} = {} & (\text{The average price per square meters of building area} \\ & \times \text{housing area})/(\text{per capita income} \times \text{family size})\end{aligned}$$

$$\begin{aligned}= {} & (\text{The average price per square meters of building area/per capita income}) \\ & \times \text{average housing floorage per capita}\end{aligned}$$

The average price per square meters of building area index and per capita income indicators can be found in the National Bureau of Statistics website, in our calculations, we assume that the average housing floorage per capita is 30 m^2.

Figure 51.1 is the price-income ratio of Beijing in 2001–2012.

Fig. 51.1 The price-income ratio



As is shown in the chart, the housing prices increased more quickly than the already high revenue growth in Beijing. Before 2004, price-income ratio of Beijing is in downward trend, and reach the minimum value in 2004, then it start rising, increasing suddenly to 18.5 times in 2010. In recent years, housing prices hovered around 18 to 20 times than the earnings, which is more grievous than a few years ago. The ratio is 0.85 from 2001 to 2012 in Beijing, which indicates housing supply can not meet the needs of the market for many years.

The price-income ratio in China should been bigger than that in America, but we can find problems by direct comparison. For example, the judgment should be in the family scale, but our data is based on per capita income, if there are much more people who make money than the average number this ratio will be reduced. Besides, the per capita living space may be less than 30 m^2 in some of the family, in this way, our calculations overestimate income into the ratio of house prices.

In addition, each family would have revenue that is not open to the public, this also explains why we exaggerate income into the ratio of house prices. A recent investment reports say, the non-public family income account for 30 % of gross domestic product in China. This proportion is very huge, and the report doesn't say whether such situation will change as the time. This means, we can't simply compare income-price ratio in China with that in USA. This also shows that the sudden change of the proportion is not due to errors in calculation, but other reasons. We therefore believe that time can provide more information. Although these statements above, one point is undeniable: a considerable part of Chinese family income is used for the purchase of housing (Xue et al. 2010).

51.5 Conclusion

Of all the house prices influencing factors, per capita income levels and the average selling price of last year have more significant effect on prices than the others. Increasing in per capita income release the rigid demand and the improving demand at the same time, which is in line with the equilibrium theory of supply and demand, but the housing prices increased more quickly than the already high revenue growth in Beijing, and the housing supply-demand ratio also shows that the housing supply can't meet the market demand over the years in Beijing; The average price of residential of the previous year reflects the impact of rational expectations on the price, and autocorrelation analysis shows that prices of two years ago influence the current prices mainly through that of one year ago, in other words, some effects are indirect. Other factors, such as the price or the supply of land, the annual interest rate, have little influence on the prices directly, but they produce effect on rational expectations and affect people's behavior indirectly.

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Chapter 52
Urbanization and Development of Housing Market: Facts in China

Yi-fan Zhang

Abstract During the thirty years after Reform and Opening up, urbanization of China has been promoted continuously and housing market developed rapidly with the increasing residential demand. Based on the basic theories about urbanization and housing, an empirical study is carried out on the relationship between urbanization of China and development of housing with the help of time-series data as well as cross-sectional data. The study result reveals that: urbanization and housing market develop and promote mutually; urbanization positively influences per capita area; there is no obvious relationship between urbanization promotion speed and investment in residence but trend of residential investment is stronger than that of urbanization, with lack of effective demand to support the investment; there is not an obvious shortage of supply for additional population in urban area.

Keywords Urbanization · Housing market · Supply and demand · Coordination

52.1 Introduction

Residence is a carrier of urbanization. The acceleration of process of urbanization needs the development of housing market urgently. Rapid development of urbanization is bound to have far-reaching impact on China's housing industry. Some scholars called urbanization and housing "twin brothers" (Jiang et al. 2003), which are closely related and mutually reinforced.

Through qualitative analysis of interactive mechanism, Sun and Sun (2007), Zhang (2008) expound the mutually reinforced and restrained relationship between China's urbanization and housing development. From the development trend of urbanization and housing industry, Zhou (2005) analyzes the relationship between the two and regresses the level of urbanization, the added value of housing and the

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added value/GDP since 1978, which shows the level of urbanization and development of housing industry have a directly positive correlation. Through the analysis of the process of urbanization in United States from 1800 to 2000, Bo (2007a, b) indicates the importance of coordinated development between urbanization and housing. Through methods of comparative analysis, Zhai (2006) shows correlation between urbanization and housing. With the use of factor analysis methods to evaluate the level of urbanization in the western center cities, the conclusion is housing and urbanization promote each other in western region.

Comprehend existing research, to summarize the relationship between urbanization and housing theoretically is as follows:

Firstly, the concentration of population continues to boost demand for urban housing; housing development offers place to reside for new urban population.

Secondly, upgrading of industrial structure in process of urbanization puts forward new requirement to the structure of land use and housing product and at the same time creates great demand; housing development provides physical space for tertiary industry.

Thirdly, the improvement of urban and rural infrastructure is conducive for the housing industry to attract investment, expand the market, which can be improved in level and area; the rise of housing industry, especially the booming of commodity housing in recent years, puts forward higher requirements for urban planning, water supply, heating, sewage and waste disposal, electricity and telecommunications, which consolidates the material foundation for high-quality urbanization.

In short, pushing forward the process of urbanization can drive demand increase for housing, improve the structure of industrial upgrading, and ultimately promote housing development. Housing on one hand has become the driving force of urbanization in the form of economy. On the other hand it has become one of the compositions to the city in the form of an entity. Development of national economy promotes the process of urbanization, with housing industry playing an important role.

52.2 General Situation of Urbanization and Housing Market in China

52.2.1 General Situation of China's Urbanization

During the thirty years after Reform and Opening up, China's cities has undergone tremendous changes. Urbanization level has been promoted continuously, especially after the level exceeded 30 % since 1998, the process of urbanization exhibits significantly accelerating trend more than ever.

52.2.2 General Situation of China's Housing Market

52.2.2.1 Changes in Total Residential Investment

Since 1990s, China's urban housing construction has made a rapid development which was further promoted by "Stopping welfare housing and implementing monetary housing" system in 1998, thereby bringing growth to the whole community residential investment. From 1996 to 2011, the whole social residential investment increased from 519.8 billion to 5.7284 trillion yuan, with an increase of 11 times. The proportion of GDP increased from 7.7 to 12 %. Urban residential investment increased from 332.6 billion to 5.1773 trillion yuan, the proportion of GDP increased from 4.9 to 9.7 %. Such a scale is rare in the history of developed market economy countries. For example, the peak of the Japanese residential investment/GDP value is 8.4, 5.8 % in United States, 3–6 % in Germany, Britain and France.[1] Large-scale residential investment benefits from China's large population and also is inseparable from institutional reformation and economic restructuring (Wang 2013; Fig. 52.1).

From Figs. 52.2 and 52.3, we can see China's national total residential Investment has been accelerated. Investment in different regions of China is on rise year by year. In comparison, the fastest in the eastern region, the central region slightly faster compared to the West. Eastern region reached 2.871848 trillion yuan in 2012, the central region over 11,909.14 billion, and the western region

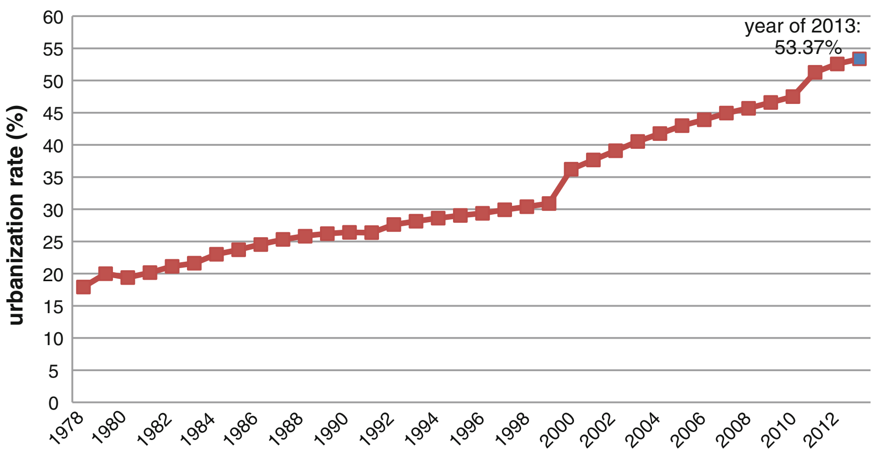

Fig. 52.1 Trend of China's urbanization rate since reform and opening up. *Data sources* China statistical yearbook

[1]Sources: Economic Planning Agency. Numerical Report on Nation Economy. The United Nations, Annual Bulletin of Housing and Building Statistics for Europe.

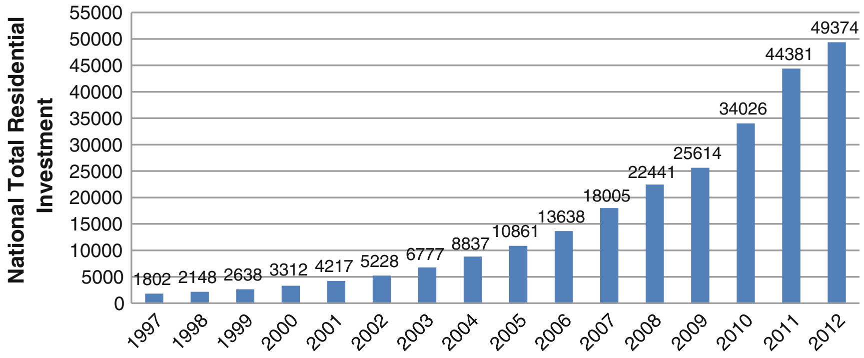

Fig. 52.2 Trend of China's national total residential investment from 1997 to 2012 (in one hundred million yuan). *Data Sources* China statistical yearbook 2000–2013

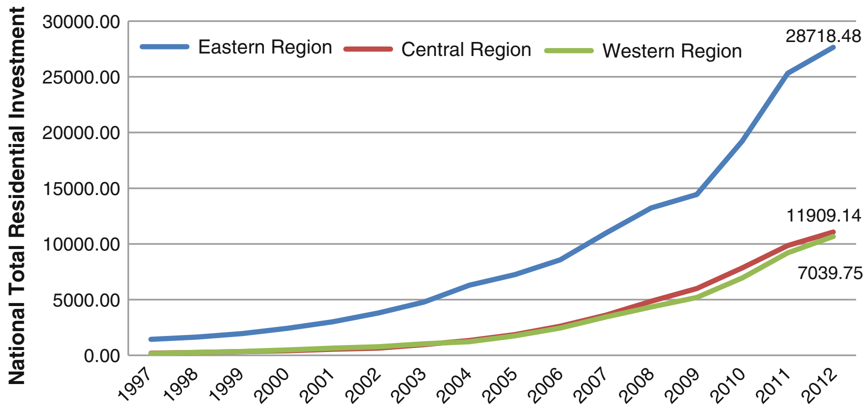

Fig. 52.3 Comparison of total residential investment in different regions of China (in one hundred million yuan). *Data Sources* China Statistical Yearbook 2000–2013

703.975 billion yuan. Residential demand is the largest in eastern region where capital is also concentrating on this area. From the provincial level, the top three are Jiangsu, Guangdong, Zhejiang, followed by Shanghai and Beijing. Thus reflects the huge demand for housing generated by population agglomeration with the rapid development of the eastern economy in recent years brought about.

52.2.2.2 Changes in Residential New Construction Housing Area

From Figs. 52.4 and 52.5, we can see China's residential new construction housing area has been accelerating from 1999 to 2011, with a decline in 2012. In

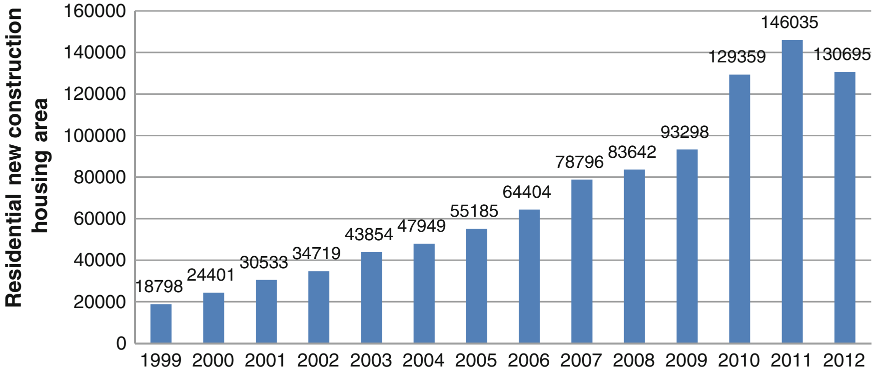

Fig. 52.4 Trend of China's residential new construction housing area from 1999 to 2012 (in ten thousand square meters). *Data Sources* China Statistical Yearbook 2000–2013

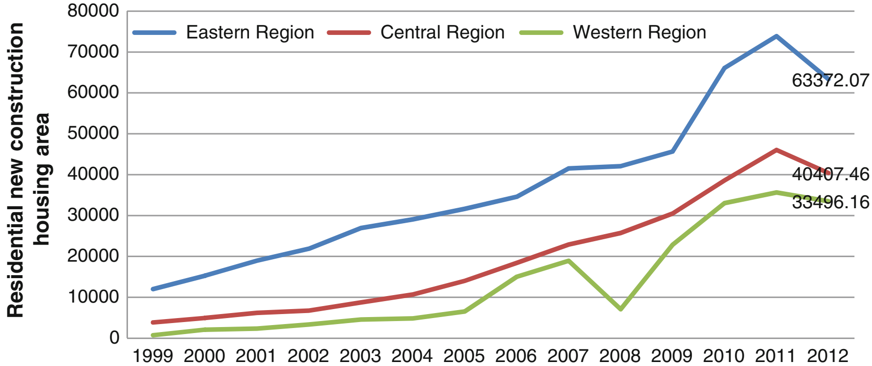

Fig. 52.5 Comparison of residential new construction housing area in different regions of China (in ten thousand square meters). *Data Sources* China Statistical Yearbook 2000–2013

comparison, relatively a stable growth in central region, but fluctuant growth in western, where leaps and bounds appeared for the first time in 2006, a rebound growth appeared after 2008. Eastern region reached 633.72 million square meters in 2012, the central region 404.07 million square meters, the western 334.96 million square meters. From the provincial level, the top three are Jiangsu, Guangdong, Shandong, followed by Liaoning and Zhejiang (Fig. 52.6).

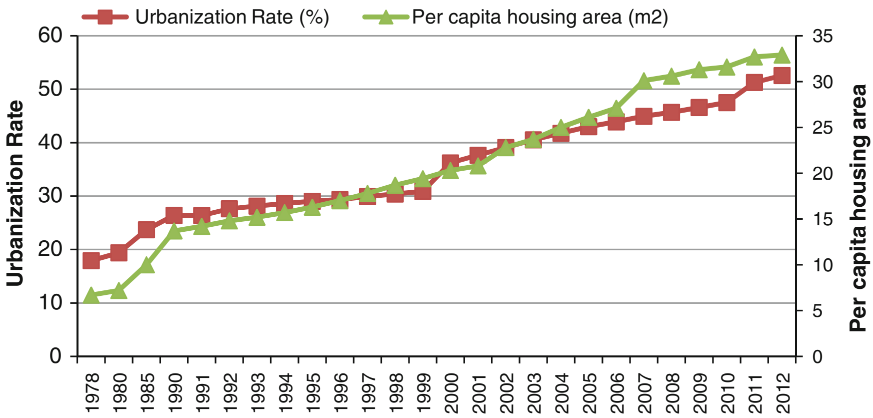

Fig. 52.6 Comparison of China's urbanization rate and urban residential building area per capita since reform and opening up

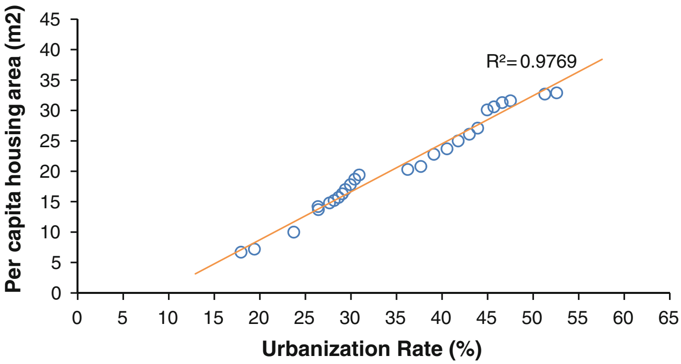

Fig. 52.7 The relationship between urbanization rate and per capita living area

52.3 Relationship Between Urbanization and Housing Market

52.3.1 Urbanization Promoting Development of Housing Market

China's urbanization rate developed from 17.92 % at the beginning of reform and opening up in 1978 to 53.37 % at the end of 2013. Since the implementation of the reform of the housing system in 1998, The average annual growth of national residential sales area reaches 21 %, and for the first time exceeded 100 million square meters in the year 1998, followed by rapid growth. 2012 exceeded 980 million square meters. Three decades of reform and opening up, the speed of urbanization and the development of China's housing market is very fast (Figs. 52.7 and 52.8).

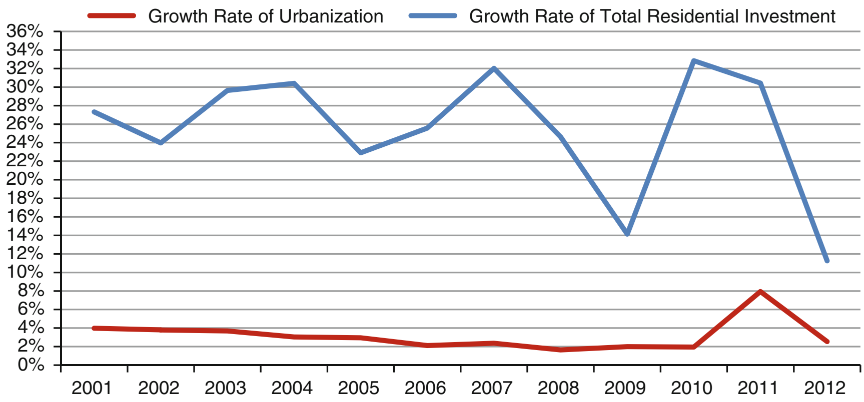

Fig. 52.8 Comparison of the growth rate of urbanization and residential investment from 2001 to 2012. *Data Sources* "China Statistical Yearbook" and "China Housing Statistics Yearbook"

The core of urbanization is the transformation process of the employment structure, economic structure and the demographic change process of urban and rural space community structure. The essential feature of urbanization is mainly reflected in three aspects: First, rural population converting in space; Second, non-agricultural industries to gathering urban area; Third is agricultural labor transferring to non-agricultural labor. Rural population conversion in space produces a large number of residential demand, and promotes the rapid development of the housing market.

China's urban population, from 1990s 302 million (4$^{t.}$ census) to 712 million in 2012. In 22 years, there is an increase of 410 million urban population. In terms of 30 m^2 per capita, demand for housing exceeds 12 billion square meters driven by urbanization from 1990 to 2012. Urbanization's role in promoting the development of the housing market can be seen clearly.

52.3.2 Housing Market Promoting Process of Urbanization

From the demand perspective, urbanization will certainly lead to employment of agricultural transferring population, so that inevitably require residence. China's urbanization rate in 2013 was 53.7 %. According to China's goal of urbanization rate reaching developed countries' 70 % in 2035, then the population shifted from rural to urban will reach 25 million on average per year. If per capita housing area reaches 35 m^2 in accordance with a well-off standard, housing area will reach 850 million square meters per year to meet new urban population's demand, that is a more than one billion square meters building area. Housing sales breakthrough 1.1 billion square meters in 2012, so that demand will be increasing strongly in the future brought about by urbanization.

From the supply perspective, on one hand, China's urbanization will continue growing rapidly. Increasing urban population is bound to bring about a huge demand for housing; Meanwhile, with revenue growth, increased household wealth accumulation and consumption structure upgrading, improvement type housing demand will be strong. Such a large demand for housing construction needs housing developers to complete. Therefore, in the next period to maintain a rapid growth in housing construction investment has its objective law requirements (Wenxuan 2008). On the other hand, according to the experience of China's urbanization in recent years, only municipal utilities (including urban roads, water supply, drainage, gas, heat, garbage and sewage disposal, public green, etc.) amounted to over 20,300 billion during the period of "10th Five-Year Plan",[2] while urban population over the same period added 10,294, which means that each new one urban person needs about 10,000 yuan of municipal infrastructure investment. Developing and investment in Housing can effectively drive infrastructure around in order to meet the demand of new urban population so that plays an important role in normal city's operation, and thus supports the process of urbanization.

All in all, the process of urbanization needs to be supported by the development of the housing market. Urbanization and the housing market is mutually reinforcing with each other.

52.3.3 *Empirical Research on the Supply and Demand Relationship Between Urbanization and Housing Market*

With the deepening of economic development and urbanization, a large number of people are gathering in the city. Old citizens hope to improve their living environment, and the concept of urban citizen of the new is gradually establishing, who will propose some other demands in their own living environment different from rural lifestyle. All of these requirements have to be resolved by housing industry. In 1949–1978 phase of the planned economy, China has only built 530 million square meters of urban residence, mainly tube-shaped apartment and bungalows, with small set of residential buildings, which resulted in acute shortage of urban residence. In 1978 China's urban residential building area per capita was 6.7 square meters only. Since 1978, especially since the 1998s housing reform, China's housing industry is rapidly developing. Urban residential building area per capita was 32.9 square meters in 2012, with own home ownership rate reaching 89.68 %.[3] That is a miracle in the history of the world's urban construction.

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[2]Data Source: Ministry of Construction issued "National Urban Construction Statistics Annual Report 2006".

[3]Data Source: the first "Chinese household financial report" on May 13, 2012, by Chinese household financial investigation and research center jointly established by the People's Bank of China Financial Research Institute and Southwest University.

From a simple comparison of the two trend lines in the figure, we can see the trends in per capita housing area and urbanization rate are basically the same, and both have a rapid growth in 1980–1990, which have a slower growth rate after 1990.

To test the relationship between urbanization rate and per capita living area, we establish a linear regression model (Tables 52.1 and 52.2).

Taking urbanization rate as the independent variable, per capita housing area as the dependent variable, we use SPSS 16.0 to conduct a linear regression analysis. Under the 95 % confidence level, F value is much more than 4.41, test passed. T-value of slope is 39.103, test passed. Regression equation is $y = 0.7895x - 7.0566$.

According to the linear model, we can see that urbanization rate increasing by one percentage point can bring about 0.79 square meters growth of per capita housing area.

52.3.4 *Comparative Analysis of Growth Rate of Urbanization and Housing Market*

According to "China Housing Statistics Yearbook", the growth rate of urbanization and residential investment from 2001 to 2012 is analyzed as shown below:

We can conclude that the growth rate of urbanization slowed down year by year from 2001 to 2010. Due to economic factors, state regulation and consumption, residential investment did not exhibit steady growth, but remained above 12 %, up more than 32 %. The trend of residential investment was stronger than that of urbanization. Thus problems in residential market are directly or indirectly reflected.

Table 52.1 Statistics of China's urbanization rate and urban residential building area per capita since reform and opening up

	Urbanization rate (%)	Per capita housing area (m^2)	Year	Urbanization rate (%)	Per capita housing area (m^2)
1978	17.92	6.7	2000	36.22	20.3
1980	19.39	7.2	2001	37.66	20.8
1985	23.71	10.0	2002	39.09	22.8
1990	26.41	13.7	2003	40.53	23.7
1991	26.37	14.2	2004	41.76	25
1992	27.63	14.8	2005	42.99	26.1
1993	28.14	15.2	2006	43.9	27.1
1994	28.62	15.7	2007	44.94	30.1
1995	29.04	16.3	2008	45.68	30.6
1996	29.37	17	2009	46.59	31.3
1997	29.92	17.8	2010	47.5	31.6
1998	30.4	18.7	2011	51.27	32.7
1999	30.89	19.4	2012	52.57	32.9

Table 52.2 Correspondence between urban population and residential building area

Year	Urban population (in ten thousand)	New urban residential area (in 100 million m^2)	Urban residential building area per capita (m^2)	Urban residential building area for improvement (in 100 million m^2)	Urban residential building area for new population and investment (in 100 million m^2)	Population corresponding to the area (in ten thousand)
2000	45,906	5.49	20.30	3.44	2.05	1008
2001	48,064	5.75	20.80	3.60	2.15	1031
2002	50,212	5.98	22.80	3.77	2.21	971
2003	52,376	5.50	23.70	3.93	1.57	663
2004	54,283	5.69	25.00	4.07	1.62	648
2005	56,212	6.61	26.10	4.22	2.39	917
2006	58,288	6.30	27.10	4.37	1.93	712
2007	60,633	6.88	30.10	4.55	2.33	775
2008	62,403	7.60	30.60	4.68	2.92	954
2009	64,512	8.21	31.30	4.84	3.37	1077
2010	66,978	8.69	31.60	5.02	3.67	1160
2011	69,079	10.25	32.70	5.18	5.07	1550
2012	71,182	10.73	32.90	5.34	5.39	1639

Note Assuming investment and speculation is zero

Whether large urban population agglomeration brings residential investment growth, or metastasis and gradient residential investment develops between cities, we need to follow the basic rules of urban economy, and fit local economic level, population size and income level. Any artificially blind and impulse “city” repairing or producing, if there is no effective demand to support, it is not only difficult to sustain, but also exacerbates distortions in the allocation of resources.

52.3.5 Coordination Analysis of Urbanization and Housing Market

New residential area can be divided into three parts: the first part is used for improvement expansion of residential area per capita of the urban population; second part is to solve the living problem of the new urban population; third part is for investment and speculation.

First, estimating annual demand for improvement expansion of residential area per capita of the urban population: Since 2000, China’s urban per capita building area increases 0.75 m^2 annually in average. Considering the data of annual urban population, we can calculate annual demand for improvement expansion of urban people. Then, after deducting this part of demand, we can get the residential area number, including that to solve the living problem of the new urban population and for investment and speculation each year.

Assuming that all new urban population reach the level of residential area of the original urban population in that year by one step directly, while assuming that investment and speculation is zero, new living urban population per year on average reaches about 10.08 million in the last few years, which has not yet reached the 13 million urban population with the urbanization rate increasing 1 %.

If we combine the two assumptions with the reality: the existing national residential investment and speculation demand will reduce the population number; Not all new urban population reach the level by one step but through filtering effect gradually reach the original level, while the population number will increase significantly. Even though we couldn't say with residence improved, an annual new residential area can meet the demand of the entire new population (including migrant workers), in general, there is not an obvious shortage in residence supply.

52.4 Main Conclusions

During the thirty years after Reform and Opening up, urbanization of China has been promoted continuously and housing market developed rapidly with the increasing residential demand. The study result reveals that: urbanization and housing market develop and promote mutually; urbanization positively influences per capita housing area; there is no obvious relationship between urbanization promotion speed and investment in residence but trend of residential investment is stronger than that of urbanization, with lack of effective demand to support the investment; there is not an obvious shortage of housing supply for additional population in urban area.

Through the analysis of this article, we have found two problems in China's residential investment and coordination of urbanization and housing market, that is: (1) there is no effective demand to support urban residential investment; (2) the amount of national total residential investment and speculation cannot be determined, and a large number of speculative investment buyers will squeeze new urban housing needs of the population, thus have serious impacts on urbanization.

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Part V
Urban Land Development and Utilization

Chapter 53
Study on the Compiling Pattern and Overall Concept of Territory Spatial Planning in Hangzhou

Chen Jiang, Yuzhe Wu, Linjie Yang and Wenzhe Yue

Abstract A strategic and integrated territory spatial planning is urgent for Hangzhou with such an existing developing environment to indeed solve the paradox of planning, coordinate regional development and change the patterns of land use and development. The discussion on compiling pattern is vital to the study of territory spatial planning. The purpose of this study is to discuss out a territory spatial planning compiling pattern suited to Hangzhou. This research adopts inductive deductive method. The result supplies the compiling concept of territory spatial planning from strategy, technology and measures aspects and gives a compiling pattern combining development leading, control guide, people-oriented.

Keywords Hangzhou · Territory spatial planning · Overall concept · Compiling pattern

53.1 Research Background

Land resources are survival and development base of a region, and its reasonable planning is of prime importance for the sustainable development of a region while it is the key carrier for social economic development. <The nation main function region planning> and <National new urbanization planning (2014–2020)> have been approved in succession at national level and <National territory spatial

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planning outline (2013–2030)> is to get the examination and approval of the State Council in the stage of implementation, to implement “promote the building of ecological civilization and optimize the national spatial development pattern” which is put forward in the CCP eighteenth. The ministry of land resources said it would improve spatial planning system of land and resources and fulfill “life line”, “ecological line” and “indemnification line” in national spatial development control by territory spatial planning on the national work conference on land resources at the beginning of 2014.

The contradictions and conflicts between areas comes most violently when per capital GDP reaches $10,000 in the US, Britain, Netherlands, Japan and other developed countries according to international experience. Under this very social economic development condition, these countries solve a series of problems such as ecological deterioration, traffic congestion, the economic downturn by formulating regional spatial planning. According to the statistical data of Hangzhou, per capital GDP of the population of permanent residents in the city is 94,256 RMB (almost $15,000). Compiling territory spatial planning in this period matches the regularity demands of economic develop and even more the internal demand of building the beautiful Hangzhou and transformation development.

Nowadays, the development and utilization of land and spatial of Hangzhou supplies a solid foundation for the fast development of economic. But the planning system defects that “fallacy of composition” represents brings badly negative impact to the utilization of land and spatial in the development process. At present, the problems and impact mainly reflect on these aspects: the obvious contradiction and paradox feature between the current planning systems; the inefficient utilization of land and space; Difficulties in regional management coordination; more and more constrained by resource and environment. National spatial planning is needed to solve the problems above. According to the characteristics of Hangzhou, this paper discusses the territory spatial planning overall concept and compiling patterns which has important theoretical and practical significance.

53.2 Theoretical Basis

Working out territory spatial planning is certain to involve different ideas and theories, and the support from relational ideas and theories are core exemplification of mode designing land and space planning compilation and determining working out thoughts (Qiang et al. 2012).

The practice of domestic and international demonstrates that the problems the plans need to solve are different under different backgrounds. So the ideas and theories of problem solving become core value exemplification of working out planning. Relational ideas and theories of land and spatial planning keep changing and developing as well.

At the end of 19th century, western countries started to study economic regionalization, theoretically based on location theory, strategically planning land

and space according to geographical division of social labor pattern, economic development level and eco-society development goals, etc. At early 20th, extremely fragmented doctrine, mechanical rationalism and humanism emerged and were applied to practice of land and space planning. But planning sizes were small city-centric and lacking in connections among cities at that time, causing a series of drawbacks. From 1929 to 1932, western countries broke out great economic crisis; Keynesian theory of nation intervention was gradually accepted, resulting in the new roads to regional development intervention. Some western countries intervened and adjusted regional development by drafting land and space plans and regional policies, like Britain passed Special Area Act in 1934, helping and intervening the most affected, waning industrial area; America set up Tennessee Valley Authority for intervention during FDR's New Deal. After WWII, European countries were devoted to rebuilding national economy and regional development theory started to blossom (Miao 1999). Developing and post-war rebuilding are the major problems planning needed to solve at that time. Developing is the main part of land and space planning.

A series of problems coming along with economic recovery, such as over-rapid population growth, plus environmental damage, resource depletion, unbalanced developing and widening gap between rich and poor caused by urban sprawl. As a result, many nations and areas began change ideas of planning. Britain published Greater London Plan at 1944 which absorbed essence of western planning thoughts since 20s, came up with concentric closed layout mode in order to control spontaneous sprawl of London City. Later, growth pole theory, large metropolitan theory, sustainable theory, compact city theory and so on were raised one by one, and became criteria for judging economic and socio development of nations and areas. At 1990s, it was a successful exploration that new urbanism rising in America blended humanism into design and practice of urban planning. It constructed living space of intensive land use, environmental friendly and humane care by making efforts of three aspects, area, town and city, in other words, repairing the centric use of big cities, emphasizing the public transportation oriented developing mode and reconstructing loose neighborhood (Crane 1996). Portland's 2040 Plan will protect environment from damage through delimit developing area boundaries and limiting city development. The land and space planning will put extra emphasis at controlling and repairing all kinds of urban diseased and correspondingly, planning theory changes from developing to controlling developing, because serious problems brought by economy developing are recognized.

Since stepping into 21st century, economy and weather globalization makes people's thoughts more and more diversifying. Ideas like eco-city, smart city, low-carbon city and so on become mature gradually and are applied to the theories and practice of urban planning. The urban construction is devoted to making sustainable urban life happen, stimulating environment-economy system transforming into a more low-carbon one (Caprotti and Romanowicz 2013). Symbiotic fusion of digital city and eco city is a future new mode of urban low-carbon and intelligent developing (Yang et al. 2013). Thus this time, the practice of land and space planning is more diversified and emphasize more on coordination of all kinds of different space scales. Public participation and humanism value will be more prominent (Pan and Cai 2007). During planning, nations and areas will give the factor of people more consideration. For example, in Japan's five full mechanized and six full mechanized; Japan took into account the population and aging's effect on economy and society and reflected in the planning. Urban planning and construction are containing more and more people's feelings. 2007 Urban Culture of Beijing Declaration (Kang and Zhang 2006) underlined that urban developing should correspond with people's requests; citizens are the masters of the city, the starting and destination of urban planning and construction; cities should be built into urban space full of humanism and humane care.

In conclusion, in the developing and changing progress of territory spatial planning compilation, different ideas lead at different backgrounds. From developing to controlling, from protecting to humanism, land and space planning has various themes at different time and areas.

53.3 The Analysis on Compiling Concept of Territory Spatial Planning in Hangzhou

Territory spatial planning is a systematic, comprehensive and obviously regional planning system, taking territory space as carrier, coordinating the same space policies among various departments at all levels, arranging overall regional space development, optimizing the allocation of land and space, regulating the economic and social development, with the features of global coverage, urban and rural, clear function. Research puts up a series of innovation on the overall concept of territory spatial planning compiling from three aspects: strategy, technology and measures combining the characteristics of territory spatial planning and the actual basis of Hangzhou (Fig. 53.1).

53.3.1 Strategy Aspect

In the analysis of national spatial strategy, start from the resources endowment of Hangzhou, with a higher level of spatial planning as a guide, regarding the regional characteristics of Hangzhou national spatial development strategy as a focus.

Strategy analysis, first of all, combined with the general land use planning, urban system planning, tourism planning, railway, highway planning and ecological planning, put forward the spatial development strategy from the perspective of coordination function, and locating the development, utilization, curing and protection of territory systematically to guide the existing planning. Based on this, take

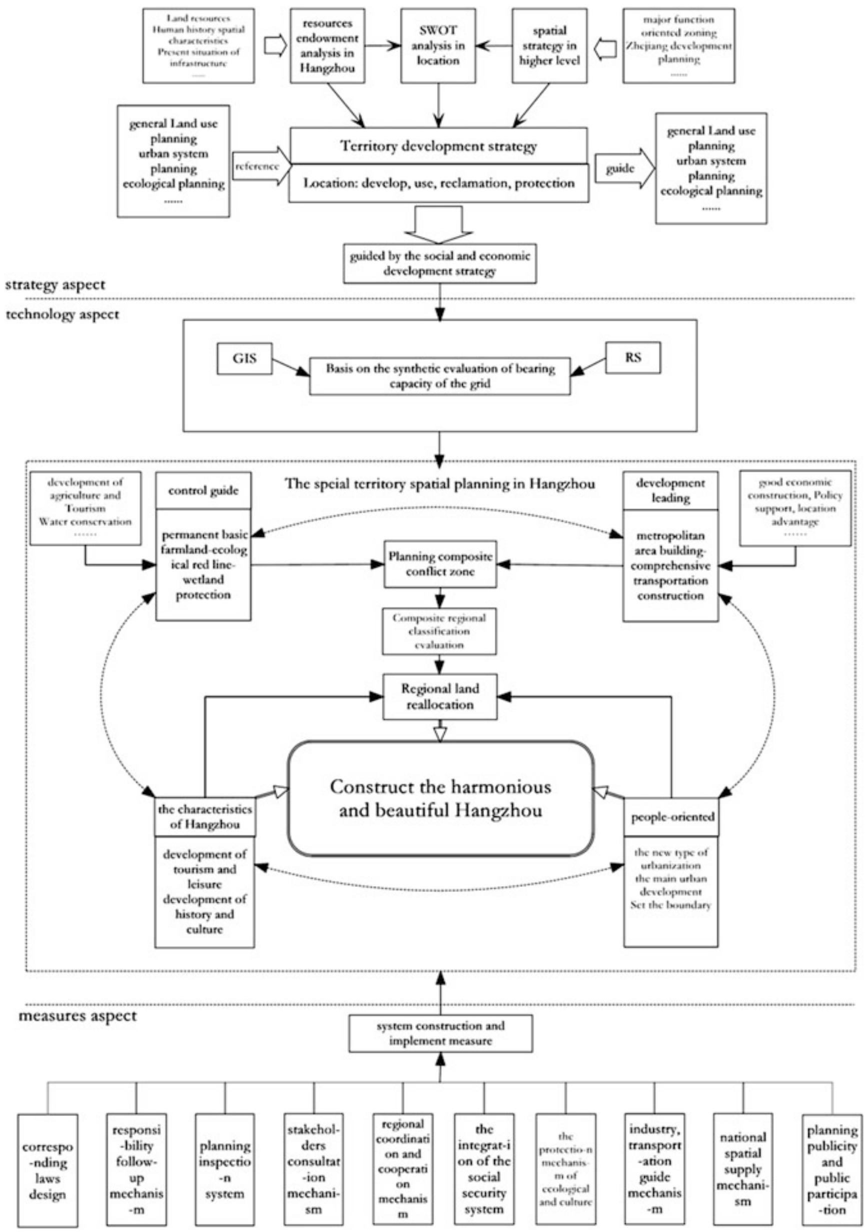

Fig. 53.1 The overall concept of territory spatial planning in Hangzhou

the further economic and social development strategy as an important basis of the guide of territory spatial planning work, make the planning clearer on the overall strategy concept.

53.3.2 Technology Aspect

Form the control guide, development leading and people-oriented three basic technologies, combine the local characteristics of Hangzhou to realize the ultimate goal of coordinating urban and rural space and create a harmonious beautiful Hangzhou.

The basic train of thought of this aspect shows as follows. First, make the whole grid covering the region space as the basic units of evaluation, analysis and operation, applying GIS. Secondary, make a suitability evaluation on territory space utilization and evaluation on territory spatial population, social, economic and social capacity aiming at ecological-life-production to get the difference between bearing capacity of the status quo and bearing capacity of evaluation of every unit and determine the overload or short load space. Then calculate the comprehensive bearing capacity after the comprehensive balance the contradiction space unit and overload unit. In the calculation of the comprehensive bearing capacity, take the "people-oriented" and "ecological priority" as the basic principle. Finally, composite the comprehensive bearing capacity on space and integrate to the village and township administrative unit base on the main principle, the principle of ecological priority, with elastic principle.

53.3.3 Measure Aspect

Formulate a series of systems and implementation measures as the guarantee of planning. According to the characteristic of the spatial planning in this new period, research and formulate a territory spatial planning rule system. And research to put forward the differentiation of land development space hierarchy, resource security strategy, way of economical and intensive use and differentiation of regional development oriented policies starting from the actual condition of Hangzhou.

53.4 Discussions on the Compiling Patterns of Territory Spatial Planning of Hangzhou

It's compiling pattern need to meet diverse value to the greatest degree. When choosing the compiling pattern, development and protection, urban and rural, efficiency and equality should in the eye of consideration. Specific performance as follows: (1) Take the environment protection and sustainable development as the control guide. (2) An efficient and intensive development is for the main line of planning. (3) Embody people-oriented and justice.

According to the multiple values orientation, from the characteristics of Hangzhou, research combining the existing features and development position in the future, comprehensively selecting development, control, people-oriented these three existing in the changing of territory spatial planning theories, finally proposes the basic compiling pattern of Hangzhou territory spatial planning.

53.4.1 The Compiling Pattern of Development Leading

Development is still the main goal of our social economic, studying and determining the compiling pattern of development leading is matching the general goal of China, Zhejiang and Hangzhou. This compiling pattern focuses on the need of development in the future of Hangzhou and the existing problems in development, and tries to establish a territory zoning system based on the prefecture-level city. It basing on the resources capability and construction actuality, under the guide of social economic development strategy and external environment of development, clearing out the current development problems and the need towards planning system from the social economic development practice at present and in the future, establish a problem-oriented, goal-oriented and focused spatial planning to reasonably optimize allocation of resources and balance the regional development and bearing capability.

The compiling pattern of development leading (Fig. 53.2) mainly contains the following points: (1) basic research on the current development situation. (2) Determination of the existing problem and objects in spatial planning. (3) Determine the overall development pattern of land resources. (4) The capacity evaluation and the suitability evaluation on resources and environment bearing. (5) Spatial layout optimization in problem-oriented and goal-oriented condition. (6) Spatial optimization of coordination in important region or resources. (7) The security system of implementation for territory spatial planning.

53.4.2 The Compiling Pattern of Control Guide

The contradiction between economic development and resources, environment protection becomes much more serious. It comes to be a consensus that transformation of the mode of economic growth and realizing the transformation and upgrading of the entire social and economic development. It is territory spatial planning that optimizes the spatial development and correctly handles the relationship between development and protection to provide theoretical and technical guidance in realizing the transformation and upgrading, and to the sustainable development of the connotation in the future for a period of time for our country.

Hangzhou is in development zones to be optimized rather than key development zones in the main function area planning of Zhejiang province. Protection and control is particularly important. Hangzhou, as the pioneer of “The Beautiful

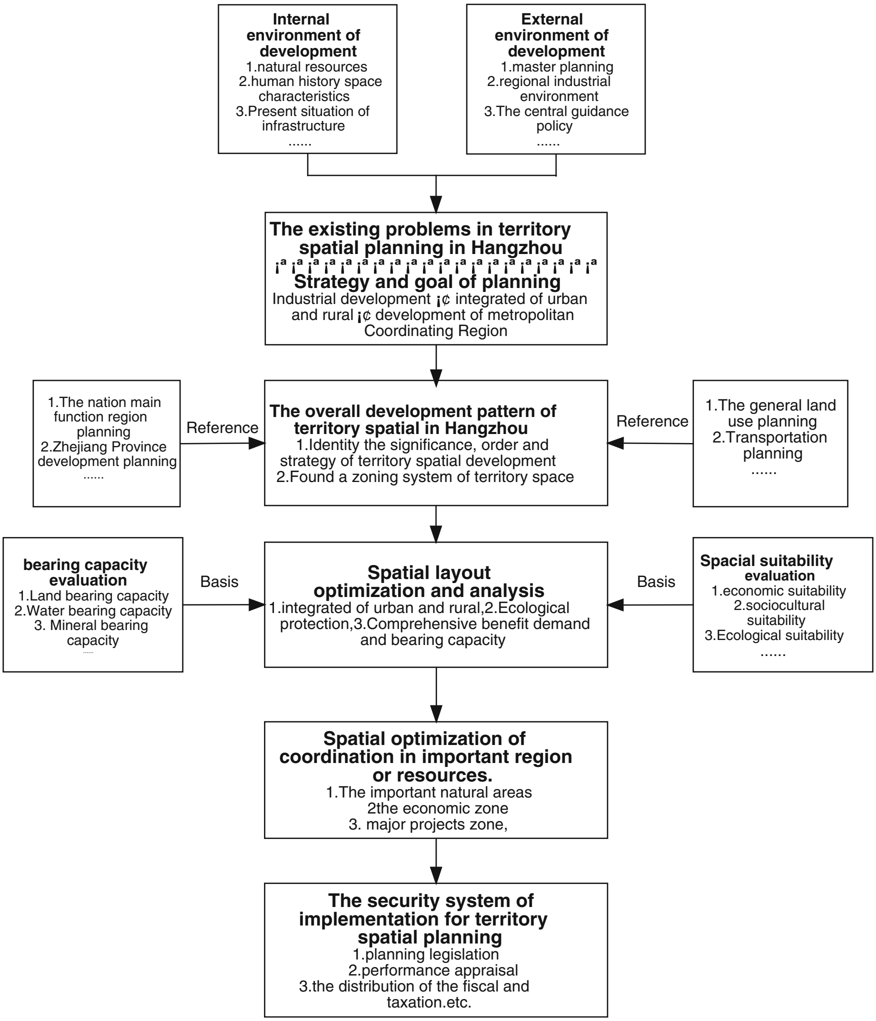

Fig. 53.2 The figure of the compiling pattern of development leading

China" in the strategy in "ecological civilization" raised in the CCP eighteenth, confronts the chance of transformation of development mode which needs to control as the leading factor of mode crack the dilemma of economic development and ecological protection.

The compiling pattern of control guide (Fig. 53.3) mainly contains the following points: (1) Divide the whole region into regular grid according to the fixed size. (2) Change the spatial factors such as the topography, weather, climate and other natural elements and pollution, ecological carrying capacity, environmental quality and ecological environment elements within the scope of region into continuous

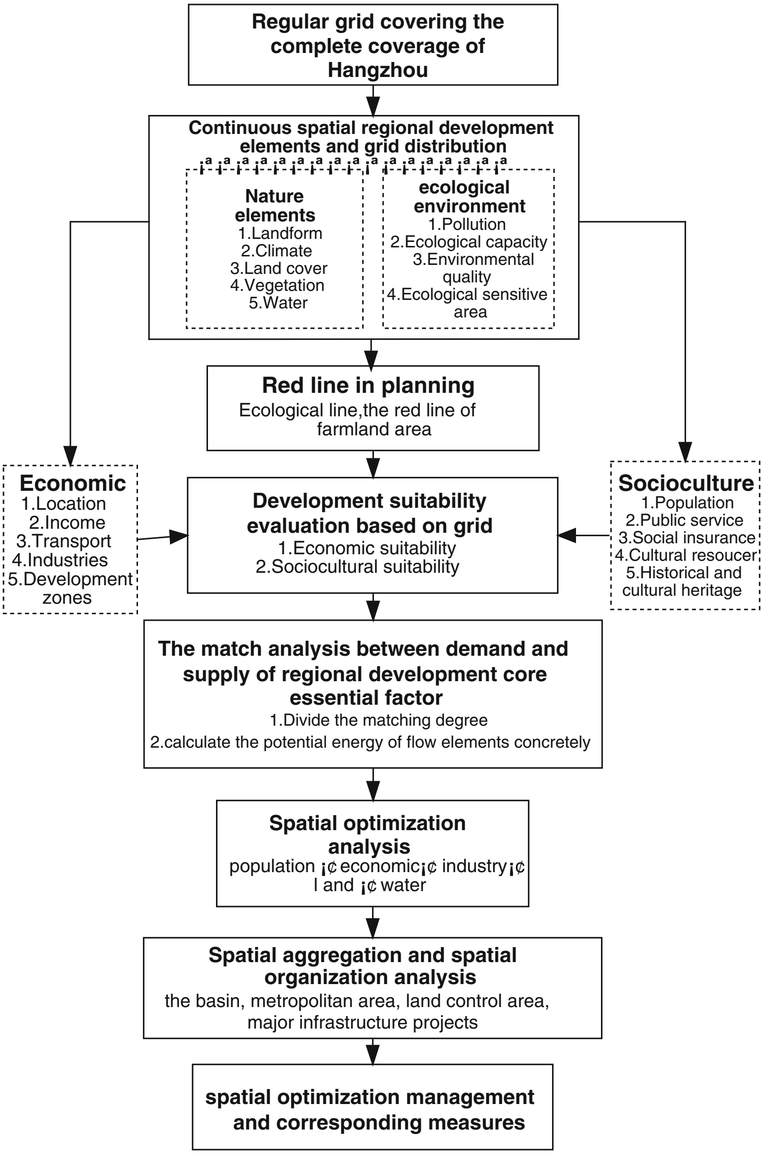

Fig. 53.3 The figure of the compiling pattern of control guide

variables through continuous technical data methods and assign to the grid. (3) According to the spatial distribution of continuous and grid and grid analysis of natural elements and ecological elements, combine the permanent basic farmland, ecological protection these planning red lines; control the intensity of urban development; prevent disorderly expansion of construction land; ensure the development of the territory spatial planning space meet the ecological environment and food security policy within a double standard. (4) Comprehensive evaluation on spatial suitability. (5) The match analysis between demand and supply of regional development core essential factor. (6) Spatial optimization analysis. (7) Spatial aggregation and spatial organization analysis. (8) Put forward spatial management optimization plan and specific measures on integration of important space entity.

53.4.3 The Compiling Pattern of People-Oriented

Population is the main driving force of urbanization. The compiling pattern of people-oriented focuses on the change of population scale and spatial aggregation in the scope of Hangzhou. Industry layout and ecological layout and so on need an overall optimization and management surrounding the characteristics of the population. People-oriented carries ecological civilization, cultural inheritance, politics participation into the compiling pattern of territory to achieve the "social justice" goal.

The compiling pattern of people-oriented (Fig. 53.4) mainly contains the following points: (1) with the population as a breakthrough point, combine industry development and ecological capacity to identify the concentrated area and analyze the road channel degree for the concentrated area of service settlements. (2) Strengthen the function of elements aggregation. According to the elements flow regulation in global value chain and population to prepare infrastructure planning, regional planning, the permanent population migration of basic farmland protection planning, industrial layout spatial guide planning, ecological protection, etc. (3) Select economic, environmental and ecological indicators and use principal component analysis to classify the urban agglomeration of Hangzhou. Best simplify high dimension data index. (4) The implement of planning involves land forestry, ministry of agriculture these departments, implementation scope appearing extensive, content appearing complex, the responsibility main body appearing various. An efficient organization guaranteeing mechanism and common responsibility mechanism is very essential. Study the capital source, financing way, and the use and management mode in implement of planning. Explore the innovation of finance, taxation, financial organization mechanism to offer the guarantee on the fiscal and taxation financial.

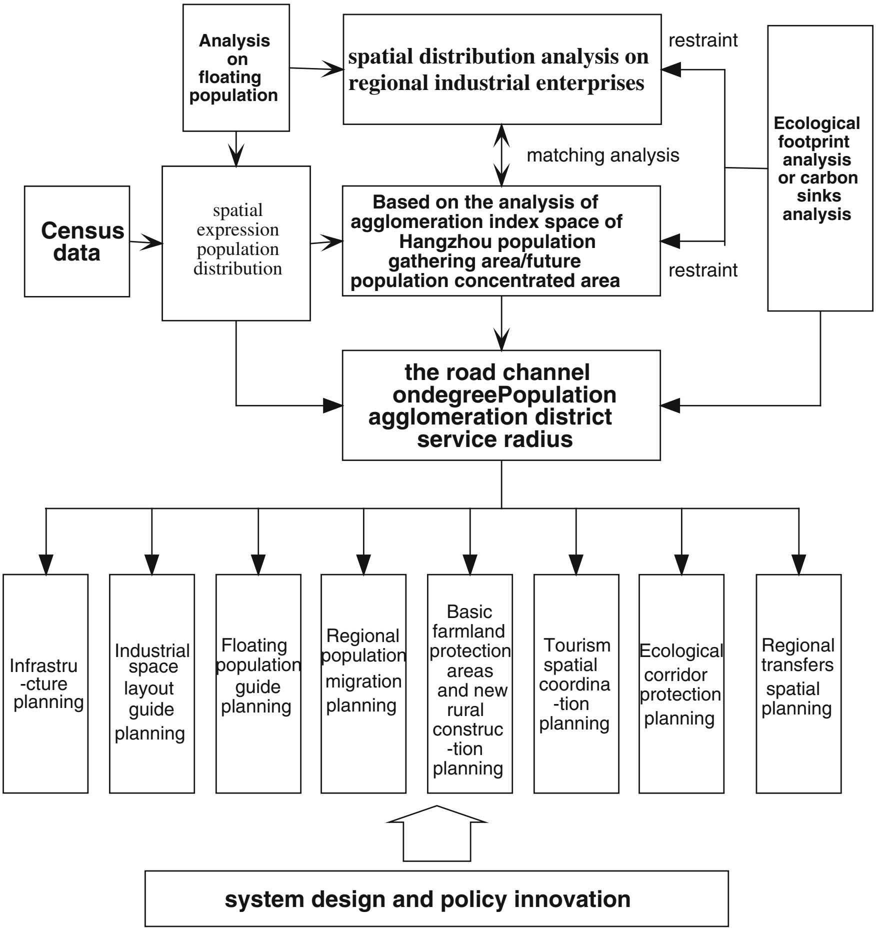

Fig. 53.4 The figure of the compiling pattern of people-oriented

53.5 Conclusion

This paper starts from the realistic significance of territory spatial planning for Hangzhou then combines the development of territory spatial planning concept and related practice and evolution, with the characteristics of territory spatial planning and basis of the actual situation of Hangzhou, finally comes up with a series of innovations in the overall concept of compiling pattern of territory spatial planning from strategy, technology and measures these three aspects. After this, research unites the existing characteristics and development position in the future of Hangzhou according to the multiple value orientation of territory spatial planning and the characteristics of Hangzhou and comprehensively selects three main lines:

development leading, control guide and people-oriented to propose the basic compiling pattern of territory spatial planning in Hangzhou.

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Chapter 54
Study on Land Price and Its Influencing Factors in Yangling District

Donglang Yang, Zhiyong Hou and Baohua Huang

Abstract Based on the Shanxi province Yangling District as an example, selects 12 land price influence factor, analysis of the impact factors and commercial Yangling demonstration zone land, residential land and industrial land price relationship between the use of factor analysis and multiple regression model, and establishes the equation corresponding to the influential factors of the land price. Revealed the main influence factor of the business of Yangling demonstration zone land and residential land prices.

Keywords Land prices · Influencing factors · Yangling district

54.1 Introduction

The land is a natural product, is a carrier for the survival and development of human society, is one of the most important natural resources for human society. With the rapid development of economy and city urbanization, population growth, a series of life and production needs to land as the basic carrier to meet. In the present situation of land utilization in China "little people", the scarcity of land resources and land demand growth has become difficult to reconcile the contradictions, become one of the important factors which restrict the economic and social development. Facing to the problems with the current situation of land saving, intensive use of land become the effective way. In this paper, starting from the land price, exploring the connotation of land prices, analysis the influence factors of the land prices, arrange and use the land scientific and reasonable. To better achieve the intensive use of land, but also for the government to revise the more reasonable city planning and provide scientific guidance, to further promote the city land market operation mechanism.

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54.2 Literature Review

City land price not only has its specific connotation, but also is a complex dynamic system with extensive. The classical price theory is generally believed that, the premium is the essence of the capitalization of the rent, capitalized rent is the land price', and the rent' is "value form". The price of land from the content point of view, is actually reflect the economic value of land, for the purchase of land acquisition earnings price of right, the land rent capitalization. The price of land from the extension point of view, the price of land is the land purchase, land purchase is the purchase of land rights, land rights for different buyers benefits are different, so the price is also different, as in practice can be represented as a price of the ownership, the price of the right to use, mortgage right price and other price forms (Guangdong Province land valuers Association 2008). At present, China's land use system is based on the socialist public ownership, the right of land ownership and use of separation of two rights. Therefore, the land price that our county institute is the price of land use rights (Marx 1975).

The development of the land market is early and relatively mature, the research about land price comparison system abroad. As Noguchi and Poterba (1994), Capozza and Sick (1994) and Weber (1997) on land price mechanism are studied; Glaeser and Ward (2009), Ihlanfeldt (2007) and Charles et al. main focus on the influence of land use regulation on land price (2001); Dachis and Duranton (2009), Henneberry and Barrows (1990). They research the impact of tax and policy on land prices; in addition to Forrest et al. (1996), Haider and Miller (2001), makes a systematic analysis on the individual factors, land prices and neighborhood factors, location factors, micro factors, at the same time in the aspects of land price model has involved such as Brueckner (1995), Paez and Uchida (2001). As can be seen, the research abroad on the price of land has been very comprehensive and system, in the aspect of theory research, theory system in foreign countries has been very mature and complete, in practice, various price model has been applied and tested.

Compared with the foreign researches, domestic researches on land prices started relatively late and relatively simple. But in recent years has made considerable progress, study on the factors of land price influence already from qualitative study to quantitative research stage. As in the qualitative research, Yang Jirui from the labor theory of value point of view, analysis of the formation, positioning and action mechanism of the land price (1994). Long Chuanfang search from the perspective of economic factors, respectively, the economic development situation, the bank interest rate, price level and saving and so on, search the effect on the city land price (2006). Wan Jun attempt to do further understanding and study through the analysis of the system of the forming process of land price (1995).

54.3 Overview of the Study Area and Data Sources

54.3.1 The General Situation of Research Area

Yangling agricultural high tech Industries Demonstration Zone is located in the Guanzhong Plain in the west of Shaanxi, the total area is 135 square kilometers. Yangling demonstration code called China agricultural town, is currently the only National Agricultural High-tech Industries Demonstration zone. Since 1997 the establishment of the Yangling demonstration zone, building area developed rapidly, land area is increasing year by year, by the end of 2007, the land area of 1200 mu, the main types of land use for construction land and industrial land, reached 29 and 28 % respectively.

54.3.2 Data Sources

This research is mainly achieved through two aspects. On the one hand is the transfer list data provide by the demonstration area of Yangling Land Bureau, on the other hand, is through the design of questionnaire, on-the-spot investigation to obtain.

1. The on-the-spot investigation, including the survey of land use situation, block infrastructure and social service facilities, environment, housing and rental counter blocks, commercial housing sales data.
2. Data access, including one is refer to the construction of the local materials nearly three years in the land and resources management departments, finishing land expropriation and requisition of land contract in all kinds of tax collection information, land leasing (including the agreement transferring, strokes he sold) data; two is the inspection cadastral archive, transfer, land consolidation mergers and restructuring of enterprises in the land disposal of the relevant transaction data; three is in the local construction planning departments access to commercial housing development and sales price data.

Because the source of the data is wide, in this paper the sample contains the types of rental housing, the sale of housing, land leasing and sale. Land samples price calculation is more complex, this research mainly through the following method to calculate the land value of sample point, one is using the income approach to calculate the rental sample price; the two is through the residual method to calculate the sale of sample point housing price; three is in accordance with the transaction price correction data sample calculation of land transfer and sale of land. All data by Moses test.

54.4 The Determination and Data Processing of the Factors Affecting Land Prices

54.4.1 Determine the Effect Factor

Considering the price of land, the land classification of Yangling demonstration zone for commercial land, residential land and industrial land three types to consider, in considering the impact of factor selection principle, combined with the "urban land valuation" (GB/T18508-2001), and ultimately determine the 12 factors that impact the land price in Yangling demonstration area:

1. The degree of prosperity (X1). Flourishing degree refers to the extent of commercial center on land quality. In this paper, the flourishing degree index is defined as the sample plots of land to commercial center distance, in meters.
2. The road accessibility (X2). Road accessibility to arrive at a specific location of the road transport conditions, generally by the road types, road location to reflect. This paper defines the accessibility of the road to block the road number, as a unit.
3. Bus convenient level (X3). Bus convenient level is a measure of land area of public traffic quality index, this paper defined that the number of sample plots can reach the bus as the bus sample plots of convenience, units of vehicles.
4. The external traffic convenience degree (X4). Foreign transportation say is the degree of perfection of various external transport facilities and the type of its transport capacity. This paper defines foreign transportation as the distance from sample plot to the train station or bus station distance, in meters.
5. The living facilities convenience degree (X5). Whether the living facilities are perfect for the land price has great influence, therefore this paper defines life facilities as the distance from sample plots to the supermarket, in meters.
6. Education facilities degree (X6). The degree of perfection of educational facilities may affect the price of land, so the definition of the educational facilities in maturity is the distance from the sample plots to the nearest primary school, in meters.
7. Health care facilities degree (X7). Health care facilities complete degree may also influence the plot of land price. This paper defines health care facilities for the distance between sample plots and the nearest hospital distance, in meters.
8. Cultural and sports entertainment facilities complete degree (X8). Cultural and sports entertainment facilities more complete, an area of land prices may be higher. This paper defines the entertainment facilities of the index value for the distance between sample plots and the nearest supermarket, in meters.
9. The park influence degree (X9). The park can reflect the degree of comfort of people living in a block within the scope of the definition, the influence degree of the index value for the park as the distance from the sample plots to the nearest park, in meters.

10. The population density (X10). Population density reflects the number of people living in a block within the scope. Population density of population within the unit block area, unit for the people.
11. The road network density (X11). The road network density reflects a block within the road conditions, the number of density is defined network unit block area within, the unit for a.
12. The postal facilities degree (X12). Postal facilities is an indicator to reflect a block within the postal facilities conditions, this paper defines as the distance from the plots to the postal facilities, the unit for %.

54.4.2 Data Processing

54.4.2.1 Reliability Analysis

In this paper, using Min-max method normalize all the data, the alpha reliability coefficients of each factor data reliability for reliability analysis.

In the reliability analysis, the reliability coefficient is higher than 0.65 that of commercial land, residential land and industrial land selected every factor, so we can determine for these data are reliable, the data is randomly selected is relatively stable, with total body sample values.

54.4.2.2 Homogeneity Test

Method using the independent samples of T-test for the homogeneity test of all data. In the commercial use of homogeneity test, excluding foreign transportation, education facilities, medical facilities, park the 4 factor. In the residential land homogeneity test, eliminating sports facilities, health care facilities of these two factors. In the industrial use of homogeneity test, excluding the education facilities, postal facilities of these two factors.

54.4.3 Principal Component Extraction

This paper extracts the principal component factors of commercial land, residential land and industrial use by the method of principal component analysis, in order to pave the way for subsequent the establishment of land price regression equation.

54.4.3.1 The Commercial Land

Done in front of independent samples T test analysis, the commercial land retained 8 main influencing factors, the 8 main factors will probably in Yangling demonstration area of commercial land price evaluation. After all the impact factors through factor analysis, extract the impact factor, before the principal component analysis, using factor analysis to test the applicability of KMO and spherical Bartlett test. The results are as follows.

Through the Table 54.1 can be seen, the result of Barlett test showed that, should reject the independent variable hypothesis, that there is a very strong correlation between variables. But the KMO statistic for 0.768 > 0.7, illustrate the extent of overlap between each variable information is not high, the factor analysis model to make the basic sound, factor analysis result is good, the applicability test of the factor analysis pass though. That is to say that the business with each factor to the index value is suitable for factor analysis.

As shown in Table 54.2 are common variable degree can be seen: for the commercial land, extract almost all variables together in more than 80 %, so a few common factors extracted from the explanatory power of the variables is strong, that is to say a few common factors extracted can represent each variable.

Table 54.3 shows the characteristic roots, only the first three components is greater than 1, so the SPSS extracts only the first three principal components. From the table data can be seen, the variance of the first principal component accounted

Table 54.1 KMO ball type identification and Bartlett ball type identification

Sampling enough degree of Kaiser-Meyer-Olkin metric		0.768
The sphericity test of Bartlett	Approximate chi square	476.151
	df	66
	Sig.	0.000

Table 54.2 Commercial use common factor variance

Factor	Initial	Extraction
The degree of prosperity	1.000	0.906
Accessibility of the road	1.000	0.679
Bus convenient level	1.000	0.967
External transport up to degree	1.000	0.735
Living facilities	1.000	0.923
Educational facilities	1.000	0.845
Medical care	1.000	0.879
A literary style	1.000	0.866
Park	1.000	0.761
Population	1.000	0.873
Post	1.000	0.897
Road	1.000	0.947

Table 54.3 The total variance explained by each component of the business

Ingredients	Initial eigenvalue			Extraction of square and load		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	6.964	58.031	58.031	6.964	58.031	58.031
2	2.187	18.222	76.253	2.187	18.222	76.253
3	1.129	9.408	85.661	1.129	9.408	85.661
4	0.666	5.552	91.213			
5	0.469	3.905	95.118			
6	0.243	2.029	97.147			
7	0.139	1.159	98.307			
8	0.101	0.841	99.147			
9	0.055	0.456	99.604			
10	0.026	0.218	99.822			
11	0.014	0.114	99.936			
12	0.008	0.064	100.000			

Table 54.4 Commercial land component matrix

Factor	Ingredients		
	1	2	3
The degree of prosperity X_1	0.928	0.204	−0.05
Accessibility of the road X_2	0.482	0.108	0.66
Bus convenient level X_3	0.973	−0.035	−0.139
External transport up to degree X_4	−0.124	0.766	−0.365
Living facilities X_5	0.834	0.444	0.177
Educational facilities X_6	0.779	0.457	0.174
Medical care X_7	0.677	−0.533	−0.369
A literary style X_8	0.746	−0.495	−0.252
Park X_9	0.25	−0.679	0.487
Population X_{10}	0.863	−0.297	−0.199
Road X_{11}	0.948	0.217	0.031
Post X_{12}	0.94	0.12	−0.007

for 58 % of the variance of main components in all, more than half of the variance of the first three principal components, the cumulative contribution rate reached 85.661 %, so the first three ingredients are enough to describe the influence of commercial land prices in Yangling demonstration zone factor condition.

It can be seen from Table 54.4, as for the 1 principal components, public transport convenience, road and postal facilities is relatively influence larger, relatively smaller impact on the park; as for the principal component 2, influence on the external traffic and the park is relatively larger, and public transport convenience and postal facilities are relatively smaller; as for the principal component 3, road accessibility and park is relatively influence larger, effects on the postal facilities, center of influence degree and the road is relatively smaller, and the effect on the postal facilities and the degree of prosperity is negative. According to Table 54.4, the business by using the principal component equation for:

$$\begin{aligned} F1 = {} & 0.928X1 + 0.482X2 + 0.973X3 - 0.124X4 + 0.834X5 + 0.779X6 \\ & + 0.677X7 + 0.746X8 + 0.250X9 + 0.863X10 + 0.948X11 + 0.94X12 \\ F2 = {} & -0.204X1 + 0.108X2 + -0.035X3 + 0.766X4 + 0.444X5 + 0.457X6 \\ & - 0.533X7 - 0.495X8 - 0.679X9 - 0.297X10 + 0.217X11 + 0.120X12 \\ F3 = {} & -0.0.05X1 + 0.660X2 - 0.139X3 - 0.365X4 + 0.177X5 + 0.174X6 \\ & - 0.369X7 - 0.252X8 + 0.487X9 - 0.199X10 + 0.031X11 - 0.007X12 \end{aligned}$$

54.4.3.2 Residential Land

Based on the same ways of KMO ball type identification and Bartlett ball type identification and factor analysis on residential land as on the commercial land. Results were obtained as follows.

Through the Table 54.5 can be seen, the result of Barlett test showed that, should reject the independent variable hypothesis, that there is a very strong correlation between variables. But the KMO statistic was 0.607, the degree of overlap between each variable information is not high, the factor analysis model to make the basic sound, factor analysis result is good, the applicability of the test and factor analysis pass through. That is to say each factor of the housing index value is suitable for factor analysis (Table 54.6).

Table 54.7 gives the cumulative contribution rate and variance contribution rate of the residential of each component, the table shows, only the first four components of the eigenvalue is greater than 1, so the SPSS extracts only the first four principal components. From the table data can be seen, the variance of the first principal component and the second principal components of all principal components variance of 56.987 %, more than half, the variance of the first four principal components' cumulative contribution rate reached 81.521 %, so choose the first four ingredients have sufficient to describe the factors affecting land prices in Yangling demonstration zone residential.

Table 54.5 KMO ball type identification and Bartlett ball type identification

Sampling enough degree of Kaiser-Meyer-Olkin metric		0.607
The sphericity test of Bartlett	Approximate chi square	285.24
	df	66
	Sig.	0.000

Table 54.6 Residential common factor variance

Factor	The initial	Extraction
The degree of prosperity	1.000	0.589
Accessibility of the road	1.000	0.659
Bus convenient level	1.000	0.704
External transport up to degree	1.000	0.853
Living facilities	1.000	0.973
Educational facilities	1.000	0.918
Medical care	1.000	0.885
Sports	1.000	0.832
Park	1.000	0.853
Population	1.000	0.856
Post	1.000	0.915
Road	1.000	0.745

Table 54.8 is the coefficient matrix of the 4 principal components extracted from the residential land. That can explain the load of each principal component in the variable, get the expressions of the principal components, pay attention to that the expression of each variable is not the original variables, but the standardized variables. It can be seen from the table, the 1 principal components, population, transportation become more convenience, postal facility and the sports facilities have bigger relative influence, the park is relatively smaller; the principal component 2, education facilities, living facilities is relatively bigger, and the influence of the road and road access is relatively smaller; the principal component 3, external transport facilities, park and road access is relatively bigger, the influence of sports and flourishing degree is relatively smaller; the principal component 4, a park and road access is relatively larger, and the effect of living facilities and sports facilities is relatively smaller. In short, according to Table 54.7 the house by using the principal component equation for:

$$\begin{aligned}
\mathrm{F1} = {} & 0.353\mathrm{X1} + 0.221\mathrm{X2} + 0.791\mathrm{X3} + 0.117\mathrm{X4} + 0.579\mathrm{X5} + 0.285\mathrm{X6} \\
& + 0.723\mathrm{X7} + 0.756\mathrm{X8} - 0.039\mathrm{X9} + 0.834\mathrm{X10} + 0.708\mathrm{X11} + 0.761\mathrm{X12} \\
\mathrm{F2} = {} & -0.445\mathrm{X1} + 0.099\mathrm{X2} - 0.223\mathrm{X3} + 0.495\mathrm{X4} + 0.775\mathrm{X5} + 0.831\mathrm{X6} \\
& - 0.5511\mathrm{X7} + -0.486\mathrm{X8} - 0.345\mathrm{X9} - 0.113\mathrm{X10} + 0.027\mathrm{X11} + 0.521\mathrm{X12} \\
\mathrm{F3} = {} & -0.122\mathrm{X1} + 0.574\mathrm{X2} - 0.169\mathrm{X3} - 0.759\mathrm{X4} + 0.194\mathrm{X5} + 0.356\mathrm{X6} \\
& + 0.356\mathrm{X7} + 0.126\mathrm{X8} + 636\mathrm{X9} - 0.168\mathrm{X10} - 0.373\mathrm{X11} + 0.226\mathrm{X12} \\
\mathrm{F4} = {} & 0.502\mathrm{X1} + 0.520\mathrm{X2} + 0.028\mathrm{X3} + 0.135\mathrm{X4} - 0.014\mathrm{X5} + 0.137\mathrm{X6} \\
& + 0.213\mathrm{X7} + 0.088\mathrm{X8} - 0.573\mathrm{X9} - 0.345\mathrm{X10} - 0.321\mathrm{X11} - 0.115\mathrm{X12}
\end{aligned}$$

Table 54.7 Residential total variance explained

Component	Initial eigenvalue			Extraction of square and load			Rotating square and load		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	4.10	34.1	34.1	4.10	34.1	34.1	2.76	23.0	23.0
2	2.73	22.8	56.9	2.73	22.8	56.9	2.76	23.0	46.1
3	1.76	14.7	71.7	1.76	14.7	71.7	2.46	20.5	66.6
4	1.17	9.81	81.5	1.17	9.81	81.5	1.77	14.8	81.5
5	0.786	6.54	88.0						
6	0.598	4.98	93.0						
7	0.356	2.96	96.0						
8	0.172	1.43	97.4						
9	0.146	1.21	98.6						
10	0.093	0.773	99.4						
11	0.052	0.436	99.8						
12	0.016	0.132	100.0						

Table 54.8 Residential component matrix

Factor	Ingredients			
	1	2	3	4
The degree of prosperity X_1	0.353	−0.445	−0.122	0.502
Accessibility of the road X_2	0.221	0.099	0.574	0.52
Bus convenient level X_3	0.791	−0.223	−0.169	0.028
External transport up to degree X_4	0.117	0.495	−0.759	0.135
Living facilities X_5	0.579	0.775	0.194	−0.014
Educational facilities X_6	0.285	0.831	0.356	0.137
Medical care X_7	0.723	−0.551	0.118	0.213
A literary style X_8	0.756	−0.486	0.126	0.088
Park X_9	−0.039	−0.345	0.636	−0.573
Population X_{10}	0.834	−0.113	−0.168	−0.345
Road X_{11}	0.708	0.027	−0.373	−0.321
Post X_{12}	0.761	0.521	0.226	−0.115

54.4.3.3 Industrial Land

Using factor analysis to test the applicability of KMO and spherical Bartlett on industrial land, the results are as follows.

As we can see from Table 54.9, the result of Barlett test showed that a very strong correlation between variables, so the independent variable hypothesis should be rejected. But the KMO was 0.538, which shows variables are highly interrelated, hence the factor analysis model is not perfect, the results are not reliable. That is to say factor analysis is not fit for the industrial land.

54.5 Analysis of Land Price Influence Factors

54.5.1 Commercial Land

Using the F1, F2 and F3 selected above as the dependent variable to component the backward linear regression, the results are shown in the following Table 54.10.

Above all, we can get regression equation as follows:

Table 54.9 KMO ball type identification and Bartlett ball type identification

Sampling enough degree of Kaiser-Meyer-Olkin metric		0.538
The sphericity test of Bartlett	Approximate chi square	149.4
	df	66
	Sig.	0.000

Table 54.10 Model summary

Model	R	R^2	Adjustment R^2	The standard error of estimate
1	0.897[a]	0.805	0.782	3534.93205

[a]Predictor variables: (Constant), REGR factor score 1 for analysis 1

$$Y = 1.042F1 + 0.245F2 + 0.187F3$$

which equals,

$$Y = 1.8X1 + 2.2X2 + 2.1X3 + 2.1X4 + 1.2X5 + 2.5X6 \\ + 2.4X7 + 0.6X8 - 0.3X9 - 0.3X10 + 0.24X11 + 1.9X12$$

With all the variables observed in the equation, we can tell the equation is capable to represent the price influence factors regression equation of Yangling District. From the equation we can see that, for commercial land of Yangling District prosperity, road accessibility, transportation, population have the most significant effect on the price of this land, and long distance transportation, entertainment facilities, infrastructure have no significant effect on the commercial land. Besides, long distance transportation and park facilities are negatively related to the price of land and the other 10 factors are positively related to commercial land prices.

54.5.2 Residential Land

With F1, F2, F3 and F4 as the dependent variable, and corresponding residential land prices as the independent variable, the results as shown in the following table.

From the table we can see that 1 is the best fitting model, regression equations brought the results as follows:

$$Y2 = -0.251F1 - 0.263F2 - 0.157F3 + 0.043F4 + 12.306$$

$$Y2 = 0.04X1 + 0.31X2 + 1.02X3 + 0.41X4 + 0.46X5 - 0.1X6 \\ + 1.27X7 + 1.15X8 - 0.05X9 - 0.35X10 + 1.26X11 + 0.36X12$$

Take all the variables into the equation to test. We can see that postal facilities, living facilities, educational facilities and road accessibility have the most significant effect on the residential land price. Except for transportation, parks and roads, the other 9 factors are positively related to the land price.

54.6 Conclusion

1. For commercial land, the degree of prosperity, road access, public transport convenience, population density have significantly influence on the land price, while external traffic convenience, entertainment facilities, living facilities have no significant impact on. The most significant factors are center influence and transportation, which perfectly demonstrate the location theory.
2. Except for external transportation and parks accessibility, the other 10 factors are positively related to the land price. It indicates that the purpose of commercial land is to pursue the profit maximization. In this way we can say, the profit of commercial increases along with the land price. Thus, the cost of land is not the determined factor of the site selection for commercial land. Instead, the market situation is the most important factor.
3. For residential land, postal facilities, living facilities, educational facilities and road accessibility are the most significant factors of the land price. Therefore, to improve the living facilities, complete education facilities can greatly increase the corresponding land price.
4. Since the factors and data of industrial land is not suitable for factor analysis, so the regression analysis of industrial land is also unfinished. Considering the particularity of industrial land, it should be analysis separately with particular analysis methods in the future research.

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Chapter 55
The Influence Factor of Low-Carbon Urban Construction Land Use in Tourism City Based on PCA Analysis: A Case Study of Hangzhou City

Shen Ping, Wu Cifang, Wang Zhenjian, Lv Tiangui and You Heyuan

Abstract The low-carbon urban construction land use level for tourism city is closely related to the sustainable development of the city's ecological environment and social economy. In this study, the concept of low-carbon urban construction land use level is defined, and then 14 specific indexes are selected from three perspectives of society, economy and ecological environment based on the PSR model, constructing the evaluating index system of the low carbon utilization level for tourism city, exemplified by the tourism city of Hangzhou. The influence factor index of the low-carbon urban construction land use in Hangzhou from 2004 to 2011 is quantitatively evaluated through principal component analysis (PCA). The result shows that tourism city is mostly affected by the industrial economical factor, social economical factor and low carbon environmental factor. Based on this result, the method for optimizing the low-carbon urban construction land use in Hangzhou is provided, which includes strengthening the management of industrial economy of carbon emissions, increasing the supply of land for public transportation and guaranteeing the public greening coverage level, etc., in order to promote the low-carbon urban construction land use in Hangzhou.

Keywords Tourism city · Construction land · Low-carbon use · Principal component analysis · Hangzhou

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55.1 Introduction

As construction land is the base of a city's social and economic development, its level of low-carbon use not only influences people's living environment, but also the realization of goals of the urban sustainable development strategy. A well-developed low-carbon urban construction land use is an important guarantee of the operation and development of urban ecological environment, which will evidently improve a city's tourism development and the quality of the city, and will directly influence the sustainable development of city investment environment and social economy. However, in recent years, the expansion of urban land use, urban and rural population migration result in the urban population swelling that breaks the original urban construction land structure, which leads to the short supply of urban construction land. In another word, low-carbon urban construction land use will directly influence the economic growth, social stability and other aspects of our country. Therefore, the low-carbon urban construction land use in urban development is an important issue that the government should think about in deciding a city's tourism development strategy, which is of great importance in promoting the sustained and healthy development of cities.

In the process of rapid advance of urbanization, the urban construction land development has an increasing pressure on carbon use. The issue of how to harmonize the low-carbon urban construction land development and use has attracted wide attention of scholars. Scholars at home and abroad conducted relevant research respectively from different perspective of the ecological environment, urban construction and utilization efficiency, etc. In terms of the urban construction land's ecological environment, some scholars think that the planning of urban construction land use needs to consider the ecological environment of the city and fully blend technology and nature, and to have a comprehensive evaluation in terms of resources, ecological carrying capacity, development suitability and other aspects, so as to realize the low-carbon urban construction land use (Zhang et al. 2011). In the respect of low-carbon urban construction, scholars analyze the residential land and conclude that freestanding residential building has strong external effect on the regional ecological environment, and is advantageous to the carbon cycle and use (Goddard et al. 2010). Some scholars believe that the expansion of city scale and the increase of construction land will affect the local ecological environment, especially that the expansion of city scale will increase emissions of carbon dioxide and other greenhouse gas (Xie et al. 2013). In the respect of urban construction land evaluation, scholars are usually based on land ecological risk and ecological service value to construct an evaluation system for land ecological environment quality, and select the relevant case for demonstration (Xu et al. 2012, 2011, 2012). Some scholars study urban construction land evaluation from the perspective of efficiency of resources and elements, and think that the carbon use in urban construction land is more effective in the east of China than in the west of China, and that implementation of differentiated regulation policy based on the resources endowment should be taken into account (Zhang et al. 2013; Li and Ou 2012). In conclusion, despite the wide research on carbon use in urban land, researches on the influence factors of carbon use in construction land in the process of urbanization are not many, and researches on low carbon use in construction of city land of tourism city are still rare. In view of this, this study tries to take tourism city as object of study, study the influence factors on carbon construction land use in the process of urbanization, in order to provide theoretical support for the development of urban construction land.

Hangzhou is a famous tourism city in China, there is a lot of discussion in terms of its low-carbon urban construction land use. At the same time, Hangzhou's rapid economic development has also brought a lot of pollution to its ecological environment. Especially, the rapid advance of industrialization process of Hangzhou bay leads to the high carbon emissions in Hangzhou, which makes the problem of low-carbon use in land construction in the process of urban development even more prominent. How to improve the low-carbon construction land use of Hangzhou has become a current heat spot in research. In view of this, this study takes tourism city of Hangzhou as the research object, and uses PCA to investigate the low-carbon city construction land use factors due to the diversity of the research data and indicator samples, so as to provide reference for the sustainable development of tourism city.

55.2 The Concept of Low-Carbon Construction Land Use of Tourism City

The development of tourism city needs land, especially construction land as a basic support. Construction land mainly includes town and rural residential areas, industrial land, land for traffic use and water conservancy facilities. All kinds of construction land increase will lead to the increase in carbon emissions. Most of all, the industrial land promotes economic growth, if construction land is mainly used for heavy industry such as petrochemical industry, a large number of energy consumption will lead to the rapid increase of CO_2 in the air. And with the increase land use for traffic and the increase of vehicles, will also lead to increased carbon emissions. Therefore, taking the concept of low-carbon use into the development and utilization of construction land, establishing an evaluation index system with the concept of low-carbon construction land use to study its crucial influence factors is extremely important.

The so called low-carbon use, as illustrated from the perspective of economics, is to take the production mode of low energy consumption, low pollution and low emissions into economic activities, which is essentially to improve energy utilization efficiency, promote the clean energy structure and pursue a green GDP, with the kernel of innovations in energy technology and regime. The key to determine the domain and concept of low-carbon construction land use and to solve the issue of low-carbon construction land use is to fully recognize the dual nature of input in construction land use, i.e., the direct input and indirect input in low-carbon construction land use. Direct input includes labor, capital and technology, while indirect input refers to that the input into one land which leads to an indirect increase in the output of other lands that equals to the output. Therefore, the concept of low-carbon construction land use can be defined as: aiming at the optimal carbon emissions of various types of land; under the condition of present and foreseeable social economy and technology development and within the area that the construction land can use, in accord with the premise of construction land planning indicators, increase the level of land use and improve the efficiency of land use by improving the management and optimizing land use structure, so as to increase construction land area, and improve construction land use with the comprehensive benefit of social economy and ecological environment.

55.3 The Selection of Low-Carbon Urban Construction Land Influence Factor Index and the Data Source

55.3.1 Relatively Low Intensity of Urban Land Use

Economic attributes of urban land use mainly refers to the economic value and special use of the land. Its main evaluation factors include location, transportation, infrastructure, etc. But construction land of different areas is different, and the low-carbon construction land use is influenced by the corresponding economic factors, social factors and ecological environment factors, etc. In view of the characteristics of low-carbon construction land use, we use for reference pressure-state-response model (PSR) for reference to analyze the low-carbon urban construction land use evaluation index system from the perspectives of economic development, ecological environment and low carbon use. The influence factor index is present in Table 55.1.

55.3.2 Research Area and Data Source

Hangzhou, located in the Yangtze River Delta region and in the southeast coastal areas in our country, is the center of economy, culture and education in Zhejiang Province, and is one of the well-developed cities in the east of China. At the same time, with a long history, Hangzhou is one of the national historic cities and tourism cities, which has many tourist attractions such as the West Lake, Xixi Wetland, and is an important tourism city of China. Hangzhou has a relatively store of rich land resources, the change and development of urban construction land in Hangzhou is very important for the effective utilization of its land resources. By the end of 2011, the whole city of Hangzhou covers an area of 16,596 square kilometers, with an

Table 55.1 The selection and connotation of the influence factors of low-carbon urban construction land use for tourism city

Goal layer	Criterion layer	Index layer	Index connotation
Influencing factors of low-carbon construction land	Economic development pressure	Carbon dioxide emissions per ten thousand yuan of GDP (x_1)	Reflects the relationship between the city's GDP and the utilization degree of carbon
		Sulfur dioxide emissions per one hundred million yuan of GDP (x_2)	Reflects the relationship between the city's GDP and the emissions of sulfur
		GDP of average per capita (x_3)	Reflects the utilization level of urban economics per capita
	Ecological environment state	The reaching-the-standard rate for industrial wastewater (x_4)	Reflects the standard rate of wastewater emission
		Comprehensive utilization rate for industrial solid waste (x_5)	Reflects the comprehensive utilization level of industrial solid waste
		Proportion of tertiary industry (x_6)	Shows the drive for ecological environment improvement
		The sulfur dioxide annual average (x_7)	Reflects the overall level of sulfur dioxide in the air
		Nitrogen dioxide annual average (x_8)	Reflects the annual average of nitrogen dioxide in the air
		The air quality (x_9)	Reflects the overall air quality in the research area
		The environmental protection investment as a share of GDP (x_{10})	Reflects the improvement of environmental protection
	State of low-carbon land use	Greening coverage ratio of the construction area (x_{11})	Reflects the ecological greening of the city
		The number of buses per ten thousand people (x_{12})	Reflects the input of air protection of the city
		Hazard-free treatment rate of waste (x_{13})	Reflects the disposal level of municipal solid waste
		The percentage of residential land for construction land (x_{14})	Reflects the occupation of residential land in urban land use

urban area of 3068 square meters; its city census registered population is 6.9571 million, including the urban population of 4.4034 million. The urban population density in Hangzhou is about 3.42 times of that in the whole city, which is one key cause of its relatively large amount of urban construction land use. Although Hangzhou has relatively abundant land resources, but the increasing demand for construction land in Hangzhou also led to the extreme scarcity of land resources in Hangzhou. Particularly, the strong tourism market in Hangzhou also pushes up the demand of local construction land.

Based on the availability of data, the selected range of all index data in this paper is 2004–2004, of which the data source of the carbon emissions ten per thousand yuan GDP index, GDP of average per capita index, industrial waste water index, the reaching-the-standard rate of waste gas emission index, utilization rate of municipal solid waste index and other major indexes is from The Statistical Year Book of Zhejiang Province 2004–2011, the data source of the percentage of residential land in construction land is from The Development Report of Hangzhou City 2004–2011.

55.4 Principal Component Analysis (PCA) of Low-Carbon Urban Construction Land Influence Factors

PCA is a dimension reduction method of multivariate statistical analysis. Through the recombination of a few comprehensive indexes that have nothing to do with each, it produces a new kind of multiple index, which preserves most of the information of the original variables. In another word, it is a recombination of many originally relevant indexes into a new set of comprehensive index, which has nothing to do with each, to replace the original indexes. Therefore, applying PCA to the analysis of urban construction land factors, is good for a micro grasp of the situation and structure of low-carbon urban construction land use, as well as to provide a scientific and reasonable basis for future planning.

55.4.1 Partition Test of Principal Component Factors

Based on the standardization of original data, further analyse the relevance of the low-carbon construction land use. First of all, conducting KMO and Bartlett sphericity test of 14 indexes to confirm whether the new index is suitable for factor analysis. Verification of principal component factors KMO and Bartlett is showed in Table 55.2.

From test results of KMO and Bartlett, it is known that the test value of KMO is 0.74, which is larger than the factor analysis standard of 0.5 and that the concomitant probability gained from Bartlett sphericity test is 0.00, less than the significance level of 0.05. Therefore, the sampling index can be used for PCA factor analysis.

Table 55.2 Verification of principal component factors KMO and Bartlett

Sampling enough KMO for test		0.74
Sphericity test of Bartlett	chi-squared approximation	344.30
	df	91
	Sig.	0.00

55.4.2 Calculation Process and Result Analysis of PCA

In terms of the indexes' correlation coefficient matrix, it is known from Table 55.1 that carbon emissions per ten thousand yuan GDP and carbon dioxide annual average, sulfur dioxide emissions per one hundred million yuan GDP and the bus number per ten thousand people, GDP average per capita and the proportion of the tertiary industry are significantly related. Thus, the direct correlation between most variables is strong, which demonstrates the information overlaps among them. Correlation coefficient matrix of low-carbon urban construction land use indexes is showed in Table 55.3.

Through the analysis, three components are selected as the principal factors in this analysis. It is shown that three components are of higher contribution rate for the evaluation of low-carbon construction land, while other factors are of lower contribution rate for the evaluation of low-carbon construction land. Therefore, this article puts forward three principal components. Conduct PCA analysis towards the 14 variables from x1 to x4, transform the original data formula and compute the covariance matrix A, then obtain the eigenvalues and corresponding eigenvectors via the matrix, we can get the variance contribution ratio of the corresponding eigenvalue of the principal components of F1, F2 and F3, which are 37.36, 22.32 and 37.36 % respectively. Because their cumulative variance contribution rate has reached 73 % > 65 %, therefore F1, F2 and F3 can interpret the basic information of the original indexes. The loading matrix of principal components of urban construction land is showed in Table 55.4.

Divide data in loading matrix of principal components by the corresponding eigenvalue of principal component, square root to get the corresponding coefficient of each index of two principal components. Multiply the feature vector with the standardized data, we will get the expression to calculate the principal component scores. According to the component matrix, the weight of each index of the principal components of F1, F2 and F3 can be obtained, and the mathematical expression to calculate factor scores can is shown below respectively:

Table 55.3 Correlation coefficient matrix of low-carbon urban construction land use indexes

R	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}
x_1	1.00	0.93	0.92	0.04	−0.36	0.81	0.74	0.92	0.39	−0.64	0.81	0.90	0.35	0.36
x_2	0.93	1.00	0.98	0.05	−0.13	0.89	0.91	0.97	0.28	−0.73	0.90	0.99	0.42	0.51
x_3	0.92	0.98	1.00	−0.04	−0.04	0.93	0.89	0.94	0.21	−0.80	0.93	0.98	0.52	0.57
x_4	0.04	0.05	−0.04	1.00	−0.22	0.00	0.19	0.19	0.46	0.25	−0.01	0.11	−0.35	−0.70
x_5	−0.36	−0.13	−0.04	−0.22	1.00	0.24	0.17	−0.18	−0.33	−0.36	0.20	−0.04	0.49	0.48
x_6	0.81	0.89	0.93	0.00	0.24	1.00	0.89	0.89	0.30	−0.85	0.99	0.93	0.61	0.63
x_7	0.74	0.91	0.89	0.19	0.17	0.89	1.00	0.87	0.15	−0.70	0.88	0.94	0.43	0.50
x_8	0.92	0.97	0.94	0.19	−0.18	0.89	0.87	1.00	0.51	−0.66	0.91	0.97	0.35	0.41
x_9	0.39	0.28	0.21	0.46	−0.33	0.30	0.15	0.51	1.00	−0.08	0.35	0.31	−0.04	−0.13
x_{10}	−0.64	−0.73	−0.80	0.25	−0.36	−0.85	−0.70	−0.66	−0.08	1.00	−0.82	−0.76	−0.93	−0.68
x_{11}	0.81	0.90	0.93	−0.01	0.20	0.99	0.88	0.91	0.35	−0.82	1.00	0.93	0.56	0.65
x_{12}	0.90	0.99	0.98	0.11	−0.04	0.93	0.94	0.97	0.31	−0.76	0.93	1.00	0.46	0.50
x_{13}	0.35	0.42	0.52	−0.35	0.49	0.61	0.43	0.35	−0.04	−0.93	0.56	0.46	1.00	0.60
x_{14}	0.36	0.51	0.57	−0.70	0.48	0.63	0.50	0.41	−0.13	−0.68	0.65	0.50	0.60	1.00

Table 55.4 Loading matrix of principal components of urban construction land

Factors of principal components	Components		
	1	2	3
Reciprocal of carbon dioxide emissions per ten thousand yuan of GDP	0.515	0.473	0.033
Reciprocal of sulfur dioxide emissions per one hundred million yuan of GDP	0.965	0.035	−0.270
GDP of average per capita	0.458	−0.534	−0.350
The reaching-the-standard rate for industrial wastewater	0.730	−0.198	0.237
Comprehensive utilization rate for industrial solid waste	0.902	0.039	0.289
Proportion of tertiary industry	0.636	−0.116	0.278
Reciprocal of the sulfur dioxide annual average	−0.551	−0.114	−0.141
Reciprocal of nitrogen dioxide annual average	−0.497	−0.472	0.080
The air quality	0.584	−0.178	0.578
The environmental protection investment as a share of GDP	0.666	−0.311	−0.196
Greening coverage ratio of the construction area	−0.667	−0.036	−0.434
The number of buses per ten thousand people	0.403	0.575	0.383
Hazard-free treatment rate of waste	0.760	0.456	−0.358
The percentage of residential land for construction land	0.075	0.003	−0.140
Initial eigenvalue	5.321	3.724	1.566
Contribution rate	37.361	22.316	13.326
Accumulative contribution rate	37.361	59.677	73.003

$$
\begin{aligned}
\mathrm{F1} = {} & 0.515 \times \mathrm{x1} + 0.965 \times \mathrm{x2} + 0.458 \times \mathrm{x3} + 0.73 \times \mathrm{x4} + 0.902 \times \mathrm{x5} \\
& + 0.636 \times \mathrm{x6} - 0.551 \times \mathrm{x7} - 0.497 \times \mathrm{x8} + 0.584 \times \mathrm{x9} + 0.666 \times \mathrm{x10} \\
& - 0.667 \times \mathrm{x11} + 0.403 \times \mathrm{x12} + 0.760 \times \mathrm{x13} + 0.075 \times \mathrm{x14}; \\
\mathrm{F2} = {} & 0.473 \times \mathrm{x1} + 0.035 \times \mathrm{x2} - 0.534 \times \mathrm{x3} - 0.198 \times \mathrm{x4} + 0.039 \times \mathrm{x5} \\
& - 0.116 \times \mathrm{x6} - 0.114 \times \mathrm{x7} - 0.472 \times \mathrm{x8} - 0.178 \times \mathrm{x9} - 0.311 \times \mathrm{x10} \\
& - 0.036 \times \mathrm{x11} + 0.575 \times \mathrm{x12} + 0.456 \times \mathrm{x13} + 0.003 \times \mathrm{x14}; \\
\mathrm{F3} = {} & 0.033 \times \mathrm{x1} - 0.27 \times \mathrm{x2} - 0.35 \times \mathrm{x3} + 0.237 \times \mathrm{x4} + 0.389 \times \mathrm{x5} \\
& + 0.278 \times \mathrm{x6} - 0.141 \times \mathrm{x7} + 0.08 \times \mathrm{x8} + 0.578 \times \mathrm{x9} - 0.196 \times \mathrm{x10} \\
& - 0.434 \times \mathrm{x11} + 0.383 \times \mathrm{x12} - 0.358 \times \mathrm{x13} - 0.14 \times \mathrm{x14}
\end{aligned}
$$

Calculate the scores of principal components, then conduct evaluation and research. Use the proportion of each principal component's eigenvalues in the sum of all principal components' eigenvalues as the weighting to obtain the principal component comprehensive scoring model.

55.4.3 Extraction of Main Factors Affecting Urban Construction Land Use

The results of loading matrix of principal components in Table 55.4 show that the main factors influencing urban construction land are:

1. From the coefficient of linear expression of the above four principal components, it is shown that coefficient of F1's x2, x4, x5 is relatively large, illustrating that component 1 mainly reflects the factors of carbon emissions per one hundred million yuan of GDP, the reaching-the-standard rate for industrial wastewater, comprehensive utilization rate for industrial solid waste. Component 1, therefore, can be named as low-carbon utilization factor of industrial economy;
2. Coefficient of F2's x3 and x12 is larger, which reflects the GDP average per capita and the bus number per ten thousand people, so the component 2 mainly reflects low-carbon utilization in people's life, so component is named as low-carbon social life factors;
3. Coefficient of F3's x9 and x11 is relatively large. x9 and x11 respectively reflect the air quality index and greening coverage rate of construction area index, thus component 3 is named as environmental factors of low-carbon construction land use.

55.5 Conclusion

The PCA analysis shows that the low-carbon use of construction land in Hangzhou is affected by the factors of low-carbon utilization in industrial economy, low-carbon social life and low-carbon environmental factors. Given the current status of low-carbon construction land use in Hangzhou, the corresponding optimization path is put forward in the following.

At the same time, adaptive management of regional resources should be established, aiming at the overall restoring force regional ecological element in the system, creating a new theory and means of operation for the succession and development of the complex, hard-to-predict ecosystem, through step-by-step implementation, adjustment to achieve maximization of ecological utility, thereby lowering the influence degree of the ecological environment.

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Chapter 56
Exploring the Way of TDR in Urban Ecological Controlling Zone: A Case Study of Jingui Community in Shenzhen

Tianjiao Li and Changchun Feng

Abstract In 2005, Shenzhen City became the first city in China to carry out the ecological controlling line policy, hoping to restrict land sprawl triggered by its rapid pace of urbanization. Though this policy is effective in maintaining the security of ecology system, it encounters many petitions from the local community, whose land development rights are deprived by the governments' rigid zoning policy, leading to their rental income loss, infrastructure inconvenience, livelihood and sustainable development crisis. Transfer of land development rights (TDR), a market-driven instrument widely employed abroad, is considered to be consensual to traditional command-and-control regulation in preserving ecological land while guaranteeing the rights of property owners. So this article taking previous TDR practices as a reference, tentatively explores how the TDR can be carried out successfully for ecological controlling area like Jingui Community, by analyzing the supply of the sending area, demand of the receiving zone, guarantee measures and multi-parties involved. In this way, we hope to offer references for government policy for this kind of ecological controlling communities.

Keywords Ecological controlling community · Transfer of land development rights · Jingui Community · China

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56.1 Introduction

In the first half of the twentieth century, especially after the Second World War, Western countries have witnessed dramatic population boon and rapid construction, which accelerates the urbanization speed to an unprecedented level and brings about land sprawl problem. In order to solve the problem of land degradation, ecology imbalance and green space erosion, many countries formulate the land use, making policy such as ecological controlling line. However, “society would have to carry the burden of an administrative agency that is in the business of passing out windfall gains and/or wipe-out losses, most often with adverse equity consequences” (Gardner 1977). Therefore, countries in rapid development stage begin to revise institutional arrangements with economic incentive, to compensate the welfare loss deprived by rigid regulation. The most representative is the transfer of land development rights system (TDR) (Cai and Zhang 2010).

With the rapid pace of industrialization and urbanization of China, land overexpansion is of great threat to cities’ ecology security and sustainable development. Shenzhen as a highly urbanized and city encounters the dilemma of growth difficult to continue with current limited resources. In this context, Shenzhen took the lead in our country in 2005 to carry out basic ecological line of control policy, which conspicuously improves local atmosphere and attracts more elites to settle down. But the negative consequence gradually shows up, similar to the cases abroad the original rural communities’ economy has been evidently lagging behind. Because of the restrictions on the second industry, the rental factory housing becomes vacant, thus leading to lease loss and income decrease, and at the meantime illegal construction is still emerging despite monitored by satellite remote sensing monitor technology. As a consequence, the local government realizes that the one-way ecological regulation lack of compensation and incentive mechanism was not feasible in reality, so new policy which takes the communities’ sustainable development into account should be explored, such as the TDR program.

In 2014, the ecological line of control will be promoted in Guangdong Province, putting forward the realistic demand for institutional innovation further. Besides, the policy of Shenzhen as the integrated reform pilot area for land management system reform will be a great advantage in exploring the TDR program. It’s worth noting that there is a huge difference in land management system between China and abroad, so the exploration in TDR should be involved in the local scenario. This article takes the highly urbanized city Shenzhen as the study area, trying to devise a TDR way for Jingui Community, a community entirely located in the ecological controlling line.

56.2 Research Background

Research on TDR in foreign countries mainly consisted of the concept of TDR, its function and objective, success factors (Jin and Shen 2010). "TDR is the sale of one parcel's development rights to the owner of another parcel, which allows more development on the second parcel while reducing or preventing development on the originating parcel. Under such a program, development rights are severed from a lot designated for protection (sending area), and the severed rights are transferred to a lot in an area where additional development is permitted (receiving area)" (Johnston and Madison 1997). Both the sending and receiving areas have specific category regulations, taking Pinelands County in New Jersey for instance, the land category of sending area can include farmland, environmental sensitive area, public space, historic area and brown-field remediation etc., and undeveloped area in the outskirts, new city centre, redevelopment area, infill development area as the receiving area (Mercer 2008). By transfer development rights between the two types of land, it can preserve farmland or open space and to make developed areas more compact. And because it's a market-oriented policy instrument, it may result in more efficient land allocations without requiring the expenditure of public funds.

The literature reports several success stories in the United States (Machemer and Kaplowitz 2002; Bredin 2000; Voget 1999; Johnston and Madison 1997) and Europe (Micelli 2002; Renard 2000), for which determinants to be a success includes development constraints of the sending area, high requirements in receiving areas and incentive measures (Pruetz and Pruetz 2007). In a successful TDR program, with down-zoned properties owners' eagerness to make up for the reduction in property value is crucial, and development constraints, regulations, infrastructure requirements in sending areas can motivate the residents to participate (Pruetz and Pruetz 2007). Besides, TDR markets can be rather inactive because of a lack of demand (Kopits et al. 2008), so researchers take great effort to figure out factors which can promote demands in receiving areas. It shows that the baseline zoning levels, sewer availability, housing demands, and surrounding land uses in the receiving areas are critical factors (Kaplowitz et al. 2008). Among them, two interesting results found in Calvert County, Maryland show that demand is high in low-density rural areas but not in the relatively high-density residential areas because of the opposition from existing residents afraid of imposing costs by extra-density, and adjacent to permanently preserved open space resulted in fewer lots built with TDRs because of the desire of higher-end housing with low density to enhance its value (Kaplowitz et al. 2008). Incentive and guarantee measures usually taken include TDR banks, joint existence of a PDR program, the background studies and institutional effects (Kaplowitz et al. 2008; Tavares 2003).

Research of TDR in our country is still limited, mainly includes TDR program design and practice description. TDR in our country is mainly originated from three kinds of externalities and government-dominated, extremely different from foreign land market. The externalities are separately caused by farmland protection policy, the segregated rural-urban land market and land use regulation (Deng 2010), leading the practices also involving the three aspects. Guangdong, Shanghai, Jiangsu and Zhejiang translated the collective built land to farmland and transferred the built quota to urban areas (Wang et al. 2011). There is limited research using TDR to analysis historic heritage protection and urban village reconstruction, and the ecology controlling is more limited. And the current research needs more details in TDR designation and the role of market. So this paper attempts to answer these questions: Why the Jingui Community is suitable to be the TDR sending area? Considering the local land market, which place has the possibility to be the receiving zone to carry out the TDR program with modest adjustment? What guarantee measures should be implemented by government in the future? How is the complicated relationship among different bodies involved in the TDR program?

56.3 The TDR Sending Area Analysis

Jingui Community is located in the southern part of Pingshan Street in Shenzhen (Fig. 56.1), covering an area of 13.852 km^2. The community consists of 7 residential groups, with the total registered population of 525, floating population of 128. Jingui Community with a history of 300 years was once abundant in oranges and even exported to Southeast Asia in the past. However, this agricultural pillar industry declined gradually. Because of its location in water-protected protection

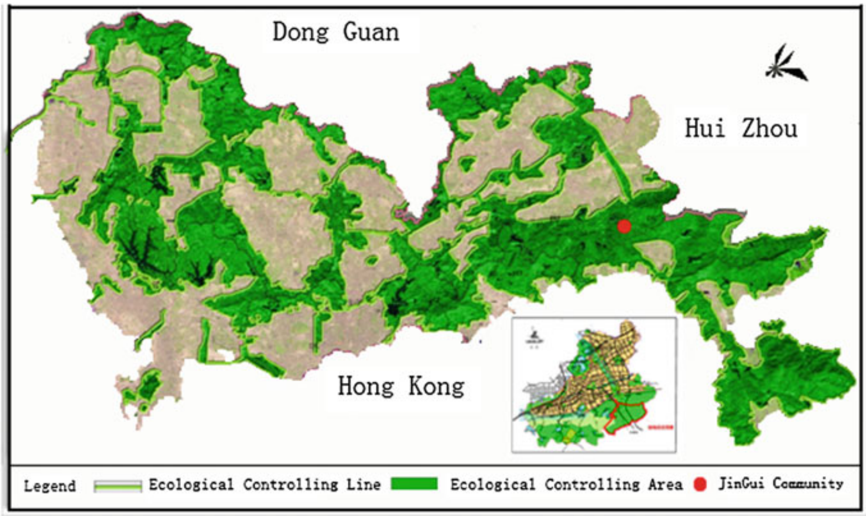

Fig. 56.1 The location of Jingui Community and the ecological controlling line (2005). *Source* http://www.szfdc.gov.cn/main/csgh/zxgh/stkzx/2.jpg

Table 56.1 Ecological regulations to Jingui Community

Year	Regulation policy
1991	Significant water source protection area; High voltage corridor (10 high-voltage line, 5 gas pipeline, covering almost half of the Community)
1998	Significant ecological forest protection area in Guangdong Province
2004	Significant ecological controlling area (Covering the whole Community)

and forest-controlled area, the community encountered restricted regulations since 90s (Table 56.1).

56.3.1 The Lease Loss

Being proximity to Hong Kong and receiving location for its labor-intensive industry transfer, Shenzhen met with great opportunity since 1980s and transformed from a small fishing village into a metropolitan city. In 2009, Shenzhen's GDP reached 820 billion yuan, ranking the fourth after Shanghai, Beijing and Guangzhou, and the floating population was 6.45 million, accounted for 72.4 % of the whole population.[1] In this economy and floating population boom, rural collective economy gained a great deal of rental profits by taking advantage of the abundant land resources, building collective and private housing illegally, offering low-price residential house for the large floating population and manufacturing housing for the joint-venture factories. By 2011, original rural collective construction land reached 393 km^2, covering 43 % of the total construction land in Shenzhen, and the amount of illegally self-built buildings above the collective land was 379,400, accounted for more than half of the total amount of the city's buildings.[2]

However, the original rural collective economic interests in ecological controlling area were greatly deprived by the ecological regulation. Since 2005, all the buildings have been under close surveillance, and every application for reconstruction or new construction is closely restricted. The manufactured buildings were shut down or relocated because the environmental sector's disapproval. At present, joint-stock company in Jingui Community rents manufacturing housing for 16 enterprises, including 8 offsite. The yearly income couldn't cover the yearly expenditure, and the net profit reaches-500,000 yuan. There are 10 households in the community depending on government allowance to maintain life, and share of bonus per resident is less than 2000 yuan, quite less compared to 10,000 yuan in

[1] Data is from the "Guangdong Statistical Yearbook 2010". http://www.gdstats.gov.cn/tjnj/ml_c.htm.

[2] Data is from "Shenzhen Planning land Supervison" http://www.szpls.gov.cn/ywpd/ghjh/201203/t20120308_71536.html.

other similar communities. For the protection of ecology, Jingui Community's economy lags more than 20 years behind.

56.3.2 Rights to Improve Infrastructure Deprived

In 2004, Shenzhen government required that all the rural areas in Shenzhen turn into urbanized communities. This policy implied that the lifestyle change of the original villagers and the new responsibility for original rural collective to afford the whole communities' social insurance and public expenditure. However, without enough financial support and severe regulation of development, it's hard to apply for newly-built housing or improve the local infrastructure. Rather than enjoy the welfare and convenience of urbanization, Jingui Community was involved in a series of problems such as water, residual, transportation and social issues.

Survey of community development demands shows, present main problems focus on employment (40 %), traffic inconvenience (20 %), and water and electricity difficulties (30 %).[3] The community residents still drink the original artesian water nowadays because being locating in high elevation, while the costs of supplying pipe water to the community will sum up to one million. Housing poverty is prevalent here. Among the whole community, there were more than 50 households without possession, majority living in 1980s-manufactured condemned buildings, and only 13 households refurnished housing before 2005. External transportation is quite inconvenient, since the arterial road at the foot of the mountain have not been extended to the community.

56.3.3 Ecological Compensation Inaccessible

The coverage of ecological land and original rural community is quite huge, which determines that government-led ecological compensation cannot satisfy the local needs for sustainable development. According to the administrative provisions of basic ecological control line in Shenzhen, the total area under ecological control is 974 km^2, occupying half the whole city area (Fig. 56.1), and more than 300 communities involved. Because of the huge financial pressure from Shenzhen government, many communities are absent in the first batch of ecological compensation list, and Jingui Community is among them. Under this background, the community started to transform idle factory buildings to wisdom valley in order to develop creative industry, whereas more financial support is inaccessible to solve the problem of water and power shortage, transportation inconvenience etc.

[3]The survey was carried by the Institute of Urban Planning Design & Research, Shenzhen University in 2011.

Table 56.2 Comparison of ecological preservation experiences in England and USA

Country	Value	Origin	Measures	Outcome
England	Fairness	1942 Uthwatt report	Compensation, mainly PDR	Market silence, black economy active
		1947 Town and Country planning act		
USA	Efficiency	1968 landmark preservation law	Joint existence of TDR & PDR	Developed areas more compact

Considering experiences abroad (Table 56.2), the ecological compensation, which is similar to purchase of development rights (PDR) impose substantial fiscal burdens on local and state governments that limit their ability to act in a timely fashion to protect local areas, whereas compared to PDR market-driven TDR can avoid the fiscal constraints and attract new participants. In England, the land management is fairness-oriented, which determines the land development right belongs to the state. In reality, the policy is the government will pay the individual compensation if the land use plan change leads to the private land value reduce. This policy not only slows down urban expansion of ecology lands, but also the development market, thus leading to active black economy. In USA, the land management is efficiency-oriented, so developers buy density permits from ecological controlling areas both through government and TDR banks, which makes the developed areas more compact.

56.4 The TDR Receiving Area Analysis

Despite the fact that available land is quite limited, construction demand is still increasing. In order to satisfy the requirements of growth, intensive land use is highly promoted by Shenzhen's government. Large potential of land locates in the original rural collective land could be the receiving area of TDR because of currently low-efficient use. According to floor area ratio guidance for the regulatory detailed plan regulation, the FAR bonus which already exists can be carried out to break through FAR limits as an incentive measure for TDR.

56.4.1 Great Demand for Construction

Like other city of China, Shenzhen' past economic development relies on land expansion in return of the GDP growth. From 1996 to 2005, the built land has doubled during these 10 years of development (Fig. 56.2). By 2011, construction land has reached 934 km^2 with only 42 km^2 of land left, which means even if keeping the development speed of just 10 km^2 per year, five years later they will be no land available.

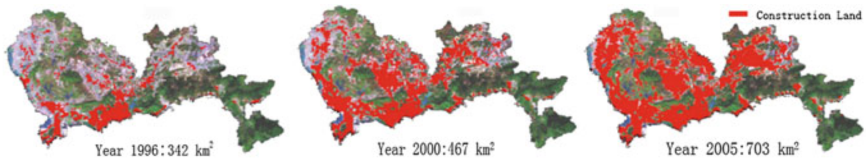

Fig. 56.2 Rapid expansion of construction land in Shenzhen. *Source* Xuyuan, Qinyuan (2008). The innovative road on the constrained condition of space resources in short supply: practice and exploration of the basic ecological control line in Shenzhen. Annual national planning conference

This rapid expansion of construction land reflects the tremendous market demand in Shenzhen currently, which also lay great emphasis on promoting intensive land use, thus offering an extraordinary opportunity to increase density of existing low-efficient-built land.

56.4.2 Floor Area Ratio Regulation

Zoning is proved to be a decisive factor for a successful TDR. In Shenzhen, "floor area ratio guidance for the regulatory detailed plan regulation" is formulated with a clear clarification of the FAR regulation (Table 56.3). For the commercial and residual lands, they are classified into six zones, and each zone represents the different base FAR value. And the maximum FAR is calculated by base FAR and the correction coefficient related to the land scale and transportation condition. For the manufacturing and warehouse land, the minimum FAR is regulated by other criterions. And the maximum FAR is exact figures distinguished by the land location (Fig. 56.3), which means when the land is located in a Hi-tech industry park or a logistic park, the FAR is a little higher than the general industrial land or warehouse land.

Table 56.3 FAR Regulation of Land in Shenzhen

Base FAR for R, C land						
Land use	I	II	III	IV	V	VI
Residual	–	1.2	1.8	2.2	2.6	3.2
Commercial	–	1.8	2.4	3.2	4.2	5.4
Maximum FAR for M, W, R, C land						
Manufacturing	Industrial park	Hi-tech industry	4.0	Warehouse	Logistics park	4.0
		Others	3.0		General	3.0
	Scattered	General	4.0	Residual	$FAR_{base} \times (1 + A_1) \times (1 + A_2)\ldots$[a]	
		Commercial intensive	4.5	Commercial		

[a]A_i represents coefficient for correction

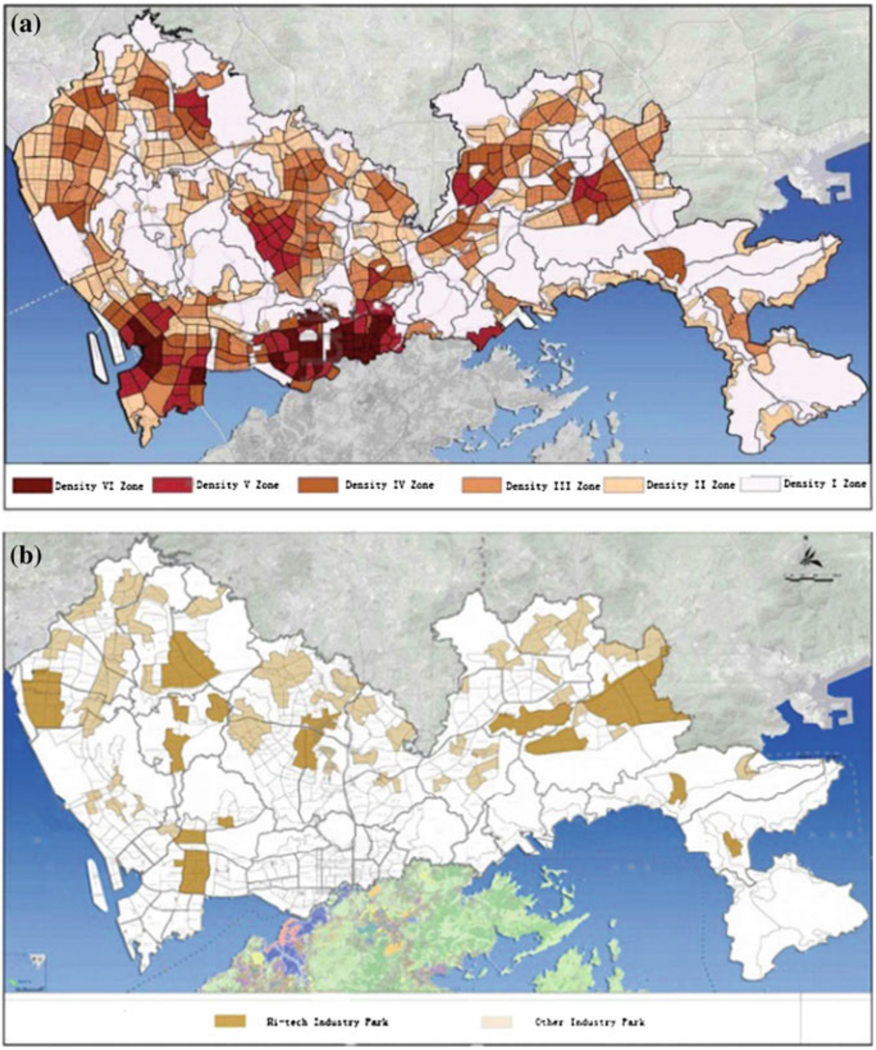

Fig. 56.3 **a** FAR baseline zoning for commercial and residential land. **b** Industry Park location in Shenzhen. *Source* Floor area ratio guidance for the regulatory detailed plan regulation, http://wenku.baidu.com/link?url=xntJzLISv2YHcdUieGrpYNYAadGaTsK3paaoJcWGcNncmvkB41SGq9ltUETnHtXPIDhnYLmRqYYa6UUClPdvsRyxrrLPb_jntz95XCbg8NO

56.4.3 FAR Bonus in Shenzhen

In USA, it's always the density bonus that takes the role of incentive measures, while recently new forms of bonus begin to emerge, such as rights to exceed baseline of floor area and baseline of lot coverage, granted exemptions from planning requirements of setback or parking, and pace of development priority (Pruetz and Pruetz 2007).

In Shenzhen, the FAR bonus is suitable for TDR since it has already been carried out in the city renewal project. The object of urban renewal is to regenerate the land of urban villages which are mostly disputed, inefficiently used, disorderly constructed with illegal unclear-property-right buildings. The "historical left-behind problem" is a huge burden for the government to solve alone, so Shenzhen government attracts the developers by introducing FAR bonus. If the developer, join the complicated renewal project, they will receive extra FAR bonus to exceed the maximum limits. Considering the FAR bonus policy speeds up the pace of renewal project, the government should also implement this policy to the ecology controlling project. What should be paid attention for is that there still lacks detailed instruction for the accurate number of FAR bonus for each project, which leaves much space for rent-seeking behavior.

56.5 Guarantee Measures in the Future

56.5.1 Establishment TDR Banks

Foreign experience proves that, only depending on the power of government is hard to establish long-term, dynamic, effective transfer mechanism, but the establishment of TDR banks can solve the bottleneck, letting the receiving area to accept bonus in time. Shenzhen's prosperous financial market provides the feasibility of building up the TDR banks, because of thirty years of market-oriented operation experience, the financial industry as the pillar industry and the location adjacent to financial center of HK.

Besides, the central government's policies give Shenzhen more authority of innovation. In 2012, "Shenzhen land management system reform of integrated pilot" started, raising the requirements of land financial tools innovation. In 2014, Shenzhen government puts up the aim of deepening financial reform. All of this provides the opportunity to build TDR banks.

56.5.2 Background Studies by Consulting Institutions

A nationwide self-administered mail survey of planning professionals about the empirical evaluation of 52 TDR programs in the United States, showed that preliminary background studies is crucial. Comprehensive preliminary studies may figure out the transfer ratio by estimating the demand of development scale or density to exceed limits of current development, and the amount of money willing to pay for each additional dwelling unit or extra square foot of floor area. Besides, the background studies also will determines the size, location and characteristics of optimum sending and receiving areas.

Background studies provide additional information to market participants, lower transactions costs to developers, thereby potentially increasing the private market demand for TDR (Courtenay 2008). So in the future, it will be helpful for the TDR success if the government or relevant consulting companies can carry out background studies.

56.5.3 Multi-parties Involved in Negotiation

For the TDR program, subjects participated in should include residents from the sending area, land developers, residents from the receiving area, TDR banks, government, plus consulting company (Fig. 56.4). There may be a lot of fierce controversies among the multi-parties. Taking the FAR bonus as an example, there will be various voices. The developers may appreciate higher intensity for more profits, the local residents' in receiving area may take high FAR as a threat to their living environment and transportation, the government may regulate the FAR by previous planning of its intensity limits, and the consulting company may make its evaluation of whether the market demand can digest the supply. By this complicated negotiation, they can calculate the optimum amount of FAR bonus for all else involved, and the TDR banks finally decide how much TDR to sell.

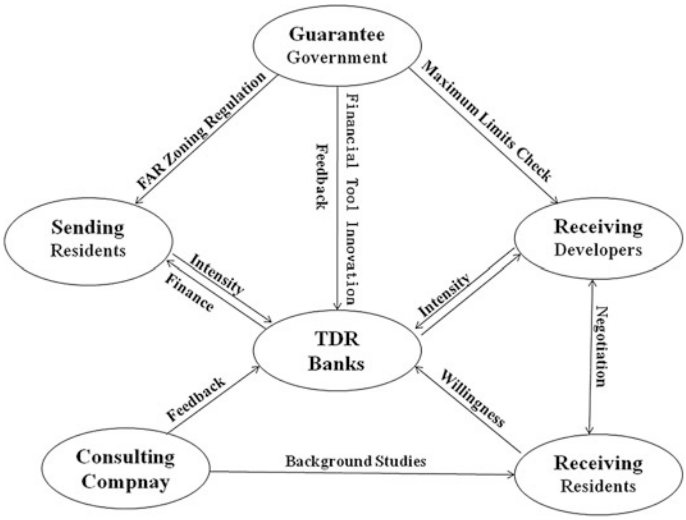

Fig. 56.4 Multi-parties involved in TDR

56.6 Main Conclusions

The success of a TDR program consists of ecological regulation, demand for TDR in receiving area, and guarantee measures. Based on the demanding and supplying analysis of Jingui Community, the TDR program for ecological controlling area seems quite feasible.

Firstly, because of rigid ecological controlling policy, Jingui Community was deprived of rental income and rights to improve infrastructure without accessible compensation, which is a huge welfare loss in Shenzhen's rapid urbanization background, making it a suitable place to send TDR.

Secondly, lack of construction land reflects the huge demand in Shenzhen land market. The floor area ratio regulation stimulates the developers buying TDR because of maximum FAR limits. And the FAR bonus which is already carried out in urban renewal projects also makes the local land attractive to the developers.

Thirdly, the government should play a role of offering guarantee measures of building TDR banks and cultivating consulting companies. With more parties involved in the negotiation, there will reach an agreement that will satisfy all the sides and realize fairness.

The case of Jingui Community is embedded in Shenzhen's highly urbanized context, the construction land shortage and intensive use of land with incentive measures offers the necessity and possibility of TDR.

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Chapter 57
Study on the Spatial Differentiation and Temporal Evolution of Urban Land Price: Evidence from Beijing

Lin Gan and Chang-chun Feng

Abstract Land is the carrier of all urban activities. Land price can sensitively reflect the supply-demand relationship in urban land market, as well as the spatial distribution of urban land-use activities. Using a data-set of 296 residential land transaction records from 2003 to 2013 within the 6th ring road in Beijing, this paper studied the spatial distribution and temporal evolution trend of land price with GIS geostatistical analysis tools, including Exploratory Spatial Data Analysis (ESDA), Ordinary Kriging interpolation and Digital Land Price Model in cross-sectional view, and arrived at the following conclusions: (1) the overall distribution of Beijing residential land price showed an obvious concentric pattern, with a decreasing trend from the north to the south; (2) high-priced districts reflected the influence of sub-centers, i.e. a new polycentric structure was replacing the traditional concentric structure; (3) from 2003 to 2013, Beijing residential land price interpolation map had expanded contour circles and transferred peak zone, which means land price in the whole city had been rising while the northwest part rose most strongly, reflecting the main direction of urban sprawl and land development.

Keywords Land price · Spatial differentiation · Temporal evolution · GIS geostatistical analysis

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57.1 Introduction

Land is the carrier of all urban activities. Land prices can sensitively reflect the supply-demand relationship in the urban land market, as well as the spatial distribution of urban land-use activities. According to Bid Rent Theory (Alonso 1964), the essence of land price is capitalized land rent, which can be understood as a function of location. In spatial dimension, land price variation shows natural, economic and social values of different locations; while in time dimension, changes of land price spatial pattern reflect changes in the location value of different spots in a city. During the process of rapid urbanization, analyzing land price under the view of temporal-spatial variation offers a new perspective to understand questions about urban sprawl, urbanization, and urban spatial structure.

With the development of GIS theory and technology, its powerful spatial analysis and data visualization functions are widely used to analyze the spatial characteristics of land price (Song 2010). Some researchers used GIS to measure distance and collect spatial data, as the preparation for econometric modelling, such as Du and Lu (2004), who studied the relation between land price and location factors in Nanjing with a combined method of GIS and multivariate regression. Some researchers used GIS Exploratory Spatial Data Analysis (ESDA) to simulate the spatial distribution of land space, such as Tang et al. (2004), Deng (2003), and Ren et al. (2011). And some researchers used GIS spatial interpolation function to generate land price contours map (Asar et al. 1994; Gamez et al. 2000; Guo et al. 2008; Zhang et al. 2009), or land price change vector map (Jiang et al. 2005; Zheng et al. 2008), visualizing land price spatial distribution and changing trend. Compared with traditional mathematical analysis and qualitative analysis, land price studies based on GIS technology have an intuitive and visual advantage. However, it requires quite large data-set to meet the accuracy of spatial analysis. As land price data had not been open to the public until the 2000s, and data collecting costs much efforts, studies in this field mainly focused on technique and method exploration, lacking reliable empirical analysis cases on land price temporal-spatial differentiation.

This paper looked into the residential land price in Beijing, firstly, a spatial dataset of Beijing residential land transaction records from 2003 to 2013 was built, then, using GIS Exploratory Spatial Data Analysis (ESDA) and GIS Kriging geostatistics techniques, spatial interpolation maps and cross-sectional maps of land price were obtained, through which this paper analyzed the spatial distribution and evolutional trend of residential land price within the 6th ring road in Beijing during the last decade.

57.2 Data

57.2.1 Data Collecting

Land price data were collected from the website of Beijing Land Reserve Center,[1] consisting of 1602 records of land bidding, auction and listing transactions, among which 566 residential parcels are selected as research data-set. Table 57.1 shows the number of land transactions in each years. The average amount of residential land transactions is approximately 50 cases and 5,000,000 m^2 per year, almost reaching 50 % of the total.

57.2.2 Study Area

As Beijing is a typical central concentrated city, most of land-using activities concentrate within the 6th ring road (Ma 2009; Ou 2007). Among all the 566 residential parcels transacted during 2003–2013, 296 were located within the 6th ring road. So in this paper, the study area was set within the 6th ring road in Beijing.

The 296 residential parcels were geocoded by matching their location information with Google Map Coordinates, which can be imported into ARCGIS 9.3. Figure 57.1 illustrates the spatial distribution of all the transacted residential parcels within the 6th ring road from 2003 to 2013 (n = 296).

Table 57.1 The amount and area of land transaction from 2003 to 2013 in Beijing

Year	Total transaction amount	Residential transaction amount	Total area of other land (ha)	Total area of residential land (ha)
2003	28	17	20.3574	134.2999
2004	60	35	101.871006	353.15554
2005	48	31	75.6653776	278.29353
2006	86	58	91.1180517	708.32116
2007	85	55	119.7121098	778.20994
2008	148	53	612.5000584	857.41072
2009	243	72	1036.970409	910.3211
2010	278	78	1818.963317	1187.9527
2011	249	57	1338.539475	626.95403
2012	163	37	893.5336137	434.52485
2013	214	73	872.29193	1210.103

[1] http://www.bjtd.com/tabid/3063/Default.aspx?year=2003-2013.

Fig. 57.1 Spatial distribution of residential parcels within the 6th ring road in Beijing (2003–2013)

57.2.3 Data Processing

The time span of this data-set is from 2003/1/1 to 2013/12/31. During this period, China's national economy and real estate market have experienced rapid growth. For the sake of comparability over years, time correction for transaction price of different years is required.

The average residential land price index of Beijing from 2003 to 2013 is applied here for correction (Zhang 1996). According to statistics, the average residential land price index of Beijing in each year from 2003 to 2013 is 108, 124, 155, 195, 254, 289, 301, 373, 376, 379, 385, taking 2001 as base time (i.e. the index on 2001 equals 100). Time correction is realized by the following formula:

$$\text{Corrected price}(t) = \text{original price}(t) * (I_{2013}/I_t)$$

where I stands for the average residential land price index of Beijing and t = 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012.

Before time correction, the correlation coefficient between land price and transaction time was 0.07, after time correction, this number reduced to 2×10^{-6}. This processing is aimed at offsetting the time trend of land price, eliminating false spatial heterogeneity caused by different distribution of land transaction samples from different year, so that corrected-price shows the spatial variation pattern in a fixed cross-section of time.

57.3 Method

The core methodology of this paper is based on geostatistical analysis. Since born in 1960s, geostatistics offered a set of estimation methods to obtain continuous data surface across space according to discrete sample points (Hou 1993). Main analysis methods used in this paper are as follows:

57.3.1 Exploratory Spatial Data Analysis (ESDA)

GIS Exploratory Spatial Data Analysis (ESDA) was applied to detect the existence of distribution trend, spatial autocorrelation, and anisotropy.

The results of Moran Test (Moran's I = 0.5144, Z Score = 37.39) showed that land price samples are positively autocorrelated over space at a confidence level of 99 %, and the results of normality test implied that logarithmically transformed land price well followed a normal distribution, which meant the data structure could meet the two preconditions of Kriging interpolation.

Trend analysis showed inverted U-shaped trends in each direction, meaning that land price decreased from center to edge at the rate of second-order function of distance. And anisotropy was proved to be significant, for autocorrelation varied with direction. Thus second-order spatial function was selected to offset spatial trend, and variogram with anisotropy was selected to fulfill spatial interpolation (Fig. 57.2).

57.3.2 Ordinary Kriging Interpolation

Ordinary Kriging interpolation was applied to generate continuous land price surface. Kriging interpolation could estimate the land price at any point x_0 with the following formula:

$$z(x_0) = \sum_{i=1}^{n} \lambda_i z(x_i)$$

where $z(x_0)$ is land price at point x_0, λ_i is the weights of land prices at point x_i (i = 1, 2, …, n), standing for the effects of $z(x_i)$ on $z(x_0)$ and determined by variogram (Tang et al. 2006).

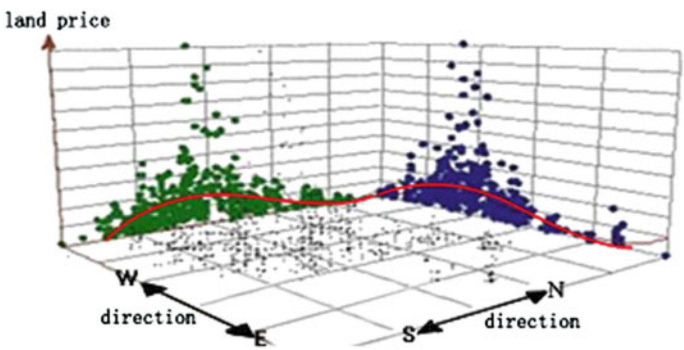

Fig. 57.2 Trend analysis results of residential land price data

In this paper, prediction errors of all interpolation results were below 2.5, able to reflect the distribution pattern with accuracy (Tang et al. 2006).

57.3.3 *Digital Land Price Model (DLPM)*

Digital Land Price Model (DLPM) was built to analyze land price distribution characteristics in 3D view. Digital Land Price Model is a 3D model of urban land price which uses land price as Z-score, location coordinate of land parcel as X-score and Y-score.

In this paper, 3D Analysis Tool in ARCGIS9.3 was used to visualize residential land price distribution in cross-sectional view along 8 main directions, in order to reveal spatial characteristics of land price distribution, as well as identify local high-priced areas, local low-priced areas, and land price highly-risen areas. Table 57.2 shows basic information of 8 section lines, each stretching in one direction and combined with one of the main traffic lines of Beijing.

57.4 Results of Interpolation Analysis

57.4.1 *Land Price Distribution Pattern Over Space*

According to the prediction map achieved through ordinary Kriging interpolation (Fig. 57.3), the spatial distribution pattern of land price during 2003–2013 can be summed up as follows:

1. Land prices differ significantly across space, showing obvious concentric ring structure. The peak of land prices is around the north part of the second ring road, where land price reaches more than ¥30,000/m^2. While around the 6th ring road the land price decreases to ¥3000/m^2, reducing ¥1000 yuan/m^2 in every 1 km on average. Significant spatial differentiation can be seen from the map, with price circles from center to edge, reflecting continuous decaying trends of land price.

Table 57.2 Information of the section lines

No.	Direction	Line	Starting and terminal point
Line 1	North	Extension of city's central axis	Tiananmen—the 6th ring road
Line 2	South	Extension of city's central axis	Tiananmen—the 6th ring road
Line 3	East	Extension of chang'an Street	Tiananmen—the 6th ring road
Line 4	West	Extension of chang'an Street	Tiananmen—the 6th ring road
Line 5	Northeast	Extension of highway G45	Tiananmen—the 6th ring road
Line 6	Southwest	Extension of highway G4	Tiananmen—the 6th ring road
Line 7	Northwest	Extension of highway G6	Tiananmen—the 6th ring road
Line 8	Southeast	Extension of highway G2	Tiananmen—the 6th ring road

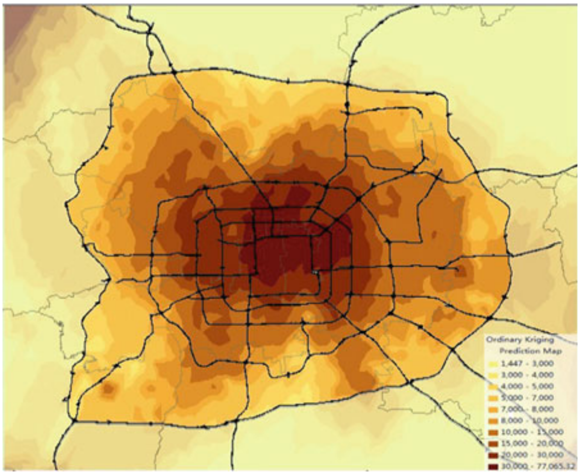

Fig. 57.3 Kriging interpolation map of residential land prices (2003–2013)

2. There is a significant unbalance between the north and the south. Most concentric price circles share a common shape which expands in the north direction and shrinks in the south direction, suggesting the northern part of city has higher land price than the southern part. This can be explained by the unbalanced socio-economic situation of Beijing. The northern part of city has superior natural and cultural environment, attracting more land development capital flows. While the southern part is low-lying, downwind, with large areas of shabby blocks and poor facilities. Although in recent years, government tried to improve the development of the southern city, the path-dependent effect makes it a slow process, at least for now, unbalance between the north and the south remains significant in residential land price.
3. There is a slight difference in four sectors of different directions. Dividing the interpolation surface into four sectors with four lines towards east, west, south, and north, the average level of land price in each sector follows the order of "Northwest > Northeast > Southwest > Southeast". That might because there are more universities, gardens and commercial centers in the north, especially in the northwest sector (Zhou et al. 2012).
4. Decaying rate slowed down from the center to the edge. According to the density of contour line, decaying of land price near city center is faster than that in further areas. This trend suggests that residential land price reacts to spatial factors more sensitively in the downtown area than in the suburban area.

57.4.2 Land Price Changing Trend Across Periods

Land price differentiation is formed during a certain time span, to analyze the changing trend of land price spatial structure, it is necessary to compare the land price spatial pattern in different periods (Guo 2007). However, the amount of land transactions in some years are quite small, which makes annual comparison unreliable. Instead, comparison of different phases seems reasonable.

According to the amounts of land transaction during 2003–2013 (Table 57.1), three phases can be distinguished:

Phase I (2003–2005) is the growing period when residential land transactions increased steadily in number during the Market-oriented Reform of the land lease around 2004;
Phase II (2006–2009) is the stable period when residential land transactions number remained high during the continuous booming of Beijing's Real estate market;
Phase III (2010–2013) is the fluctuating period when a series of real estate regulatory policies came into force, leading to significant fluctuation of residential land market.

Comparing the Kriging interpolation results of these three phases (Fig. 57.4a–c), main trend of land price spatial evolution over the last decade can be summed up in two aspects:

1. Land price has been rising in the whole area within the 6th ring road, which is proved by the expanding contours. And this expansion has a change in direction, for example, Phase II has east-west expanded contours compared with Phase I, while in Phase III the price contours particularly expand to the northwest, suggesting different direction of urban sprawl in each phase.
2. Land price peak has moved towards northwest. By observing the ¥20,000/m^2 contour in Phase III, it can be seen that the range of high-priced zone moved from the center to the northwest near suburbs. Also, a new polycentric structure is replacing the traditional concentric structure. That is likely to be caused by the attraction of new-rising commercial centers in the northwest, such as Zhongguancun and the Olympic Center, which balance the attraction of the traditional city center.

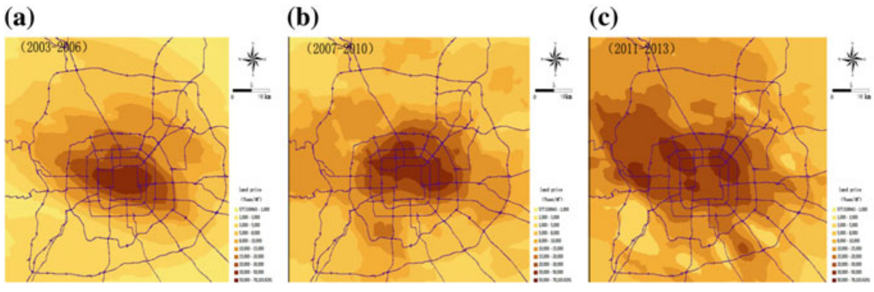

Fig. 57.4 Kriging interpolation map of residential land prices **a** 2003–2005, **b** 2006–2009, **c** 2010–2013

57.5 Results of Cross-Sectional Analysis

Base on interpolation results of 2003–2005, 2006–2009, 2010–2013, and 2003–2013, digital land price models are built with ARCGIS9.3. According to the 8 section lines selected above (Table 57.1), the cross-sectional land price decaying modes in 8 main directions can be drawn in line charts (Fig. 57.5)

In the cross-section view, several characteristics of land price decaying mode can be concluded:

Firstly, the average decaying rate within the 6th ring road is about ¥1900/m^2/km. In all the 8 directions, the level of land price falls faster near the center and slower in the outer rings. On the whole, the decaying rate follow the order of "West > Southeast > South > East > Northeast > North > Northwest > Southwest". Negative decaying rates occur in North 4th to 5th ring road, Northwest 3rd to 4th ring road, and Southwest 3rd to 4th ring road, etc., reflecting that in these areas the attraction of sub-centers outweighs the effect of the city center (Table 57.3).

Secondly, some places have relatively high land price compared to the area around (Fig. 57.6). On the whole, high-priced areas can be classified into 4 kinds: (1) regional commercial centers, such as Xidan—Financial Street, CBD, Gongzhufen—Wukesong, Zhongguancun—Chengfu Road, Dongzhimen—Sanlitun, etc.; (2) development zones, new towns and satellite towns, like Yizhuang Development Zone, Daxing New Town, and Liangxiang Development Zone; (3) large residential community, such as Tiantongyuan, Wangjing, Huilongguan and so on; (4) around traffic lines and hubs, such as area around airport and area along subway line 1. More than half of the high-priced areas are located in the northern part of city, some even merging into high-priced belt, such as the north 4th ring road. On the contrary, high-priced areas in southern part of city are mainly development zones, new towns and satellite towns, often dispersed and independent from each other.

Thirdly, compared with high-priced areas, low-priced areas are less. The most notable low land price occurs in the southwest, between the 2nd ring road and the 3rd ring road, which belong to Fengtai District.

Fourthly, in some places the land price has risen obviously during three phases, which indicate the hotspots of land-use and urban development (Jiang 2007). For example, the rise of sub-centers in near suburbs, old city reconstruction within the 2nd ring road, major projects such as Beijing South Railway Station and the Olympic Center, recently-built subways, and recently-approved development zones.

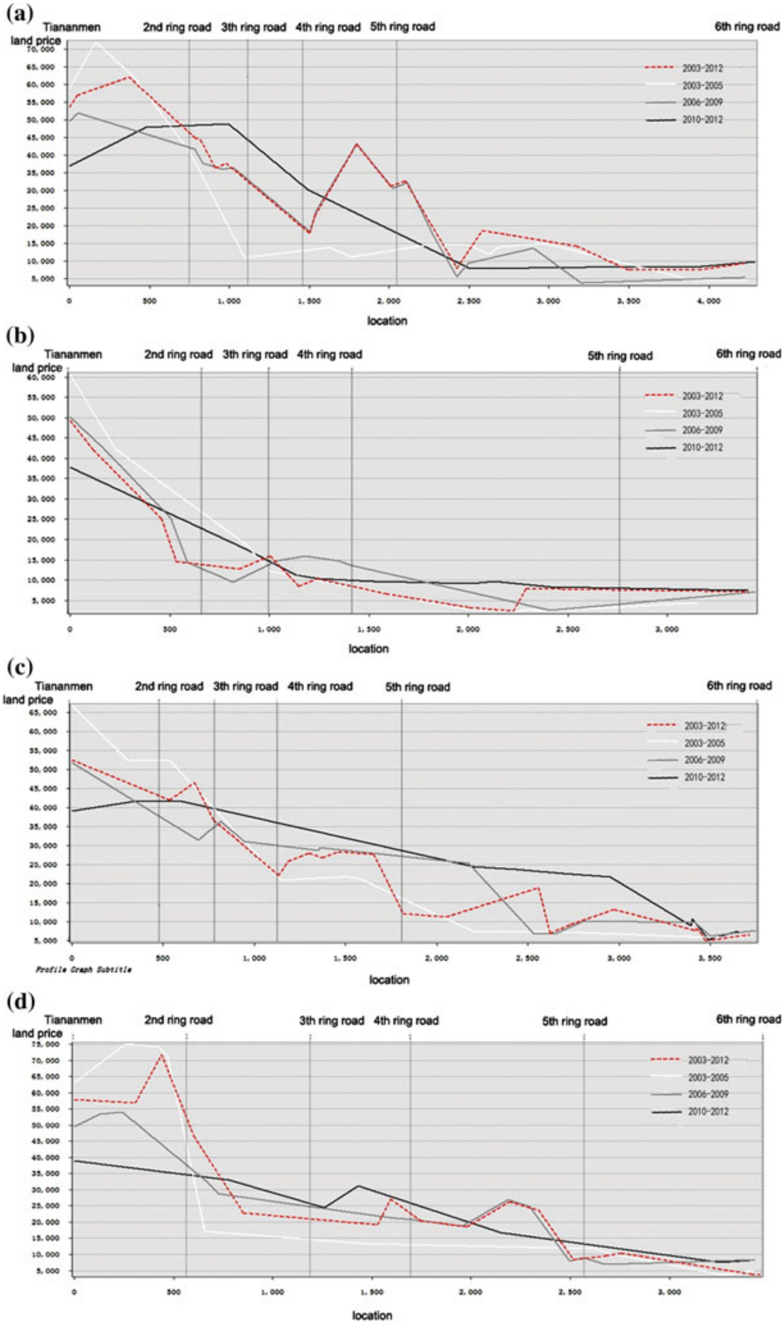

Fig. 57.5 Residential land price changes in cross-sectional view along the main direction. **a** Line 1: North extension of city's central axis. **b** Line 2: South extension of city's central axis. **c** Line 3: East extension of Chang's street. **d** Line 4: West extension of Chang's street. **e** Line 5: Northeast extension of highway G45. **f** Line 7: Northwest extension of highway G6. **g** Line 8: Southeast extension of highway G2. **h** Line 6: Southwest extension of highway G4

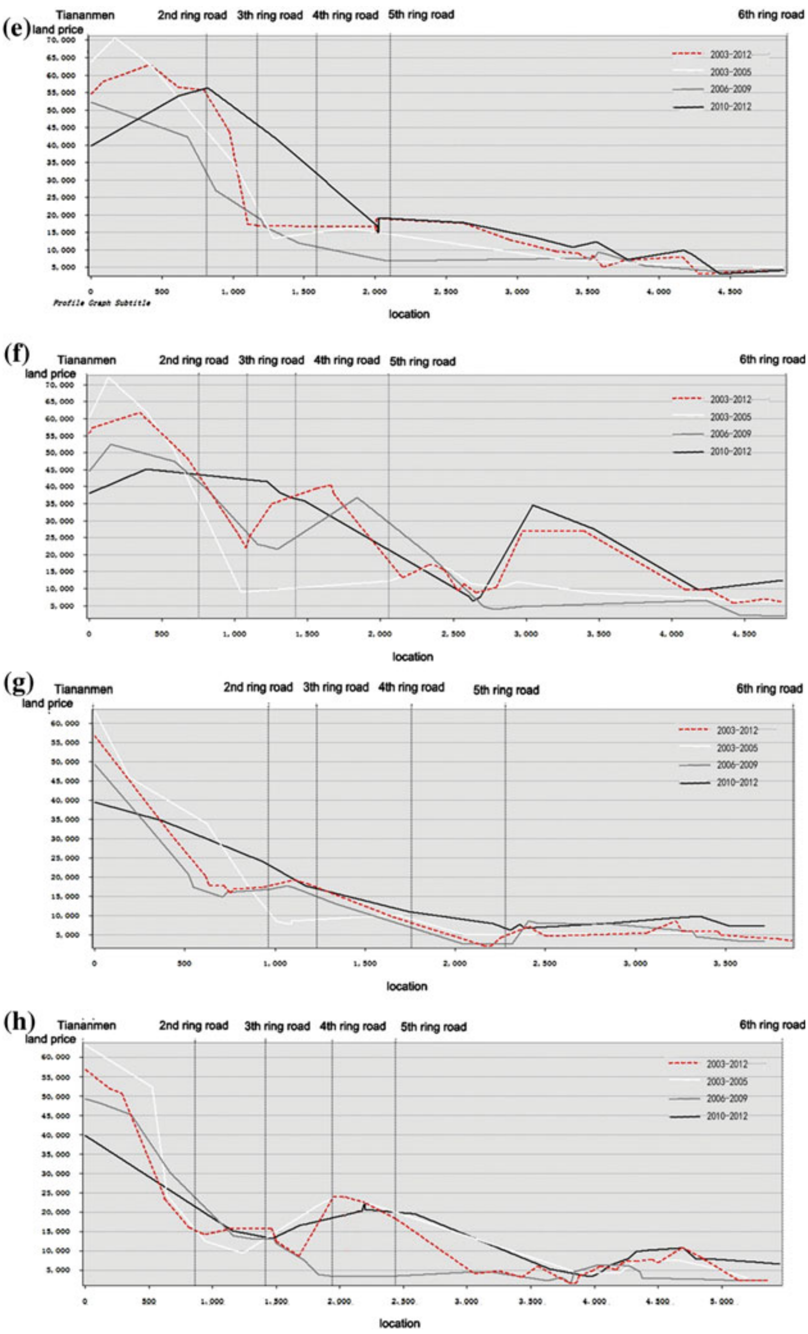

Fig. 57.5 (continued)

Table 57.3 Decaying rate in each direction along section lines (yuan/km)

Section line	Within the 2nd ring road	The 2nd to 3th ring road	The 3rd to 4th ring road	The 4th to 5th ring road	The 5th to 6th ring road	Average
North	1956.522	6136.364	5681.818	−2702.7	1307.19	1607.143
South	10,000	−588.235	2777.778	64.10256	108.6957	2283.654
East	3676.471	3095.238	5400	2127.66	464.2857	1835.206
West	1470.588	7073.171	−500	2547.17	1034.483	2407.407
Northeast	−100	16,521.74	192.3077	−645.161	833.3333	1677.852
Southwest	2000	9782.609	−6521.74	4651.163	683.0601	1552.795
Northwest	6818.182	0	3225.806	757.5758	219.7802	2300.885
Southeast	7547.17	−13.8889	−2632.35	1875	837.8378	1544.118
Average	4171.117	5250.875	952.9523	1084.351	686.0831	1901.133

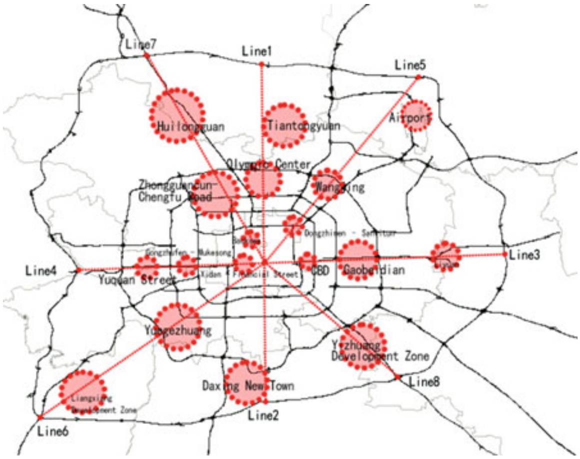

Fig. 57.6 High-priced area within the 6th ring road in Beijing (2003–2013)

57.6 Conclusions

This paper used GIS as analysis tool, with geostatistical analysis methods, realizing the visualization of residential land price differentiation within the 6th ring road in Beijing. Kringing interpolation surface map and digital land price model in cross-sectional view showed the distribution pattern over space and changing trend across periods. In the end, the paper arrived at the following conclusions.

As to Land price distribution pattern over space, residential land price in Beijing shows obvious concentric pattern, with a decreasing trend from the north to the south. Among four sectors of different directions, land price follows the order of "Northwest > Northeast > Southwest > Southeast". And decaying rate slowed down from the center to the edge.

As to land price changing trend across periods, from 2003 to 2013, land price has been rising in the whole area within the 6th ring road, particularly in the northwest part, leading to a transferred price peak from the center to the northwest near suburbs. A new polycentric structure is replacing the traditional concentric structure, and in some places, the attraction of sub-centers even outweighs the effect of the city center.

The results of this paper also proved that geostatistical analysis could offer effective methodology for land price spatial analysis. Compared with traditional statistical methods, its visualization effect turns out to be a most significant advantage. As GIS technology develops further in the future, visual methodology will gain lager prospects in land price analysis field.

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Part VI
Management for Large Infrastructure Projects

Chapter 58
Customer Investment Strategies Developed with the Benefit of Hindsight: Pre-contract Award Performance and Critical Success Factors for New Development Projects

John Douglas Thomson

Abstract Before a contract is awarded, a customer's new project conceptualization and design require investment in resources so that the project can be properly developed. Suppliers over this period also require the time and costs for their investment in tendering for the project. This research investigates these investments and establishes new insights into how a customer's past project investment data could be used to improve resource allocation investment in future projects. Based on a sample of eleven Australian defense projects, new insights into a customer's pre-contract award investments are provided as well as how this information could be used for estimating and allocating investments for future projects. There has been virtually no empirical research of this phenomenon which has the potential to improve project delivery outcomes for both customer and supplier.

Keywords Innovation · Project management · Customer · Supplier · Transaction costs · Critical success factors

58.1 Introduction

Successful projects are dependent upon the customer making the right decisions through project development, tender processes, contract award, delivery and completion (BIS 2010). Pre-contract award, customers find managing these processes complex and uncertain involving the coordination of many industries, entities, tasks and stakeholders with differing priorities and objectives (Forschner

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2006). There is potential for moral hazard problems (Dembe and Boden 2000) which many customers try to limit through highly specifying contracts, close control and distrust (Kadefors et al. 2004). Post contract award, incomplete project contract arrangements require that when a customer chooses to change requirements or when errors or omissions in the specifications are found, the supplier has the right to carry out the additional work based on supplier costs not subject to competition (BIS 2010). Such specification defects and customer changes cause extra costs for the customer and moral hazard opportunities for a supplier to improve profits for little or no risk (Kadefors et al. 2004). This creates relationship difficulties because the customer fears the supplier will scrutinize the contract for errors and ambiguities that may lead to claims, exploit its monopolistic position by excessive pricing of the extra work, or save money by skimping on quality—a customer is very dependent upon the good will of the supplier both to deliver good workmanship and to handle unforeseen circumstances in a cooperative way—the scope for emotions and social tensions to influence relationships is considerable (Kadefors et al. 2004).

58.2 Purpose

This research examines a customer's pre-contract award project investments with a view to using past resource investments as the basis for estimating and allocating future pre-contract award project delivery resource investment and improving governance structures.

58.3 Information Governance and Organizational Processes

The role of information governance is important in understanding organizational processes because information is never complete, either because it is not available or because of its abundance which inhibits grasping the entire complexity of a given situation (Lindstadt 2001). As a result, customers are always faced with making decisions in uncertainty, and information is often distributed unequally. Some customers are better informed than others and are capable of turning this information into favorable outcomes for themselves. However, the problem of incomplete information is particularly pronounced in procurements such as construction contracting (Milgrom and Roberts 1992, Chap. 5).

In an effort to reduce such uncertainties and complexities, a customer may choose transaction cost economics as a means to assist in assessing project delivery performance. Dahlman (1979) defined transaction costs as search and information costs, bargaining and decision costs, policing and enforcement costs. Transaction cost economics holds that all complex contracts are unavoidably incomplete (Williamson 1991a, b, 2000, 2002). An incomplete contract can cause costly inefficiency. Transaction costs associated with project delivery may be able to help customers identify costly inefficiencies and assist in the development of governance structures which have superior adaptive properties which will yield efficiency gains (Williamson 1991a, b, 2000, 2002). Williamson (1991a, b, 2000, 2002) argues that transactions align with governance structures differing in their cost and competence in an economizing and efficient way. For these reasons, the unit of analysis for this research is the transaction, where economy of transaction will be measured over the pre-contract award period. This is the period over which the customer designs and develops its project delivery model for which large numbers of suppliers register and are transformed into smaller numbers of suppliers during the tender process. One supplier is awarded the project contract. Williamson (1991a, b, 2000, 2002) maintains that efficient project delivery governance will arise mainly from economizing on the transaction costs of these processes.

Chan and Chan (2004) concluded in their review of journals on project success that time, cost and quality were the three basic and most important critical success factors in construction projects. Aspects of the early consideration of critical success factors are sometimes overlooked by those who view the marketplace in a theory of choice way i.e. the meeting of rational 'faceless' customers and ubiquitous sellers in a commodity marketplace for instantaneous exchange gains (Williamson 1991a, b, 2000, 2002). Even those who are inclined towards a transaction cost economics and theory of contract approach may not take into account some of these considerations. Project delivery is in the interests of the customer organization, or there would be no project in the first place. Suppliers respond to customer demand, unless a supplier can orchestrate marketplace demand to its goods and forecasts (Galbraith 1967). A measure of the transaction costs associated with a customer's 'search and information costs, bargaining and decision costs, policing and enforcement costs (Dahlman 1979) may provide the means to examine the 'three basic and most important critical success factors'.

58.4 A Customer's Vision and Strategy Deepen into Capability Concepts

It is in the pre-contract award phases of procurement that a customer's vision and strategy are deepened into capability concepts. These are in turn further developed, requirements determined, specifications decided, 'make or buy' decisions made, tenders called and contracts let. The importance of transaction economy over these phases is that of increasing the alignment between customer and supplier, improving future adaptive properties and flow of information, while reducing self interest and uncertainty gains (Williamson 1991a, b, 2000, 2002). During a customer's project concept and development phases there is high risk cost but also high

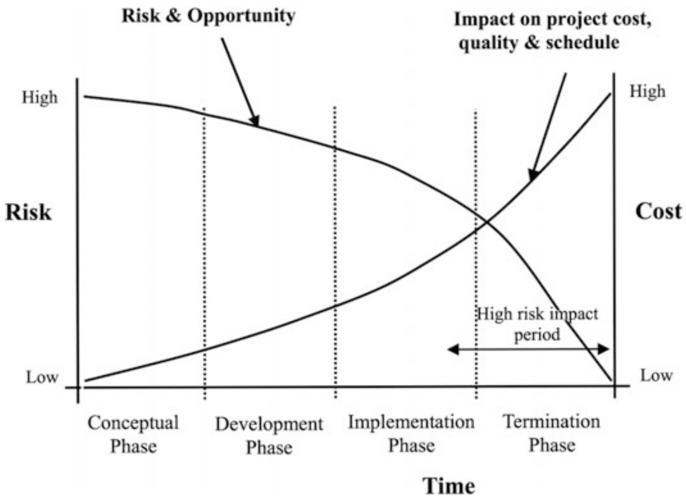

Fig. 58.1 Customer's ability to influence risk and opportunity for lowest cost. *Source* Project Management Institute (2008), a guide to the project management body of knowledge (PMBOK) 4th edition, project management institute, PA, USA

opportunity for trade-off between the impacts of project cost, quality and schedule (Hlaing et al. 2008). Hlaing et al. (2008) relate that recent changes in the corporate environment have exposed participants in the construction industry to more and more surprises in project management. As a result, customers are allocating greater risks to contractors. This means there is a need to examine the whole life of a project from inception to use. But such research has been undertaken mostly from the construction industry's perspective. For example, the Hlaing et al. (2008) research was an investigation based on a survey of construction contractors, not customers. Yet project risk and opportunity is highest and investment lowest over the conceptual and development phases where customers are instrumental in making decisions (Fig. 58.1).

This is further highlighted by Artisan (2008) which, by drawing on earlier research by the Defense Systems Management College 9/93, found that committing to investment in the early development of a project's concept, design and development may avoid significant customer costs to extract defects. This generalized research indicates that 20 % of the cumulative percentage of a project's life cycle costs should be invested during the concept (8 %), design (7 %) and development phases (5 %). The costs to extract defects beyond these phases increase rapidly (Fig. 58.2).

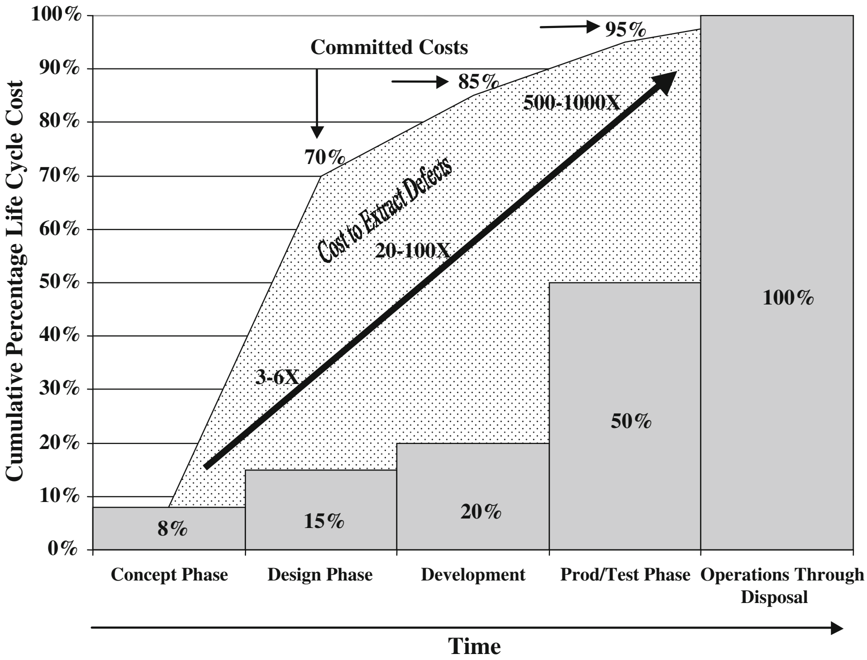

Fig. 58.2 Cumulative percentage life cycle cost over time and cost to extract defects. *Source* Artisan 2008, defense systems management college 9/93, in model based systems engineering—opportunity to improve efficiencies with sysMl, artisan software tools, p 6

58.5 Customers Need to Manage Both Uncertainty and Equivocality

Levander et al. (2011) found that customers needed to manage both uncertainty and equivocality, and that a customer's ability to do this was limited—consequently, when customers are moved beyond their current frame of reference, their information processing practice does not support decision making. Gannon and Smith (2011) suggest that market information is poorly considered within a (customer's) business case and that more transparency and commitment is required from suppliers. Currently, suppliers become involved when invited to register their interest in a project and are then shortlisted for tendering purposes. Tenderers are then obliged to develop and submit a tender for which there can be significant transaction costs. Only one tenderer is awarded the contract, so the others remain in debit. The contractor needs to move as quickly as possible into credit (Fig. 58.3, A–B), while the customer continues to invest uncertainly and equivocally in the achievement of the required capability at some time in the future (Fig. 58.3, C–D).

In Australia, many customers attempt to reduce this uncertainty and equivocality through the use of 'traditional' processes. 'Traditional' pre-contract award

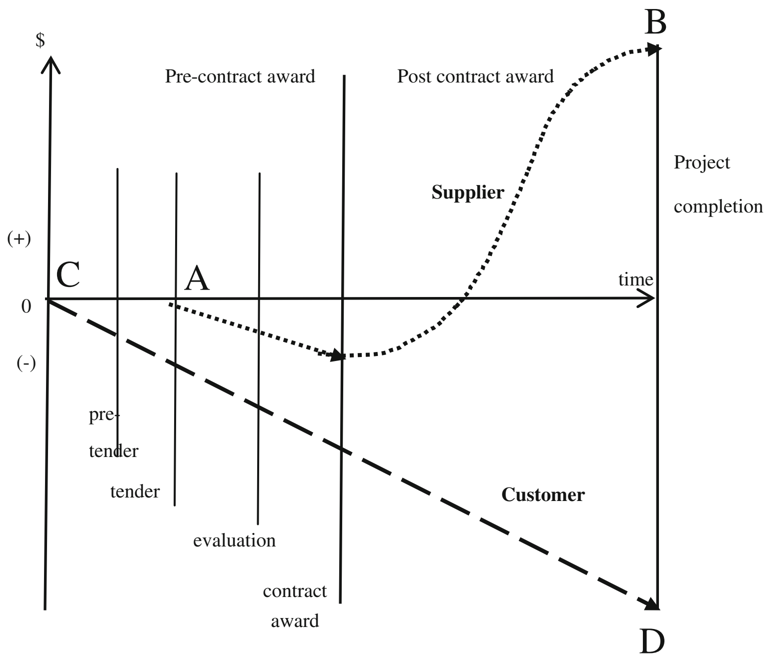

Fig. 58.3 The stages, timing and cash flow of new project development

processes typically comprise four main phases: pre-tender, tender, evaluation, and award (Australian Government 2011; State Government of Victoria 2011).

58.6 The Pre-tender Phase

In the pre-tender phase, customers draw on their organization's vision and strategy to identify future performance needs, often expressed through a capability brief. Once agreed, the capability brief provides the basis for a business case which is then developed into the project's scope. But pre-tender, 'many customers do a poor job of adequately defining a project's scope leading to a poor design basis' (Cho and Gibson 2001, p 115). The development of the project's scope can include not only construction but also many other industries such as finance, venture capitalists, equity/debt providers, manufacturers, industrialists, and marketers. The construction component may be but a lesser fraction of the total project. The resources a customer allocates to the pre-tender planning phase are often well intentioned but inadequate or excessive.

58.7 Tender

Mohemad et al. (2010) found that successful new construction projects are heavily dependent on making the right decisions during the tender process, and that managing tender processes is very complex and uncertain involving coordination of many tasks and individuals with different priorities and objectives. Laryea (2011, pp 275–286) established that in the UK, 'tendering is one of the stages in construction procurement that requires extensive information and documents exchange', that 'a significant amount of tender queries, amendments and addenda were recorded' and that 'poor quality tender documents are a source of inaccurate estimates, claims and disputes on contracts' (Laryea 2011, pp 275–286).

58.8 Evaluation

Mohamed et al. (2010) argue that a lack of clarity of information, customer preferences, potential competitors and the overall marketplace make bidding a very complex process (Fig. 58.3). This is evident from the findings that 'industry reliance on performance metrics fixed at the project outset is being superseded by increasing use of emergent customer judgments to characterize success' (Thomson 2012). But customers may still consider a 'project that fails to meet formalized time, cost and performance goals successful if it satisfies emergent requirements not understood during the initial briefing' and that 'construction practitioners do not routinely recognize that customer awareness of requirements improves as projects progress' (Thomson 2012). Further, 'internal conflict among the customer stakeholders and their reflections on the emerging project solution help customer stakeholders to better understand their needs'. However, it has been found that 'dissatisfaction results when these emergent requirements are not acknowledged'. These findings indicate customer distress with current process and regulation (Thomson 2012). In Australia, the customer's evaluation stage applies key selection criteria and weightings to conforming tenders, checks referees, negotiates variations such as options, re-confirms the budget and recommends the preferred supplier. During this process, a tenderer will often have to maintain the bid team including 'a mix of expertise and knowledge to enable it to handle requests for clarification and information from the customer (Industry Commission 1994, p 102). This can represent significant transaction costs for each tenderer.

58.9 Award

The contract award stage includes discussions and negotiations with tenderers concerning contract variations, tradeoffs, options, budget confirmation and final vetting of the preferred tenderer for viability (Capital Projects and Service Planning 2011). These are expensive and time consuming processes for both customer and suppliers, which add to the pre-contract award transaction costs of all parties (Thomson 1995).

58.10 Methodology

The Phelps and Horman (2010, p 58) paper identifies a critical need for theory building methods and methodological challenges. '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' (Hughes 2007, p iii). This research takes a pluralist methodology (Kellert et al. 2006) through the development of an artefact in the form of a construct, model or method and test case using a fine grained approach over a lengthy period. From this some general conclusions, insights and frames may evolve which contribute to theory, and in doing so gather empirical data that is replicable.

58.11 Method

Cooke-Davies and Arzymanow (2003, p 471) found that 'the most highly developed project management models are in the petrochemical and defence industries'. Representative of this is the Australian defence customer. Its pre-tender process begins with new project entry into the defence ten year capability plan (Australian Government 2006), that is the defence 'project portfolio' (Jonas 2010, p 818) which comprises over 200 significant projects. This customer process begins with identifying the need to address the government's defence vision and related capability gaps and performance needs. These needs are progressively deepened into capability briefs and business case options derived from strategic guidance, current and future operational concepts and technology, emerging environmental issues, and already identified capability requirements. Drafts of the capability briefs and business case options are circulated for comment and transformed progressively into detailed, costed, defined requirements with business case options to be considered by the appropriate executives and defence boards. The preferred capability brief/business case option will be identified, a project design brief developed and given a schedule for procurement and budgetary provision for acquisition and through life costs (Australian Government 2006, pp 98–101). The period, price and scope/quality of the required capability will be well developed during this process, sometimes with the assistance of industry experts such as quantity surveyors.

58.12 Defence Projects Selected and Data Collected

The defence commercial support program exposed selected non 'core' defence support activities to competition (Industry Commission 1994, pp 69–90). This outsourcing program offered industry the opportunity to compete for work previously delivered exclusively by military and defence civilian personnel. Critical success factors were that a lowest cost option would not always be successful, that cost effectiveness took into account the financial viability of the tenderer, the demonstrated management and technical capabilities, the capacity to provide long-term support to defence, and other value for money criteria. In this pilot study, pre-contract award transaction costs and time data were collected for eleven of these projects for which defence followed its 'traditional' pre-contract award delivery processes (Table 58.1).

Pre-contract award transaction cost and time data was collected from each of the defence project managers of the selected projects (Table 58.1). This involved an initial meeting to outline the time and cost data to be provided, a return meeting after the data had been collected, and then a final meeting to ensure that the data provided was interpreted correctly. The transaction cost and time data covered

Table 58.1 Eleven projects offered by defence for pre-contract award transaction resource investment

No.	Project description	Defence base	Contract awarded	Value of contract (AU$m)
1	F111 maintenance	Amberley, QLD	IHO	48
2	P3C depot level maintenance	Amberley, QLD	De Havilland	20
3	PC9 pearce maintenance	Pearce WA	Airflite	20
4	PC9 maintenance	East sale Vic	Airflite	10
5	HS748	East sale Vic	IHO	6
6	RAAF surface finishing	Richmond, NSW	IHO	9
7	Fairbairn base support	Fairbairn ACT	IHO	4
8	RAAF williams base support	Point cook Vic	SERCO	5
9	RAAF basic flying training	Point cook Vic	BAe	4
10	Fairbairn catering	Fairbairn ACT	AFS	12
11	RAAF williams	Point cook Vic	Spotless	32

Source Industry Commission 1994, defence procurement report no. 41 Appendix E, p 197, Commonwealth of Australia, AGPS, Canberra direct ‘search and information costs, bargaining and decision costs, policing and enforcement costs’ for the defence customer (Table 58.2) and for the suppliers (Table 58.3).

These findings (Table 58.2) indicate that there was significant investment (57.0 %) by the customer in tender evaluation with only 26.8 % investment in the concept, design and development of project performance. For a customer, most value for money is in the development of the project performance requirement. From Table 58.3, the cost for suppliers to retain their project teams until they knew the outcome of the customer’s tender deliberations is noticeably high (33.8 %), caused by the customer’s complex tender evaluation process.

Using the lagging customer data (Table 58.2), leading transaction costs and times for future projects can be developed (Fig. 58.4). The solid line represents the average of the eleven project’s performance, while the dotted line represents a future project, in this case, the best performing of the eleven projects.

Figure 58.4 graphically indicates the need for a customer to make greater investment in the concept, design and development of a project, and less intender evaluation. From this graphic, it is possible for defence to pre-determine the most desirable transaction cost and time allocation for each phase of the pre-contract award process. This could be adjusted as necessary for a particular project, and used for project management and monitoring.

Table 58.2 Pre contract award summary of customer transaction costs and times for the selected eleven defence projects

Pre contract award phase	% of total cost	% of total time
Pre-tender: concept approval to proceed to RFT issued	26.8	56.0
Tender: RFT issued to RFT closed	1.0	17.7
Tender: RFT closed to tenders evaluated	57.0	7.7
Evaluation: tenders evaluated to source selected	8.9	8.2
Evaluation: source selected to contract negotiated	4.0	6.3
Award: contract negotiated to contract award	2.3	4.1
Total	100.0	100.0

Table 58.3 Pre contract award summary of supplier transaction costs and times for the selected eleven defence projects

Pre contract award phase	% of total cost	% of total time
Pre-tender: concept approval to proceed to RFT issued	15.6	56.0
Tender: RFT issued to RFT closed	41.7	17.7
Tender: RFT closed to tenders evaluated	33.8	7.7
Evaluation: tenders evaluated to source selected	5.2	8.2
Evaluation: source selected to contract negotiated	2.3	6.3
Award: contract negotiated to contract award	1.4	4.1
Total	100.0	100.0

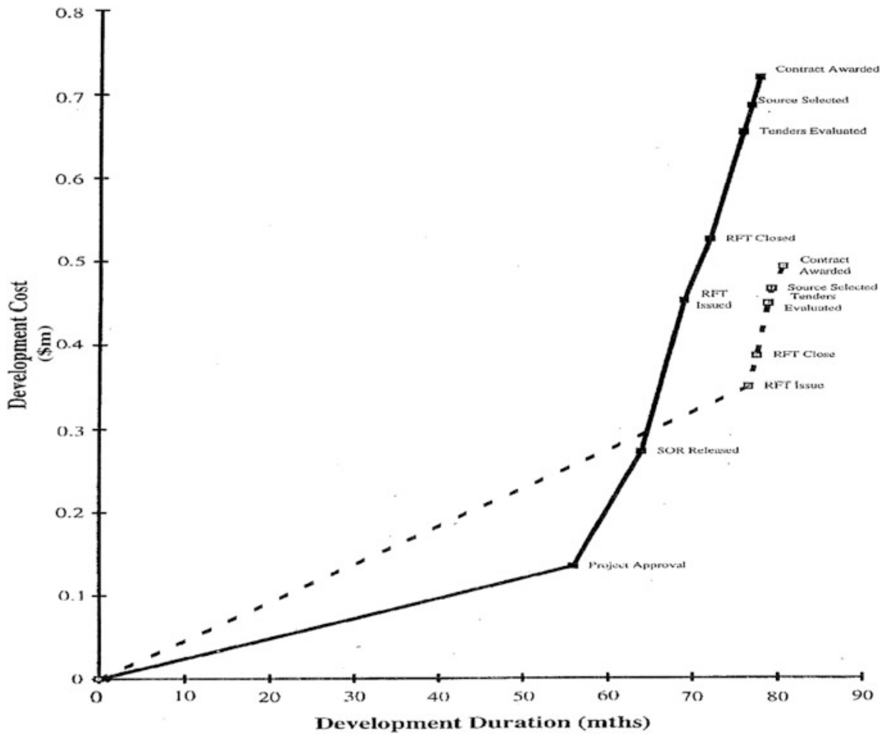

Fig. 58.4 Average (*solid line*) versus improved (*dotted line*) transaction costs and times

58.13 Comparing 'Performance' and 'Traditional' Project Governance Arrangements

'Performance' governance and risk arrangements are different from 'traditional' governance and risk arrangements. Calvert et al. (1996) research found 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 customer to the supplier, and that risks arising in performance, such as the risk of unforeseen conditions or necessary changes, are shifted to the supplier. This finding is based on the Supreme Court of the United States (1920) principle that: '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.' For such contracts, fixing the project sum is necessary. 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 customer provides some of the design but the supplier is required to complete contract 'performance' utilizing the supplier's own means and

Table 58.4 Comparison of a customer's 'design and construct' versus 'performance' transaction costs and times

Pre and post contract award	*Predicted* customer's 'design and construct' contract transaction cost and time (estimated by third party quantity surveyors)	*Actual* customer's 'performance' contract transaction cost and time
Pre-contract award (concept to contract award)	$133,650 4 months	$49,874 2 months
Post-contract award (contract award to contract completion)	$89,100 8 months	$50,961 7 months
Total	$222,750 12 months	$99,835 9 months

methods. When a contract contains 'performance' specifications it allows the supplier discretion to select the means and methods, but the supplier 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. A case study to compare such project governance arrangements was proposed and approved by defence. Such comparisons were to be based on the transaction costs and times for 'traditional' design and construct project delivery governance processes and compared to 'performance' governance arrangements.

For the test case, defence provided a fixed sum of $0.891 m for a navy senior sailor's accommodation project in Victoria, Australia. The pre-contract award transaction costs and times for this project using Australia's traditional 'design and construct' process were estimated by a third party (John Holland Group) to be $133,650 and 4 months. The post contract award transaction cost and time estimates were $89,100 and 8 months. The actual use of a 'performance' contract resulted in actual pre-contract award transaction costs of $49,874 and 2 months and actual post contract award transaction costs of $50,961 and 7 months. Overall, the comparison between the two corporate governance arrangements favoured the 'performance' contract by $122,915 and three months (Table 58.4) (Thomson 2012).

58.14 Conclusions

This research demonstrates that effective project delivery requires traceability, as comparability and performance of project components and subsystems must be examined in detail. Transaction cost analysis enables such detailed analysis to be undertaken, where lagging performance indicators were used to develop useful leading indicators for improving project delivery performance from both the customer's and supplier's perspectives. This need not be a large operational expense if the necessary data is collected on a routine basis or is accessible from existing sources such as project accounts or reports. Data systems can now capture most of this information which can then be used to analyse the critical success factors of transaction cost and time, so using a holistic view of the process across the complete value chain. This is particularly important as the cost and time to remove defects escalate over time. While transaction cost economics holds that all complex contracts are unavoidably incomplete (Williamson 1991a, b, 2000, 2002), an incomplete contract can cause costly inefficiency. In the test case use of a 'performance' contract, there was no customer's warranty of the sufficiency of the plans and specifications, or liability for design failures, or risks arising in performance such as the risk of unforeseen conditions or necessary changes. These risks were shifted to the supplier through the competitive tender process, while the customer retained cost and time risk, thus allocating risk to the party best able to carry the risk. In using a 'performance' contract, the customer saved the transaction costs, time and risks in developing a detailed 'design brief'. The customer was able to focus its efforts on the development of its required capability 'performance'. It did not need to extend this into the complex development of a 'design brief' and the responsibility and risk this carries as construction industry tenderers were then given the opportunity to respond competitively and innovatively to the 'performance' specification using their expertise and knowledge of their industry and its marketplace. With the time and cost fixed, tender assessment was simplified and shortened and 'value for money' (quality) became the only tender differentiator.

This research has taken a pluralist methodology and developed an artifact using a fine grained approach over a lengthy period. From this some general conclusions, insights and frames may evolve which contribute to theory, and in doing so gather further empirical data that is reliable and replicable.

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Chapter 59
The X Factor Investigation of a Price Cap Regulation of Infrastructure Under Public-Private Partnerships

Suxia Gao and Zhitao Ren

Abstract Price regulation is an integral part of the infrastructure under the public-private partnerships. The traditional means of price regulation is replaced by the price cap regulation which is one of the incentive regulations due to its high cost and low efficiency. Determining the X factor is the kernel of price cap regulation. This paper analyzes the X factor by constructing a new model based on the RPI-X model, it is concluded that the total factor productivity growth of regulated businesses and the entire economy, and the input prices growth rate are the key elements to the X factor. The relationship between the X factor and the private sector, the government and the public is obtained and it provides a certain criteria for the Government Regulation Department for timely adjusting the X factor.

Keywords Infrastructure · Price cap regulation · Public-private partnerships · The X factor

59.1 Introduction

Government is not the only provider of infrastructure, it has become an international trend that attracting private investment and introducing market mechanisms achieve the public-private partnerships in the infrastructure. The emergence and development of public-private partnerships in facilities is an important shift in contemporary public management concepts that taking full use the advantage of the market mechanisms and the private sector of management, technology, maximize the efficiency and the value of public funds, to ensure that the public can enjoy the high service quality and efficiency of infrastructure.

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The infrastructure has these characteristics that non-competitive, non-exclusive, positive externalities, natural monopoly and so on, so the market can not form a reasonable price, it is essential that the government implement price regulation of infrastructure. The goal of the government price regulation of infrastructure is to coordinate the interests of enterprises and consumers, and not only improve the infrastructure supply efficiency, but also maximize the level of social welfare.

For a long time, the Chinese government used cost-plus pricing and ROR (Rate of Return) method to encourage private sector to enter infrastructure construction in the field of infrastructure under public-private partnerships, but this price regulation actually encourages the private sector to input unnecessary excessive investment. Companies have little incentive to reduce cost and improve efficiency, and frequently appear of high cost and low efficiency situation. With the increase of the size of the infrastructure, the traditional price regulation can not meet the needs of social development, gradually being replaced by price cap regulation. Price cap regulation is originated in Britain, as an alternative to the traditional fair rate of return regulation. As the first person Stephen Littlechild proposed the theory during the private sector joined the telephone communications company in the United Kingdom in 1983. Price cap regulation related to the retail price index and production efficiency and replaced the investment regulation that only linked to production costs, thus avoiding the past complex procedures that establish or modify the price scrutinizing costs and other procedures, and giving the motivation that being regulated firms cost improve efficiency and increase costs, so as the "epoch-making price regulation mode" (Uekusa 1992). The most important thing of the price cap is determining a ceiling price that does not harm the public interest and not dampen the enthusiasm of the regulated firms, the main factor affecting the price cap is the X factor, so the key issue is that determining the X factor and the deadline of the X factor by the department of government (Tirole 1999). This paper finds the key factors affecting the X factor by constructing a mode and analysis the relationship between the X factor and the private sector, the government and the public. And this paper provides some help to the government regulation department when they determine the X factor.

59.2 The Operate Mechanism of the Price Cap Regulation

Price cap regulation is a price change contract which is signed between the regulator and the regulated enterprises, the contract stipulate the ceiling price of the enterprise average price movements. Enterprises can free to price changes within the cap price. The essence of the price cap regulation is separated the price and the cost, and the regulator allow the enterprise to obtain the revenue which is brought from cost improvement in the cap price. It is a major factor to consider the X factor and retail price inflation rate of the year when determining the cap price. The X factor is determined by the contract that is signed between the regulator and the regulated in advance. X is an adjustment factor, the regulator can be regulated the sharing revenue between the consumer and enterprise by adjusting X size. When the actual rate of increase in productivity in the enterprise over it, the amount of the resulting increase in profits would all belong to enterprises. Therefore, the price cap regulation can be seen as a residual claimant contract. The significance of the price cap regulation is encourage enterprises to reduce costs, improve productivity and gives enterprises to make price power to better compete. Roberts et al. (2002) put forward a suggestion that the government need to establish a complete legal and regulatory system to address the conflict of interest with involving parties under public-private partnerships of the infrastructure. The government may establish an cap incentive regulation.

Price cap regulation is a typical high-strength incentive regulation model. It does not rely on corporate cost information, and has two important characteristics: first, the incentive mechanism reduces costs, and this incentive mechanism is stable and feasible; second, enterprises adjust the price incentive is freedom, which can realize the price difference (Zhang 2004). Since the 1990s, as the link of infrastructure electric power industry reform, regulators around the world began to use incentive regulation to replace the tradition ROR (Rate of Return) regulation, to promote the production efficiency of the regulated enterprise (Jamasb and Pollitt 2001, 2003).

In the aspect of reducing cost and improve efficiency: price cap regulation regulates the price of enterprise rather than profit, it stimulates enterprises to improve productivity and promote innovation, because cost reduction profits will all belong to enterprises. The enterprises exist over-investment behavior under the traditional pattern of price regulation to gain more profits, then prone to "A-J effect (Averch and Johnson 1962)." Price cap regulation only need to measure the price index, not measure the fair rate of return. Regulation method is relatively simple, it just needs to estimate the cost of production and the level of demand, and the cap price just is converted into compensation current cost of the price level (Coase 1998). In the management efficiency of the regulation, Tinghui (2002) pointed out that compared with the traditional rate of return regulation, the price cap regulation is a "slight hand of regulation," management is relatively simple, and improving the efficiency of management is easy.

There is another important feature of price cap incentive that it is not depend on the information of enterprises information. In the construction of infrastructure, it is important that the communication between public and private information, (Schmidt 2008) considered that strengthening the communication and incentive mechanism between the public and private can promote the formation of interaction and synergy of public and private sector that is lead to better use of resources to complete infrastructure projects. He emphasized the importance of information between public and private. However, in reality, there is always exist the information asymmetry between government and enterprises, which is a big obstacle for the government to formulate a reasonable regulatory policy. To solve the problem of information asymmetry between the two sides, Laffont and Tirole (1993), Laffont (1994) applied the game theory and the incentive theory of information economics to analysis regulation theory, and systematically expounded the issue that the regulatory agencies designed the incentives regulation under the conditions of incomplete information (Laffont and Tirole 1993; Laffont 1994). Iossa and Stroffolini (2002) discussed how to induce corporate exposed to the true cost of information in the case of asymmetric information when it exists the price-cap. Lin and Xiaopeng believed that compared with the traditional theory of regulation, price cap regulation theory is focused on addressing the issues like the adverse selection, moral hazard, lack of competition, setting rent, rent-seeking and so on, which is caused by the information asymmetry (Lin and Xiaopeng 2004). The price of price cap regulation does not directly include business cost, so the regulator need not to fully grasp the cost information of enterprises.

Compared with other incentive regulation, the idea of price cap regulation is simple, and the efficiency is high. This paper obtains from the profits of enterprises, draws the X factor determinants factors, and its relationship with business and government sectors, assuming that the enterprise's production growth rate does not affect the production growth of the while economy.

59.3 Establish the Price Cap Regulation Model

59.3.1 The Basic Model

This article talks about the regulation represented by the United Kingdom. The price-cap regulation model links to the retail price index and business productivity. The principle of determining the regulation is that the industry price increase can not be higher than the inflation rate, at the same time taking into account the improvement of labor productivity makes the industry's price decline. The formula is:

$$P = RPI - X$$

Among them, RPI represents the retail price index, X is determined by the regulator in the percentage of the productivity growth in certain period, usually 3–5 years once approved. Clearly, in this model, the focus of negotiations is choosing the X between the enterprise and the regulator, X is a productivity adjustment factor (also reflects the remaining split between enterprises and consumers, the bigger X, the more the consumers residual) (Littlechild 1983).

59.3.2 The X Factor Model

59.3.2.1 Determine the Growth Rate of Enterprise Output Price

First, assuming that the regulated enterprises profit is π, which is equal to revenue minus cost. When enterprises produce n products and services with m products input, if all prices are be regulated, enterprises profit obtained from the regulation as follows:

$$\pi = R - C = \sum_{i=1}^{n} p_i q_i - \sum_{j=1}^{m} w_j v_j \tag{59.1}$$

Among them:

p_i is the unit price of the i regulated output product.
q_i is the enterprise sale quantity of the i regulated output product.
w_j is the unit price of the j input factor.
v_j is quantity of the j input factor.

Second, when the price, quantity of the output product and input factors changed, the profits of an enterprise as follows:

$$\prod \frac{d\prod}{\prod} = \sum_{i=1}^{n} p_i q_i \frac{dq_i}{q_i} + \sum_{i=1}^{n} p_i q_i \frac{dp_i}{p_i} - \sum_{j=1}^{m} w_j v_j \frac{dv_j}{v_j} \tag{59.2}$$

Further decomposed into

$$\sum_{i=1}^{n} r_i \overline{p_i} = \frac{C}{C + \prod} \left\{ \sum_{j=1}^{m} s_j \overline{w_j} - \sum_{i=1}^{n} r_i \overline{q_i} + \sum_{j=1}^{m} s_j \overline{v_j} + \frac{\prod}{C} \overline{\prod} - \frac{\prod}{C} \sum_{i=1}^{n} r_i \overline{q_i} \right\} \tag{59.3}$$

Among them:

$r_i \equiv \frac{p_i q_i}{R}$ is sell i product revenue accounted for the total share of proceeds.
$s_j \equiv \frac{w_j v_j}{C}$ is the cost of j factor accounted for the total costs.
$\overline{x} \equiv \frac{dx}{x}$ is the variable x (x is p_i, q_i, w_j, v_j) for the rate of change.

Assumed

$$\overline{P} = \sum_{i=1}^{n} r_i \overline{p_i}, \quad \overline{W} = \sum_{j=1}^{m} s_j \overline{w_j}, \quad \overline{Q} = \sum_{i=1}^{n} r_i \overline{q_i}, \quad \overline{V} = \sum_{j=1}^{m} s_j \overline{v_j}$$

The above equation is that:

$$\overline{P} = \left(\frac{C}{C+\prod}\right)\left\{\overline{W} - [\overline{Q} - \overline{V}] + \frac{\prod}{C}\left[\overline{\prod} - \overline{Q}\right]\right\} \tag{59.4}$$

$[\overline{Q} - \overline{V}]$ is the regulated enterprises total factor productivity $(\overline{T})$, namely the difference of the enterprise growth rate between the output and input quantity. Therefore:

$$\overline{P} = \left(\frac{C}{C+\prod}\right)\left\{\overline{W} - \overline{T} + \frac{\prod}{C}\left[\overline{\prod} - \overline{Q}\right]\right\} \tag{59.5}$$

Type indicated that the enterprise output price growth, the condition of the growth rate is that the enterprise profit is $\prod$, the cost is C, the growth rate of input price is $\overline{W}$, the output growth rate is $\overline{Q}$, the total factor growth rate is $\overline{T}$, and the profit growth rate is $\overline{\prod}$.

In a perfectly competitive industry, enterprise profits is zero, then:

$$\prod = 0, \quad \overline{\prod} = 0, \tag{59.6}$$

$$\overline{P} = \overline{W} - \overline{T} \tag{59.7}$$

If the price cap only measures the actual changes of input product price and the growth rate of output product, price cap regulation will be same as the ROR regulation.

59.3.2.2 Set the X Factor

Price cap allows enterprises to retain profits due to cost reduction, so companies have cut costs, cost-minimization incentive. Government regulation sector set the X factor, coordinating the remainder split between enterprise and consumer. The bigger X factor, the more consumer surplus. The X factor reflects the growth rate of enterprise productivity and the reduced level of input prices; the feedback relationship between the ceiling price of the regulated enterprises and the inflation rate of the whole economy (Eragas and Small 2001).

Assuming that the changes in the whole economy impact the enterprise output levels, input prices and productivity levels, but the price changes which is indicated by the regulated firms do not affect the whole economy. Under the baseline conditions, output growth of the enterprise has a relationship with profit growth rate, and productivity. E is assumed for other departments, then:

$$\overline{P}^E = \left[\frac{C^E}{\prod^E + C^E}\right]\left\{\overline{W^E} - \overline{T^E} + \frac{\prod^E}{C^E}\left[\overline{\prod^E} - \overline{Q^E}\right]\right\} \tag{59.8}$$

By the formula (59.5) and (59.7) can be obtained that:

$$\begin{aligned}\overline{P} = \overline{P}^E - &\left[\left(\frac{C}{C+\prod}\right)\overline{T} - \left(\frac{C^E}{C^E+\prod^E}\right)\overline{T}^E\right] \\ &- \left[\left(\frac{C^E}{C^E+\prod^E}\right)\overline{W}^E - \left(\frac{C}{C+\prod}\right)\overline{W}\right] \\ &- \left[\left(\frac{\prod^E}{C^E+\prod^E}\right)\overline{\prod}^E - \left(\frac{\prod}{C+\prod}\right)\overline{\prod}\right] \\ &- \left[\left(\frac{\prod}{C+\prod}\right)\overline{Q} - \left(\frac{\prod^E}{C^E+\prod^E}\right)\overline{Q}^E\right]]\end{aligned} \tag{59.9}$$

$$\begin{aligned}X_1^b = &\left[\left(\frac{C}{C+\prod}\right)\overline{T} - \left(\frac{C^E}{C^E+\prod^E}\right)\overline{T}^E\right] \\ &- \left[\left(\frac{C^E}{C^E+\prod^E}\right)\overline{W}^E - \left(\frac{C}{C+\prod}\right)\overline{W}\right] \\ &- \left[\left(\frac{\prod^E}{C^E+\prod^E}\right)\overline{\prod}^E - \left(\frac{\prod}{C+\prod}\right)\overline{\prod}\right] \\ &- \left[\left(\frac{\prod}{C+\prod}\right)\overline{Q} - \left(\frac{\prod^E}{C^E-\prod^E}\right)\overline{Q}^E\right]\end{aligned} \tag{59.10}$$

Then:

$$\overline{P} = \overline{P}^E - X_1^b \tag{59.11}$$

The formula is a expression of price cap regulation. It shows that enterprise output price is the inflation rate minus a factor, that is the X factor. To further analyze the determinants factor of X, under the condition of perfect competition, Eqs. (59.6) and (59.10) have:

$$X_0^b = [\overline{T} - \overline{T}^E] + [\overline{W}^E - \overline{W}] \tag{59.12}$$

Then:

$$\overline{P} = \overline{P}^E - X_0^b = \overline{p}^E - \{[\overline{T} - \overline{T}^E] + [\overline{W}^E - \overline{W}]\} \tag{59.13}$$

In order to be regulated business profits, government regulation department need to consider the following factors: first, setting the zero profit price index of the regulated enterprise; second, allowing these prices can rise equally to the entire economic output growth prices rate (inflation rate $\overline{P}^E$) minus the factor (X_0^b).

The enterprises have not enough private incentives to improve the quality of the product, making them also responsible for the management of the incentives in the case of the positive externality. Since the price cap regulation replaced the traditional regulation in the past 20 years, many countries selected the price cap regulation in infrastructure construction, at the same time the quality of the services became the focus of concern by the scholars (Ian 2013). Yaodong (2004) considered that the essential question of our current government regulation is the incentive excessive and insufficient, we should establish a comprehensive and effective arrangements to allow all the various control tools to play their function. Vareda (2011) analyzed that the regulator set two access prices to the incumbent network, to incentive them improve network quality. Napel and Oldehaver (2011) pointed out that the minimum quality standard price regulation can prevent the manufacturers conspired and produce dynamic welfare gains.

The regulated enterprise's products quality is related to the cost, so price regulation should link with the quality to encourage enterprises to improve and maintain a high level of quality consciously. In order to make regulated enterprise improve efficiency while ensuring product quality, the model can make the following change:

$$\overline{P} = (\overline{P}^E - X_0^b) * Q = \{\overline{P}^E - \{[\overline{T} - \overline{T}^E] + [\overline{W}^E - \overline{W}]\}\} * Q^* \tag{59.14}$$

Q^* is infrastructure quality service factor.

59.3.2.3 Determine the Elements of the Model

$\overline{P}^E$: It can come from the retail price index which is published by the government. It is the inflation rate that reflects the comprehensive changes in the retail price of production and consumer goods prices.

$\overline{T}$: It can be determined according the quantity of output and input of the enterprise's previous.

$\overline{W}$: It can take the average price based on the actual market survey.

$\overline{T}^E$: It can come from the government economic factor growth of the production.

$\overline{W}^E$: According to the industry all kinds of reference price released by the government.

Q^*: Quality factor comes from the standards of the product and service quality published by the government, and the public evaluation of the quality of products. In terms of professional performance, according to the technical characteristics of different industries sets appropriate technical indicators, and using the professional measurement methods determines the level of quality; in the use of performance, the public evaluations of the product come from public hearing or questionnaire. Considering that set different weights for different technical, and then integrated the suggestion of the public, calculated the Q^*. If the product and service quality meet the standard product required, the $Q^* = 1$; if not, the $Q^* < 1$.

The government regulation department set the validity of the regulated contract which is depending on the specific parameter values, and its associated payback period. The validity of the regulated contract should be told to the enterprise in advance. When the parameter value change dramatically, the government department adjust the X factor to adapt to the development of society. But the construction of infrastructure needs massive investment to improve competitiveness in the future and the payback period is very long, so the cycle of the contract should be extension on the basis of the general level (3–5 years).

59.3.2.4 Analysis the Result of the Model

As can be seen from the model results, the key factor that determined the X factor is the total factor productivity growth in the regulated enterprise and the throughout economy, and the input price growth in the regulated enterprise and the throughout economy. The regulated enterprise only can control the total factor productivity growth of themselves. The government can control the total factor productivity growth and the input price growth of the while economy by macro-control. The public not only pursuit the low price, but also the high quality of the product. The effects of the X Factor on the field of infrastructure under public-private cooperation is that:

- To the private enterprise: Private enterprises pursue the maximize personal interest, but government regulated the price cap, if the enterprises want to get more profit only one way that reduced costs, increased X factor. In terms of the enterprises, the key factors affect the X factor is $\overline{T}$, so enterprises should constantly optimize the technical means of the various kinds of production factor, improve the management level, and make the actual increase rate of the productivity in the enterprise over the X that determined in the contract. The X Factor will encourage enterprises to pay more attention to the rational combination of all factors production to achieve the best output effect, not too much emphasis the proportion of capital, and will not generate A-J effect which is often formed in the traditional price regulation.
- To the government: The X factor could encourage enterprises to increase productivity and reduce costs, but the unreasonable X factor will lead to appear the opposite effect. The X factor set too high, the price cap will be relatively low, if the enterprise's production efficiency not raise, the cost will be higher than the ceiling price, which will lead to business losses or even bankruptcy. On the other hand if the X factor is too low, and the production efficiency of the enterprise is high, the enterprise will have a lot of residual profits, and that will lead to enterprises loss innovation. If the enterprises lose money even on the brink of bankruptcy, enterprise will asked to modify the regulatory contract in

advance to increase profit as possible. And if regulatory agencies meet the requirement of enterprises, regulation will produce the "soft budget constraint." The goal of the government is to maximize the social and business interests. If enterprises get a lot of residual profits, the regulator will bear too much political pressure. At this time the regulatory department will be ask the enterprise to renegotiate and modify the contract, it will weaken the incentive intensity. So the government regulation department should pay attention to the changes that are the key factors to the X factor, and adjust the size of the X factor timely.
- To the public: Public is an important participant in the construction of infrastructure, their purpose is low price and good quality. The enterprise may sacrifice the quality of products when they increase productivity, reduce costs. The public is not only the user of the product but also determine the value of the X Factor. The public will cause the enterprise to emphasis on product quality. High-powered incentives may also give excessive information rents to the operator in adverse selection contexts. These rents may provide enterprises with an incentive to capture the government regulation department to manipulate his decision so that bundling is always chose. Information rents are the engines of any capture such a regulator. So if the public participate as the supervisor participate the construction, it will avoid the "regulatory capture" phenomenon.

59.4 Instance Analysis

In practice, some price cap plans allow unanticipated events in the industry to trigger changes in the X factor. For instance, the X factor might be decreased if new taxes are imposed on the X factor can be appropriate if they do not insure the regulated firm against inappropriate activities that it might undertake. For instance, it is generally unwise to automatically raise the authorized X factor to account for all of the extra costs that a power producer incurs as fuel costs rise. Such automatic adjustments reduce the firm's incentives to secure fuel at low prices and to choose the least-cost technology for production.

In the telecommunication industry, only a subset of the regulated firm's services are typically subjected to price cap regulation. Furthermore, joint total factor productivity growth of regulated businesses and the entire economy, and the input prices growth rates. Consequently, corrections to the standard X factor to account for a limited span of regulatory control are both important and subtle. In the electric power and telecommunications industries, the primary outputs of the regulated firm are often important inputs for other producers. Since output price inflation in the economy is influenced by changes in input prices, the regulated firm's pricing decisions will influence the realized economy wide inflation rate when the firm's outputs are inputs in other sectors. The standard X factor requires modification in the presence of such influence.

59.5 Conclusion

In this paper, constructing the X factor model which is basis on the RPI-X model in the field of infrastructure under public-private partnerships found the key factors to affect the X factor. On the basis, analyzing the relationship between enterprises, government, the public and the X factor concluded that the enterprise need to continuously improve its production efficiency to get more profits, the government should increase the macro-control to overall economy and adjust the size of the X factor timely, the public's supervision may encourage enterprises to improve the X factor and focus on the quality.

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Chapter 60
Developing Capabilities for Public Construction Clients

Abderisak Adam, Göran Lindahl and Per-Erik Josephson

Abstract Clients in the public sector face a large number of challenges in designing, procuring and managing major construction projects in a manner that is conducive to the organization's overall goals. The role of the client in bringing about successful project completion has more recently been emphasized with a growing number of studies focusing on developing dynamic client capabilities that facilitate the handling of a project through all of its different phases. Though the capabilities of the client carries immense importance in all construction projects, the importance is further exacerbated by the sheer scale of the projects involved in major construction projects, a development which has prompted governmental agencies to inquire into ways to improve processes in the client organization. To address such inquiries, this paper which is based on a literature review, explores the types of dynamic capabilities that emerge with respect to public construction clients and in particular, if and how a specific client capability influences a specific project outcome. The mapping of capabilities constitutes a theoretical foundation for a forthcoming empirical study on the same topic.

Keywords Public clients · Dynamic capabilities · Infrastructure

60.1 Introduction

It is an oft-repeated truism that the more capable the organization, the more enhanced its ability to thrive. Perhaps nowhere is that more evident than in construction. The industry is inundated with myriads of stakeholders, from the more obvious actors: the owners, contractors and consultants to the extensive range of, architects, banks, regulatory institutions and users who all—in one way or the other—come in contact with the project (Chinyio and Olomolaiye 2010).

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These different stakeholders have their own standards with respect to what qualifies as a successful project. In the case of the client organization, Frödell et al. (2008) recount how clients often perceived the actual process of executing project goals to be less challenging than that of defining the goals to begin with, a difficulty which can be alleviated by better communication with the users; the ability to properly communicate with the end user, define project goals and execute in accordance to those goals are all pivotal capabilities that the client organization needs to possess (Kometa et al. 1994; Lim and Ling 2002; Xia and Chan 2010). The Oxford Dictionaries (2014) defines the term capability as "the power or ability to do something" which seems to suggest a sort of executional potential, a conotation that is stated more explicitly in Merriam-Webster's Dictionary (2014) in which capability is viewed as "a feature or faculty capable of development." This attribute of potentiality is at the heart of the term. It alludes to capability as a form of resource that can not only be acquired, harvested and improved but also deployed at will. In a similar fashion, capability, and dynamic capability in particular, has been defined in terms of the ability to enact organizational change by adopting various operational measures (Teece et al. 1997).

Developing the competencies of public clients is important as it serves to protect and strengthen the role of the client organization in fostering innovation in the construction industry (Manley 2006). This becomes especially important considering the complexity and the enormity of the projects that are procured by governmental agencies (APCC 2002). For that reason, governments need to take the client organizations' capabilities into account when designing procuring strategies and safeguarding mechanisms (Furneaux et al. 2008). Part of doing so is to ensure that the client does not engage in behavior that sets out to make the project more complex than it needs to be and instead steer away from unnecessary demands that increases project complexity (Lim and Ling 2002).

The client is in the position of the procurer and therefore has the overall responsibility to manage the direction of the project. This, both in terms of designing the initial contractual obligation in a way that is conducive to the project's overall goals but also in terms of achieving better cooperation between the different actors in the supply chain to overcome project challenges and thereby improve the success of the project (Briscoe et al. 2004). In discussing these challenges, The National Audit Office (NAO 2009) of the United Kingdom issued a report calling for the development of public clients' skills. A particular emphasis was placed on improving commercial skills due to their importance in determining the trajectory of a specific project and how it eventually unfolds. This line of thought can also be found in the work of Kometa et al. (1994) in which it was shown that client performance is not solely dependent on a single attribute but instead on a number of different attributes of which financial attributes play a substantial role.

Recommendations to public organizations included the call for a more rigorous hiring process in order to attract candidates with a greater exposure to the private sector. The report issued by the NAO also suggests the use of mentoring programs to support skill development of current employees, that career paths be made more clear, standardization of work procedures be implemented and more adequate ways of measuring commercial skills be introduced despite the difficulties involved in doing so (NAO 2009). However, in stressing the importance of commercial capabilities, it is important not to lose sight of the complete picture.

Consequently, this paper takes as a point of departure the recognition that client capabilities should be discussed not solely from the point of view of commercial considerations, but instead from that of a holistic outlook encompassing both the relational and contractual capabilities discussed by Hartman et al. (2010), the commercial capabilities stressed by NAO (2009) as well as other forms of capabilities that fall outside of these categories but whose impact on the outcome of the project is palpable.

The objective of this paper is to describe how the public construction client can harness, utilize and prioritize the capabilities required to handle large scale construction projects in a manner conducive to the client organization's overall goals.

In pursuit of this objective, a literature study was carried out which resulted in a mapping and subsequent categorization of capabilities based on research literature dealing with the client role, dynamic capabilities and organizational learning. The mapping of capabilities constitutes a theoretical foundation for a forthcoming empirical study on the addressed topic.

60.2 Literature Review

This section gives an overlook of the public construction client in terms of the role which the client embodies in the construction arena and how that affects the projects that emerge.

60.2.1 Dynamic Capabilities

Teece et al. (1997) notes that dynamic capabilities are essentially routines, be they organizational or strategic, that serve to create new resource configurations for firms. The term can thus be viewed as a type of process that integrates, reconfigures as well as gains and relinquishes resources. The original definition put forward by Teece et al. (1997, p. 516) explained dynamic capabilities as "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments." This particular description has gained a considerable amount of traction and is often adopted as the standard definition for the term, see Eisenhardt and Martin (2000), Helfat et al. (2007), and Wilkens et al. (2004) for notable examples. In spite of the definition's popular use, it is not without its detractors. Zollo and Winter (2002) points out that the definition of dynamic capabilities offered by Teece et al. is firmly predicated on the assumption that the environment of the firm is rapidly changing even though this might be less pertinent for certain organizations that operate in environments where change occurs slowly. Firms such as these also do acquire, integrate and reconfigure the competencies inherent in the organization despite not working under rapidly changing conditions.

As such, Zollo and Winter (2002, p. 340) instead lay forward the following definition for capability: “a dynamic capability is a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness.” This paper adopts the latter definition, in part due to the usefulness of using the term ‘organization’ as opposed to ‘firm’ which has the benefit of having larger applicability, which is more appropriate when discussing public client organizations. Secondly, this particular definition also does not necessitate the existence of a drastically changing business environment which is a more relevant outlook considering that the construction industry is typically known for its sluggishness and unwillingness to embrace innovation in the form of new technologies and change (Lindahl et al. 2010).

Capabilities are essentially a fusion of skills and processes. The value of a process is non-existent without the accompanying skills needed to perform it; likewise a skill has a very limited domain if it is not applied within an effective process (Dawson 2012). Regardless of the degree of rapid change that occurs in the business environment, dynamic capabilities will follow a path that is dependent on the organization’s history in a manner characterized by idiosyncrasy (Teece et al. 1997). The uniqueness of this path does not, according to Eisenhardt and Martin (2000), preclude the notion that there exist best practices in utilizing dynamic capabilities to prompt organizational change.

In this respect, dynamic capabilities can be said to contain practices that are more or less effective in bringing about the intended change, especially with regards to certain elements of dynamic capabilities such as strategic decision making, alliancing, and knowledge brokering. Teece (2007) makes the claim that organizations no longer compete in who has the best process but rather in who has the best process improving capability. At the heart of this philosophy is the contention that improving processes is necessary in order to be able to compete in the current fast paced business environment.

However, as Anand et al. (2009) illustrate, a large share of companies that have adopted continuous learning initiatives—of which developing dynamic capabilities is a subset—have not yielded satisfactory results; a development that Anand et al. ascribe to the lack of a framework. Initiatives of this nature differ depending on the type of capability that is sought after. As Dawson (2012) points out, improving specific business related capabilities such as attracting and retaining effective employees, improving product quality and ensuring efficient back-office processing are all immensely important and contribute to the competitive advantage of the organization.

However, these are not always the most influential capabilities; instead Dawson (2012) alludes to meta-capabilities as being the single most important capability that an organization can develop. These are the type of capabilities that enable the continued development of other integrated competencies. It may include the capability to rapidly learn new skills and processes, communicating openly within the organization, knowledge acquiring and sharing as well as adaptability and flexibility of organizational structure.

Although developing meta-capabilities can potentially be of immense value, they are also more difficult to achieve than other types of capabilities. In order for these to be developed, the client should not be preoccupied with short term results at the expense of long term objectives (Dawson 2012).

60.2.2 Clients' Dynamic Capabilities

Hartman et al. (2010) stress the significance of developing both relational and contractual capabilities. Building on the works of Argyres and Mayer (2007), Hartman et al. (2010, p. 1166) define contractual capabilities as "[the] successful management of the contingencies involved in transaction relationships with other parties, and their implications for the efficiency and effectiveness of the service delivery." To be contractually capable is to be able to perceive in advance where there might be room for opportunism in the contract and address such concerns prior to the commencement of the project, as early as in the tendering, drafting or negotiation phase (Hartmann et al. 2010). This is of particular interest in the construction industry where opportunism has been identified as a core problem for clients (Boukendour 2007; Reve and Levitt 1984; Winch 1989).

Opportunistic behavior has been shown to emerge as a result of changes that are undertaken by the client with regards to the project specification. By introducing changes in the project specification, the client may inadvertently induce the contractors to engage in opportunistic pricing of 'extras', a burden which is then carried by the client (Winch 1989).

There are a number of contractual ways to deal with this predicament. It could be addressed by allowing the clients to specify in detail the roles and responsibilities of the different stakeholders, thereby removing any ambiguities that could potentially be exploited by contractors and thus reduce the overall scope of opportunistic behavior (Argyres and Mayer 2007). In a study of design-build clients' competencies, Xia and Chan (2010) found that having a clearly defined project scope, in addition to sufficient financial and contract management capability, were key in ensuring project success. It is however important to be able to distinguish which of the parties constitutes the primary loci of contract management capabilities.

According to Argyres and Mayer (2007), control is allocated in accordance to the given contract terms; whereas roles and responsibilities, decision and control rights as well as communication fall under the managers' responsibilities, contingency planning and in particular dispute resolution fall under the domain of lawyers. This way of allocating contract design capability may serve to improve contract performance if relevant personnel develop contract design capabilities, given the sort of terms that are typically included in the organization's contracts.

This is grounded in the assumption that the capabilities for designing such terms reside differentially in different kinds of personnel, in particular with respect to the managers, engineers or lawyers within the organization.

In contrast to contractual capabilities, relational capabilities deal with socially intricate routines, policies and procedures in an interorganizational context. The chief purpose of which is to govern the relationships as a way to achieve organizational goals (Hartmann et al. 2010). To achieve these goals however, the client organization needs to develop relational and contractual capabilities and should not serve to hamper performance improvement by unremittingly retaining deeply seeded organizational routines that are not conducive to project performance (Haroglu and Leiringer 2010).

In certain cases, what appears to be deficiencies in certain capabilities such the difficulty in producing accurate plans and estimates of cost and time related matters may not necessarily be attributable to the lack of a particular capability. Rather, as shown by Flyvbjerg et al. (2009), in some cases, this can be explained by the client's deliberate intent to overstate benefits by assuming higher traffic flows, underestimating risks and by using artificially low values for determining costs, all in an effort to embellish the benefits of a specific project and thereby promote decisions not necessarily grounded on a complete analysis of outcomes. Regardless of whether this misjudgment occurs as a result of delusion or deception, it nonetheless clearly signifies a skillset that the client is in need of improving. It may also be the case that the organization's capabilities differ depending on the individual client organization.

However, institutional arrangements in the form of public policy tend to simply assume that the level of capability that exists in a given client organization is adequate to meet the requirements put forward by policy. Instead, an assessment of these capabilities should be undertaken in order to ensure that beneficial outcomes are obtained from the procurement processes and that public values are safeguarded (Furneaux et al. 2008). Part of assessing the organization's own capabilities is to be able to distinguish between times when the organizations capabilities suffice to reach the intended goal and when it may be more prudent to outsource those capabilities.

A knowledgeable client may even leave room for some modifications in the early design in order to make use of the contractors' comparative advantages (Warsame et al. 2013). The Australian Procurement and Construction Council (APCC) recommend that the assessment of the organizations capabilities ought to be predicated on the basis of best practice criteria in which individual members of the client organization can be measured and compared to a given standard. This assessment would be akin to the assessing that occurs when the client organization monitors consultants and contractors but instead of evaluating external parties, the evaluation would be internal (APCC 2002).

Kometa et al. (1994) set out to investigate the chief attributes that clients need to possess in positively influence project consultant's performance. Having established that the weight of culpability is often been placed on consultants in cases where performance has been lacking, Kometa et al. (1994) suggest that the consultants are not necessarily exclusively to blame for a poor performance. Rather, it may also be ascribed to the client's lack of management the situation. To address this issue, the authors identify 10 main attributes and 47 sub-attributes that influence project consultants' performance.

Lim and Ling (2002) reduced the number of attributes to five, highlighting the most influential ones, and then proceeded to base those attributes as the theoretical underpinning for a model predicting client's contribution to project success. This was achieved by analyzing the attributes of the clients that consultants and contractors viewed as significant in contributing to project success. In particular, clients should have a clearer focus on specifying objectives, be creditworthy and allow for a more trusting relationship with the projects team members and in doing so avoid litigious behavior. Unfortunately, as Wong et al. (2008) explains, instead of building trusting relationships that would aid in achieving a successful project outcome, clients and contractors tend to collaborate in a highly confrontational environment where distrust is the norm.

60.2.3 Capability Maturity Models

An approach developed in the IT-sector is the Capability Maturity Model (CMM) which gave birth to a number of similar models that have been applied in such varied industries as Manufacturing, Health Care and Construction (Curtis et al. 2009). In essence, the model was originally developed to identify strengths, weaknesses and risks of an organization's software process (Paulk 1993). Later revisions have included an adaptation to suit infrastructure projects, but according to Jia et al. (2011) these have been adapted adequately. Additionally, the evidence base by which many maturity models are based have been characterized as thin (Grant and Pennypacker 2006).

60.3 Concluding Remarks

This paper has attempted to show the complexities involved in the term capabilities as it relates to public construction clients. The number of capabilities that are relevant to consider in discussing public construction clients are numerous in length and cover a wide range of disciplines, from the technical to the psychological. Although there appears to be a unanimous agreement in regards to the importance of both acquiring and further developing client capabilities, no all-encompassing method seems to exist for that purpose.

This might be explained on the ground that projects in construction have a unique component to them, a structure often characterized as loosely coupled (Dubois and Gadde 2002). In addition to this, dynamic capabilities are also typified by their uniqueness with respect to how they manifest from one organization to another

(Teece et al. 1997). It seems therefore that the problem becomes double folded in the case of developing dynamic capabilities for public construction clients, who after all, function in both a highly uncertain and highly complex environment.

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Chapter 61
Implications of Cost Overruns and Time Delays on Major Public Construction Projects

Abderisak Adam, Per-Erik Josephson and Göran Lindahl

Abstract For decades, the construction industry has been characterized by costs exceeding budgetary limits and completion times reaching further than what was set out initially. This has been particularly noticeable for large public construction projects where cost overruns and time delays have long been regarded a common occurrence. Due to the magnitude and frequency of these overruns, they have come to pose a significant financial risk to both clients and contractors, in addition to the impact exerted on the sustainability of the project. In dealing with this, researchers, auditors and practitioners have suggested a broad range of solutions, ranging from technical and economical to psychological and political approaches. In doing so, the contractor's role has been emphasized whereas the role of the client organization has often been overlooked. This paper which is based on a literature review investigates the occurrence of and the explanations for cost overruns and time delays in major construction projects from the public client's perspective. It also explores the implications of cost overruns and time delays; the purpose of which is to offer an extended understanding of the relationship between the client's actions and effects on cost, time and sustainability parameters.

Keywords Cost overruns · Time delays · Infrastructure · Sustainability

61.1 Introduction

For decades, the construction industry has been plagued by cost overruns (Akinci and Fischer 1998). Unrelenting in its severity, the mere mention of a construction project by media outlets, especially infrastructure projects of considerable size, has become more or less tantamount to costs exceeding budget and completion times reaching further than what was set out initially (Morris 1990; Raftery 2003;

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Siemiatycki 2009). The public's perception can hardly be deemed unwarranted as made evident by the staggering number of projects that go beyond budgetary limits. According to a study by Baloi and Price (2003), a sizable majority (63 %) of 1778 construction projects funded by the World Bank exceeded their budgets.

The case is further aggravated when it comes to large infrastructure projects such as rail and road construction in which Skamris and Flyvbjerg (1997) reports that a large share of such projects exceed their initial budgets with cost increases of 50–100 % being commonplace and increases beyond 100 % not unheard of. In stating these figures, Flyvbjerg et al. not only shed light on the severity of the problem, but also its global implications. The data upon which the study is based has been gathered from a range of different geographical locations, spanning five continents, 20 countries, both developed and developing nations, from late 20s to the late 90s. This shows that the challenge of cost overruns is clearly a global phenomenon and although there are minor differences depending on the geographical location, the problems persist in every continent. The situation is even more dire in the developing world where corruption carries a significant impact on actual costs and accounts for 10–30 % of the value of a single construction contract (World Bank 2012).

More significantly, while there has been strong interest in sustainability as it relates to urban development, there's been a lack of clarification as to what constitutes as sustainable in the public construction context, most notably in relation to infrastructure projects. Questions regarding how sustainability can be quantified and the key contributors of sustainability in the urban context have all, to a large degree, been left undealt with KPMG (2012).

61.2 Research Methodology

This paper explores the impact that cost overruns and time delays exert on the sustainability of large public construction projects. In particular, the study focuses on uncovering the causes underlying cost overruns and time delays in large public construction projects; these causes are subsequently examined in relation to their impact on the projects' sustainability.

Though the study encompasses large public construction projects in general, the lion's share of projects covered in this study relate primarily to infrastructure projects as these are the most prevalent type of large scale public projects discussed in the research literature.

In order to investigate the aforementioned research objectives, a literature study was carried out. The literature covered consisted predominately of empirical studies discussing cost overruns, time delays and sustainability in public construction projects.

61.3 Literature Review

This section describes the challenges that cost overruns and time delays pose on large scale public construction projects and how these challenges impact the sustainability of the projects.

61.3.1 Reining in Expenses—Cost Overruns and Public Construction Procurement

Jahren and Ashe (1990) demonstrated the existence of a correlation between project size and cost overruns showing that the larger the construction project is, the greater the percentage cost overrun will be. Similar results were obtained by Shrestha et al. (2013) who in a study of 363 public construction projects found that a greater project size resulted in more substantial cost overruns. These projects, often referred to as mega projects, are defined in terms of their expensiveness, physical nature and their impact on society leading to increased public attention (Altshuler and Luberoff 2003). Various estimates are used as a criterion for what constitutes a mega project, The U.S Federal Highway Administration (FHWA 2004) state that projects in excess of $1 billion can be considered mega projects, other common estimates include half a billion U.S dollars (Flyvbjerg 2004) and 250 million U.S dollars (Altshuler and Luberoff 2003).

Flyvbjerg makes the case that the definition of a mega project differs depending on the geographical setting, thus what might constitute a mega project in a more rural area might not be considered as such in a metropolis (Flyvbjerg 2004). Though there appears to be a strong indication that a large project size will yield higher cost overruns, conflicting views have also been reported. Odeck (2004) investigated cost overruns in exclusively road projects showing that smaller project sizes contributed to lower cost overruns than larger ones, an observation that Odeck attributed to larger road projects having been under better management than their smaller counterparts. Although Odeck does not offer an explanation for the contrary results, Cantarelli et al. (2010) proposes that the conflicting results may be due to the small sample size of large projects listed in that study.

The passing of time seem to have had little effect on curbing cost overruns. Instead, the trend has marched towards the undertaking of larger and more costly projects; "never" remarks Flyvbjerg (2007, p. 3) "have so many expensive, large-scale projects been built over so short a historical period which consequently entails significantly higher economic risks." On a similar note, Shrestha et al. (2013) could not find any correlation between project completion year and cost overruns, suggesting that the situation was not improving over time. These findings run contrary to those by Randolph et al. (1987) who indeed did establish a correlation between project completion year and cost overruns. The differing results were attributed to whether or not the construction planning systems had been significantly altered during the time period in question. In the study by Shrestha et al. (2013), the construction practices in the studied region had not been changed significantly over the time interval studied and for that reason; the cost overrun figures saw no drastic variation. It may also suggest something entirely different. Granted that both the construction technology and the techniques for estimating costs have improved with time, the observation that level of cost increases still persist may instead suggest that the root of the problem is not engineering nor accounting but rather in the realm of politics (Altshuler and Luberoff 2003).

Furthermore, price increases have been identified by both governmental agencies (The Swedish National Audit Office 2010) as well as by researchers (Morris 1990; Mosey 2009) as one of the chief causes for cost overruns. Morris (1990) argues that approximately 20–25 % of all cost overruns can be attributed to price increases. The remainder can be traced to different factors of which the most important are: poor design and implementation, inadequate project funding, bureaucratic indecisiveness and the lack of coordination between enterprises. This view is not necessarily shared by project managers as shown in a study by Brunes and Lind (2014) in which it was found that the majority of the respondents in the observed sample size of 101 project managers were either unsure (32 %) or opposed (48 %) to the idea that price increases was a [common] cause of cost overruns. In addition to the factors mentioned above, the time to deliver the project will also affect whether or not cost overruns will occur (Morris 1990).

The many intricacies of construction projects allow for a large number of cost increasing causes to emerge, thereby elevating the risks and uncertainties involved. The trend toward larger projects with increased complexity results in greater cost and schedule variations which in turn produces unsuccessful ventures (Abdelgawad and Fayek 2010).

In order to appropriately discuss the large plethora of causes, it becomes necessary to categorize each cost with respect to a specific domain. This is what Cantarelli et al. (2010) set out to do in a review of some of the most prolific reports and papers that deal with explanations for cost overruns. The authors conclude that the general consensus of researchers showed that political explanations constituted the primary source for cost overruns in large infrastructure projects. Included in this category were cost underestimation and forecast manipulation that were also identified as primary causes (Cantarelli et al. 2010). This forecast manipulation occurs as a byproduct of incorrect assumptions about traffic flows.

Having established the occurrence of incorrect forecasts, Wachs' (1989) proposes a number of explanations to account for the phenomenon, most notably; that planners are either intentionally producing inaccurate forecasts or the tools to produce these forecasts are inadequate insofar as their utility to produce accurate estimations. In regards to the first point, Wachs' asserts that data is fudged in order to support a more politically sound narrative by using traffic flows that are not representative of the proposed area and in some cases, the figures are downright fabrications. The lack of ethics can in certain cases cause planners to produce estimates that support a predetermined goal, disregard weaknesses in estimations and find consultants who are willing to produce such numbers, disavowing those who refuse.

In general, causes for cost overruns can be attributed to political, economic, technical or psychological causes. Moreover, each category involves a different explanatory narrative and should therefore be dealt with a different and suitable theoretical model. Whereas political explanations can be explained by Machiavellian theory (focuses on power and influence) or agency theory (focuses on motives based on self-interest), technical explanations may be explained through planning and forecasting theory. Likewise, economical explanations necessitate economic theories such as neoclassical economics or rational theory whereas psychological explanations fall under prospect theory (Cantarelli et al. 2010).

In a Norwegian study of road constructions, it was shown that cost overruns tended to rise when the planned completion time was shorter. A number of explanations to this were considered; it may be that uncertainties decrease when project time increases as cost predictions become easier to formulate. It may also be due to the project management team improving their ability to oversee the chief causes of cost overruns which in turn is facilitated by the lengthier project time (Odeck 2004). Though a planned completion time that is short in duration is advantageous in terms of cost overruns, a lengthy planning process is not. Overly complicated and lengthy planning initiatives have become standard in both OECD countries as well as non-members nations (OECD 2007). This is certainly the case in the Swedish transportation sector where overly complex planning processes has been identified as a central problem in domestic infrastructure projects (The Swedish National Audit Office 2010). A common response to this is to emphasize initiatives that serve to increase the capabilities of the client organization in handling projects of such complexity.

This line of thought is most vividly expressed by auditors who have been assigned to investigate the causes and remedies of cost overruns (Siemiatycki 2009). Unlike researchers who have studied the phenomenon of cost increases in construction and transportation, auditors have had the benefit of an inside view from inside the governmental client organization lending them greater access to internal data. Consequently, this inside view has shaped their understanding of both the causes for cost overruns as well as possible remedies to alleviate the situation. Researchers, on the other hand, have largely been outside observers and thereby been able to broadly define the mandate of their studies and to take on an interdisciplinary approach. This approach has emanated in researchers focusing on the need for developing technological processes, uphold incentive structures that rewards accurate cost estimations and that discourages optimism bias (Siemiatycki 2009).

61.3.2 Curbing Time Delays in Public Construction Projects

In similitude to cost overruns, scheduling delays for construction projects are a common occurrence (Anastasopoulos et al. 2012). In order to mitigate the risk of time delays occurring, a number of contractual schemes can be put in place such as the use of liquidated damages. It is not uncommon for a provision to be included in the contract stating that punitive damages must be paid by the contractor to the client in the event of a time delay for which the contractor is responsible. In general, such delays do not necessarily result in liquidated damages (Bordat et al. 2004). Likewise, not all delays can be attributed to the contractor. Scheduling delays are typically divided into: (a) excusable delays; (b) compensable delays; and (c) non-excusable delays. The first category refers to delays in which neither the client nor the contractor can be assigned blame, typically a force majeure clause is included in the contract to addresses this. Compensable delays are those where the contractor is owed a compensation for delays caused by an unwarranted course of action taken by the client. This might consist of changes in the scope of the project or change of site conditions that differ from what the client stated. Nonexcusable delays refer to delays caused by the actions or lack of action by the contractor and where the client may be subject to compensation from the contractor (Kraiem and Diekmann 1987).

It may be of interest to note that a considerable amount of research has been conducted investigating the cause behind nonexcusable delays, a focus on the contractor's role and not the client's (Majid and McCaffer 1998). The classification of delays into the aforementioned groups, though useful, does not necessarily offer a complete account of time related complications. Instead, as Arditi and Pattanakitchamroon (2006) points out, there are several different situations in which it becomes difficult to assign the cause of a delay to a specific party. This in turn renders it difficult to enforce legal ramifications in terms of which party should compensate the other. This is particularly palpable in the case of concurrent delays, a type of project delay whereby two or more delays occur simultaneously, either of which would have caused the entire project to exceed the time limit had it occurred by itself (Rubin 1983). In order to mitigate the occurrence of time delays managers must first be able to identify the lead causes behind time delays as this constitutes an essential step in finding a suitable solution. To achieve this, Majid and McCaffer (1998) analyzed eight studies involving over 900 construction organizations in order to identify 21 factors that contributed to delays in completion times.

Following this, the authors ranked each factor in terms of the impact that it exuded on the project's duration. Most notably: late deliveries, damaged goods and poor planning were identified as the most influential factors in causing time delays (Majid and McCaffer 1998). A common manifestation of poor planning is the occurrence of change orders. It offers an indication that events did not pan out as originally intended and tends to lead to both longer completion times as well as increased cost due to the purchase of new materials. Similarly, Josephson et al. (2002) highlight how rework has become an endemic occurrence in the world of construction, causing both cost overruns and time delays.

Despite this being the case, it may not be entirely feasible to eliminate change orders and rework altogether for as Bordat et al. (2004) points out, few construction projects are exempt from the advent of unforeseen circumstances and projects are therefore rarely completed without changes from the owner. Instead, efforts should be taken to minimize the frequency by which they occur.

The high risk nature of the construction industry serves to obfuscate the driving forces behind cost increases (Akinci and Fischer 1998). Specifically, it becomes difficult to assign responsibility to the actor who primarily caused the surge in costs. It thereby becomes possible for different interpretations to emerge as different groups of stakeholders assign blame to divergent causes, an observation made palpable by Kumaraswamy and Chan's (1998) study documenting the different viewpoints of contractors, consultants and clients in regards to the source of cost overruns. The survey based study found wide disagreements among the 147 respondents in regards to the type of factors that causes time overruns in construction projects. According to the response by contractors, the chief causes for delays were due to postponements in design information, lengthy duration for approving drawings and inadequate site management. Conversely, consultants attributed delays to primarily unforeseen ground conditions, inadequate contractor experience and poor site management and supervision.

Furthermore, the length of the delay is also dependent on the type of project undertaken. Maintenance projects generally experience the most severe time delays (Bordat et al. 2004). This may seem counterintuitive as pointed out by Bhargava et al. (2010), maintenance projects are after all fairly standardized and one might then expect them to be less prone to cost overruns and time delays. On the contrary, road maintenance projects are frequently associated with unpredictable and unforeseen site conditions that often require the relocation of utilities and redirection of traffic flow which in turn tends to result in significant time delays.

Whereas maintenance projects were most problematic in terms of time delays, Bordat et al. (2004) found that bridge and resurfacing projects were consistently better with respect time delays (one average 94 and 101 day respectively, compared to 153 days for maintenance projects). In similitude to cost overruns, the more expensive projects tended to result in more significant time delays.

61.3.3 Relationship Between Time Delays and Sustainability

Sustainability in construction is a comprehensive topic with many different facets; it includes a range of topics from air, water and noise pollution to ecological impacts (Shen et al. 2007). Time delays have a direct impact on sustainability since an increase in project delivery time is associated with traffic congestion, delays, economic activities being disrupted, increased pollution, damage to ecosystems, and an impact on existing infrastructure systems (Gilchrist and Allouche 2005).

Table 61.1 Causes of client related cost overruns and time delays in construction projects

Root cause	Study type	Cost overruns	Delays
Communication • Lack of communication between contractors and clients • Inefficient communication	Qualitative Quantitative		(Majid and McCaffer 1998) (Chan and Kumaraswamy 1997)
Management • Poor site management • Inadequate managerial skills • Poor monitoring and control • Slow decision making	Qualitative Quantitative	(Cantarelli et al. 2010; Morris 1990)	(Majid and McCaffer 1998; Morris 1990) (Chan and Kumaraswamy 1997; Anastasopoulos et al. 2012)
Personnel • Shortage of managerial and supervisory staff • Shortage of skilled labor • Lack of experience • Low motivation • Too many responsibilities	Qualitative Quantitative		(Majid and McCaffer 1998) (Chan and Kumaraswamy 1997)
Organizational • Unsuitable management structure • Poor organization structure	Qualitative Quantitative	(Cantarelli et al. 2010)	(Chan and Kumaraswamy 1997)
Planning • Client initiated change orders • Inadequate design specs • Rework • Poor labor planning	Qualitative Quantitative	(Cantarelli et al. 2010; Morris 1990) (Jahren and Ashe 1990)	(Majid and McCaffer 1998; Han et al. 2009; Morris 1990) (Chan and Kumaraswamy 1997)
Site conditions • Unforeseen ground conditions	Qualitative Quantitative		(Han, et al. 2009) (Chan and Kumaraswamy 1997)
Weather • Harsh weather conditions	Qualitative Quantitative	(Bhargava, et al. 2010)	(Chan and Kumaraswamy 1997; Bhargava et al. 2010; Anastasopoulos, et al. 2012)

(continued)

Table 61.1 (continued)

Root cause	Study type	Cost overruns	Delays
Project related • Project complexity • Project duration	Qualitative Quantitative	(Bhargava, et al. 2010; Bordat et al. 2004; Odeck 2004; Jahren and Ashe 1990)	(Chan and Kumaraswamy 1997; Bhargava et al. 2010; Bordat et al. 2004; Anastasopoulos et al. 2012)
Material related • Shortage of equipment • Poor material planning	Qualitative Quantitative		(Majid and McCaffer 1998) (Chan and Kumaraswamy 1997)
Process related • Poor procedures	Qualitative Quantitative	(Siemiatycki 2009)	(Majid and McCaffer 1998)
Psychological • Optimism bias • Deception	Qualitative Quantitative	(Flyvbjerg et al. 2009; Flyvbjerg et al. 2003; Cantarelli et al. 2010; Siemiatycki 2009)	
Financial • Delayed payment to contractors/consultants • Poor financial planning	Qualitative Quantitative		(Majid and McCaffer 1998)
Price related • Price increases	Qualitative Quantitative	(Mosey 2009; Morris 1990) (The Swedish National Audit Office 2010)	

61.4 Discussion and Conclusion

This section contains an abridged list of the most common causes behind cost overruns and time delays in public construction projects, based on prevalent research literature on the topic. Though some factors are more frequently mentioned than others, this does not necessarily imply that they are more influential in determining the scale of the cost overruns and/or delay. Indeed, the frequency by which a particular cause is mentioned may instead offer an indication of it being easily observable as opposed to having a greater impact (Table 61.1).

The results in the table do not take into account factors that are outside of the control of the client, for instance the lack of communication between contractors and consultants which does have an impact on cost overruns and time delays (Chan and Kumaraswamy 1997). However causes such as this does not relate directly to the client organization and are therefore omitted.

It ought to be mentioned that the above categorization is merely a simplification and that the causes determining cost overruns and time delays often intersect

(Bhargava et al. 2010). For instance, it may be argued that rework is a subset of improper planning and that deception is an indication of bad hiring policies. In understanding the underlying causes, it may therefore be prudent, like Cantarelli et al. (2010), to distinguish between causes and explanations. The former consist of the singular factors resulting in an effect (i.e. cost overruns and/or time delay) whereas the latter attempt to offer a broader and more general description of what may have transpired that led to the subsequent effect. An explanation could therefore consist of several causes. This is illustrated well in the case of sustainability; take the case of a construction project that causes severe disturbances to the local milieu through excessive amounts of noise and congestion. It may be as Majid and McCaffer (1998) suggest that the cause can consist of improper planning which in turn is an indication of either inadequacies in the organizational structure that allows for such decisions to be made and/or the shortcomings of individual personnel assigned to the project. Irrespective of the first cause identified, other causes can be introduced to form a descriptive narrative. Thus, two projects may have the same primary cause determining a cost overrun or time delay but still have differing explanations. Each explanation is unique and path dependent to the project being studied and can therefore not be directly transferable to a different project.

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Chapter 62
Principal Agent Problems Evident in Chinese PPP Infrastructure Projects

Asheem Shrestha and Igor Martek

Abstract The demand for infrastructure remains high in China. In order to meet this demand under conditions of limited government funding availability, local governments have increasingly sought private participation through 'public, private partnerships' (PPPs). While PPPs are recognised as a reliable mode for delivering infrastructure projects, agency problems are also known to interfere with their success. The nature of these agency problems, along with the types of partnership arrangements under which they occur, is the subject of this research. Semi-structured interviews were conducted with PPP consultants working on infrastructure projects in China. Results suggest that opportunistic behaviour is to be found both within the private sector and within the government sector. While the private sector is shown to take advantage of 'information asymmetries,' the government sector is shown to allocate project risks and responsibilities disproportionately in their favour. Results also indicate that PPP arrangements between local government and 'state owned enterprises' (SOEs) were less prone to agency abuse, while agency problems in PPP arrangements between local government and private firms were relatively greater.

Keywords China · Principal agent theory (PAT) · Public private partnerships (PPPs)

62.1 Introduction

China's economy began to open up under Deng Xiaoping, in 1978. Since that time to the present China has grown at an extraordinary pace, displacing first Germany, and then Japan, to become the world's second largest economy behind the US. This

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growth has been largely fuelled by the manufacturing sector. In turn, growth in manufacturing required massive investment in infrastructure to support it. Initial infrastructure was financed by large capital reserves held by government. These projects were delivered through traditional tendering techniques where the role of project provider was limited to project delivery according to a contracted cost. Here, the financial viability of the project along with its operating risks were left entirely in the hands of the state procurer. In short time, however, as available government funding sources began to dry up, while government appetite for projects has not, Chinese government agencies have turned to Western models for attracting private participation in the longer-term investment, risk-sharing, and on-going management of these projects. The most ubiquitous of these is the 'public, private partnership' (PPP) model, now widely adopted throughout China. In short time, however, alternate financing sources were needed, and China looked to the west to absorb its lessons in PPP infrastructure procurement. Despite occasional lulls, such as in 1999 and 2010, private participation in infrastructure in China has remained high. See Fig. 62.1. In recent years it has been argued that China is now saturated in infrastructure and that further investment may be increasingly difficult to justify. Nevertheless, provincial and local governments remain competitive in outperforming each other on growth indicators. This climate continues to encourage infrastructure investment, but puts more pressure than ever on governments to ensure that any such investment delivers in terms of cost, quality, investment priority and performance.

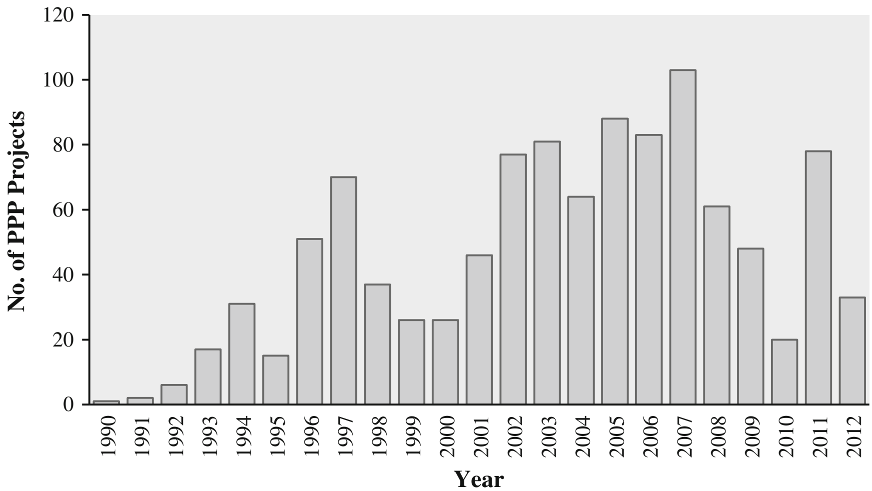

Fig. 62.1 Number of PPP projects in China by year (adapted from private participation in infrastructure database, http://ppi.worldbank.org)

62.2 Principal Agent Problems in PPPs

Essentially, ‘principal agent’ problems arise when a supplier is contracted to provide a service to a consumer, where it is actually not in the providers’ interest to deliver the service to the standard or in the manner that the consumer would want. A simplistic example would be that by cutting corners in quality or other standards that ultimately may compromise a project being delivered to a consumer, the provider is able to pocket the cost difference and so increase their own profit. The dilemma of PPP project procurement is that while private participation off-sets procurer cost burdens, it also puts the private partner in significant control of the whole project, inviting actions that siphon off benefits to themselves at the cost of the procurer, whose interests they are supposed to serve. The principal agent problem is recognized as real and significant (Greiling 2009). Since infrastructure projects remain in demand and since private participation in the financing of these projects remains necessary, understanding the nature and character of principal agent problems that arise in the procurement of infrastructure projects is a key first step in managing their debilitating effects.

Several past studies have investigated the principal agent theory (PAT) in PPPs. For example, Hart (2003) and Greiling (2009) use the PAT to look at transaction costs in PPPs. Others like De Palma’s et al. (2009) and Shrestha et al. (2013) have used PAT to look at risk allocation. Mu et al. (2010) explore strategic behavior of the private sector in PPP transport projects in China where they find moral hazard problems. In all these studies, the government is taken to be the principal who hires the private sector as the agent in PPP projects and agency problems are identified as arising from information asymmetry that is maintained as a result of an environment of conflicting interests. Both parties to PPPs use undisclosed information to gain advantage over the other in matters such as risk allocation and pricing.

The importance of safeguarding public interests in PPP contracts has also been pointed out in the literature. Public interest is treated as something which promotes the general welfare and is synonymous with public policy (Bloomfield 2006; Buxbaum and Ortiz 2009). In PPPs, it can be assumed that the main goal of the government is different to that of the private sector. Though PPPs are defined as partnerships, some aspects of PPPs do not sit within the traditional norms of partnerships where the two partners work together in achieving the same goals and where the profits as well as risks are shared (De Palma et al. 2009). The government may implement PPP projects for the purpose of improving social benefits and economic development. Private firms will not share these goals as a priority and are motivated by profit, and consequently may focus more on innovation and efficiency. On the other hand, private firms may also favour reducing short-term expenses which can lead to cost-cutting and reduced outcomes (Amagoh 2009).

Assuming a principal agent relationship between an informed agent and an uninformed principal, the principal agent theory (PAT) highlights two problems: (1) Adverse selection, and, (2) Moral hazard (Oudot 2005). Adverse selection occurs when the principal selects the agent that may not be the best for the contract. The problem arises when the principal is unable to correctly determine the ability of the agent, either at the time of selection (ex-ante) or while the agent is under contract (ex-post) (Amagoh 2009). A moral hazard is a situation in which an agent may act opportunistically and in such a manner that their own goals are met at the expense of the principal's goals, which the agent was in fact contracted to fulfil (Laffont and Martimort 2002). Moral hazard cannot easily be observed by principals where there is a lack of information available to them.

Mainstream PAT identifies the principal as being further from the project than the agent entrusted to bring it about, and consequently more vulnerable to abuse from the agent as a consequence of project related informational asymmetry. The goal, therefore, of PAT is to seek strategies to satisfactorily resolve principal-agent conflicts from the principal's perspective. This paper acknowledges that tradition and contributes to the discussion by identifying specific agent related problems with PPP projects in China.

However, according to De Palma et al. (2009), one of the drawbacks of applying PAT in PPPs is that it ignores the opportunism that may arise from the principal. The problems associated with government opportunism can have marked undesirable effects, not just on the project, but also on government's social agenda. Spiller and Savedoff (1999) find that government opportunism is the main reason for reduced performance in water utilities. Mu et al. (2010) finds some government officials misuse their power by favouring their 'pet projects' in PPP toll roads. Consequently, principal related problems need to also be identified, and this is considered in this paper as well.

62.3 Methodology

The approach taken in this investigation is qualitative, since the aim is to uncover the nature of principal-agent issues that exist in Chinese PPP infrastructure projects. A semi-structured interview method was adopted. This method is generally regarded as appropriate to uncovering the range and breadth of issues related to a problem. The method allowed the participants the freedom to express their views in a non-rigid manner while the framework of the interviews provided reliable, comparable qualitative data for the analysis. PPP consultants were specifically chosen for the interviews, as these people are not only recognised as experts in the field, but as representatives of local governments in writing and negotiating PPP contracts. They are ideally in a position of recognizing the challenges in bringing the public and private sectors together on projects. The information they provide can moreover be expected to be free of conflicts of interest and any resulting bias.

Candidates were initially identified through personal contacts, with further subsequent candidates being nominated by industry insiders; a sampling technique described as 'snowballing.' The interviewees were chosen based of their degree of experience in the PPP infrastructure industry. The final list of eight interviewees were all PPP consultants with a senior role within their organisation, and with at least 5 years' experience within the PPP environment.

The semi-structured nature of interviews allowed the interviewees to explain their ideas in detail and focus on the issues that were of greatest concern to them. Discussions included problems related to information asymmetry and opportunism in and across different PPP projects throughout China. Problems associated with adverse selection and moral hazard was also investigated. Questions were also asked with the intention of exploring these issues from the perspective of both the principal and the agent. The interviews were recorded and the audio recordings and transcript of the interviews were analysed.

Following 'the basics of qualitative research' (Strauss and Corbin 1990), references were classified according to general characteristics and grouped into dominant concepts or ideas. Data was coded based on the repetition of ideas, the interviewees' emphasis regarding certain concepts, along with topics previously identified in the literature. The recorded codes and themes became inputs to the analysis and from this; a cohesive story revealing the problem parameters of PAT with respect to Chinese infrastructure PPP projects was developed.

62.4 Result and Analysis

62.4.1 The Problem of Identifying the Best Agent

During procurement, it is the government's responsibility to select the best agents and to ensure that adverse selection does not occur. To do so, governments need to collect appropriate and accurate information with respect to potential agents in order to determine their capability as well as their credibility. Through competition, governments can determine which agents are willing to take on more risks with more efficiently. However, before this can happen, the public sector also needs to provide information to potential agents regarding the project. Without that information—correct and complete—bidders cannot fully determine what the risks are and what their response will be. When the agent is selected and when risk allocations are negotiated, information regarding all aspects of the project in the possession of both parties needs to be shared in order to minimise information asymmetry.

Interview results revealed that there is are no formal procedures regarding the release of information from the government before the procurement notice is released on PPP projects. The bidders only get information quite late. During procurement, the private companies primarily get information regarding the project through tendering documents, pre-bid conferences or 'clarification conferences' held by governments, project information documents for potential bidders, onsite visits etc. During bidder selection, governments depend on the information regarding the private company provided solely by them through bidding documents.

In only a minority of cases are the private company's credentials investigated in any detail at this stage. Even so, there is no clear policy or process regarding how to investigate the capability of bidders. Usually, bidder pre-selection is based on track record and experience. There are normally two types of administrative arrangements for tender evaluation in PPP projects. The first is to set up a separate tendering office, which is formulated jointly by the construction commission, planning commission, fiscal and auditing bureau, and other relative departments, and with the construction commission representative fulfilling the leadership role of this office. The second option is to employ an agency that is entrusted with the whole tendering process. Most interviewees suggested that where the government does not have the experience or competent level of knowledge regarding PPPs, the second option can be more beneficial.

Adverse selection can also result from a lack of ex-ante competition. After all, the main reason for administering competition is to recognise and select the best agent; and in so doing, avert adverse selection. According to the findings, bidders are not always selected with reference to the information governments have in hand. It is not uncommon that the information available is not properly scrutinised, with decisions sometimes being made without undergoing a formal process, while sometimes the backgrounds of private bidders are simply not thoroughly investigated.

The tender law issued by the central government in China in 1999 has made it mandatory for projects that include large scale construction, as well as projects of a public utility nature, to undergo bidding. The aim of the law is to ensure and enhance competition. However, results suggested that, in many cases, competition for PPP projects in China remain uncompetitive. The unfair allocation of contracts is due to a range of unethical practices, including bribery, nepotism, conflicts of interest, collusion (between the government and the bidders) and breaches of confidentiality. Bribery occurs when government officials accept benefits or gifts from the private bidder, and in return favour that bidder during bid evaluation. Nepotism is related to public officials abusing their powers to award the bid to someone they favour. Breach of confidentiality occurs when officials intentionally provide secret bidding information to certain private bidders in order to help them win. The findings also suggest that the cost of gifts would be incorporated by the bidders into their project costs if and when they won the bid, and consequently bidders would expect a higher project return to offset these costs.

Interviews suggested that information asymmetry is widespread, with government failing to systematically collect information on projects, at both the construction and operational phases. This lack of scrutiny creates disincentives for the private sector to perform efficiently. The accountability and disclosure problems can be exacerbated when more than one government department is involved. It would seem that the boundaries of responsibility between government departments are not always clearly defined and that they sometimes overlap. Such overlap can result in intra-government information sharing problems, which in turn can lead to internal informational asymmetries, jurisdictional and policy conflict, as well as higher transaction costs. Worse still, it also may be the case, in certain circumstances, that no government department takes oversight control of certain aspects of a project, or the monitoring of agent performance.

62.4.2 The Problem of Managing Information Asymmetry

Moral hazard can be a result of opportunism of the agent in an environment of information asymmetry. This study identified a range of opportunistic behaviour carried out by the private sector that would lead to moral hazard problems. Opportunism by agents can occur both ex-ante and ex-post. In particular, the private sector rarely provides complete and accurate information to the government regarding their actual profit. With the imperative to maximise profits, private companies in PPP projects in China try to cut costs. In order to do so, they may look for ways that ultimately result in the compromise of project quality, both during construction and operation. Where the government does not have the resources or motivation to monitor the performance of the private sector, such behaviour can go unchecked and moral hazards will flourish. Interviews suggested that the private sector systematically hired the cheapest subcontractors to order to save costs, and that such an approach created major risks in PPP projects. This was found to be especially the case with PPP toll roads. In PPPs in the water sector, where the water output quality needs to be regularly monitored during the operation stage, the moral hazard problem associated with lowering the quality in the absence of a suitable information monitoring system was also common.

Another form of common opportunistic behaviour was ‘lowballing.’ This occurs in PPP projects during the tendering stage. Effectively, an agent puts in a ridiculously low bid, designed simply for the purpose of being unambiguously awarded the contract. However, once the contract is awarded, and the other competitors effectively removed from the stage, the agent then begins to renegotiate the contract to achieve favourable terms. This approach leads to project ‘hold ups’ where time is on the side of the agent, and not on the side of the principal. According to Kumar (2009), when the private sector can induce possibilities of renegotiation, they have strong incentives to submit bids containing promises difficult to satisfy where the sole purpose of those promises is to guarantee a winning bid. This study found similar behaviour from agents in the Chinese PPP projects. Private companies were found to try to re-negotiate the contract in their favour ex-post when they had strong bargaining power. In fact, this was a found to be a particularly common practice among powerful stage owned enterprises (SOEs). The corollary is of course that where the principal has full information, and scrutinises bids closely, they will be in a better position to discover ‘lowballing’ strategies and test the authenticity of presented bids.

Interviews also shed light on a type of opportunism of the private sector which has been described as ‘land strategies.’ Land is a valuable asset in China and some private companies bid for PPP projects mainly to gain control of the land associated with a project. Agents may appraise a project's attractiveness on the basis of further projects that could be opened up once the land is secured. Once the project is underway, the private company will then negotiate unsolicited proposals with the government to develop those other projects on that land. This type of agent opportunism has been seen in several PPPs, and should raise serious concerns.

Interestingly, our findings also indicate that for some private companies, the main reason they get involved in PPPs is to gain easier access to loans from commercial banks. Commercial banks may be instructed to offer preferable loan conditions to agents in the service of government projects, or simply see long term PPP projects as stable and therefore less of a lending risk. Moreover, it was also revealed that some private companies bid for PPP projects on the basis that certain projects are viewed as assets that may inflate stock prices. Securing high-profile projects may also make it easier to raise capital at lower costs on the finance markets.

62.4.3 The Problem of Minimising Political Risk

Though the principal agent theory of literature focuses on the opportunism of the agent, interview results clearly indicate that opportunism arising from government officials is also a major problem in PPP projects. Opportunistic behaviour on the part of the principal in PPP projects thus also need to be considered. Findings suggested that there are two key characteristics shared by principals that regularly emerge as factors adversely impacting PPP project performance. These are governments' lack of technical knowledge, along with their inflexibility in more appropriately allocating risks and responsibilities.

Also strongly highlighted in the interviews was the problem of a lack of credibility of many local government authorities. It was found that even when contracts were well written, government would typically fail to deliver the terms. This background reputation has raised serious concerns among the private sector. Nevertheless, it was also found that local governments from certain regions were more reliable and credible than others. It is generally well known that the developed coastal areas of China, such as around Shanghai, Guangzhou, Beijing and Tianjin have government systems that can be relied on to honour contracts. It is for this reason that many foreign firms tend to cling to PPP projects centred on these coastal regions.

The problem of government credibility contributes to several moral hazard problems. Results were clear that governments are more powerful when it comes to risk negotiation; however, results also implied that the private companies are smarter. Where government credibility is an issue, the agent has a greater incentive to protect itself by creating and maintaining information asymmetry. Government untrustworthiness can thus work against government interests. With the barrier of information asymmetry government will have difficulty monitoring the agent's activities, may recognise its inability to do so and thus lose motivation to try, and ultimately become disengaged. With this withdrawal, the agent wins a disincentive to perform well, or act in the governments' interest. Ultimately, government dishonesty can be shown to lead to agent maximizing self-interest at the government's expense.

The involvement of several government departments in the PPP process, combined with an inadequate legal environment for PPPs in China, creates a volatile climate of political risk. Of these risks, and despite great progress in implementing the 'rule of law' in China, expropriation was still seen as one of the biggest threats to agents partaking in PPP projects in China. It was found that in many cases, expropriation by the government is influenced by the opportunism of government officials. In examining this issue, several reasons for expropriation were identified. Firstly, decisions to implement PPPs are made when local governments lack the needed funding. It is for this reason that the private sector is often lured into taking part in government sponsored projects. However, once the government has the capacity to raise enough funds, projects may be taken back. Secondly, a change in government leadership may also see projects revoked. Newly elected officials may have a tendency to seek legitimacy by removing legacies of a predecessor, and with that, the previous leader's programme of projects. He may then start again with a whole new swathe of projects. Thirdly, SOEs can be predatory in acquiring growth, and with that strategy, look to displace agents already in place on projects. It was mentioned during interviews that over the last five to six years, SOEs have become aggressive in expanding their businesses into the utility sector. They use their resources and relationships to coerce government into reacquiring PPPs from the original bid winners, and to hand the projects over to them. There are several recent examples of PPP toll roads projects being reacquired by municipal governments who have then handed them to favoured SOEs.

Moreover, it was also found that where PPPs have been expropriated by the government sector, there have been several occasions that the private sector was not fairly compensated. While it may be argued that the government's right to expropriate is necessary in order to maintain an incentive for the private sector to perform, it is also important to maintain agent confidence in government that it will follow contractual terms and provide credible commitments. Such assurances depend on well written contracts involving reliable dispute resolution mechanisms. Our findings suggest that in many cases PPP contracts lack a fair compensation mechanism and, when PPPs are terminated, private sector agents are not properly compensated.

Finally, unethical practices by government officials during the construction and operation of PPP projects were also found to be a major issue. For example, corruption can lead to government officials turning a blind eye to the required standards of a project. As a result, the project quality is likely to suffer. According to Guasch et al. (2008) opportunistic behaviour by governments may sometimes be necessary to control the moral hazard problem created by the agent during the ex post stages. This situation can occur when the private sector take actions to hold up' the government to renegotiate the contract in their favour. However, it is also important to realise that when agents can anticipate government opportunism, they will try to protect propriety information as a strategy to protect their future rents (Guasch et al. 2008).

62.4.4 *The Problem of Separating SOE and Government Roles*

A major theme that emerged during the interviews was the relationship between the government and SOEs in PPP contracts. SOEs remain a major player, active in PPP infrastructure procurement. State-owned enterprises (SOEs) in the PRC have been involved in several PPP infrastructure projects, creating a category of public SOE partnerships. Thus, it is necessary to look at them independently. Our findings indicate that fewer principal agent problems arise between the government and SOEs on PPPs as compared to PPPs where local government engages the private sector. In general, interviews revealed that there is more trust between government and SOEs. The interview data explained this as arising because while ostensibly business enterprises, SOEs are understood by its own senior representatives as well as by government representatives proper, as effectively extensions of government. As such, the understanding of all parties is that they are colleagues, playing for the same team, sharing the same aims as government, and motivated to realize government objectives. This was particularly the case when the SOE came from the same provincial or municipal are in which the contract was awarded.

Still, it seems that even though SOEs would have somewhat more incentive to share the goals of the principal, they still behave in similar ways to other private sector companies. SOEs pursue profit maximization and will resort to similar tactics to retain informational asymmetry as do private sector agents in order to do so. In fact, it was also revealed that where local governments went into contract with a powerful SOE, they could simply expect to have that SOE dictate contract terms to them.

62.5 Conclusion and Discussion

China has built its economic growth on the back of a heavy investment in infrastructure. That infrastructure has been largely procured through PPP projects in which government has served as principal and private enterprise contractors, primarily, have served as agents. Such arrangements are inherently problematic since, while the project goal is ostensibly shared, the interests, incentives, and therefore actual goals, of both parties will differ. Principal Agent Theory was developed out of recognition of this paradox. Initially PAT took the principal as more vulnerable in the arrangement and much research work has been done in developing remedies to the exploitation of the principal by agents. The context of China, and in particular the procurement of public infrastructure in China, has been less studied. Here the issues that drive misalignment of incentives on projects are moderated by local circumstances. Moreover, the agent is not in a unique position to take advantage of the principal; sometimes it can be the other way around. What the circumstances are that drive PAT dynamics in China, along with the strategies that are employed by both parties to a PPP project in China to extract advantage, remain less well documented. This paper is an effort to remedy that deficit.

Our findings confirm the existence of adverse agent selection and moral hazards as a symptom of poor PPP arrangements. Specifically adverse agent selection manifests as a consequence of asymmetric information exchange, poor tender evaluation and unethical selection practices. Agent hazards were shown to arise from extreme cost-cutting, dilution of project quality both in building and running, duplicitous renegotiation of contracts, as well as looking to extract further rents from land granted under a project tender. Principal hazards for PPP infrastructure projects in China were revealed to include lack of technical knowledge needed to evaluate bids and on-going performance, inflexibility in allocating risks and resources, lack of credibility in honouring contracts, and finally, tendencies to expropriate projects from agents under conditions of unfair compensation. See Fig. 62.2.

These findings confirm the PAT problems identified in preceding studies. However, they also reveal nuances that have not been appreciated. These features seem to highlight the peculiar characteristics of current PPP infrastructure project

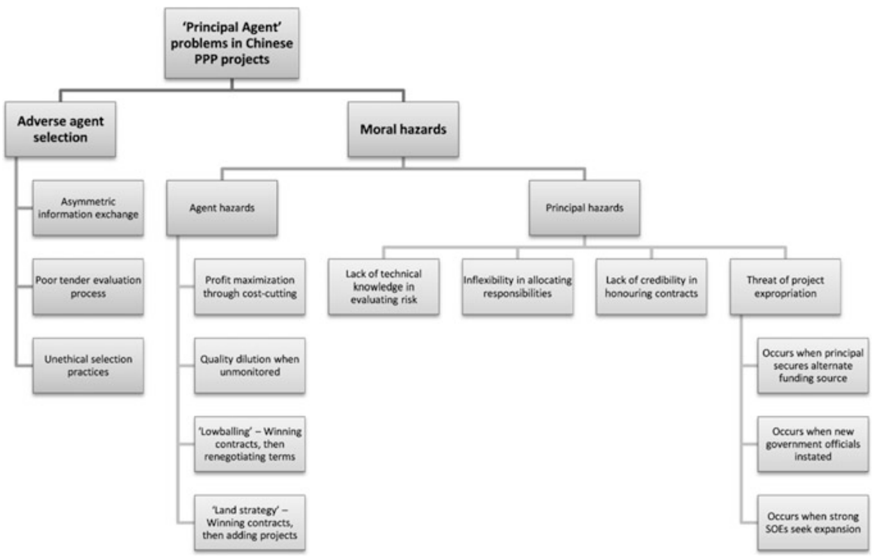

Fig. 62.2 Representation of the 'Principal Agent' problems identified in Chinese PPP infrastructure procurement projects

procurement in China. As such, these findings should better equip practitioners to the challenges of PPP projects, both as principal and as agent. Moreover, these findings may well direct academics wishing to further explore the phenomenon of PAT and the management of PPPs.

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Chapter 63
Evolutionary Game Analysis and Countermeasure Study of Construction Enterprises Safety Supervision in China

Xueqin Zeng and Jianguo Chen

Abstract The increasing complexity and dynamics of construction projects have plagued the construction industry with substantial hazards and losses. Government regulatory departments as the external constraint forces, has been recognized critical for construction safety. This article presents an evolutionary game model of safety supervision to analyze the dynamic evolution tendency and stability of replicator dynamic equation. The results demonstrate that the stable state of construction safety supervision is related to certain key factors, e.g. cost of regulatory procedures, probability of accidents, lost of construction enterprise resulted from accident, penalty strength and cost of safety supervision. To improve safety level of construction enterprises, it is necessary to introduce an appropriate external supervision and restraint mechanism enhancing both sides to control the security risk. Finally, some policy suggestions on construction safety supervising are proposed based on above analyses.

Keywords Safety supervision · Evolutionary game · Replicator dynamic, construction safety

63.1 Introduction

The construction industry, perhaps more than others, has been plagued by various risks often resulting in poor performance with increasing costs and time delay, even project failure (An et al. 2005; Goh et al. 2012). The nature of construction has made it a challenging regime to handle safety risks, e.g. constant change on

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building environment, direct exposure to hazardous sources, high pressure on demanding schedules and costs, and increasing complexity on construction techniques (Sudbury 2001; Han et al. 2014). However, government supervision as the external constraint forces has been recognized critical for the construction industry to improve their performance and secure the success of projects (Huang and Hinze 2006; Zhou et al. 2010; Cheng and Cheng 2011; Cheng et al. 2011). Due to the construction project involves the interests of many parties, safety supervision often can't be effectively carried out. On the one hand, the construction enterprises motivated by profit, may carry out a game between accident risks and economic interests; On the other hand, the local regulatory personnel, may conspire with the enterprises to pursue private interests, thus affecting the effective implementation of safety supervision (Paul and Maiti 2007). Therefore, research on strategy choice behavior of the government regulatory departments and the construction enterprises is helpful to explore the automatic evolution of information from asymmetry to equilibrium (Zeng and Chen 2013).

The current study is mainly focus on the problems about construction enterprises' moral hazard and adverse selection in the non-cooperative game by classical game theory, discussing the root cause of non-systematic risk in safety regulatory process (Zeng and Chen 2013; Qu and Cheng 2010; Shen et al. 2010; Chen 2011; Liang and Zhu 2009). The classic game theory is based on the hypothesis that all the participants in the game are entirely rational, they can find the best strategy to achieve the best state in a game or in a repeated game, obviously in the actual decision-making, which cannot meet the basic assumptions for game participants having diffident wisdom, knowledge and ability to learn (Weibull 1995; Hammerstein and Selten 1994).

Classical game theory has high standard for participants, because of bounded rationality and information asymmetry in safety management cooperation. The evolutionary process of the game equilibrium is very complex, and both sides do not have the ability to calculate the optimal choice. Evolutionary game theory, abandons the hypothesis that all the participants in the game are entirely rational, but considers the participants are limited rational. Evolutionary game theory thinks the behavior adjustment process of the government regulatory departments and the construction enterprises is a dynamic process. In the evolution process of safety supervision system, the two sides of the game can make mistakes, but also constantly modify their behavior rules and strategies through imitation and learning. Therefore, in the evolvement process of safety supervision system from information asymmetry to information equilibrium, it has more advantages and more persuasive by using evolutionary game theory to analyze the dynamic evolution process of strategy choice behavior of the regulatory departments and the construction enterprises.

This paper presents a game model between the government regulatory authorities and the construction companies, studies the participants' strategy choice behavior from the perspective of evolutionary game theory, analyzes the dynamic evolutionary process of stable equilibrium state, and points out the main reasons of China's construction safety problems from the game angle. Finally some policy suggestions on construction safety supervising are proposed at the end of this article based on above analysis.

63.2 Safety Problems in Construction

A labor workforce is a valuable asset to all industries, and determines a region's productivity and economic growth if the best protection protocols for the workforce are in place (Occupational Safety and Health Council, 2001a). The construction industry is a major source of employment in China and plays a vital role in the local economy. However, the industry also suffers from high accident rates, which results in absenteeism, loss of productivity, permanent disability, and even fatalities (Fung et al. 2010; Mohamed 1999; Niza et al. 2008) (see Fig. 63.1).

Although there is a distinct improvement on the safety performance, the construction industry is now still recording an extremely high accident rates when comparing to other industries, and construction industry of other countries. According to statistics, the numbers of deaths and accidents in our construction industry are in third place, only second to transportation industry, mining industry. There are some major reasons for the high accident rate in China.

1. Most construction sites are crowed, which do not have sufficient storage spaces or spaces for auxiliary works. In the construction site, different tradesmen have to work close together within limited spaces. The most frequent accidents include stepping on, striking against or being struck by objects (An Annual Report of the Construction Industry of China in Hong Kong, 2003).
2. High rise buildings remain predominant. Many hazards are associated with working at heights and with the vertical transportation of materials, such as falling objects or the fall of person.
3. Routine violations are habitual departures from the rules and often tolerated by supervision. This may involve behaviors that are established practice as opposed to the specified practice, such as driving 5–10 mph faster than the speed limit. Exceptional violations are neither typical of the individual nor condoned by management (Mitropoulos et al. 2005).

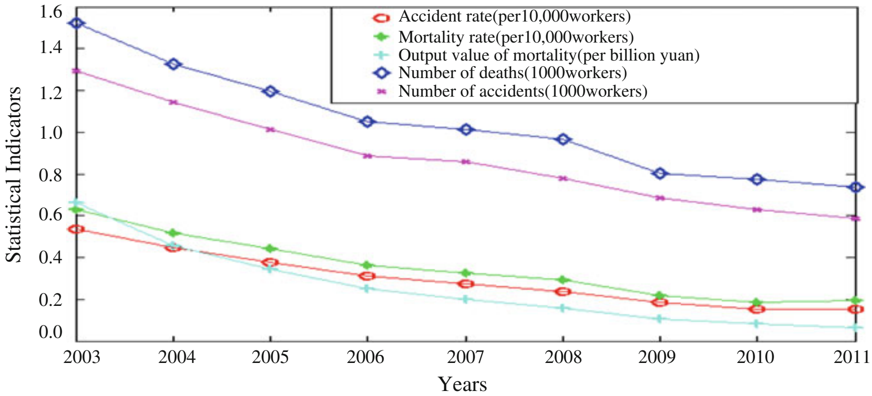

Fig. 63.1 Building industry safety evaluation from 2003 to 2011 based on different indicators in China

63.3 Evolutionary Game Model

63.3.1 Model Overview

Since 1973, Maynard Smith and Price proposed the concept of evolutionary stable strategy; evolutionary game theory has been become the general concern of the theorists. Evolutionary game, the core concept are evolutionary stable strategy (ESS) and copy dynamic (RD).

1. ESS represents a stable state that a population resists mutation strategy, which is defined as follows: when the game participants are random pairing, the payment level of local population members is higher than the intruder. Each game participant has the probability $(1-\varepsilon)$ encountered the participant who selected strategy x, at the same time, the probability ε encountered the intruder. Thus ESS can be defined as:

$$\mu[x,(1-\varepsilon)x+\varepsilon x'] > \mu[x',(1-\varepsilon)x+\varepsilon x'] \tag{63.1}$$

   In the formula, x is a very small positive number.
2. RDE is a frequency differential equation which describes a particular strategy to be adopted in a population. The basic idea is: if a strategy is better than average, then the proportion of those groups who select the strategy will rise in the entire population. The differential equation is generally as follows:

$$\frac{dx_k}{dt} = x_k[\mu(k,s)-\overline{\mu}(s,s)] \quad k=1,\ldots,n \tag{63.2}$$

   In the formula, x_k is the proportion of a population selecting strategy x; $\mu(k,s)$ represents the degree of adaptation selecting strategy k; $\overline{\mu}(s,s)$ represents the average degree of adaptation.

63.3.2 Model Hypothesis

According to the status of our country construction enterprise safety supervision, this paper makes the following hypothesis:

1. There are two limited rational players: construction enterprise and supervision department;
2. Action sets for both sides: construction enterprise A1 = {attach importance to safety management or not}, supervision department A2 = {regulation or not};
3. Both sides have incomplete information;
4. Construction enterprises revenue assumptions: when construction enterprises select to attach importance to safety management, the safety management input

costs is c_1 and the normal profit is i_1, construction enterprises' income is $i_1 - c_1$; On the contrary, when construction enterprises do not pay attention to safety management, the safety management input costs is $c_2 (c_1 > c_2)$, construction accidents probability is p, when the accidents happen the enterprise loss is l which includes the claim paid and payable fine. Building enterprises do not pay attention to safety management will be fined f when found by regulators, and then the profit is $i_1 - c_2 - pl - f$; construction enterprise's profit will be $i_1 - c_2 - pl$ when no regulation.

5. Supervision department revenue assumptions: no matter supervision or not, supervision departments will gain i_2, when the departments select regulation the cost is c, and then supervision departments will gain $i_2 - c$; when no regulation and construction accidents happen, supervision departments will be punished m, and the loss of social reputation for the supervision department is n, the profit will be $i_2 - pm - n$.
6. Assuming that the proportion of construction enterprises pay attention to safety management is x, the proportion of government regulators select safety supervision is y.

63.3.3 Model and Fitness Analysis

Based on the above assumptions, construction safety supervision payoff matrix is shown in Table 63.1.

1. When the construction enterprises choose strategy of safety management, the fitness is:

$$\mu(do) = y(i_1 - c_1) + (1 - y)(i_1 - c_1) = i_1 - c_1 \tag{63.3}$$

On the contrary, the fitness is:

$$\mu(undo) = y(i_1 - c_2 - pl - f) + (1 - y)(i_1 - c_2 - pl) = i_1 - c_2 - pl - yf \tag{63.4}$$

Table 63.1 Payoff matrix of construction safety supervision

Construction enterprise	Supervision department	
	Supervision (y)	No supervision ($1 - y$)
Emphasis on safety management (x)	$i_1 - c_1,\ i_2 - c$	$i_1 - c_1,\ i_2$
No emphasis on safety management ($1 - x$)	$i_1 - c_2 - pl - f, i_2 + f - c$	$i_1 - c_2 - pl, i_2 - pm - n$

Then average fitness for the construction enterprises is:

$$\begin{aligned}\overline{\mu} &= x(i_1 - c_1) + (1-x)(i_1 - c_2 - pl - yf) \\ &= (i_1 - c_2 - pl - yf) + x(yf + pl + c_2 - c_1)\end{aligned} \tag{63.5}$$

Therefore, when the construction enterprises choose strategy of safety management, the replicator dynamics equation (RDE) is as follows:

$$\begin{aligned}\mu' &= F(x) = x(\mu(do) - \overline{\mu}) = x(1-x)(\mu(do) - \mu(undo)) \\ &= x(1-x)(yf + pl + c_2 - c_1)\end{aligned} \tag{63.6}$$

(2) Similarly, when the supervision departments choose monitoring strategy, the fitness is:

$$v(do) = x(i_2 - c) + (1-x)(i_2 + f - c) = (i_2 + f - c) - xf \tag{63.7}$$

On the contrary, the fitness is:

$$v(undo) = xi_2 + (1-x)(i_2 - pm - n) = (i_2 - pm - n) + x(pm + n) \tag{63.8}$$

Then average fitness for the supervision departments is:

$$\overline{v} = y[(i_2 + f - c) - xf] + (1-y)[(i_2 - pm - n) + x(pm + n)] \tag{63.9}$$

Therefore, when the supervision departments choose monitoring strategy, the replicator dynamics equation (RDE) is as follows:

$$v' = F(y) = y(v(do) - \overline{v}) = y(1-y)[(pm + n + f - c) - x(pm + n + f)] \tag{63.10}$$

63.4 Model Analysis

63.4.1 Stability Analysis of Construction Enterprise

From the formula (63.6), building enterprises' RDE is:

$$F(x) = x(1-x)(yf + pl + c_2 - c_1)$$

Let $F(x) = 0$, the $x_1 = 0,\ x_2 = 1$ or $y = (c_1 - c_2 - pl)/f$. If $y = (c_1 - c_2 - pl)/f$, $F(x) = 0$, shows that all x is stable state; if $y \neq (c_1 - c_2 - pl)/f$, evolutionary stable strategy (ESS) must meet: $\begin{cases} F(x) = 0 \\ F'(x^*) < 0 \end{cases}$,

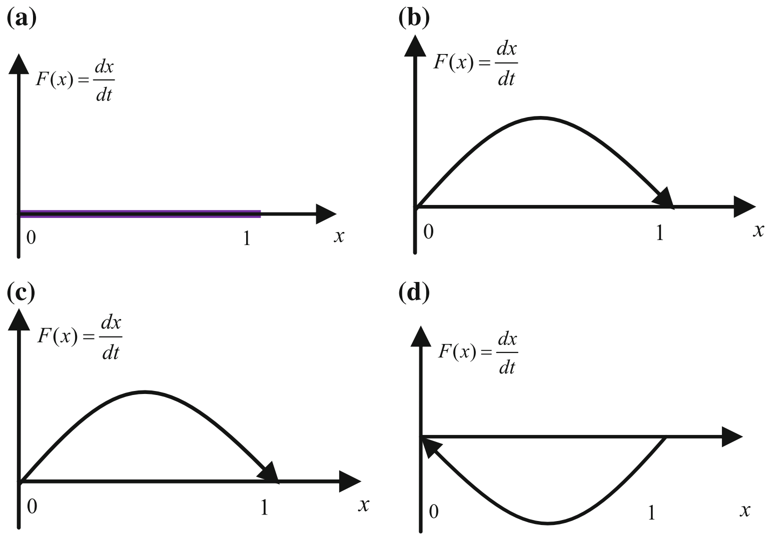

Fig. 63.2 Construction enterprise replication dynamic phase diagram. **a** $y=(c_1-c_2-pl)/f$. **b** $c_2+pl>c_1,\ F'(1)<0$. **c** $c_2+pl<c_1\cap yf+pl+c_2-c_1>0,\ F'(1)<0$. **d** $c_2+pl<c_1\cap yf+pl+c_2-c_1>0,\ F'(0)<0$

according to the symbol of $F'(x^*)$ to analyze evolution stable equilibrium of the construction enterprise.

1. When $(c_2+pl)>c_1$, the expected loss is greater than the safe production input costs, $yf+pl+c_2-c_1>0,\ F'(x_2^*)<0$, the evolutionary stable equilibrium is $x_2^*=1$, that limited rational construction companies have chosen to pay attention to production safety management;
2. When $(c_2+pl)<c_1$, the expected loss is less than the safe production input costs. And when $y>(c_1-c_2-pl)/f,\ yf+pl+c_2-c_1>0,\ F'(x_2^*)<0$, the evolutionary stable equilibrium is $x_2^*=1$, shows that: after a long repeated game, limited rational construction enterprises will choose to pay attention to safety management strategy; When $(c_2+pl)<c_1$ and $y<(c_1-c_2-pl)/f$, $yf+pl+c_2-c_1<0,\ F'(x_1^*)<0$, the evolutionary stable equilibrium is $x_1^*=0$, shows that: after a long repeated game, limited rational construction enterprises will choose not to pay attention to safety management strategy (see Fig. 63.2).

From the above analysis, we can conclude that when construction enterprises do not pay attention to safety production management and the expected loss is greater than the cost of safe production. No matter supervision or not, limited rational construction enterprises would choose safety production management strategy; when the expected loss is less than the cost of safe production, building enterprise strategy choice depends on supervision department strategy choice, the more greater probability of the supervision department choose regulatory strategy, the more greater probability for construction enterprise choose to take safety management strategy.

63.4.2 Stability Analysis of Supervision Department

From the formula (63.10), supervision department' RDE is:

$$F(y) = y(1-y)[(pm+n+f-c) - x(pm+n+f)]$$

Let $F(y) = 0$, the $y_1 = 0$, $y_2 = 1$ or $x = (pm+n+f-c)/(pm+n+f)$. If $x = (pm+n+f-c)/(pm+n+f)$, $F(y) = 0$, shows that all y is stable state; if $x \neq (pm+n+f-c)/(pm+n+f)$, evolutionary stable strategy (ESS) must meet: $\begin{cases} F(y) = 0 \\ F'(y^*) < 0 \end{cases}$, according to the symbol of $F'(y^*)$ to analyze evolution stable equilibrium of the construction enterprise.

(1) When $(pm+n+f) > c$, the losses including social reputation losses and penalty is greater than the cost of supervision without inspection, $x > (pm+n+f-c)/(pm+n+f)$, $F'(y_1^*) < 0$, the evolutionary stable equilibrium is $y_1^* = 0$, that limited rational supervision department choose no supervision; when $(pm+n+f) > c$ and $x < (pm+n+f-c)/(pm+n+f)$, $F'(y_2^*) < 0$, the evolutionary stable equilibrium is $y_2^* = 1$, that limited rational supervision department choose supervision.
(2) When $(pm+n+f) < c$, the losses including social reputation losses and penalty is less than the cost of supervision without inspection, $(pm+n+f-c) - x(pm+n+f) < 0$, $F'(y_1^*) < 0$, the evolutionary stable equilibrium is $y_1^* = 0$, that limited rational supervision department choose no supervision (see Fig. 63.3).

63.4.3 Stability Analysis of the Equilibrium

System evolution equation of construction enterprises and safety supervision department as follows:

$$\begin{cases} F(x) = x(1-x)(yf + pl + c_2 - c_1) \\ F(y) = y(1-y)[(pm+n+f-c) - x(pm+n+f)] \end{cases}$$

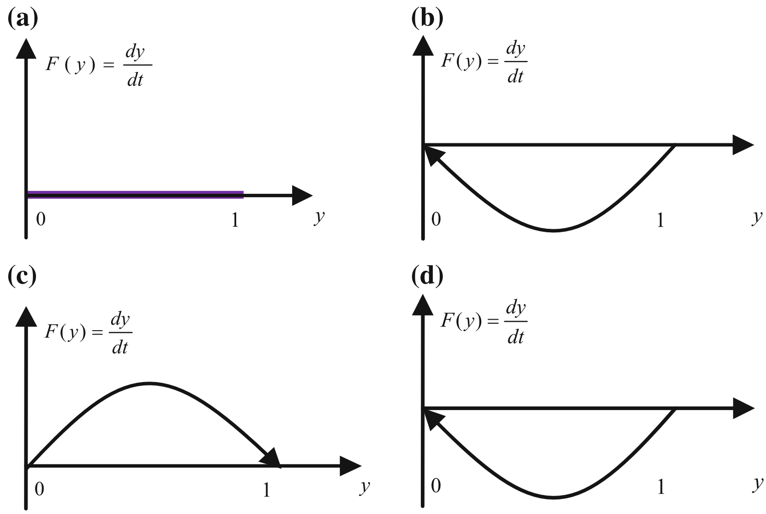

Fig. 63.3 Supervision department replication dynamic phase diagram. **a** $x=(pm+n+f-c)/(pm+n+f)$. **b** $\begin{cases}(pm+n+f)>c\\ x>(pm+n+f-c)/(pm+n+f)\end{cases} F'(0)<0$. **c** $\begin{cases}(pm+n+f)>c\\ x<(pm+n+f-c)/(pm+n+f)\end{cases} F'(1)<0$. **d** $\begin{cases}(pm+n+f)>c\\ (pm+n+f-c)-x(pm+n+f)<0\end{cases} F'(0)<0$

From the above analysis, the dynamic replication system have five equilibrium points: $E_1(0,0)$, $E_2(1,0)$, $E_3(0,1)$, $E_4(1,1)$, $E_5((pm+n+f-c)/(pm+n+f),(c_1-c_2-pl)/f)$. But the replication dynamic evolutionary process will eventually tend to which equilibrium point, depending on the initial condition of game participants strategy proportion and the value of dynamic differential equation.

According to the method proposed by Friedman (1991), the group dynamics of a differential equation can be obtained by Jacobian matrix.

The Jacobian matrix of formula (63.6) and (63.10):

$$J=\begin{vmatrix}\frac{df(x)}{dx} & \frac{df(x)}{dy}\\ \frac{df(y)}{dx} & \frac{df(y)}{dy}\end{vmatrix}$$
$$=\begin{vmatrix}(1-2x)(yf+pl+c_2-c_1) & fx(1-x)\\ -y(1-y)(pm+n+f) & (1-2y)[(pm+n+f-c)-x(pm+n+f)]\end{vmatrix} \tag{63.11}$$

Then, the determinant of the matrix:

$$\det J = [(1-2x)(yf + pl + c_2 - c_1)]\{(1-2y)[(pm + n + f - c) - x(pm + n + f)]\} \\ + fx(1-x)[y(1-y)(pm + n + f)]$$

The trace of the matrix:

$$trJ = (1-2x)(yf + pl + c_2 - c_1) + (1-2y)[(pm + n + f - c) - x(pm + n + f)]$$

System equilibrium point and its $\det J$ and trJ value are shown in Table 63.2.

For discrete system, if the equilibrium points of evolution game meet $\begin{cases} \det J > 0 \\ trJ < 0 \end{cases}$, the evolutionary stable strategy has stability. The stability of the above five equilibrium points are affected by the size of $(pl + c_2 - c_1)$ and $(pm + n + f - c)$. According to the Jacobian matrix analysis, the stability of the equilibrium process is shown in Table 63.3, the phase diagram is shown in Fig. 63.4a–d.

1. When $\begin{cases} (c_2 + pl) > c_1 \\ (pm + n + f) > c \end{cases}$, the system converges to the (1,0) seen from Fig. 63.3a, which illustrates that: When construction enterprises pay attention to safety production management, the cost less than the expected accident loss, construction enterprises choose safety production management strategy; When the cost of supervision is less than the sum of penalty and accident loss, regulatory behavior can appear a hybrid state, that is, sometimes choose supervision sometimes choose not, but eventually will tend to regulatory strategy.
2. When $\begin{cases} (c_2 + pl + f) < c_1 \\ (pm + n + f) < c \end{cases}$, the system converges to the (0,0) seen from Fig. 63.3b, which illustrates that: when the cost of supervision is greater than the sum of penalty and accident loss, regulatory will not choose supervision; When construction enterprises pay attention to safety production management, the cost greater than the sum of expected accident loss and penalty, construction enterprises will not choose safety production management strategy.
3. When $\begin{cases} (c_2 + pl + f) < c_1 \\ (pm + n + f) > c \end{cases}$, the system converges to the (0,1) seen from Fig. 63.3c, which illustrates that: when the cost of supervision is less than the sum of penalty and accident loss, and when construction enterprises pay attention to safety production management, the cost greater than the sum of expected accident loss and penalty, regulators and construction enterprise will adopt the hybrid strategy for interests driving. But after long-term repeated games, regulators will choose regulatory strategy and construction enterprises will not choose safety management.

Table 63.2 System equilibrium point and its $\det J$ and trJ value

Equilibrium point	$\det J$	trJ
$E_1(0,0)$	$(pl+c_2-c_1)\times(pm+n+f-c)$	$(pl+c_2-c_1)+(pm+n+f-c)$
$E_2(1,0)$	$(pl+c_2-c_1)\times c$	$-(pl+c_2-c_1)-c$
$E_3(0,1)$	$(f+pl+c_2-c_1)\times(c-pm-n-f)$	$(pl+c_2+f-c_1)+(c-pm-n-f)$
$E_4(1,1)$	$-(f+pl+c_2-c_1)\times c$	$-(f+pl+c_2-c_1)+c$
$E_5\left(\frac{pm+n+f-c}{pm+n+f},\frac{c_1-c_2-pl}{f}\right)$	$\frac{c(pm+n+f-c)}{pm+n+f}\times\frac{(c_1-c_2-pl)\times(f+c_2+pl-c_1)}{f}$	0

Table 63.3 Stability analysis of evolutionary game model equilibrium point

	Conditions	Equilibrium point	$\det J$ symbol	trJ symbol	Conclusion	Phase diagram
Case 1	$\begin{cases}(c_2+pl) > c_1\\(pm+n+f) > c\end{cases}$	$E_1(0,0)$	+	+	UnstableStable (ESS)	Figure 63.3a
		$E_2(1,0)$	+	−		
		$E_3(0,1)$	−	Uncertain	Saddle point	
		$E_4(1,1)$	−	Uncertain	Saddle point	
Case 2	$\begin{cases}(c_2+pl+f) < c_1\\(pm+n+f) < c\end{cases}$	$E_1(0,0)$	+	−	Stable (ESS)	Figure 63.3b
		$E_2(1,0)$	−	Uncertain	Saddle point	
		$E_3(0,1)$	−	Uncertain	Saddle point	
		$E_4(1,1)$	+	+	Unstable	
Case 3	$\begin{cases}(c_2+pl+f) < c_1\\(pm+n+f) > c\end{cases}$	$E_1(0,0)$	−	Uncertain	Saddle point	Figure 63.3c
		$E_2(1,0)$	−	Uncertain	Saddle point	
		$E_3(0,1)$	+	−	Stable (ESS)	
		$E_4(1,1)$	+	+	Unstable	
		E_5	−	0	Saddle point	
Case 4	$\begin{cases}(c_2+pl+f) > c_1 > c_2+pl\\(pm+n+f) < c\end{cases}$	$E_1(0,0)$	+	−	Stable (ESS)	Figure 63.3d
		$E_2(1,0)$	−	Uncertain	Saddle point	
		$E_3(0,1)$	+	+	Unstable	
		$E_4(1,1)$	−	Uncertain	Saddle point	

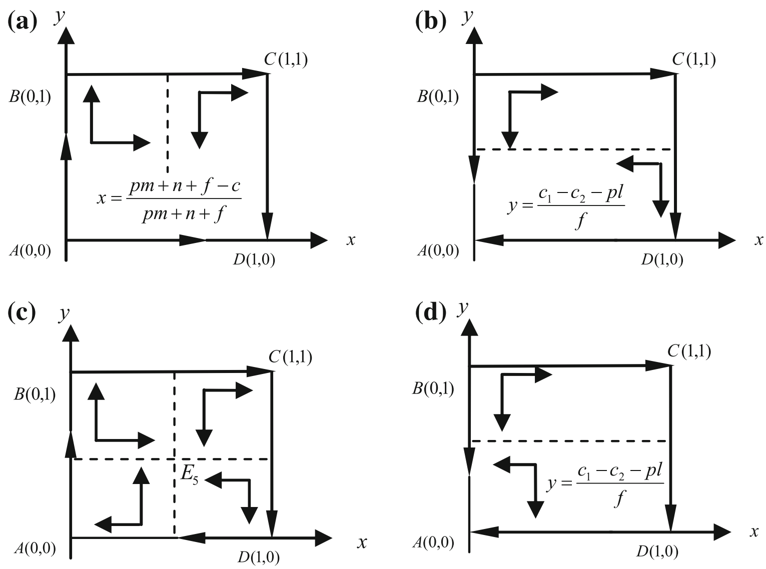

Fig. 63.4 System evolution phase diagram. **a** Case 1. **b** Case 2. **c** Case 3. **d** Case 4.

63.5 Conclusion and Countermeasures

Through the above evolution game analysis of construction enterprise safety management, shows that the steady state of construction enterprise safety production is affected by supervision department and construction enterprise strategy choice. To achieve the cooperation of relevant actors in the production safety issue and to improve safety level of construction enterprises, it is necessary to build a new mechanism of interests and risk sharing. By introducing appropriate external supervision and restraint mechanism, enhance both sides to control the security risk. Specific recommendations are as follows:

1. Improve the regulatory management efficiency; reduce the supervision costs.
   In order to achieve the evolutionary game stable state of supervision department and contractors, regulatory costs are not as high as better, and reasonable penalty should try to close or equal to safety investment of the construction enterprises actively implementing safety strategy. The more regulatory authorities take regulation, the less construction enterprises do not attach importance to safe production management. Reasonably reducing supervision costs, to a certain extent can not only encourage building enterprises self regulation, also can reflect reform ideas of a conservation-oriented government and economical society.

2. Strengthen the credit system; promote the development of construction market norms.
   On the one hand, establishing a unified market surveillance platform and improving the legal system of the construction market credit. Through the government promoting, market operation and the whole society widely participation, establishing an objective and fair credit files about construction enterprises, and supervision units and related practicing personnel (employees); On the other hand, building unified credit rewards and punishment mechanism, combining quality and safety performance of construction market participants with market access, qualification lifting, tender and bid, enterprise assessment, rewards and punishments, etc., to achieve “market” and “field” linkage mechanism, reflect incentive and punishment. Finally foster honest market environment.
3. Strict market access system; strengthen the third-party status in the qualification management; and weaken the powers of the administration.
   On the one hand, to prevent embezzlement, enterprise qualification recognition and management should be gradually carried out by intermediary organizations which commissioned by the construction authorities, and construction authorities are only responsible for the final audit qualification; On the other hand, intermediary organizations should have checks and balances with construction enterprises in the aspects of rights and obligations.[1] In order to pursue the maximal profit and minimal risk, security companies and insurance companies must review enterprise qualification before providing security and insurance (Guo and Ren 2012). At the same time take floating insurance rate, combine the insurance cost with construction enterprise safety risk level and the past safety performance.
4. Strengthen the industry organization self-discipline management; give full play to social third party.
   Introducing industry associations or other industry management organization, strengthen the third party in construction safety production supervision, to make up for the lack of government supervision, forming a new pattern of “mixed supervision”. Industry organization has professional and technical advantages; its information asymmetric degree is relatively small. The more mature market economy, the industry organizations’ role is more prominent. When the industry organization self-discipline management activities become the enterprises’ aware behavior, the costs of government’s supervision and law enforcement will be greatly reduced.
5. Increase security technology development strength; improve the enterprise safety input enthusiasm. Enhance safety technical ability, can improve the enthusiasm of construction enterprise safety input. On the one hand, the relevant

[1]At present there two intermediary institutions: engineering guarantee and engineering insurance company, but they do not have enterprise qualification recognition and review conditions, needing government policy support and actively cultivate, making them growing as soon as possible.

government departments should make full use of their own advantages organizing experts to solve the key technology of construction safety production, and study economic efficient safety technology and tools to improve the enthusiasm of enterprises safety input. On the other hand, the construction enterprise shall adopt scientific precautionary measures in production safety to control the costs of safety measures. Finally, with the improvement of construction safety management level, the construction enterprise's economic benefit and social benefit will significantly increase (Yuan et al. 2006).

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Chapter 64
A Constructivist Orientation to Effectively Align VfM Objectives in PPP Infrastructure Projects

Christy P. Gomez and Muhammad M. Gambo

Abstract Public Private Partnerships (PPP) has evolved to serve the growing demand for infrastructure development in Malaysia. However, the Value for Money (VfM) evaluative aspect embedded within the Public Sector Comparator (PSC) of the PPP procurement form has faced lots of criticism. Much of the criticism is directed at the inability within PPP practice to effectively steer Special Purpose Vehicles (SPVs) towards established VfM objectives right from the inception stage. This inability is viewed as a constraint in the successful delivery of PPP projects. Using Theory of Constraints (TOC) analysis alongside critical theory perspective, three basic deficiencies in PPP practice is identified, namely: ignoring the much more permanent construction project organization; lack of consideration towards the partnership principle; and finally the lack of alignment within the project organizational framework towards delivering customized VfM objectives. In tackling the third deficiency, this paper proposes the Balanced Scorecard (BSC) approach with a clear emphasis on 'Learning and Growth' perspective as a means to consistently align the SPV towards achieving set VfM objectives. The underlying philosophical context of this work is based on augmenting the mainstream positivist orientation towards research and practice with a constructivist understanding of knowledge production.

Keywords Balanced scorecard · Critical success factors · Public private partnership · Special purpose vehicle · Value for money

64.1 Introduction

PPP as an infrastructure delivery approach is adopted in many countries to engage the private sector, wherein traditionally public organizations and government departments used to operate singlehandedly. The adoption of PPP is in line with the

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growing need to be able to deliver projects of public interest in a greatly enhanced value-added manner. Admittedly most of the PPP infrastructure projects are expected to play a major role in determining the success of key sectors of the economy. In the case of developing countries, the provision of much needed infrastructure facilities in housing, water, energy and transport are critical in achieving improved standard of living and such projects also help towards poverty reduction (Sanghi et al. 2007). Hence, there is an even greater need to secure such infrastructure, although faced with traditional time and resource constraints, but not limited by them.

In the Malaysian context, the involvement of the private sector in delivering public facilities and services is not new, as it has been in existence for the past 25 years. The involvement of the private sector in the delivery of such needed infrastructure was in the form of the privatization program then; and was initiated primarily as a result of the adverse impact of the global economic recession of the late 1970s to early 1980s. The Malaysian government was prompted to seek the participation of the private sector for the provision of the required infrastructure projects necessary for development and economic activities (Ismail and Rashid 2007). In 2006, the privatization policy of the private sector's role in infrastructure delivery evolved into that of PPP as a more viable mechanism for the private sector's role in infrastructure delivery. Since the advent of the initial PPP form of collaboration between the public and private sector, the partnership initiative has progressed to wider and more all-encompassing perspectives bringing in key strengths and capabilities available within the private sector, requiring greater private sector involvement.

Despite the widespread adoption of this procurement approach for delivering the required infrastructure projects in Malaysia, the achievement of the Value for Money (VfM) objectives in PPP by the private sector bodies structured within respective SPV's has had non-satisfactory attestation from project end users. It has been variously claimed by researchers as to the lack of a systematic formulation and application of the VfM concept in Malaysian PPP practice and hence a failure to adequately attend to the end user's needs and expectations (Takim et al. 2011; Ismail et al. 2011). From a research and policy perspective, this failure to deliver the required VfM objectives has not been addressed in a serious manner in Malaysia. Government policy reviews on governance structures aimed at delivering VfM objectives in PPP projects and research on VfM per se has been rather scant. It was reported in 2007, that under the Private Finance Initiative (PFI) scheme, the Public Sector Comparator (PSC) was yet to be established, hence requiring one to be constructed urgently (Ismail and Rashid 2007).

In order to address this issue of the lack of systematic formulation and application of VfM in the Malaysian PPP practice, a two prong research methodology was seen as being appropriate, herein termed as the: strategic level research methodology and the operational level research methodology.

64.1.1 VfM, PSC and the Balanced Scorecard

It is clear that VfM is maximized by allocating risk optimally. Wherein the PSC is used to estimate the hypothetical risk adjusted cost to government of delivering the proposed project using the most efficient form of government delivery. The PSC is then compared against private bids. Often care has to be taken to ensure that the comparison is between genuinely comparable items, whilst there is a strong possibility that bids will not be identical to the proposed service specifications, and risk allocation outlines in the bid documentation on which the PSC is based. To compare such a bid with the PSC without appropriate adjustment would be therefore misleading. Hence, if the bids are higher than the PSC, and the level of service delivery and the risk allocation in the bids is similar, in the absence of other offsetting qualitative benefits, the project would be best delivered as a public project. This decision should be based on the total cost of each alternative, i.e., considering not only the estimated contract cost, but also the cost to the government of contract monitoring and administration. Achievement of VfM for the taxpayer means looking beyond initial price to take account of whole life costs and quality as well. A low cost design may result in high maintenance and operating costs as well as result in negative environmental impacts.

Although the PPP initiative in Malaysia is said to have evolved from the earlier privatization policy by the government, it is important to remember that PPPs are however not privatization per se. Under PPPs, accountability for delivery of the public service is retained by the public sector, whereas under privatization, accountability moves across to the private sector (the public sector might retain some regulatory price control). Under PPPs, there is no transfer of ownership and the public sector remains accountable (United Nations 2008).

64.1.2 Balanced Scorecard

The Balance scorecard (BSC) can be described as a management system which is structured as a tool to achieve a "plan-do-check-act" measure for the strategic performance of organizations in the delivery of their projects and services (Bieker 2003). Every organization requires a system where their results are compared with their initial strategic goals and aims. The BSC is a performance measurement system that enables the organization to clarify their strategy and translate them into action, a form of organizational alignment. The fundamental precept of striving towards Value for Money in relation to the PSC can be reflected closely with that of the BSC strategy aspect. The BSC is an approach, derived from the strategy of the organization, reflecting the business objectives which the firm had set for itself (Punniyamoorthy and Muralli 2008). The balanced scorecard measures are built around four perspectives. These four perspectives of the scorecard reflect the different views and aspects from which an organization can be looked into. The four perspectives of the BSC are represented and described below.

Learning and growth perspective: The required capabilities and skills in which the organization must seek to improve continuously in order to achieve a superior and effective internal organizational process that offers value for the customers and shareholders.

Internal business processes perspective: The needed processes, decisions and strategies that organizations effects within the context of their internal operational strategies in order to achieve their desired set goals and objectives.

Customer perspective: How the customer's objective in an organization can be achieved; that is in respect of the ability of the organization to offer goods and services, at the required and stipulated quality and standards, to the overall satisfaction of the customers.

Financial perspective: Evaluating the financial aspect of the organization towards enabling the shareholders to achieve a return on their investments while at same time not neglecting the customer's objectives in the organizations service delivery.

64.2 Strategic Level Research Methodology

As organizations develop towards delivering their underlying objectives, there is the need for incorporation of strategic intent in every of their activities. Whittington et al. (2004) describe strategy as the direction and scope of an organization over the long term; by which this enables the organization to achieve the advantage of configuring its resources within a changing and diverse environment, to meet the needs of the market.

The research methodology is seen as being generative in the sense of being developmental in nature, with the provision of a conceptual framework for alignment of VfM objectives with the structure of the SPV organization. According to Gergen and Thatchenkery (1998) this generative theorising approach is designed to unseat conventional assumptions and to open new alternatives for action. This paper is structured on the premise that *PPP practitioners have a dominant perspective of themselves as action people* who seek out theorists to bring them immediate applications underpinned by the notion of human agency; and this phenomena can thus be understood in terms of constructivist rationalism (see Griffin et al. 1998). In fact, this was the experience of the research student, Mustafa Gambo, whence interviewing PPP practitioners during the initial phase of his research (as part of the preliminary in-depth literature study and interview) to identify the major attributes of an effective private sector-led SPV organization in the delivery of PPP projects using the PARETO principle. The researcher encountered numerous requests on feedback regarding the ongoing research as well as continued interest by PPP practitioners to participate as research respondents.

The other aspect is that of taking into account the necessary orientation of key stakeholders in the PPP process, primarily the SPV; which is the unit of analysis in this case. In taking on the constructivist orientation within a critical theory perspective towards formulation and application of the VfM concept, the traditional PPP practitioners within SPVs are seen as a constraint as well. Often these PPP practitioners are generally construction industry practitioners sourced to work on PPP projects without prior specialized training or experience related to PPP projects. Hence, the organization of the SPV over the lifecycle of the project requires periodical scrutiny for addressing the issue of alignment. Besides, it is important for these PPP practitioners to engage in the practice of critical reflection which can provide access to the most sophisticated process of learning available at any one time. The measures that are put in place is not meant to replace practice but to allow such information to be treated as 'success' terms, as the efforts are essentially that of an instrumentalist one. The purpose is then 'to know', which is to possess ways and means of acting and thinking that can allow practitioners to attain the goals they happen to have chosen.

64.2.1 Improvement Methodology Using Theory of Constraints

Whilst as human agents, we the researchers are seen to be engaged within the process of contributing theories to managers. In this particular instance, it is found that the practical application of the Theory of Constraints as a generative methodology for the formulation of actionable problem solving to improve processes is a valid theory to utilize. Hence, the approach has been to use the Goldratt's Theory of Constraints (TOC) approach to address this delibitating effect on the inability of effective delivery of VfM objectives in PPP infrastructure projects in Malaysia. The theory of constraints is a system approach based on the premise that there is at least one constraint (known as bottlenecks, delays, and barriers) in every organization that prevents the organization from utilizing its capability and capacity to achieve the organizational objectives (Goldratt 1986). According to Goldratt (1986), the TOC approach focuses on the process of the ongoing improvement inclusive of effectively performing a series of five steps which are essentially involved in cause and effect thinking processes (see Fig. 64.1).

The theory of constraints (TOC) adopts the common idiom "A chain is no stronger than its weakest link" as a new management paradigm. This means that processes, organizations, etc., are vulnerable because the weakest person or part can always damage or break them or at least adversely affect the outcome. The analytic approach of TOC comes from the contention that any manageable system is limited in achieving more of its goals by a very small number of constraints, and that there is always at least one such constraint. Hence the TOC process seeks to identify the constraint and restructure the rest of the organization around it. Theory of Constraints outlines a five-step process to applying the theory:

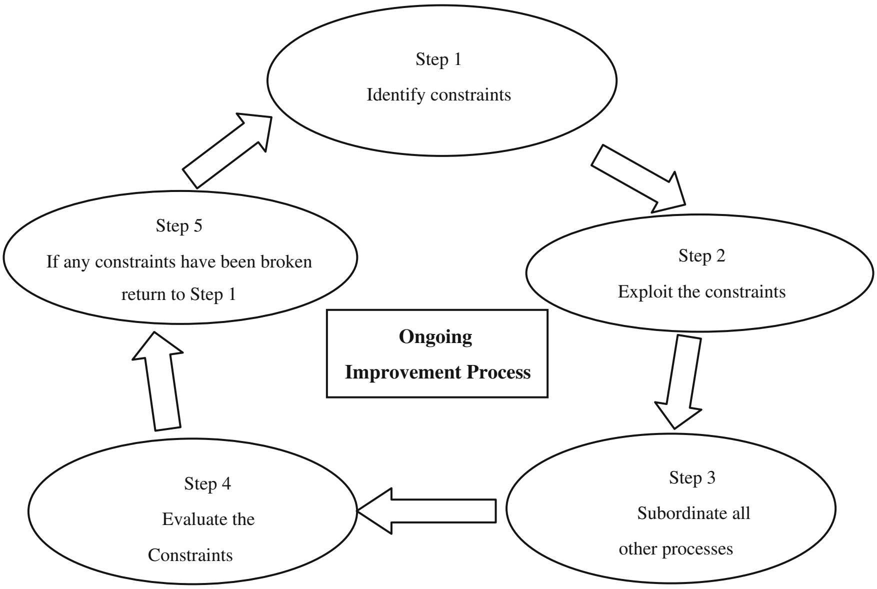

Fig. 64.1 Five steps of TOC process (adapted from Goldratt 1986)

1. Identify the process' constraints
2. Decide how best to exploit the process constraints
3. Subordinate everything else to the above decisions
4. Evaluate the process constraint
5. Remove the constraint and re-evaluate the process

The Theory of Constraints is applied here on two levels, the strategic level and the operational level. The strategic level, as described above, is to actively engage in problem solving on the issue of the lack of a systematic formulation and application of the VfM concept in PPP infrastructure projects in a dynamic sense.

Whilst at the operational level, it is the Learning and Growth Perspective, framed within the four Balanced Scorecard perspectives (see Fig. 64.2) seems to be a constraint based on existing ongoing research on the relative effectiveness of knowledge management enablers in large construction contracting organizations in Malaysia. In relation to this, a view expressed by Schon (1987) is still prevalent; wherein there is still an innate inability to address the problem of research (as well as taken to be 'learning and growth', in this case) that can be disconnected with the world of practice. Thus the role of PPP practitioners from SPVs is seen as a possibility to bridge this gap, providing the connectiveness, and timeliness of intervention to take on the more generative form of natural growth and improvement, which then is seen as integral to the organizations continued success within their specific context of consistently delivering VfM objectives.

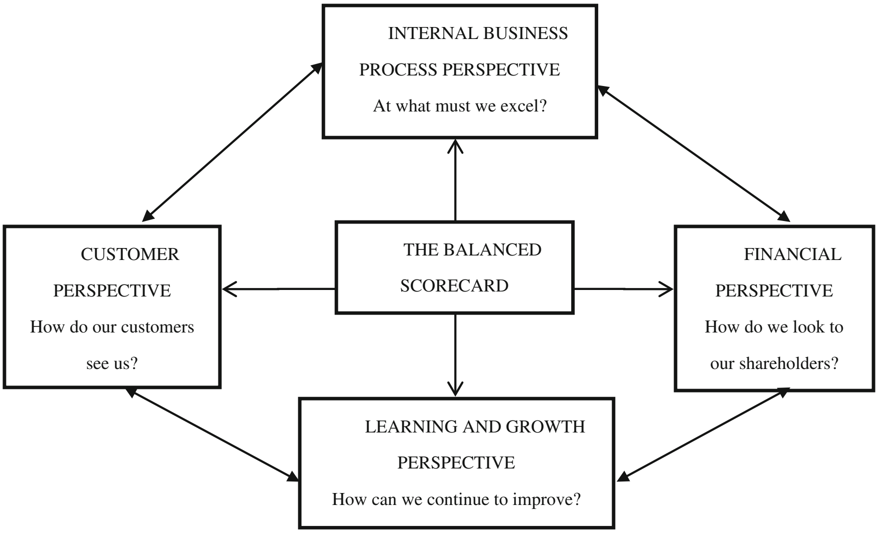

Fig. 64.2 The four perspectives of the balanced scorecard (adapted from: Kaplan and Norton 1996)

The Learning and Growth Perspective—refers to the required capabilities and skills that the organization must seek to improve continuously in order to achieve a superior and effective internal organizational process that offers value for the customers and shareholders. This can ensure that continuous alignment is achieved. This perspective of the BSC is often accorded minimal attention; and hence contributing to the inability of organizations to actively engage on improvement and to focus on providing value to the customers.

The philosophical underpinning for such problem solving action leading to knowledge production is primarily constructivist in nature involving the concept of engagement. Hence, in applying the TOC approach, it has been identified that although there has been growing amount of work in the area of PPP, however it cannot be denied that previous researchers have failed to review cross-industry practice on performance measurement and the alignment of key business and service strategies and adapt it where necessary. This is evident for instance in the work of Yuan et al. (2008), who developed a conceptual model to identify the Key Performance Indicators (KPIs) in assessing PPP performance in terms of VFM achievement. The authors claimed that KPIs are useful tools for project performance management and performance measurement in identifying the strength and weakness of the projects and thus an appropriate decision can be adopted for improving efficiency, effectiveness and economy, which ultimately provides VFM to both public and private sectors. The study identified a set of indicators from five attributes, namely: ‘the physical characteristics of projects’, ‘financing and marketing’, ‘innovation and learning’, ‘stakeholders’, and ‘process’. Clearly, focus is very much on reworking the BSC perspectives (reinventing the wheel) whilst at the same time ignoring the importance of addressing the disability within SPVs with regard to the Learning and Growth perspective.

It is argued in this paper that the VfM concept can have a sustaining quality provided it is embedded and aligned within the organizational structure of the project delivery system, led by the SPV. The VfM concept in Malaysian PPP practice has only received scant attention in the extant literature that is framed under solely positivist orientations; warranting the need for further studies undertaken within the constructivist understanding of knowledge production, as is being undertaken here.

This paper is part of a wider study focused on: "Structuring the Special Purpose Vehicle for the Delivery of Best Value Objectives in Malaysian PPP Infrastructure Projects". The focus is on the identification of the critical success factors (CSFs) that will enable the achievement of the VfM objective in PPP using an effective performance measurement concept based on the principle of alignment of objectives more beneficially undertaken based on a constructivist orientation. This will enable an insightful analysis of the identified operational parameters of the SPV organization which adopts Kaplan and Norton's concept of the Balanced Scorecard methodology. In attempting to develop a set of viable CSFs, it is not to be mistaken that measuring their performance through the Balanced Scorecard methodology is intended to replace practice.

This has resulted in the proposition of aligning VfM objectives within a Balanced Scorecard Methodology. Based on initial literature review, this endeavour has been structured in a generic sense and refined through questionnaire survey method with PPP practitioners (see Table 64.1).

64.3 Operational Level Research Methodology

64.3.1 Collection of Research Data

An empirical questionnaire survey was undertaken in Malaysia from October 2013 to March 2014 to analyze the CSFs that contribute to the success of PPP projects in Malaysia based on the adoption of the Balanced Scorecard methodology. In this study, the target survey respondents of the questionnaire included industrial practitioners from the public and private institutions, financiers, contractors and other stakeholders that have been involved in the execution of PPP projects.

These respondents were requested to rate their degree of agreement against each of the identified CSFs according to a five-point Likert scale, where 1 = least important and 5 = highly important. Survey questionnaires were sent to 95 target respondents which were identified based on purposive sampling technique, where the respondents were considered based on their direct involvement in PPP projects in the study area. In all, 48 completed questionnaires were returned.

Table 64.1 Perception of respondents concerning the relative importance of CSFs in PPP projects based on the balanced scorecard methodology

BSC 1: learning and growth perspective	**Mean**	**Rank**
(1) Technology transfer methodologies	3.79	6
(2) Good communication skills between the relevant parties	4.15	2
(3) Willingness to compromise and collaborate	3.88	4
(4) Risk awareness	4.35	1
(5) Clear roles and responsibilities	4.15	2
(6) Entrepreneurship and leadership potentials	3.81	5
(7) Continuous improvement practice	4.02	3
BSC 2: internal business process perspective	**Mean**	**Rank**
(1) Strong private consortium	4.44	1
(2) Appropriate risk allocation and risk sharing	4.00	6
(3) Project technical feasibility	4.13	3
(4) Effective project organization structure	4.04	5
(5) Innovative sourcing of technical solutions	3.77	9
(6) Strong internal networking	3.85	7
(7) Use of effective management practices	4.08	4
(8) Effective supervision mechanism	4.17	2
(9) Ability to provide a suitable transfer package	3.81	8
(10) Built-in flexibility for future growth and changes	4.08	4
(11) Transparency	4.17	2
BSC perspective 3: customer perspective	**Mean**	**Rank**
(1) Low environmental impact strategy	3.90	6
(2) Appropriate toll/tariff level(s) and suitable adjustment formula	4.06	4
(3) Feedback mechanisms	4.08	3
(4) Adoption of user-friendly technology	4.00	5
(5) Developing a supportive and understanding end user community	4.15	2
(6) Clear project brief and client requirements	4.31	1
BSC perspective 4: financial perspective	**Mean**	**Rank**
(1) Reasonably high equity to debt ratio	3.94	4
(2) Low construction costs	3.90	5
(3) High prediction capability in foreign exchange risk	3.81	7
(4) Rational pricing mechanism	4.17	1
(5) Preferential loan rates	4.06	2
(6) Government guarantees and subsidies	3.83	6
(7) Financial package differentiation	3.96	3

64.3.2 Survey Data Analysis and Results

The relative importance of the 31 CSFs identified from the literature review was explored by means of Likert rating scale questions in the survey instrument. The data was analysed using the SPSS statistical package. Statistical analyses undertaken included firstly reliability tests using Cronbach alpha and then the determination of the mean ranking, where the descriptive statistic of mean score was computed for the five-point Likert scale on the importance of each of the 31 success factors categorized. Then, based on the mean scores, the factors were ranked according to the level of their importance, as perceived by the overall respondents. The Cronbach alpha reliability for the factors is 0.883, suggesting that the data collected are reliable.

64.4 Discussion and Conclusion

The importance of organizational alignment cannot be overemphasized, especially with respect to SPVs, wherein dysfunctionality in service provision is often attributed to overriding business interests. The attempt is not to be prescriptive, but to perform the role of human agency in the capacity as researchers providing theories to managers, bridging the gap between theory and practice. First and foremost being undertaken here to challenge taken for granted assumptions, and thus engaging with management. There are at least two ways of understanding the term 'management'. In the instances when it is taken as an activity of organizing people and things to create and achieve purposes, then it can be seen as a universal activity in space and time. Whilst, in a more specific sense management learning emphasises the practice of critical reflection among practitioners as providing access to the most sophisticated process of learning available at any one time. From the research methodology perspective, the attempt here is seen as generative research—taking a constructivist rationalist stance; the researcher within the context of human agency is engaged to provide theories to the PPP practitioners. In this paper, the academic concern for undertaking research that appears disconnected from the world of practice has been seriously addressed. In the main, it is the response aimed at resolving the issues related to the lack of alignment of VfM objectives to SPV organization structure by identifying deficiencies in the practice. This initial attempt to structure VfM objective measures aligned with the SPV organization that is undertaken using the BSC approach, however requires PPP practitioners to be engaged in the process of learning and growth within a constructivist orientation, skills not currently considered as core skills within the PPP practitioner portfolio.

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Chapter 65
An Attempt to Apply Vulnerability for Quantifying Risks in Public Private Partnership Projects

Tielan Teng, Qiming Li, Jingfeng Yuan and Xiaopeng Deng

Abstract To cope with the complexity and dynamic characteristic of risks in PPP infrastructure projects, this paper attempts to incorporate the notion of vulnerability into traditional risk process. The fundamental definitions and framework of risk vulnerability process for PPP infrastructure projects are proposed to describe the formation mechanism of risks, by which a generic methodology is derived to quantify the vulnerability and the risks in PPP projects. Integrated vulnerability management into risk management process may help the decision maker to identify the weakness of a project system and take action to mitigate identified vulnerabilities aiming to reduce the risk consequence.

Keywords Public private partnership · Vulnerability · Risk process · Risk event · Risk consequence

65.1 Introduction

Due to rapid social and economic growth, a massive demand for investment in infrastructure has been witnessed in many countries (The World Bank 2008). A range of public-private partnership (PPP) arrangements are rapidly becoming the preferred way to provide public services worldwide because PPPs have been seen

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as a mechanism to tackle inefficacies and insufficient governmental funds for infrastructure development. However, evidence from projects worldwide shows that risks are not managed properly. Much of the risk of a PPP project comes from the complexity of the arrangement itself and the nature of the risk structure alters over the duration of PPP projects, all that require the dynamic risk management which is different from the traditional risk identification, risk evaluation, risk response and risk control method applied in other research fields.

Research on vulnerability has its roots in the social sciences. It has a particularly long history in the literature of risk hazards and geography. The term "vulnerability" is used to explain inborn characteristics of a system, which is usually defined as the extent or the capacity of a system, a subsystem or system components to respond to a hazard or its impacts (Kelly and Adger 2000). Through vulnerability management, the weakness of a project system can be identified and the project may be adapted to probable risks to minimize their impact on project outcomes. This paper describes a study that applies the notion of vulnerability to quantify the risks in PPP infrastructure projects.

65.2 Incorporating Vulnerability into Risk Process

A tendency in project risk process analysis is to represent the relationship between risk event and risk consequence as statistical risk event-consequence link. Practically, the causal mechanism between risk event and risk consequence is usually considered to be direct. This tendency has a limitation, however, the direct causal mechanism between risk event and risk consequence tends to downplay or neglect the influence of project systems (including physical system and organization system) lying between them.

Approximately 30 years ago, risk was firstly defined as a measure of the probability and severity of adverse effects. Afterwards, risk was defined as a triplet of scenario, likelihood, and consequence (Ezell 2007). The difference is the notion of scenario as a euphemism for "what can go wrong." The scenario is an important addition to the earlier definition. From the synthesis of literature, a relationship emerges then between vulnerability and risk.

Therefore, vulnerability is a condition of the system and it should be assessed within the context of a scenario, which could have a mediating influence on the risk process and should be incorporated into traditional risk process analysis. The notion of vulnerability was firstly suggested by Zhang (2007) to characterize the influence of project system in risk processes (Zhang 2007), as shown in Fig. 65.1. However, the situation shown in Fig. 65.1 is just a static, logical and abstract process, in which the interactions mechanism and feedbacks between risk events and vulnerability are omitted, and it could not provide the sufficient foundation for the quantization of the risk process.

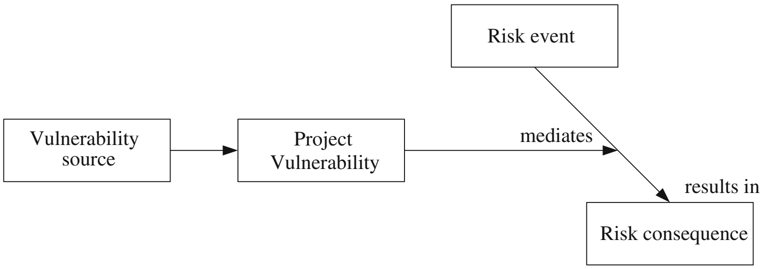

Fig. 65.1 The risk process defined by Zhang

65.3 Defining the Risk Vulnerability Process

The diversity of interpretations and reformulations of the vulnerability concept across disciplines and problem areas are as varied as evolutionary biology, ecology, cultural studies, and computer science, to cite just a few (Gallopín 2006), so as the basic elements of Vulnerability. The Intergovernmental Panel on Climate Change (IPCC) definitions of vulnerability to climate change, and relevant basic elements such as exposure, sensitivity, and adaptive capacity, form a suitable starting position to explore possibilities for quantification (IPCC 2001). However, because PPP infrastructure project system is different from the ecology system greatly, the IPCC definitions should be adjusted. Table 65.1 lists the definitions of some fundamental terms used in this paper.

The risk process and the definitions of the fundamental terms for PPP projects presented in Fig. 65.1 and Table 65.1 give ample building stones to construct a general framework for PPP vulnerability and risk assessment. This framework should be such that it can be used for different types of risk event and at different hierarchical levels of project system. Our aim is to develop a framework for defining the risk vulnerability process of PPP projects and identifying the conceptual linkages between the risk and the fundamental attributes of the three basic vulnerability elements (Fig. 65.2).

Risk Event (left-hand side of the framework) and Risk Consequence (right-hand side) are linked by vulnerability (grey shaded area). Risk event can be of systematic or non-systematic risk, and includes two dimensions: probability (PE) and magnitude (LE) of it according to the definitions. The chain of effects is from left to right in the framework indicated by different kinds of arrows that has been illustrated below the framework. As described in Table 65.1, vulnerability is a function of three elements: Exposure is the extent in which the project system is in contact with the probability of risk event and Sensitivity is the degree to which the project system is affected by the magnitude of risk event; Adaptability that is the system's ability to adjust to a less vulnerable condition may reduce the

Table 65.1 Definitions of important terminology related to vulnerability in ppp projects, with exampled

Term	Definitions used in this paper	Example in PPP infrastructure projects
Project system	The whole function system composed of interdependent subsystems between the public and private sectors, where resources and risks are shared for the purpose of delivering a public service	BOT projects, PFI projects
Risk event (R_E)	A threatening event, or the probability of occurrence of a shock, hazard or perturbation which could bring the uncertainty change of project system and result in the risk consequence, including probability (P_E) and magnitude (L_E) two dimensions	Interest rate fluctuation risk, Design defects or delay risk, Construction time delay risk
Vulnerability (V)	All the inborn factors that make the project system more susceptible to threat in case of a risk event occurrence, including exposure, sensitivity and adaptability three basic elements	Low project management level, Poor financial structure, Imperfect contract clauses
Exposure (EX)	In general the degree and/or extent in which the project system is in contact with, or subject to relevant risk event	The proportion of foreign capital in the financial structure determines the extent exposed to the foreign exchange risk
Sensitivity (SE)	The degree to which the project system is modified or affected by a risk event or set of risk events	The project with more complexity of construction technology could be more sensitive to the same design defects, and then result in larger construction time delay risk
Adaptability (AD)	Improvements in the adjustments of the project system to move to a less vulnerable condition that reduce its sensitivity to risk events, and its exposure to them	The perfect management level and contract clauses would make the project recovery better from a risk event
Risk consequence (R_C)	Expected losses due to a particular risk event, the product of event risk and vulnerability, including probability (P_C) and magnitude (L_C) two dimensions	The operation cost overran risk caused by the interest rate fluctuation risk and poor financial structure

Exposure and Sensitivity and transfer them to a new situation. These three elements are all determined by the project system, together with the risk event, they determine the risk consequence which also two dimensions: probability (PC) and magnitude (LC).

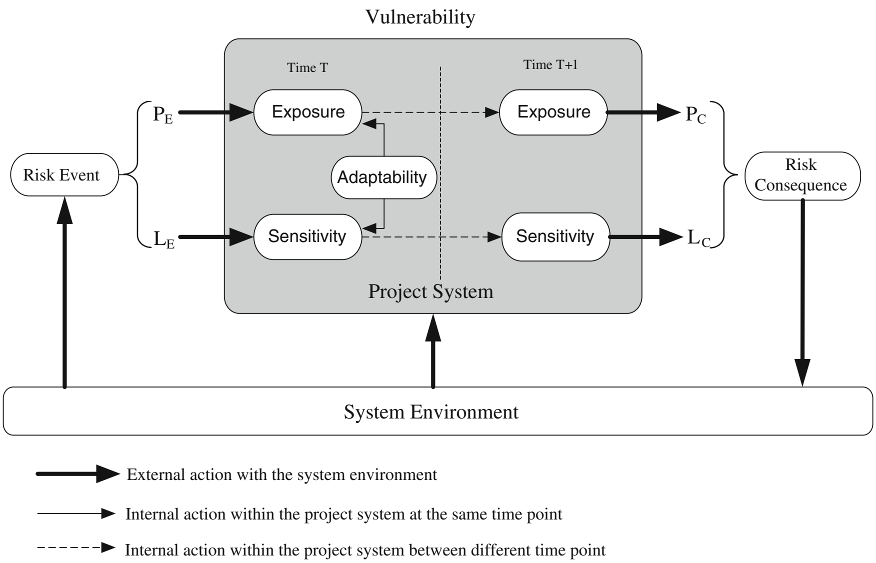

Fig. 65.2 The framework of risk vulnerability process for PPP projects

65.4 Quantifying the Risk Vulnerability Process

In this section a generic method to quantify the vulnerability and the risks in PPP projects is derived. To do this some basic hypothesis are proposed first: (1) Risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective (Project Management Institute 2000). However, we just concern the negative effect which would lead to a loss or injury that should be controlled practically. (2) All the variables proposed in this paper are considered to be continuous random variables. (3) A one-dimensional example is presented in this paper for simplicity. However, this approach could be applied to a system of multiple risk events and multiple outcomes variables of concern.

65.4.1 Risk Event

From the definitions in this paper, the value of risk event (R_E) consists of two dimensions including probability of occurrence (P_E) and magnitude of loss (L_E) of the risk event. The following generic functions relevant to risks are constructed, by translating a general definition into a mathematical expression.

$$\begin{cases} \mathrm{R_E} = [\mathrm{P_E}, \mathrm{L_E}] \\ \mathrm{P_E} = \mathrm{F}(\mathrm{L_E}) \\ \mathrm{P_E} \in [0, 1] \\ \mathrm{L_E} \in [0, +\infty) \end{cases} \tag{65.1}$$

where $\mathrm{F}(\mathrm{L_E})$ represent the continuous probability distribution function of $\mathrm{L_E}$. The concrete forms of probability distribution function that are generally normal distribution, exponential distribution, etc. can be determined by a particular risk event. Conceptually, $\mathrm{P_E}$ is the probability occurrence of risk that can be measured as probability. $\mathrm{L_E}$ can be measured as economic loss or money loss transferred from any other kind of risk loss for the purpose of unity and normalization of the magnitude of loss.

65.4.2 Vulnerability

Project vulnerabilities can be differentiated from risk events in terms of their causal relationship with risk consequences (Zhang 2007). Different communities and systems are exposed to varying magnitudes and frequencies of disturbing forces, often resulting in differential vulnerabilities. Therefore, the vulnerability ought to be determined by a particular risk event-consequence link. Vulnerability is also a function of exposure, sensitivity and adaptive capacity referring to the definition. Therefore the conceptual function of vulnerability is conducted for the foundation of further quantification.

$$\mathrm{V} = \mathrm{G}(\mathrm{R_E}, \mathrm{R_C}) = \mathrm{H}(\mathrm{EX},\ \mathrm{SE},\ \mathrm{AD}) \tag{65.2}$$

65.4.2.1 Exposure

Exposure (EX) in most formulations is seen as one of the basic elements constituting vulnerability (Gallopín 2006), which represents the degree or extent in which the project system is in contact with, or subject to a risk event (Table 65.1). The mechanism which has been proposed in Fig. 65.2 is that exposure determines probability of the occurrence of risk consequence $(\mathrm{P_c})$ through probability of the occurrence of corresponding risk event $(\mathrm{P_E})$. In most cases, the relationship between $\mathrm{P_E}$ and $\mathrm{P_c}$ are linear correlation. Therefore, exposure can be measured as the rate of $\mathrm{P_c}$ divided by $\mathrm{P_E}$.

$$\begin{cases} P_c = k_{EX} \cdot P_E \\ EX = \frac{\partial P_C}{\partial P_E} = k_{EX} \\ k_{EX} \in [0, 1] \end{cases} \tag{65.3}$$

where k_{EX} is defined as the exposure coefficient. To measure the k_{EX} in exposure assessment need to be able to establish the Evaluation Index System (EIS) of it. The exposure indexes of PPP project system corresponding to the particular risk event-consequence link can be abstracted from the case study of history projects or through a detailed literature review. The data needed can be collected from the questionnaire survey and conducted by the statistic analysis such as T-test, structural equation, etc.

65.4.2.2 Sensitivity

Sensitivity (SE) is an attribute of the system, existing prior to the perturbation, and separate from exposure (Gallopín 2006), which has been defined as the degree to which the project system is modified or affected by a risk event or set of risk events, then resulting in the risk consequence shaped by sensitivity (Table 65.1). In general sense, sensitivity links the magnitude of the loss of risk event (L_E) and the magnitude of the loss of risk consequence (L_C). The functional relationships between them can be preliminarily observed by theoretical models and mathematic statistic, proving out to be the monotone increasing function. The relationship function can be simply divided into three sub-functions including all the situations according to the relative increasing rates between L_E and L_C.

$$L_C = \begin{cases} e^{k_{SE} \cdot L_E} - 1, & if\ rate(L_E) < rate(L_C) \\ k_{SE} \cdot L_E, & if\ rate(L_E) = rate(L_C) \\ k_{SE} \cdot ln(L_E + 1), & if\ rate(L_E) > rate(L_C) \end{cases} \tag{65.4}$$

where $rate(L_E)$ refers to the increasing rate of L_E and $rate(L_C)$ refers to the increasing rate of L_C in the same relationship function. Conceptually, sensitivity can be measured as the amount of transformation of the system per unit of change perturbation, which can also be interpreted as the amount of change of L_C per unit change of L_E.

$$\mathrm{SE} = \frac{\partial \mathrm{L_C}}{\partial \mathrm{L_E}} = \begin{cases} \mathrm{k_{SE}} \cdot \mathrm{e}^{\mathrm{k_{SE}} \cdot \mathrm{L_E}}, & \text{if } \mathrm{rate}(\mathrm{L_E}) < rate(\mathrm{L_C}) \\ \mathrm{k_{SE}}, & \text{if } \mathrm{rate}(\mathrm{L_E}) = \mathrm{rate}(\mathrm{L_C}) \\ \mathrm{k_{SE}}/\mathrm{L_E} + 1, & \text{if } \mathrm{rate}(\mathrm{L_E}) > rate(\mathrm{L_C}) \end{cases} \tag{65.5}$$

where k_{SE} is defined as the sensitivity coefficient. Although it is impossible to determine the precise sensitivity coefficients that include all of the risk event-consequence links of concern, analysis based on simple theoretical models and multivariate regressions from empirical data can provide valuable information about parameter estimation that can be applied in this measure.

65.4.2.3 Adaptability

Adaptability (AD) is defined that the improvements in the adjustments of the project system to move to a less vulnerable condition (Table 65.1), which are system responses to perturbations or stress that are sufficiently fundamental to alter the system itself, sometimes shifting the system to a new state that can reduce its sensitivity to risk events, and its exposure to them.

Adaptability has been analyzed in various ways, including via "thresholds", "coping ranges" defined by the conditions that a system can deal with, accommodate, adapt to, and recover from (Jones 2001), and using "engineering resilience" as measure to quantify resilience (Thrush et al. 2009). Conceptually, the "rate of recovery" is proposed in this paper to measure the adaptability by defining that θ_{EX} as the recovery rate to exposure and θ_{SE} as the recovery rate to sensitivity. $\theta_{EX}, \theta_{SE} \in [0, 1]$.

For the purpose of comparison of the vulnerability among different project systems to different risk process, a simple Vulnerability Assessment Model (VAM) is conducted according to Eq. (65.2).

$$V = H(EX, SE, AD) = EX \cdot SE - AD \tag{65.6}$$

Adaptability is quantified as the difference in the vulnerability under existing conditions and under the less vulnerable condition to which the system could potentially shift:

$$\begin{aligned} AD &= V(\text{existing conditions}) - V(\text{modified conditions}) \\ &= EX \cdot SE - EX \cdot (1 - \theta_{EX}) \cdot SE \cdot (1 - \theta_{SE}) \\ &= EX \cdot SE \cdot (\theta_{EX} + \theta_{SE} - \theta_{EX} \cdot \theta_{SE}) \end{aligned} \tag{65.7}$$

where the measure method of θ_{EX} and θ_{SE} can refer to the quantization approach for k_{EX} and k_{SE} analogously. Therefore, exposure, sensitivity and adaptability are almost inseparable properties of a system and are dependent on the interaction between the characteristics of the project system and on the attribute of risk process. Furthermore, the adaptability quantifying method could be applied to guild the quantization of threshold of project system vulnerability as the primary parameter for the further research on risk early-warning system or risk control model.

65.4.3 Risk Consequence

Similar to the functions of risk event, risk consequence can be easily conducted through the Eqs. (65.1)–(65.7).

$$\begin{cases} R_C = \begin{bmatrix} P_C \\ L_C \end{bmatrix} = \begin{bmatrix} P_E \cdot EX \cdot (1 - \theta_{EX}) \\ L_E \cdot SE \cdot (1 - \theta_{SE}) \end{bmatrix} \\ P_C = F'(L_C) \\ P_C \in [0, 1] \\ L_C \in [0, +\infty) \end{cases} \tag{65.8}$$

where $F'(L_C)$ represent the continuous probability distribution function of L_C conducted from the original $F(L_E)$.

65.5 Conclusion

The tendency in project risk analysis is to represent the relationship between risk event and risk consequence as statistical risk event-consequence link is incomplete. This paper gives an attempt to incorporate the notion of vulnerability into traditional risk process in case of neglecting the mediating influence of project systems. The fundamental definitions and framework of risk vulnerability process for PPP infrastructure projects are proposed to describe the formation mechanism of risks, by which a generic methodology is derived to quantify the vulnerability and the risks in PPP projects. No single measure will be able to capture completely the multiple dimensions of vulnerability. Ultimately, vulnerability research will require a set of metrics that can help analyze and explain vulnerability characteristics within and between systems. Integrated vulnerability management into risk management process may help the decision maker to identify the weakness of a project system and take action to mitigate identified vulnerabilities aiming to reduce the loss resulted from risk consequence.

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Part VII
Green Construction Materials and Construction Waste Management

Chapter 66
Causal Relationship Analysis of the Impact of Prefabrication on Construction Waste Reduction

Huanyu Wu, Jiayuan Wang and Wenmin Huang

Abstract Prefabrication technology has been commonly taken an important new perspective in terms of its impact on environmental protections, one important aspect of which is its influence on construction waste reduction and subsequent waste handling activities such as waste sorting, reuse, recycle and disposal. Nevertheless, existing research with regard to this topic failed to take into account its dynamics innate character and integrate all essential waste handling activities. This paper thus attempts to propose a causal-loop model for qualitatively depict the interrelationships among the application of prefabricated technology and subsequent waste handling activities through employing system dynamics approach by a Vensim software package. First, a definition of material flow consisting of a series of material processing activities has been developed to facilitate the illustration of the prefabrication-adoption-to-waste-disposal process. A causal-loop diagram is then constructed based on the identified variables within the material flow. This study is of value in exploring interactional and interdependent relationships underlying the identified significant variables within the processes of policy implementation, prefabrication application and construction waste handling.

Keywords System dynamic · Causal relationship analysis · Prefabrication · Construction waste reduction

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66.1 Introduction

In recent years, along with China's rapid economic development and the expanding process of urbanization over the past decades, the growth in waste generation, particularly in construction waste, has resulted in a series of environmental problem in urban construction. Statistics showed that annual construction waste in China accounted for about 40 % of the total municipal waste (Li 2007), which is accorded for more than 200 million tons, and construction waste generated from new buildings is approximately 100 million tons (Huang 2011). Facing this situation, Researchers and industry practitioners have paid growing attention on the construction waste's impact on the environment, emphasizing on waste management and putting forward a variety of measures with potential to minimize the adverse impacts of construction waste, ranging from waste minimization, reusing and recycling, to disposal (Yuan et al. 2011). Waste minimization is a process which avoids, eliminates or reduces waste at its source or permit reuse/recycling of waste for benign purposes, and is granted as the most desirable method of waste management for its benefits in eliminating waste disposal and reducing construction cost on waste sorting and transportation (Lu and Yuan 2011).

Off-site prefabrication is a manufacturing process, generally taking place at a specialized facility where various materials are joined to form a component part of the final installation (Tatum et al. 1987). A variety of forms of prefabricated construction modules normally applied in the industry could be divided into three categories: semi-prefabrication embodies non-structural elements like windows, ceiling, facades and partition walls; comprehensive prefabrication contains structural prefabrication elements such as columns, beams, floor or roof sheathing, slabs, load-bearing walls and staircases, most of which are accomplished in the factory prior to assembling; while modular building is wholly completed offsite as a one-stop system (Tam et al. 2007a, b).

Prefabrication has been commonly considered as a key strategy to drive construction waste minimization in an effective manner (Chiang et al. 2006; Yee and Eng 2001; Aye et al. 2012), in large part due to it can lessen dependence on conventional construction technologies such as cast-in-place concrete, bamboo scaffolding, timber template, reinforcement, tiling and plastering (Tam et al. 2007a, b), subsequently reducing the complexity of wet-trade work and thus contributing to construction waste minimization (Aye et al. 2012). A typical sustainable prefabricated building-T30 Tower Hotel constructed by The Broad sustainable building Co., LTD, a leading enterprise specialized in factory-made skyscrapers, are demonstrated to have a series of benefits including Magnitude 9 Earthquake resistant, low cost of construction, high thermal efficiency (leading to low maintenance cost) and specially, 1 % construction waste generation compared to conventional buildings. Furthermore, in line with sustainable building development programmer proposed by the Chinese Housing and Urban-Rural Development Ministry in 2012, many property developers typically including Vanke Group, have taken actions to practice building industrialization by promoting the adoption of prefabrication technology in the past several years. The practical experience indicated that there is lack of a tool for effectively forecasting possible impact of prefabrication in terms of waste generation and subsequent waste disposal activities.

So as to fulfill the practical need with regard to quantifying the impact of prefabrication adoption on construction waste reduction and subsequent handling activities, this paper proposes a concept model employing system dynamics approach by a Vensim software package. The purposes of establishing this concept model are (1) to identify influence factors that embodied in the material flow that explain how the use of prefabrication would have an impact on construction waste management activities and (2) to explore interactional, and interdependent relationships underlying the identified significant variables within the processes of policy implementation, prefabrication application and construction waste handling.

66.2 Background Research

Researchers are prone to be conscious of the significance of analyzing the influence of the application of prefabrication technology on construction waste related issues as some attempts have been already made during the past decades. A study implemented by Tam et al. suggested through the adoption of prefabrication construction waste resulted from conventional template installation and concrete construction could be reduced by 74–87 % and 51–60 % respectively (Tam et al. 2005) while a similar research revealed waste generation can reduce up to 100 % after using prefabrication, in which up to 84.7 % can be saved on wastage reduction (Tam et al. 2007a, b). Previous researches with respect to this topic also have contributed a variety of instruments for assessing the impact of adopting prefabrication. For instance, on the basis of questionnaire survey and case study analysis, (Jaillon et al. 2009) compared prefabrication with conventional construction in relation to waste reduction and found that the average waste reduction level was about 52 % when adopting precast construction. Information modeling and Design Structure Matrix techniques are employed by Andrew Baldwin et al. to assist designers visualize the complicated construction design process and analyze the impact of precast technique on construction waste reduction on site (Baldwin et al. 2008, 2009). Through the employment of Multi-Attribute Utility Theory, (Chen et al. 2010) developed a decision support model for evaluating the potential merits (including construction waste reduction) of prefabrication adoption in concrete buildings. Moreover, the sustainable construction aspect considerations in construction dust reduction, noise lessening and waste minimization were inspected via a comparative case study on environmental perspective between prefabrication and traditional construction method (Jaillon and Poon 2008). While giving recognition to their contributions on analyzing the influence of prefabrication adoption on waste reduction, it is of importance to note that there exist two immanent problems in these researches deserved to be further probed. First, no decision support tool exists that takes account into the impact of prefabrication adoption on all significant construction waste management activities such as waste sorting, recycle, disposal and so on. Secondly, previous studies are expected to be conducted from a static point of view, failing to consider the impact of feedback loops and complex interactions between policy, prefabrication and subsequent waste handling activities.

Furthermore, the objectives of this article lies in formulating, simulating and validating the impacts of prefabrication on construction waste reduction and waste handling activities, then the major characteristics of this process should be first given sufficient consideration: (1) The quantitative assessment of the influence of prefabrication on construction waste management demands a fully understanding of related material flows, covering holistic processes including prefabricated component application, waste generation, waste sorting, reuse, recycle and landfilling, which is a complicated system with numerous variables to be considered; (2) Secondly, the vast majority of variables involved in this system tend to be interactional and interdependent while conventional researchers are prone to separate them as independent individuals; (3) Last but not the least, the process-from applying prefabricated component to construction waste generation and disposal is dynamic, varying from traditional research that gets used to take into account the whole process from a static perspective.

Recently, system dynamics theory, integrating the feature of conventional management with the science of dynamic feedback regulating, has been extensively putted into use in a variety of topics. For instance, Shen et al. (2009) formulated a system dynamics model that comprises an integrated environmental-social-economic system for the sustainable land use and urban development and indicated that this methodology can effectively examine interactions among five sub-systems. Through applying system dynamics discipline to assess the social performance of construction waste management, Yuan (2012) found it is expert in straightening out various complicated interrelationships and feedback loops underlying numerous variables in studied system. With the assistance of system dynamics method, a decision-making tool was developed by Chaerul et al. for hospital waste management (Chaerul et al. 2008); It is found from the conclusions that system dynamics technique have contributed to analyze interactive relation among a variety of factors in hospital waste management system from a static perspective. These studies expressly indicated that system dynamics is an appropriate method for better depicting interrelationships underlying variables within a complex system from a static point of view. In this regard, it could match the above major characteristics of material flow and fill the gap of existing research, thus is applied in this paper to quantify the impact of prefabrication on construction waste management.

66.3 Research Methodology

System dynamics, which was introduced by Jay Forrester in the 1960s at the Massachusetts Institute of Technology, is defined as a computer aided approach to understanding the behavior of a system in course of time (Egilmez and Tatari

2012). It now has been wildly applied into a variety of fields such as social science, agriculture, management, economics and engineering and accepted as an effective decision-making technique capable of understanding, studying, simulating, analyzing large-scale complex system. The conventional methodology to system issues tends to depict relationships underlying system variables and comprehend subsequent system behavior from a separate perspective. Nevertheless, large-scale complex system normally comprises numerous sub-systems, among which causal relationships are interactive and interactional, that is, one value-changed variable would have an impact on another, in a feedback way, and eventually influence the behavior of the whole system. System dynamics methodology specializes in dealing with the stated characteristics as it could simplify complex system into operable units through its specially analysis tools like causal loop diagrams and stock flow diagrams, which also contribute to analyzing feedback relationships from a multi-dimensional and dynamic perspective.

Causal loop diagram and stock flow diagram are two major tools for system dynamics modeling. The former severs as preliminary sketches of causal hypotheses during model formulation and simplified representation of a model while the stock flow diagram is computer based tool visualized for quantitative simulation and analysis and is built on the basis of the causal loop diagram. As shown in the Fig. 66.1, causal loop diagram comprises elements (which represent influencing factors in a system) and arrows (connecting elements) and a sign (+ or −) on each link, A feedback would be determined as positive feedback if it includes an even number of negative causal links and negative feedback when containing an off number of negative causal links. Stock flow diagram can be represented by four structural elements, stocks (represented by a rectangle) represent the major accumulation within a system, flows (value with block arrow symbol) sever as an instrument to hinder or prompt the flow of information from the stock, converter (symbolized by a lone circle) acted as intermediate variables for miscellaneous calculation and connectors (symbolized as simple arrows) sever as information links representing the reasons and impacts within the model structure (Yuan et al. 2012).

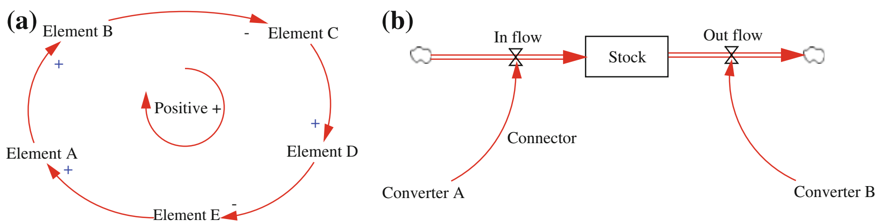

Fig. 66.1 A simple Vensim model showing causal loop diagram and stock flow diagram

66.4 Model Formulation

Normally, a five-step procedure, as exhibited in Fig. 66.2, could be adopted to develop a system dynamics model, including: (1) System description, in which step researchers are required to determine the scope of proposed system and give particular emphasis on identifying major variables associated with research questions; (2) Causal loop diagram and (3) Stock flow diagram, in these two steps, as defined above, qualitative analysis would be conducted for depicting interrelationships underlying the identified variables before mapping them into causal loop diagrams, while stock flow diagram is subsequently be constructed based on the causal loop diagram and visualized by Vensim software package for the purpose of quantitative analyzing; (4) model validation severs as an essential process for building up confidence into the proposed model, in which a series of test suggested by Coyle

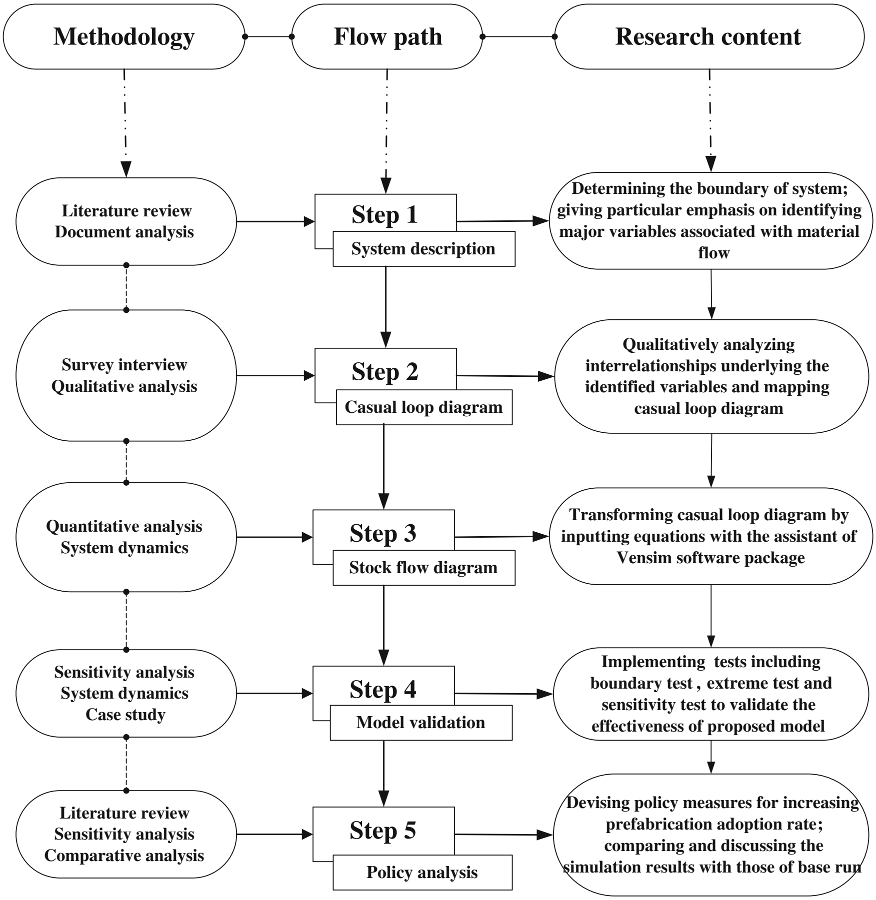

Fig. 66.2 Research path for model development

would be implemented prior to model implication; (5) policy analysis which mainly comprises base run simulation and scenario simulation would be finally conducted to analyze the possible impacts of devised management strategies after the model have been proven reliable through validation. Note that in this paper, only the concept model, namely, causal loop diagram is established, the stock flow diagram and the model validation are conducted in the further research.

66.4.1 Identification of Influence Factors

To facilitate the illustration of the prefabrication-adoption-to-waste-disposal process, a definition of material flow is adopted, that is, a flow consisting of a series of material processing activities, mainly including prefabricated component adoption, prefabrication assembly, waste generation, waste sorting, waste reuse and recycle and waste disposal. Construction materials run through all activities of the flow in sequence and the former is about to have an impact upon the consequent activity. For instance, the adoption of prefabricated facades are expected to reduce the amount of conventional construction trades such as concreting, rebar fixing and plastering, which are supported to minimize the generation of concrete, wood, and metal waste. Naturally, the quantity of on-site sorting waste will be cut down along with waste reduction, subsequently imposing influence on other relevant waste handling issues. Material flow can provide a framework for understanding the stream direction of building materials and the way prefabrication are influencing the waste disposal activities as a result of construction trades cut. Furthermore, it is of importance to note that the material flow is not merely a muster of separate material handling activities but a complex system in which various activities are interdependent and interactive, which is the reason why adopt system dynamics as the major methodology of this research. A series of typical variables influencing material handling activities derived from existing literature, site survey and related reports are presented along with the concept model of material flow, as shown in Fig. 66.3.

66.4.2 Causal-Loop Diagram

After the identification of variables with the potential of influencing the behavior of proposed system, qualitative analysis is conducted to analyze underlying interrelationships among them based on extensive literature review, semi-structure interview toward professionals. The diagram, as displayed in the Fig. 66.4, consisting of a series of feedback loops which determine the behavior of the whole system via establishing connections among various factors, severs as a visualized concept model for presenting the results of qualitative analysis. Meanings of typical variables and their underlying causal relationships within the diagram are ulteriorly made clear as follows:

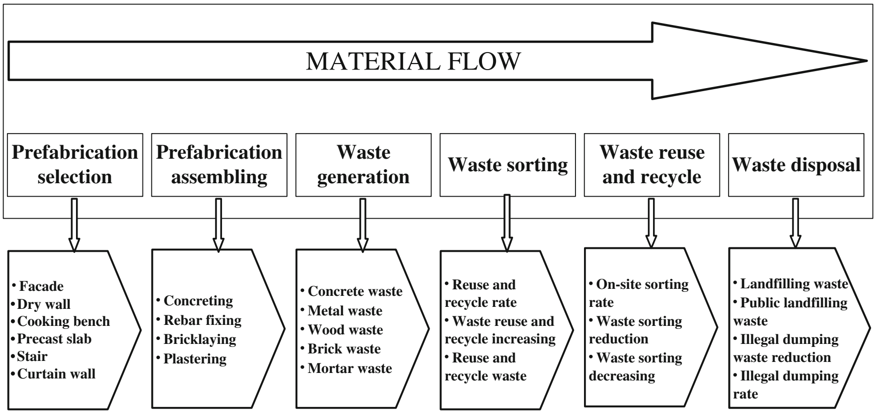

Fig. 66.3 A concept frame of material flow

Prefabrication adoption refers to applying innovative prefabricated items such as facades, dry walls, cooking benches, precast slabs and stairs, which are produced, assembled and pre-finished in off-site factory, for replacing cast-in situ, bamboo scaffolding, timber formwork, plastering and painting etc. conventional construction technologies. It is highlighted by interviewees that the adoption of prefabrication can lessen the amount of original labor-intensive construction trades

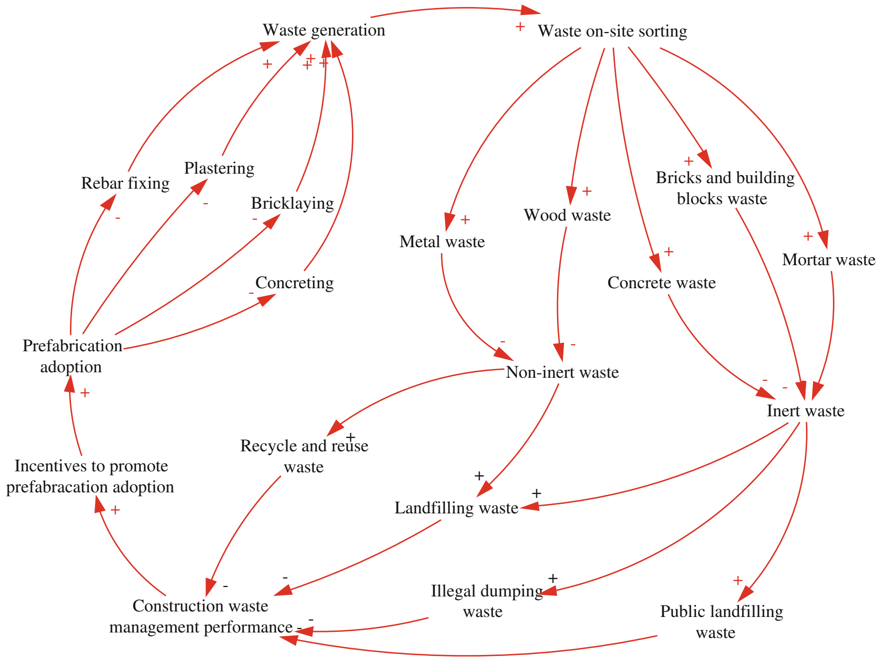

Fig. 66.4 Causal loop diagram of prefabrication application evaluation system

including concreting, rebar fixing, bricklaying and plastering, which normally render poor workmanship quality, overwhelm use of multi-layered subcontractors, hampers management control and result in excessive waste generation. Thus, along with the cut of construction trades, the expectation of minimizing various waste streams (Concrete, brick, mortar, metal and wood) are inclined to be met.

Inert waste and Non-inert waste: Construction waste is generally categorized into inert waste and non-inert waste, where the inert construction materials, containing mainly concrete, building blocks and tiles, are deposited at public filling areas for land reclamation, while the non-inert portion, comprising mainly wood, plastics and other organic materials, is disposed of at landfills as solid waste (Yuan et al. 2013).

On-site sorting: In many cases, construction waste is a mixture of both inert and non-inert construction materials (Poon et al. 2001), on-site sorting is an activity to separate construction waste according to their categories, so that some of the waste could be reused and recycled while the rest of them could be determined to be deposited at public filling areas or landfills.

Reuse and recycle, deposit at public landfill, deposit at landfill, and illegal dumping are suggested by interviewed contractors as the major four ways commonly adopted for dealing with construction waste generated from residence projects in mainland, China, arranged in ascending order of their adverse impact to environment from low to high. Reuse and recycle is regarded as the most adoptable for handling the generated waste as it not only influence environment in a minimum manner, but also help in cutting the cost of waste disposal. When reuse and recycle became difficult, it should be disposed of at landfills and/or public fills to avoid polluting the environment. Furthermore, it is reflected by interviewees that uncontrolled and illegal dumping widely occurs in inadequately supervised districts.

Construction waste management performance refers to the overall performance consisting of four attributes, namely, recycle and reuse waste, landfilling waste, public landfilling waste and illegal dumping waste, which cover all perspectives of terminal disposal of construction waste management activities. Among the four attributes, the recycle and reuse waste is positively correlated with the overall performance, that is, the more construction waste is recycled and/or reused, the more contribution it would make toward the overall performance, while the rest attributes are expected to show negative correlation toward the overall performance.

Incentives to promote prefabrication adoption mean the conjunct effect of policies of measures proposed by government for facilitating the application of prefabricated technologies. Construction is by nature not environment-friendly activity, and economic benefit is priority target of various construction participants (Chen et al. 2002), in other words, economic incentives from government is necessary for promoting the use of prefabrication because the construction cost of prefabrication is still relatively higher compared to conventional building method, as suggested by the interviewees. In addition, it should be noted that the definition of incentive in this study mainly confines to economic incentives such as tax relaxation and fiscal subsidy, other environmental or social regulations are out of the scope of this study.

Based on the analyses above, two typical feedback loop clusters are defined within the diagram:

Feedback loop cluster A:

Construction waste management performance → Incentives to promote prefabrication adoption → Prefabrication adoption → (Rebar fixing, Plastering, Bricklaying, Concreting) → Waste generation → waste on-site sorting → (Metal waste, Wood waste) → Non-inert waste → (Recycle and reuse waste, Landfilling waste) → Construction waste management performance

Feedback loop cluster B:

Construction waste management performance → Incentives to promote prefabrication adoption → Prefabrication adoption → (Rebar fixing, Plastering, Bricklaying, Concreting) → Waste generation → waste on-site sorting → (Concrete waste, Bricks and building blocks waste, Mortar waste) → Inert waste → (Illegal dumping waste, Landfilling waste, Public landfilling waste) → Construction waste management performance

It should be noted that each feedback loop is a closed loop circuit, within which one variables influence another along the direction of arrow in either positive or negative feedback. All feedback loops together constitute the causal loop diagram, as displayed in the Fig. 66.4.

66.5 Conclusion

In this paper, a concept model is developed to propose a causal-loop model for qualitatively depicting the interrelationships among the application of prefabricated technology and subsequent waste handling activities through employing system dynamics approach by a Vensim software package. Major variables in relation to the material flow are first identified; then a causal loop diagram is formulated to depict the potential interrelationship underlying the identified variables prior to the establishment of quantitative model. This paper is of value in serving as a utility tool for exploring interactional and interdependent relationships underlying the identified significant variables within the processes of policy implementation, prefabrication application and construction waste handling.

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Chapter 67
Disparity of Willingness-to-Pay and Ought-to-Pay for Construction Waste in Hong Kong: A Conceptual Model

Yi Peng, Weisheng Lu and Ke Chen

Abstract There is an urgency to deal with the looming waste crisis, and ultimately to make Hong Kong a self-sustained city. Amongst many measures, a construction waste disposal charging schemes (CWDCS), espoused by the 'polluter pays principle', is often deemed as a very effective public policy not only to reduce waste but also to further reuse and recycle waste materials. In a nutshell, a waste disposal fee is devised to impose a levy on those who dispose of their construction waste into public landfills. There are two important research directions for exploring the charging price: one is willingness-to-pay (WTP) and the other is ought-to-pay (OTP). WTP, as a tool developed by the environmental economist, aims to identify the construction stakeholders' maximum willingness to pay (WTP) for CWDCS. The result of WTP demonstrates the maximum subjective charging price for CWDCS. Meanwhile, OTP is the price level for realizing the effectiveness of CWDCS, which is determined by different decision rules. The outcome from OTP shows the minimum objective charging price to be set if the government is to achieve a certain goal in CWM, i.e. to maximize the potential of reduce, reuse, and recycle, or to deplete the landfills slower. However, the two methods were usually employed separately and few studies have investigated the disparity of WTP and OTP for a specific city. In order to rationalize the development of the CWDCS, these two important concepts must be better understood by contextualizing them in the particular socio-economic background for CWM in Hong Kong. This study aims to develop a conceptual model to investigate the disparity of WTP and OTP for C&D waste in Hong Kong. The logic and operation process of the conceptual model would be introduced. The conceptual model is helpful to guide data collection and data processing. The result from the conceptual model is helpful to improve the CWDCS in Hong Kong.

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Keywords Construction and demolition (C&D) waste · Willingness-to-pay (WTP) · Ought-to-pay (OTP) · Disparity, Hong Kong, conceptual model

67.1 Introduction

Management of construction and demolition (C&D) waste has attracted widespread concerns from developed to developing countries but probably no comparable consideration has been seen in Hong Kong than in any other region. The debate over C&D waste management (CWM) has been lengthy in the Legislative Council, local media, forums, workshops, white books, and research reports. The main reason is that more buildings have to be built in this compact city, inevitably generating more C&D waste on the one hand while on the other there are fewer landfill spaces for waste disposal (Lu 2013a). Generally, C&D waste is defined as a mixture of surplus materials arising from any excavation, civil/building construction, site clearance, demolition activities, road works and building renovation (EPD 1998). In Hong Kong, the composition of construction waste is divided into two major categories: inert materials and non-inert waste (Lu 2013b). Over 80 % of C&D materials including debris, rubble, earth and concrete are inert which could be used for land reclamation and site formation (EPD 1998). The remaining is non-inert C&D waste which includes bamboo, timber, vegetation, packaging waste and other organic materials. In contrast to inert materials, non-inert waste is not suitable for land reclamation and is disposed of at landfills. Statistics show that from 1993 to 2004 the annual generation of C&D waste has more than doubled in Hong Kong, reaching an amount of about 20 million tons in the single year 2004 (Poon 2007). In the past, C&D waste was mixed with general municipal solid waste (MSW) and used for landfill. This C&D waste alone cost the government more than HK $ 200 million annually for landfill disposal and took up valuable landfill space at a rate of about 3500 m^3 per day (Poon et al. 2001). Wong and Tanner (1997) predicted that the landfills in Hong Kong, originally expected to last approximately 40–50 years, would be filled up by 2010. Similarly, the EPD (2007) predicted that with an estimated about 24 % annual increase in C&D waste to be disposed of in landfills and public filling areas, it is likely that these facilities will be full in the next 10 years. There is an urgency to revisit these measures to deal with the looming waste crisis, and ultimately to make Hong Kong a self-sustained city.

Amongst the many measures, a construction waste disposal charging schemes (CWDCS), espoused by the 'polluter pays principle', is often deemed as a very effective public policy not only to reduce waste but also to further reuse and recycle waste materials (Hao et al. 2008). In a nutshell, a waste disposal fee is devised to impose a levy on those who dispose of their construction waste into public landfills. It is thus also called landfill charging scheme or waste disposal charging scheme. In Hong Kong, a CWDCS was enacted in 2006. According to the CWDCS, a construction contractor will be charged HK$125 for every ton of (non-inert) construction waste it disposes of at landfills; a contractor will be levied HK$100 per ton if the construction waste (as a mixture of inert and non-inert waste) is accepted by off-site sorting facilities; a contractor will be charged HK$27 per ton if the waste consists entirely of inert materials accepted by public fill reception facilities (PFRF) (Lu and Yuan 2012).

In dealing with the increasing burden from the inert and non-inert C&D waste, the Government is considering revisit the current CWDCS. To this end, the Hong Kong Green Building Council (HKGBC) and the Business Environment Council (BEC) have recently formed a joint working group (JWG) with the aim to gather views from industry stakeholders and to draw consensus on the targets and recommendations for the reduction of construction waste. The JWG has engaged a wide range of stakeholders in the construction sectors to discuss the CWDCS. However, it was observed that there was a general lack of scientific foundation for the stakeholder engagement, based on which CWM related public policies will be rationalized. It is thus an opportune time to propose this research, which aims to provide scientific foundation to the heated debate on the rationalization of the CWDCS, in particular a specific level of charging that can alleviate the waste crisis in Hong Kong. Research in other economies has reported the willingness to pay (WTP) investigated as a reference for understanding how much one is willing to pay for waste disposal. Meanwhile, there is a target level of charging (termed as ought to pay [OTP]) to be set if the government is to achieve a certain goal in CWM, i.e. to maximize the potential of reduce, reuse, and recycle, or to deplete the landfills slower. In order to rationalize the development of the CWDCS, these two important concepts must be better understood by contextualizing them in the particular socio-economic background for CWM in Hong Kong.

The construct WTP is often used to solicit the maximum amount an individual is willing to sacrifice to procure a good or avoid something undesirable (e.g. environmental degradation). These goods or undesirable things give people utility, but certain aspects of them do not have a market price as they are not directly sold. The espoused theory of investigating the WTP is contingent valuation method (CVM). It is a survey-based economic technique for the valuation of these non-market resources with passive use value. The method often provides respondents with hypothetical goods or scenarios (e.g. different construction waste disposal arrangement) and solicit their stated preference (e.g. willingness to pay) of the goods or scenarios (Mitchell and Carson 1989). The method has also been adopted in other economies to investigate the WTP for waste disposal. For example, Lake et al. (1996) reports on the results of a contingent valuation survey of a kerbside recycling scheme in the U.K. Ku et al. (2009) investigated WTP for improving the residential waste disposal system in Korea. Nnorom et al. (2009) surveyed residents' WTP for participating in electronic waste recycling in Nigeria. As far as C&D waste is concerned, Begum et al. (2007) used contingent valuation (CV) as the underlying theoretical foundation and investigated construction contractors' willingness to pay for improved construction waste management (CWM) in Malaysia. The study assessed the contractors' average maximum willingness to pay

(WTP) for improved CWM to be MYR 69.88 (US$ 21.4) per tonne of waste. Yet, if comparing it with that on municipal solid waste (MSW), research on the determination of construction waste disposal charging level is few and far between. This is largely owing to the inherent complexity of the problem itself.

The construct OTP is probably less familiar to researchers, practitioners, and policy makers. It can be understood as the minimum objective level of charging that is seen as effective by authorities to realize their CWM goals, e.g. to slow down the depletion of the landfill to its planned service life, say, till 2020. An associate question is "how much we ought to charge to lead to polluters' behavioral change to ensure the effectiveness of a CWDCS?". For example, based on simulation results, Yuan et al. (2011) found that a low charging fee would be ineffective in activating project stakeholders' waste reduction behavior because they could easily bear the additional cost associated with waste disposal. Similarly, a high charging fee would induce higher costs for waste disposal and consequently cause more illegal waste dumping activities. It is thus important to present a waste disposal charging scheme with an appropriate charging fee so that the role of the charging fee in reducing C&D waste can be maximized. Yuan and Wang (2014) used a system dynamics model to determine the level of construction waste disposal charging should be 80 Yuan/t (US$12.9/t) in Shenzhen, South China, which is much higher than the current charging price. In Hong Kong, although the CWDCS has already generated about HK$55 million (US$7 million), legislators expressed concern at the increasing number of cheats trying to work their way around the scheme (Chui 2007). Other researchers also suggested fine-tuning the scheme (e.g. Tam and Tam 2006; Hao et al. 2008; Lu and Tam 2013).

These studies provide good reference to improve CWDCS in one way or another. However, there are still some problems in the existing research, which are listed as follows:

Few scientific studies have been conducted to identify a reasonable charging price of the construction waste in Hong Kong

Few studies have been conducted to investigate WTP of different stakeholders for the charging price of the construction waste in Hong Kong

Few studies have been conducted to investigate both WTP and OTP for construction waste in a specific area like Hong Kong simultaneously

In order to alleviate these deficiencies, this study aims to develop a conceptual model to investigate the disparity of WTP and OTP for C&D waste in Hong Kong. Practical implications can be put forward to improve the CWDCS based on the results of this model.

67.2 The Conceptual Model

The research plan for identifying and reconciling the disparity between WTP and OTP for C&D waste in Hong Kong can be illustrated in Fig. 67.1.

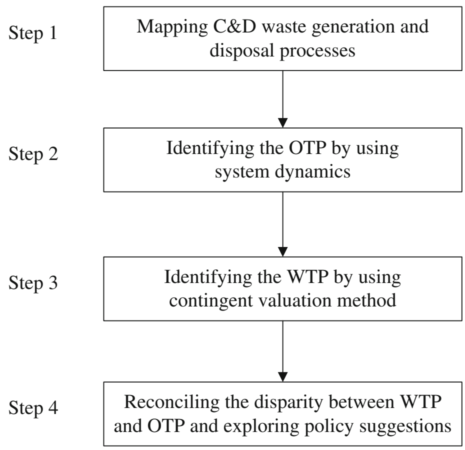

Fig. 67.1 Flow chart of measuring the disparity of WTP and OTP for C&D waste in Hong Kong

Step 1: **Mapping C&D waste generation and disposal processes**

As this study intends to examine the OTP and WTP for C&D waste in Hong Kong, the waste generation and disposal processes should be mapped. This mapping process is useful to understand the relevant stakeholders and impact factors, which are indispensable to develop the SD model for determining the OTP and conduct questionnaire survey for finding the WTP.

Figure 67.2 shows a "roadmap" of how construction waste is generated and disposed of in Hong Kong. Construction waste is often categorized into an inert and non-inert dichotomy, whereby the inert materials, comprising predominantly sand, bricks and concrete, are deposited at public filling areas for land reclamation, while the non-inert portion, consisting of materials such as bamboo, plastics, glass, wood, paper,

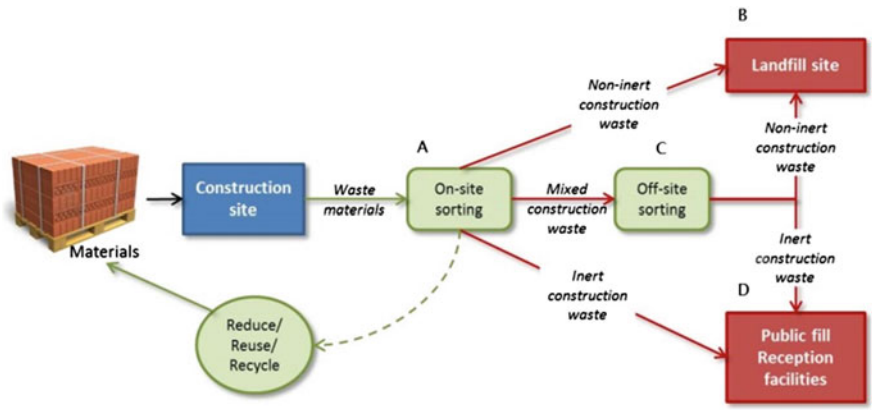

Fig. 67.2 Illustration of construction waste generation and disposal process in Hong Kong

vegetation and other organic materials, is disposed of at landfills as solid waste.

The construction waste produced is usually in the form of a mixture of both inert and non-inert materials. The segregation of the two types is of paramount importance (Poon et al. 2001). As a consequence of on-site sorting [Point A in Fig. 67.2], waste materials can be reduced, reused, or recycled to a certain extent. Contractors must dispose of the residual construction waste to designated places including landfill sites [Point B], construction waste off-site sorting facilities [Point C], or public fill reception facilities [Point D]. The Government implemented a Construction Waste Disposal Charging Scheme (CWDCS) in 2006 based on the "polluter pays principle". Starting from 1 December 2005, main contractors who undertake construction work with a contract value of $1 million or above are required to open a billing account solely for the disposal of construction waste. For construction work with a contract value of less than $1 million, any person such as the owner of the premises can open a billing account, or engage a contractor with a billing account, for disposal of construction waste.

By following this process, the relevant stakeholders and impact factors, with consideration of CWDCS, can be identifies through combining literature review and interview. For example, the stakeholders in CWM may include: (1) public or private clients, (2) designers (e.g. architects and engineers), (3) consultants, (4) main contractors, (5) sub-contractors and material vendors, (6) C&D recyclers, (7) regulators, (8) environmentalists, and (9) the general public. The important factors affecting CWDCS may include amount of generated waste, amount of C&D waste landfilled, amount of recycled waste, amount of C&D waste in public fill reception facilities, amount of illegally dumped waste, charging fee for every ton of waste landfilled, charging fee for every ton of waste sending to off-site sorting facilities, and charging fee for every ton of waste sending to public fill reception facilities etc.

Step 2: **Identifying the OTP by using system dynamics**

Based on the identified C&D waste generation and disposal process and the important impact factors, a system dynamic (SD) model can be developed. Figure 67.3 is an illustration of the SD model for determining the OTP for C&D waste. In this model, the observation variables include the amount of generated waste, amount of C&D waste landfilled, amount of recycled waste, amount of C&D waste in public fill reception facilities, and amount of illegally dumped waste. The objective variables are charging fee for every ton of waste landfilled, charging fee for every ton of waste sending to off-site sorting facilities, and charging fee for every ton of waste sending to public fill reception facilities. Other control variables are important impact factors in the CWDCS. The model is

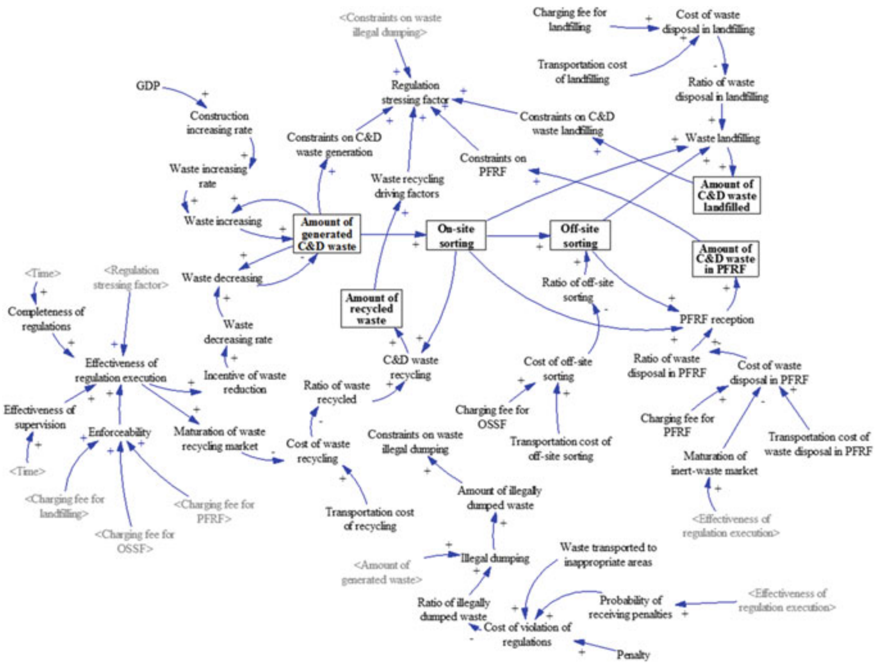

Fig. 67.3 The causal loop diagram of the SD model for determining the waste disposal charging fee in construction in Hong Kong (adopted from Yuan and Wang 2014)

adopted from Yuan and Wang (2014) to reflect the waste management practices in Hong Kong.

The historical data for this model comes from the government statistics book from 2000 to 2013. The data for some subjective variables can be obtained from interview and model calibration. The observation period is from 2014 to 2030. The model should be validated through checking whether the included factors are important and relevant, whether the model is dimensionally consistent, and whether the error of the values of the observation variable and their historical records is within the preset tolerance during 2000–2013.

i-Think® 9.0 software package can be used to simulate the model. Through the process of trial-error, the trend of the observation variables from 2014 to 2030, with the changes of the three kinds of charging fee, can be generated. The critical output for observation is the time series of amount of generated waste, amount of recycled waste, amount of waste disposed at landfills, amount of waste disposed at public fill reception facilities, and amount of illegally dumped waste. The amount of generated waste, amount of C&D waste landfilled, and amount of illegally dumped waste in the end year 2030 is used to judge which scheme shall produce the minimized volume of generated waste, waste for landfill and illegally dumped waste. Also the amount of recycled waste is used to judge which scheme shall maximize practices of recycling and reusing C&D waste. And the reasonable charging scheme, as the objective describes, can be reached through comprehensive analysis of these four aspects.

Step 3: **Identifying the WTP by using contingent valuation method**

Contingent valuation (CV) surveys for soliciting stakeholders' willingness to pay (WTP) could be a useful tool only if it is applied carefully. In designing the survey, there are two typical approaches: (a) the payment card version (Mitchell and Carson 1989), whereby respondents are provided with a list of monetized passive use values and they are asked to circle the maximum amount he/she is willing to pay for the values, and (b) the referendum version, whereby individual respondents are asked to vote 'yes' or 'no' to a random selection of amount and the vote is repeated until the maximum amount of WTP is identified. The NOAA panel seemed recommending the referendum approach using personal interviews whilst Blaine et al. (2005) reported that "neither approach emerges as unambiguously superior". In order to effectively approach the busy stakeholders involved in construction waste management (CWM) policy-making, this research decided to use the payment card approach rather than using a referendum whereby each stakeholder gets the opportunity to vote on a single offer amount.

The questionnaire would mainly include four parts. First is a cover letter introducing the current CWM situation, the CWDCS, and the background and urgency of revisiting the CWDCS in Hong Kong. In order to find the factors affecting WTP, the second part would inquiry the general background information of the interviewees. In the first question, respondents are requested to pick up an option that best describes themselves as a stakeholder, e.g. government officers, clients, and so on. Second, if the interviewees work in construction companies, which would pay the C&D waste fee in current CWDCS, the questions would be asked to understand the status of the company including the type of company (private or public); the experience in construction work (how many years); the capital of the company; frequency rate of waste collection on construction site; whether buying repairable, refillable and durable materials; the percentage of recycling and reusing waste; and satisfaction degree of existing waste collection and disposal services. The third part is designed to solicit stakeholders' WTP. Given that likely the CWDCS will continue imposing different levies on the three types of construction waste, three different questions were designed. Further, an 'open-ended' question called 'other' is designed after each question to allow respondents to fill in their own values. The fourth part of the questionnaire is an open-end optional question soliciting respondents' other view, if there is any, about the current and future CWDCS in Hong Kong.

The questionnaire can be designed and sent through Google Docs, which is easy to design and administrate. Through a random sampling, the questionnaire can be sent to the identified stakeholder groups. The average value of each stakeholder group is taken as the WTP of each stakeholder group for CWDCS.

Based on the questionnaire survey, two kinds of analysis would be conducted. First is to find the average and variance value of WTP for each stakeholder group. This is useful to understand the overall WTP for C&D waste disposed at landfills, OSSF, and PFRF. The difference of WTP among different groups of stakeholder is also clear. Second is to find the relationship between WTP and the independent variables. A multiple regression model with the ordinary least square (OLS) method would be used to estimate the parameters in the multiple regression models. The model is shown in Eq. (67.1)

$$WTP_i = \beta_0 + \sum \beta_j I_j + \varepsilon \tag{67.1}$$

where WTPi is the maximum willingness-to-pay for C&D waste disposed at landfills, OSSF, and PFRF respectively, β_0 is the constant term, I_j is the respective impact factors preset in the questionnaire survey, β_j is the coefficients of relevant impact factors, and ε is the error term.

The coefficients of these impacts factors are useful to understand whether respective factor would enhance or weaken WTP for C&D waste disposal.

Step 4: **Reconciling the disparity of WTP and OTP and exploring policy suggestions**

By comparing the OTP, WTP, and current charging fees, it is easy to find (a) whether current charging fees have reached the level of OTP for realizing the preset waste management objectives, (b) the disparity of WTP and OTP, namely whether the relevant stakeholders are willing to pay more to obtain a better results of waste management, and (c) the distribution of WTP among different stakeholders. This information provides significant references to proposing an appropriate charging level for C&D waste disposal. Intuitively, there is a disparity between the two. If the WTP is larger than the OTP, the policy-makers can just set the OTP as the charging level and there will be no resistance to implement it. If the WTP is smaller than the OTP, they can try to reconcile the disparity through (1) better stakeholder engagement, (2) providing subsidiaries, or (3) other methods. By identifying and reconciling the disparity between OTP and WTP, CWM policy-making can be much better guided and monitored.

67.3 Conclusion

CWDCS plays an important role in reducing C&D waste. With regards to the charging price, there are two research mainstreams: one is willingness-to-pay (WTP) and the other is ought-to-pay (OTP). The result of WTP demonstrates the maximum subjective charging price for CWDCS. Meanwhile, the outcome from OTP shows the minimum objective charging price for reducing C&D waste through CWDCS. However, the two methods were usually employed separately and few studies have investigated the disparity of WTP and OTP for a specific city. Therefore, it remains unknown whether the current charging price is effective and how to improve the CWDCS. This paper put forward a specific work plan to identify the disparity of WTP and OTP for construction waste in Hong Kong. As a result of this plan, it is easy to find (a) whether current charging fees have reached the level of OTP for realizing the preset waste management objectives, (b) the disparity of WTP and OTP, namely whether the relevant stakeholders are willing to pay more to obtain a better results of waste management, and (c) the distribution of WTP among different stakeholders. Practical policy suggestions can therefore be put forward. Future study should implement this model to investigate the real disparity of WTP and OTP for construction waste in Hong Kong and put forward corresponding suggestions on improving the current CWDCS.

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Chapter 68
Legislative Framework for the Construction and Demolition Landfill in Western Regions of China—A Critical Analysis

Jian Zuo, Hongping Yuan and Hongwei Sun

Abstract A significant amount of construction and demolition (C&D) waste has been produced in China in the past two decades. Previous literature determined that the regulation has an important role to play in cultivating an appropriate regulatory environment for managing C&D waste, and the C&D waste landfilling regulation has been an essential component in the total regulatory system. However, it is also observed that the existing C&D waste landfilling regulations in China are by and large perceived as insufficient in supporting the effective reduction of the waste. Thus, this study aims to conduct a systematic review of China's C&D waste landfilling regulations. The C&D waste landfilling related regulations of the six regions located in the Western China, including Sichuan, Chongqing, Yunnan, Guizhou, Guangxi, and Shanxi, were analyzed. The content analysis approach was adopted to analyze the data collected from previous literature, governmental reports and data retrieved from relevant C&D waste landfilling regulations. Comparisons of regulations between these six regions were also carried out. It is anticipated that the outcomes could help in advancing the regulatory environment of C&D waste landfilling in these regions and also could be potentially used by other regions in the country.

Keywords Construction and demolition waste, C&D waste · Landfilling regulations · Content analysis · Review

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68.1 Introduction

The construction industry is one of biggest producers of waste. According to the official statistics, the Construction and Demolition waste (C&D waste) generated from the rapid urbanisation and urban renewal has accounted for 30–40 % of municipal waste in China (Lu 1999). Since the introduction of Grand Western Development strategy in 2000, a large number of construction activities were undertaken in the western regions of China. The natural disaster is also responsible for the generation of C&D waste. More than 600 million tonnes of C&D waste were generated from the Wenchun earthquake (Shi 2008). However, these huge amounts of C&D waste are not dealt properly, most of which are dumped illegally or being sent to landfill directly. This has led to severe environmental issues as well as challenges to land resource management (Ding 2009). It is well recognized that recycling is the most effective approach of managing C&D waste. However, there are no more than 30 enterprises nationwide specialising in resource recovery from C&D waste. Compounded by the immature technologies, the recycling rate from C&D waste is comparatively low (Ding 2009). As a result, C&D waste management has attracted a growing attention.

The existing studies on C&D waste management can be classified into three groups. The first group of literatures placed focuses on basics such as the definition, composition and physical attributes (Li 2007; Wu 2000). The second group focused on the technologies and codes related to C&D waste. The third group emphasized the related management tools, policies, mechanisms, laws and regulations, and economics (Zhang 2007). These studies contribute to the C&D waste management in China. However, there is lack of systematic analysis of the existing legislative framework related to C&D waste.

It is well recognized that landfill regulations form an integral part of legislative framework of C&D waste management. Landfill regulations define the following critical issues in the legislative framework: (1) major stakeholders; (2) the planning and construction of landfill facilities; (3) the determination and collection of landfill charges; and (4) administration of landfill activities. Currently, there are many regulations related to C&D waste landfill. It is not unusual that discrepancies exist between national regulation and regional regulation; and amongst regional regulations. In addition, the revolution of regulations related to C&D waste landfill varies from one region to another in China. Therefore, it is imperative to systematically analyse these regulations with an aim to further improve the legislative landscape of C&D waste management. Considering the significant variations between regions in China, six provinces in the western region are selected in this study, i.e. Sichuan, Chongqing, Yunnan, Guizhou, Guangxi and Shanxi.

68.2 Overview of the Legislative Framework for the Construction and Demolition Landfill

As shown in Table 68.1, regulations related to C&D waste management can be generally classified into two levels, i.e. national regulations and regional regulations. Measures for the treatment of municipal solid waste was released in 1995 which is the first time to specify that producers of waste should be charged. However, the Measures placed focuses on municipal waste without specific clauses on the construction and demolition waste. In 2003, the Administrative measures for

Table 68.1 Regulations related to C&D waste management in the western region

Level	Year	Regulations	Note
National	1995	Measures for the treatment of municipal solid waste	
	2003	Administrative measures for the construction waste and dregs in urban areas	
	2005	Administrative measures for the C&D waste in urban areas	
	2008	Technical guidelines for handling the construction waste in earthquake zones	
Sichuan	1998	Provisions of Chengdu city on handling construction wastes	Amended in 2002
	2013	Opinions on comprehensive utilization of construction waste post-Wenchuan earthquake	
	2014	Regulations of Chengdu city on handling construction wastes	
Chongqing	2005	Measures on the conditions and procedures for handling construction waste in Chongqing municipality	
	2012	Administrative measures for the C&D waste in Chongqing municipality	
Shanxi	1994	Regulations on the city appearance and environmental sanitation management in Xi'an city	Amended in 2003
	2012	Administrative measures on the construction waste management in Xi'an city	
Yunnan	2005	Administrative measures on the municipal waste management in Kunming city	
	2007	Administrative measures on the construction waste management in Kunming city	
Guizhou	2003	Administrative measures on the municipal waste management in Guizhou province	
	2007	Administrative measures on the construction waste management in Guiyang city	
Guangxi	2003	Regulations on the city appearance and environmental sanitation management in Nanning city	Amended in 2009
	2006	Administrative measures on the construction waste management in Nanning city	Amended in 2012

the construction waste and dregs in urban areas was released by the Ministry of Construction, which specified the principles of C&D waste management as "producer's responsibility" and "resource recovery". This to a certain degree reflects the growing recognition of importance of C&D waste management and resource recovery. Consequently, the Ministry of Housing and Urban-Rural Development released the Administrative measures for the C&D waste in urban areas which provided detailed specifications of various aspects of C&D waste management such as sorting, development of landfill facilities, landfill charges, and penalties. In addition, local governments of the western region have released C&D waste regulations under specific contexts. For instance, a large quantity of construction waste was generated from the 2008 Wenchuan earthquake. As a result, technical guidelines for handling the construction waste in earthquake zones were developed to guide the C&D waste management activities.

In general, national regulations are fundamentals of each local government for the development and implementation of regional regulations. Following the national regulations such as Administrative measures for the C&D waste in urban areas, a number of regional regulations were released to suit the local conditions. The evolution path of regional regulations is similar to that of national regulations with the first focus on municipal waste. These include: Regulations on the city appearance and environmental sanitation management in Xi'an city (1994); Administrative measures on the municipal waste management in Guizhou province (2003) and Regulations on the city appearance and environmental sanitation management in Nanning city (2005). These regulations simply covered general issues the city appearance and environmental sanitation management without specific description of C&D waste landfill. Associated with the advancement of municipal waste management, regulations dedicated to C&D waste landfill were gradually developed. For instance, Measures on the conditions and procedures for handling construction waste in Chongqing Municipality was released in 2005. This is the first ever dedicated measure for C&D waste which defined various activities associated with C&D waste management such as transport, dispose, and recovery however without specification on landfill. This on the one hand indicated the growing recognition of the importance of C&D waste management by governments, on the other hand showed that the applicability of municipal waste management is questionable for C&D waste due to its uniqueness. In 2012, Administrative measures for the C&D waste in Chongqing Municipality was released to specifically define the planning of landfill facilities, landfill charge standards and permits, and management mechanisms. Similarly, Administrative measures on the construction waste management in Xi'an city was released in 2012 which defined the responsibilities of each major stakeholder and the 3R principles of construction and demolition waste management.

68.3 Issues Associated with the Current Legislative Landscape

68.3.1 Legal Framework Related to C&D Waste Landfill

The contents of regulations are not detailed enough. It is well recognized that the landfill charge is one of effective measures to manage C&D waste. If managed properly, landfill charge can motivate the client and contractor to be actively engaged in the waste reduction. Otherwise they will have to bear the extra cost incurred from landfill. The benefits include: promoting the recycling and reuse of building materials, and saving land resources. The regional regulations specified various aspects of landfill such as transport of C&D waste and penalty for illegal dumping. Some of these regulations even have defined the basic principles of landfill activities will be charges. However, there is lack of detailed description and operatable measures of how the landfill charge will be determined. Similarly, many of regional regulations are duplications of national regulations without providing guidance on C&D waste practice under the local conditions.

68.3.2 Duties and Coordination of Authorities

The C&D waste landfill is a complex system which is related to a number of authorities such as environmental protection, construction, and transport (Yuan et al. 2012a). The coordination between these authorities is crucial for the effective implementation of C&D waste related regulations.

There are generally two major issues associated with the coordination between various authorities as defined in the regional regulations. First, there are vague descriptions on the punishment of illegal dumping and authority in charge. For instance, it is stated in the Regulations of Chengdu City on Handling Construction Wastes that "the punishment to illegal dumping will be implemented by the local government as delegated by the related authorities". Second, there is lack of clear description of the coordination mechanism between various authorities. This is detrimental to the effective implementation of C&D waste regulations.

68.3.3 Planning and Management of C&D Waste Landfill Facilities

Currently, direct landfill is still the main approach of handing C&D waste in most regions of China. Therefore, it is imperative to ensure the appropriateness of landfill facilities. However, planning and management of C&D waste landfill facilities were not paid attention in western regions of China, as evidenced in the regional regulations. For instance, Measures on the conditions and procedures for handling construction waste in Chongqing Municipality does not cover such aspects at all. Administrative measures on the construction waste management in Kunming city is arguably the best regional regulation in terms of defining the planning and management of landfill facilities. In general, regional regulations should be further improved in this aspect by issuing more detailed administrative measures on mid to long term strategic planning of landfill facilities; site selection; routine management and financing models.

68.3.4 Landfill Charge Standards

The experience from developed countries showed that landfill charge is an effective approach of motivating contractors toward waste reduction (Hao et al. 2008). The analysis showed that "producer paid the charge" principle has been determined in western regions of China for C&D waste management. The C&D waste landfill charge rate of western regions of China varies according to the geographical locations, economic development level, and development level of the construction industry. However, there is lack of consistency in terms of the way the landfill charge standard is defined amongst the regional regulations, e.g. by weight (tonnes) or by volume (m^3). Such inconsistency makes it difficult for cross-regional comparison and hence the development of comprehensive policy at the national level (Yuan et al. 2012b). Similarly, the landfill charge rate varied significantly, from 5 to 150 RMB per tonne. Existing studies have suggested that an appropriate landfill charge rate helps to engage major stakeholders in waste reduction or vice versa.

68.3.5 Punishment for Illegal Dumping

Illegal dumping not only presents difficulties to C&D waste management but also affects the natural environment. Therefore, attention has been paid in western regions of China to deal with illegal dumping as evidenced in regional regulations. However, there are some issues associated with these regulations. Most of these regulations concentrated on penalty after the event of illegal dumping which should be shifted toward prevention. In addition, the level of penalty is comparatively lower in western regions which may weaken its effectiveness. Similarly, there is lack of incentive of C&D waste landfill management which overlooked the role of market mechanism.

68.4 Conclusions

This study critically analysed the regional regulations on C&D waste management in western regions of China, i.e. Sichuan, Chongqing, Yunnan, Guizhou, Guangxi and Shanxi. Results showed that regional regulations are somewhat detailed version of national regulations. This is in line with the current legislative framework of China. These regional regulations varied significantly from one region to another. This study revealed that the duties and coordination amongst various related authorities need to be clarified. There is lack of appropriate and effective landfill charge rate. Similarly, a long term mechanism needs to be established for the planning and development of landfill facilities, so as to dealing with illegal dumping. These findings provide useful inputs for future policy making.

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Chapter 69
Construction Waste Generation Rate (WGR) Revisited: A Big Data Approach

Xi Chen, Weisheng Lu, Meng Ye and Liyin Shen

Abstract Benchmarking performance is one of the most efficient ways to improve construction and demolition (C&D) waste management continuously. Waste generation rate (WGR), however it is defined, is often utilized as the key performance indicator (KPI) for this benchmarking purpose. Yet, the WGR cannot be known with any precision, as current studies, for various reasons, can only investigate a relatively small sample of projects hence their results cannot justifiably be generalized to estimate WGRs in other projects. Managers have complained that current WGRs are too divergent to be confidently accepted as KPIs for benchmarking. This research aims at developing a set of convergent KPIs/WGRs, by making use of a large set of data that has become available only recently. By mining the big data of construction waste disposal records accumulated in Hong Kong over 2011, it is found that the WGRis convergent with the increase of data. It thus can be used for benchmarking the performance of C&D waste management. The study provides not only more accurate WGRs in Hong Kong, but also insightful understanding of the usage of WGRs for C&D waste management decision-makers, researchers and the like.

Keywords Construction and demolition (C&D) waste management · Key performance indicator (KPI) · Waste generation rate (WGR) · Benchmarking · Big data · Data mining

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69.1 Introduction

It is widely recognized that a huge amount of waste is generated from construction activities every year throughout the world. The Hong Kong Environmental Protection Department (EPD 2014b) defined construction and demolition (C&D) waste as any substance, matter or thing which arises from construction work and abandoned whether or not it has been processed or stockpiled before being abandoned. C&D waste in Hong Kong is broadly divided into two categories: (1) inert waste, which consists of soft inert materials (e.g. soil, earth, silt and slurry) as well as hard inert materials (e.g. rocks and concrete); and (2) non-inert materials (e.g. metal, timber, and packaging waste) (Poon 2007; Lu 2013). C&D waste not only depletes finite landfill resources and contaminates the environment, but it also harms society (Lu and Yuan 2013; Yuan et al. 2013; Yuan 2011). With the increasing embracement of sustainable development, responsible management of C&D waste is an essential aspect for mitigating its negative impact on the natural environment. To deal with the construction waste, a series of initiatives have been introduced in Hong Kong. Particularly, based on the "polluter pays principle" (PPP), a Construction Waste Disposal Charging Scheme (CWDCS) was enacted in 2006. In line with the Scheme, a contractor will be imposed a levy for the construction waste it disposes of.

There is a prevailing culture of measuring performance of waste management in construction sector. Over the past two decades, C&D waste management has attracted researchers worldwide to extend their interest in this emerging discipline. Bossink and Brouwers (1996) quantified and evaluated the source of Construction Waste. Poon et al. (2004) investigated the causes and quantities of C&D waste generated on public housing building sites in Hong Kong, and found the major causes of waste materials were improper preparation, handling, misuse, and incorrect processing. Lu and Yuan (2010) identified seven critical factors for successful C&D waste management: (1) waste management regulations, (2) waste management system, (3) awareness of C&D waste management, (4) low-waste building technologies, (5) fewer design changes, (6) research and development in waste management, and (7) vocational training in waste management. Here, real data from the waste management system are used for examining the effectiveness of C&D waste management policies in Hong Kong. It is vital that a specific benchmark for measuring the performance of C&D waste management in a project and an economy can be set by referring to key performance indicators (KPIs). Here, the C&D waste management in projects or the management policies as a whole can be treated as a system. In measuring C&D waste management performance, waste generation rates (WGRs) often act as proxies of the KPIs (Lu et al. 2011; Poon et al. 2001; Lin 2006). From now on, WGR and KPI will be used interchangeably.

Lu and Tam (2013) conducted a qualitative investigation on the C&D waste management in Hong Kong through reviewing relevant policies in Hong Kong. Compared with qualitative investigation, quantitative studies are more convincing in providing the data references for benchmarking waste management. There are some previous quantitative studies applying WGRs as KPIs for estimating the performance of C&D waste management. For example, Lu et al. (2011) investigated the C&D waste management by focusing on WGRs of different materials in four construction sites. Formoso et al. (2002) examined the C&D waste management through analyzing the generation rate of waste produced from 41 sites. However, they both failed to provide a full reflection of performance of C&D waste management in the studied region, because for various reasons they only conducted limited case studies. In addition to the insufficiency of data volume, the construction types of these studies seem also imbalance. Building projects were the mainstream in those cases applied to investigating the WGRs of C&D waste. However, according to the definition of C&D waste from EPD (2014a), results from investigating building cases could only reveal a spot of the C&D waste management issues. In this context, there is a need to provide accurate WGRs of construction waste by mining full-scale data.

The aim of this study is to develop a set of convergent KPIs/WGRs by taking advantage of a large set of data that has become available recently. The big data set covers around 3000 sites, large or small, scattered in Hong Kong, and more than 1.1 million waste generation/disposal records in 2011 alone. According to the Law of Large Numbers (LLN), the average of the results obtained from a large number of trials should tend to become convergent to a certain value as more trials are performed (Sen and Singer 1994). It is hoped that the WGRs could converge with the increase of the samples in the big data. The rest of the paper is structured into five sections. Subsequent to this introduction section is a detailed description of the methodology consisting of the big data, data mining and K-means clustering approaches. The analysis process of the big data are presented in the figures and the table in the data analysis and results section. Discussions are conducted to deepen the understanding of the analytic results, and conclusions are drew at last.

69.2 Methodology

69.2.1 The Big Data

It is noticed that for every truck of construction waste received at the designated facilities, which could be land fill sites, public fill disposal facilities, off-site sorting facilities or outlying island transfer facilities (Lu and Tam 2013). This practice leads to around 1.2 million transaction records per year. The records form the big data. The record contains a lot of useful information, such as a certain vehicle (labeled by vehicle no.), a certain amount of construction waste (weight-in, weight-out, and net weight) and a certain time (time-in, and time-out). The waste is generated from a project with a unique billing account number, which is the bridge connecting information for a certain project. There are other relational databases recording the project and vehicle information respectively. By examining the big data, it is possible to answer the above questions, and extract some meaningful rules and patterns of waste disposal behavior for policy-makers or developers in C&D waste management.

69.2.2 Data Mining

Data mining is a computational process of discovering patterns in large data sets using multidisciplinary methods such as artificial intelligence, machine learning, statistics, and database systems (Clifton 2010). The overall goal of the data mining process is to extract information from a data set and transform it into an understandable structure for further use (Clifton 2010). A classic example of data mining is the discovery of knowledge that four out of five customers that bought beer also bought potato chips after analyze supermarket transaction data to examine customers' consumption behavior; a supermarket can then purposely have beer next to the chips, resulting in increased sales of both (Lee and Siau 2001). Information that can be used as KPIs for measuring and benchmarking purposes is waiting to be explored in the big data. A set of WGRs are mined from the data by correlating a database to another owing to their common and unique information, account number for an individual project.

69.2.3 Cluster Analysis (K-means Clustering)

Cluster analysis can form groups of related variables. There are numerous ways for sorting cases into groups. The adoption of methods depends on, inter alia, the size of the data file. Methods commonly used for small data sets are impractical for data files with thousands of cases. Generally, there are several basic methods for cluster analysis, such as hierarchical clustering, two-step clustering and k-means clustering. K-means clustering is a centroid-based technique, where a case is assigned to the cluster for which its distance to the cluster mean is the smallest (Han et al. 2012). The number of clusters should be decided in advance. The means for a range of cluster numbers can be solved by rerunning the analysis for every cluster. K is the number of algorithm centers (Han et al. 2012). There are a few steps for clustering and finding the means of the K clusters. An initial set of means are based on the distances of clustering cases to their centers. Next, the cluster means of the cases that are assigned to the clusters are calculated again, all cases in the new clusters are reclassified in order to reduce the distance between cases and cluster centers. Until cluster means stop changing, the computation ends up with a fixed set of cluster means and a fixed group of clusters (Han et al. 2012).

It's perfectly acceptable to cluster data that may not meet the assumptions for best performance, but only he analyzer can determine whether the solution is satisfactory for its use (Norušis 2011). Here, WGRs are the cases for K-means clustering owing to the characteristics of the WGR distribution. Equation 69.1 is the theoretical foundation of the K-means clustering for WGRs (Aravind et al. 2010). Excel is the main computational tool in this study.

$$\varepsilon_K = \sum_{i=1}^{m} \sum_{k=1}^{K} Z_{ki} (WGR_i - \overline{WGR}_k)^2 \tag{69.1}$$

In the equation, K is the number of clusters, m is the number of WGR values that fall in the kth cluster, $\overline{WGR}_k$ is the mean of all WGRs in the kth cluster, and WGR_i is the ith WGR in the kth cluster. The parameter Z_{ki} is an indicator variable indicating the suitability of the ith data point x_i to be a part of the kth cluster. Now the objective of the algorithm is to find an optimum $\overline{WGR}_k$ for the above equation so that the value of ε_K (the measure of overall cluster quality) reaches its minimum.

69.3 Data Analyses and Results

The WGRs of individual projects in the whole year of 2011 are calculated and plotted (see Fig. 69.1). In total, there are 2818 contracts available of WGRs. Figure 69.2 is the picture of the 2818 projects ranked in order of significance of WGRs, which vary from the lowest 0.0001 to the highest 2491 ton/million HKD (t/Mhkd). Figure 69.3 presents the distribution of the 2818 WGRs every 100 t/ Mhkd in 2011. It appears that most WGRs are in the interval (0, 100) t/Mhkd, followed by two order of magnitude lower frequencies for projects that fall in every 100 t/Mhkd in the WGR range of 100–2500 t/Mhkd. These WGRs seem be convergent in 0–100 t/Mhkd, but divergent in 100–2500 t/Mhkd. Since WGRs are the

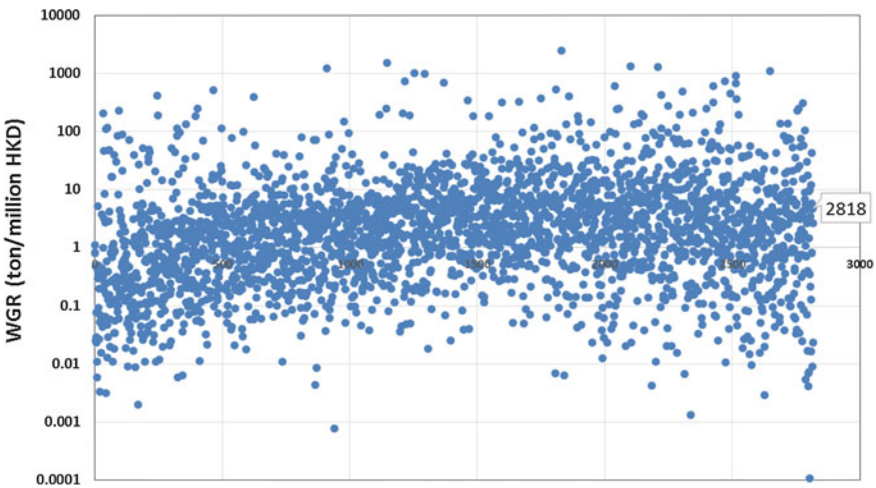

Fig. 69.1 Overall WGRs in 2011

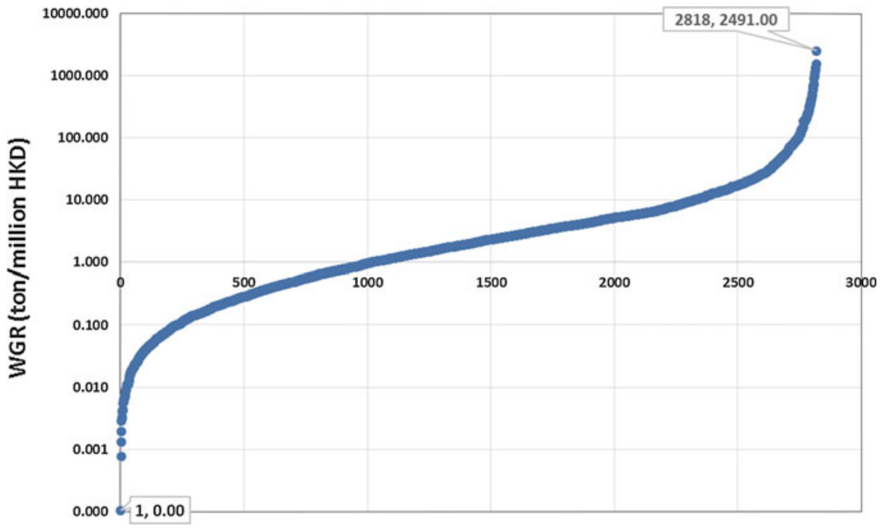

Fig. 69.2 Overall WGRs in 2011 ranked in order of significance of WGR

KPIs for identifying the performance of C&D waste management, projects with exceptionally high WGRs fail to satisfy the expectation of right waste management. K-means clustering is reasonably applied to define the convergent WGR interval in order to distinguish the “AVERAGE&GOOD” and “NOT SO GOOD” performed projects. Two Clusters are selected to conduct K-means clustering analysis, which means K = 2 in this study. Cluster 1 is supposed to identify the WGRs with lower value, while Cluster 2 is expected to identify the WGRs with higher value.

The WGR range, average value, standard deviation (STDEV) and project quantity in the two clusters, namely Cluster 1 and Cluster 2 (see Table 69.1). The

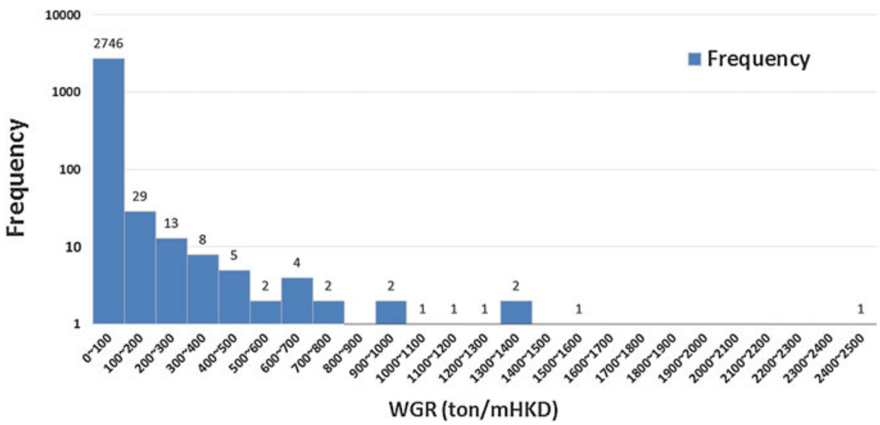

Fig. 69.3 Distribution of WGRs in 2011

Table 69.1 Results of clustering analysis

Description	Cluster 1	Cluster 2
Range (t/Mhkd)	0–117.54	131.57–2491
Average (t/Mhkd)	6.61	448.52
Standard deviation	14.22	429.49
Quantity of projects (proportion)	2755 (97.76 %)	63 (2.24 %)

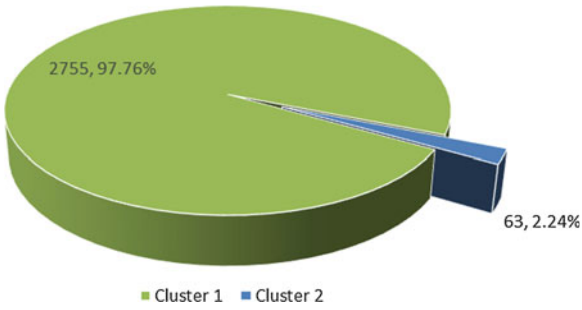

Fig. 69.4 Proportions for cluster 1 and cluster 2 based on WGRs in 2011

output meets the expectation that the two clusters distinguish the 2818 WGRs into a convergent group with low WGRs and a divergent one with exceptionally high WGRs respectively. STDEV stands for the degree of dispersion of a group of data. As expected, the average WGR value of Cluster 1 is 6.61 with an STDEV of 14.22, which is obviously much lower than that of Cluster 2 (average: 448.52 and STDEV: 429.49). Moreover, there are as much as 2755 projects (97.76 %) in Cluster 1, whilst Cluster 2 consists of 63 projects (2.24 %). Given the sample size is large enough, it is reasonable that the proportion 97.76 % is trustable, and the other 2.24 % projects are singular ones. Figure 69.4 shows a direct-viewing picture of the proportion of Cluster 1 and Cluster 2 for readers. Therefore, Cluster 1 is the group of projects with "AVERAGE&GOOD" waste management measures, while Cluster 2 is the "NOT SO GOOD" project group. Figure 69.5 shows the zoning for differentiating the "AVERAGE&GOOD" and "NOT SO GOOD" among the scattered projects.

69.4 Discussion

WGRs used for indicating performance of C&D waste management policies are compared between present and previous studies. Benchmarking the performance of C&D waste management is discussed. The projects with exceptionally high and low WGRs is explained and criticized from the perspective of management. Finally,

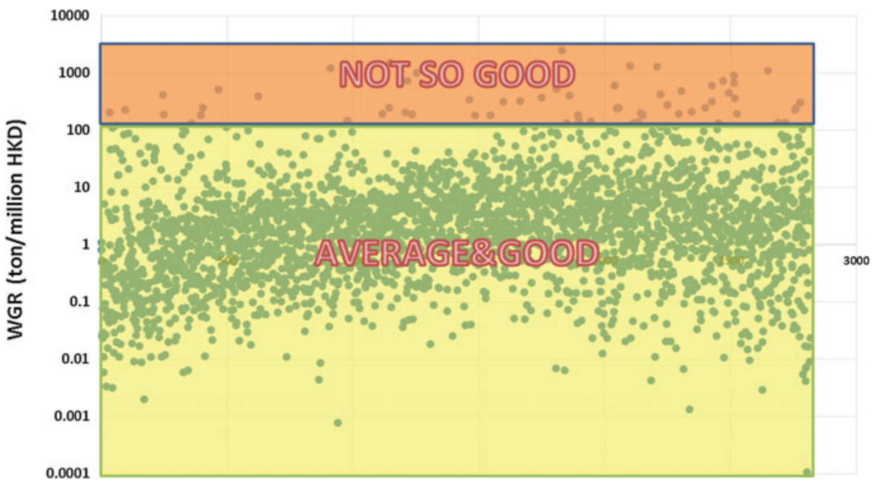

Fig. 69.5 Zoning based on waste management performance of projects in 2011

strategies for construction organizations and government are also suggested for improving the C&D waste management.

69.4.1 Comparison of the WGRs as KPIs Between This Study and Previous Study

The measurement in this study is different from previous studies, which take waste volume per gross floor area (GFA) (e.g. m^3/m^2) (Poon et al. 2001; Lin 2006) or waste weight per GFA (kg/m^2 or t/m^2) (Lu et al. 2011; Mercader-Moyano and Ramírez-de-Arellano-Agudo 2013) as the unit of WGRs. This study seems to be the first case that waste weight per cost is utilized to benchmark waste management performance. However, it is notable that the exact volume of construction waste is hard to measure. For example, the volume of a wooden box can be much larger than that after it is torn down as wood chip boards. On the other hand, waste weight is more accurate for measuring because it excludes the spare space in calculation. Although GFA is feasible in measuring the WGRs of building works, it is improper for other construction works unavailable of GFA, such as installation of municipal wastewater pipes, maintenance of external walls, construction of subway station and roof waterproofing engineering. On the contrary, introducing project cost to measure the WGRs is much better for indicating the performance of C&D waste management politics, particularly in economies like Hong Kong with a relatively unified socioeconomic level in all regions. Therefore, waste weight per cost is recommended in the estimation of WGRs to generally benchmark the waste management performance in versatile C&D works.

69.4.2 Benchmarking the C&D Waste Management by Examining WGRs as KPIs

As presented in Table 69.1, the average WGR for the “AVERAGE&GOOD” construction projects is 6.61 t/Mhkd. The average waste net weight for each lorry transaction is nearly 4 t, which means about 1.65 lorries of waste are produced with every million Hong Kong dollar spent on construction works. As this number is produced from analyzing big data by applying reliable statistical method, 6.61 t/M can be used as a benchmark for measuring the annual C&D waste management performance in the following years. The range 0–117.54 t/Mhkd (see Table 69.1) can be used as the reference range for determining an “AVERAGE&GOOD” construction project. Otherwise, the project is poorly performed in waste management. Also, it is necessary to estimate waste management performance of a project after the completion of construction through comparing the WGR with the benchmark. It also has its reference value for government in adjusting the waste disposal fee or penalty in waste disposal charging schemes, such as the CWDCS in Hong Kong. Government should set a WGR-step toll system for fining the poor performed projects in C&D waste management. In simple terms, the fine should be increased with the WGR step by step.

69.4.3 Projects with Exceptionally High WGRs

“NOT SO GOOD” projects account for about 2.24 %. Since the range is from 131.57 to 2491 t/Mhkd, there must be some contracts with exceptionally high WGR. For contractors, appropriate strategies, such as “Reducing”, “Reusing” and “Recycling” waste materials on construction sites (Three Rs principle) are recommended to bring down the waste finally sent to waste disposal facilities. Meanwhile, government should launch effective financial incentives or regulations for consolidating the implementation of these strategies, in order to keep the volume of poorly performed projects as low as possible. Non-inert and a part of inert waste materials are disposed in landfill sites, which are depleting the land resource of Hong Kong. Therefore, dissemination of awareness of environmental and land-resource protection is needed among construction sectors for improving sense of social responsibility. The dissemination methods can be community activities, roll-modeling on public projects and advertising on subway TVs, bus panels and newspapers.

69.4.4 Projects with Exceptionally Low WGRs

It is operable to identify the poor performed projects with extremely high WGRs, but it is difficult to identify the poor performed projects with extremely low WGRs.

Except for those minor works, such as air-conditioning drainage engineering, elevator maintenance and water faucet alternative work, projects with extremely low WGRs may be involved in waste transferring from site to site (WTSS) and/or illegal dumping in the waste transportation process. Measures such as using Radio Frequency Identification (RFID), Global Position System (GPS), and Global Information System (GIS) technologies to track the lorries carrying construction waste have been explored for monitoring illegal dumping in Hong Kong. However, it is noticed that understanding of current construction waste disposal behavior, including the alleged illegal dumping, is still superficial, despite it being a prerequisite to the success of the waste management strategies from government. For example, the construction work with the lowest WGR is a contract of foundation, site formation and building. The WGR of this project is near 0.0001 t/Mhkd, which appears be problematic owing to the work nature of the project.

With the enforcement of CWDCS, illegal dumping and WTSS might largely bring down the amount of waste disposed by government department. The latter behavior is economically, environmentally and socially beneficial if the materials are acceptable for reusing for the following reasons:

(1) the contractors can be exempted from the disposal fee charged by government department;
(2) transferring waste from site to site may bring profits for contractors;
(3) this can alleviate the workload of public fill reception facilities and off-site sorting facilities; and
(4) appropriately reusing materials can be environmentally friendly.

With establishing a proper management system, WTSS can be a prosperous method in construction waste management. However, illegal dumping is a behavior positive for neither the society nor the environment. Possible measures should be taken to distinguish illegal dumping and waste transferring behaviors. A robust waste tracking system may help enormously reduce the disposal amount for the public fill reception facilities, because about 94 % of construction waste are inert materials, which can be used for land reclamation and site formation as public-fill activities (EPD 2014b). Such system should also help mitigate illegal dumping when government puts it into practical use.

69.5 Conclusions

The present study investigated the effectiveness of C&D waste management policies by focusing on the WGRs in the year 2011 in Hong Kong. There are 2818 projects with valid WGRs from 0.00 to 2451 t/Mhkd. WGRs of these projects are estimated and serve as the key performance indicator in determining the performance of C&D waste management of Hong Kong. K-means clustering method is applied to differentiate the projects with relatively normal WGRs and those with exceptionally high WGRs.

It was found that the WGR unit, waste weight per cost is relatively reasonable for benchmarking C&D waste management in an overall situation. A benchmark for examining the performance of C&D waste management of a project is set using a WGR interval [0, 117.54] (t/Mhkd). The average WGR for the relatively normal performed group, 6.61 t/Mhkd is also set as a measurement criterion for annually estimating the performance of C&D waste management policies of government in a large scale. Strategies for construction companies and contractors, such as "Three Rs principle" are suggested for reducing the poor performed projects with exceptionally high WGRs. For this purpose, financial incentives from governments, dissemination of environment and land resource protection awareness, and WGR-step toll fining system for poor waste management performance are also suggested to stimulate better management strategies among organizations. Projects with extremely low WGRs are suggested to be carefully checked by relevant government departments in order to identify whether illegal dumping behavior and/or waste transferring from site to site are involved.

The study presents more accurate WGR sin Hong Kong, and a deep-going understanding of the usage of WGRs as KPIs for examining C&D waste management for decision-makers, researchers and the like. For the good of the environment and society, future studies are suggested to develop a robust tracking system for monitoring the illegal dumping and waste transferring behaviors for government use.

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Chapter 70
Life Cycle Costs of Metal Roof, Concrete Tile Roof and the Intelligent Cooling Roof

Min Wu, Guangwei Chen, Peter Davis, Willy Sher, John Smolders, Shuo Chen, Zhidan Qin, Zhou Yan and Ying Wang

Abstract This study introduces the principle of an intelligent cooling and compares the life cycle costs of a concrete cooling roof, a metal cooling roof and the intelligent cooling roof. We conclude that the intelligent cooling roof is more cost effective than both the concrete cooling roof and the metal cooling roof. The intelligent cooling roof is friendly in installation and effective in producing cooling in summer without consuming any electricity, potentially it could be the next generation of roof for houses in Australia and many other countries.

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Keywords Solar cooling · Air-conditioning · Solar energy · Life cycle costing

70.1 Introduction

Summer in Australia is hot. The highest temperature recorded in Cloncurry in Queensland was over 50 °C (Burt 2011). The outdoor air temperature in summer in Newcastle can be up to 40.0 °C. Implementing solar energy driven air conditioning is an ideal option to provide cooling while saving electricity and reducing greenhouse gas emission (Baniyounes et al. 2013). In Australia, particularly Newcastle, more and more households are seeking for energy-saving building materials or solutions for the renovations of existing house or new homes. Building products can provide long-term cost-cutting on energy bills and promote environmental and economic sustainability in the community are encouraged by the Australian government as well.

70.1.1 Roofs

A roof is a basic building component. In addition to provide a shelf against rains, the roof also provides insulation for solar radiation, thus protecting the occupants. The solar radiation is either reflected by the roof into the atmosphere or absorbed and transferred through conduction into the building.

Cooling roof is a roof that can provide cooling. There are many types of roof systems available, the surface exposed to the sun is the one that determines if a roof is cool or not. We can usually make a new or existing roof cool by selecting the appropriate surface or installing a set of refrigeration system. In this paper, we will introduce three kinds of roof: metal roof, concrete tile roof and intelligent cooling roof.

1. Cooling method for metal roof and concrete tile roof

The design (type, color, elevation) of metal roof and concrete tile roof will determine how the heat is reflected, absorbed, or emitted. "Cool" coating technology, one of the main methods, focuses on reflecting off solar radiation (Solar Reflectivity). Cool roof coatings are white or special reflective pigments that reflect sunlight. Coatings are like very thick paints that can protect the roof surface from ultra-violet (UV) light and chemical damage, and some may offer water protection and restorative features as well. Products are available for metal roof and concrete tile roof. Mainly, cool coatings can alleviate roof surface temperatures, reducing the need for cooling energy in conditioned buildings and making unconditioned buildings more comfortable.

2. Cooling method for intelligent cooling roof

Intelligent cooling roof is a new kind of roof, on which refrigeration facilities are placed. The roof could be metal or non-metal tiles. When the intelligent refrigeration system was installed, it became a new kind of roof, and presented many new characteristics. Intelligent cooling roof could absorb solar energy and use it to drive refrigeration system to reduce the indoor temperature. The intelligent cooling roof and its working principle will be introduced later.

Previous researchers have developed different kinds of solar roof for household heating and cooling. Most of them have been produced as experimental units, and computer codes were written to simulate the systems. Some of these designs are discussed below.

Parker and Barkaszi (1997) studied on roof solar reflectance and cooling energy use. They conducted an experiments on nine residential buildings from 1991 to 1994 using a before and after test protocol where the roofs were whitened at midsummer. Measured air conditioner electrical savings in the buildings during similar pre and post-weather periods averaged 19 %, ranging from a low of 2 % to a high of 43 %. Utility peak coincident peak savings averaged 22 % with a similar range of values. Cooling energy reductions appear to depend also on initial ceiling insulation level and roof solar reflectance, air duct system location and air conditioner sizing.

Hanif et al. (2014) designed a radioactive cooling system by using a flat-plate rooftop as a radiator to reject heat to the cooler nocturnal sky for cooling purposes. In addition, the radioactive cooling potential is determined by using the climate data of 10 different locations in Malaysia. The study found that radioactive cooling can save up to 11 % of the power consumption for cooling purposes.

Juanicó (2010) presented a sola roof, which is configurable by water redistribution. The roof is design for providing household heating and cooling. The experimental results showed that total cost is similar to standard roofs, and significant energy savings could be achieved. Other researchers focused on the optical and thermal properties of cool roof coatings (Synnefa et al. 2006; Berdahl and Bretz 1997; Uemoto et al. 2010; Synnefa et al. 2007; Jia and Jin 2011; Smith et al. 2003; Ma‡ et al. 2001).

Researchers in (Maneewan et al. 2004) reported a "thermoelectric roof solar collector (TE-RSC)" for power generation using solar energy. The TE-RSC was composed of a transparent acrylic sheet, air gap, a copper plate, thermoelectric modules and a rectangular fin heat sink. The incident solar radiation heats up the copper plate so that a temperature difference is created between the TE modules that generate a direct current (Maneewan et al. 2004).

Our literatures reviews suggest that no paper or patent has been published on reduce the temperature of houses by the design of solar smart absorption refrigerator. Thus, this paper proposes a smart solar refrigerator for houses in Australia and compares the life cycle costing of the conventional roof systems and the smart cooling roof system. Commonwealth Scientific and Industrial Research Organization (CSIRO) predicts that by 2050 around 30 % of Australia's energy supply will come from solar power (CSIRO 2010; Bahadori and Nwaoha 2013). The cooling system proposed here potentially could be the new generation of roof systems for houses in Australia.

70.2 Cost Calculation

The cooling roof will be produced in Guangzhou, China and imported to Newcastle in Australia. Calculation is based on a 40 m^2 single story unit for four solutions: Metal roof with coatings (S1), concrete tile roof with coatings (S2), metal roof with intelligent cooling system (S3), and concrete roof with intelligent cooling system (S4).

70.2.1 The Cost of Raw Material Purchase

As an important manufacturing country, the procurement of raw material in China has a price advantage. We selected Chinese main e-commerce purchasing site as research objects, the price of components and raw material were investigated and analyzed, the average market procurement price were chose for cost analysis of raw material purchase.

1. The cost of intelligent cooling roof

To buy a refrigerator from Guangzhou (China), raw materials and components include: solar panels, generator, condenser, evaporator, absorber, pipeline etc. The cost of intelligent cooling roof system is analysis in Table 70.1.

With reference to Table 70.1 we can see that the cost of an intelligent cooling roof system is PI, $PI = 470 + 250N + 30M$, $N \geq 1$ and $N \in Z$, $M \geq 10$. When $N = 1$, $M = 10$, $PImin = 1020$. PImin indicated the lowest cost price to buy an intelligent cooling roof system.

Table 70.1 The cost of intelligent cooling roof system

	Procurement unit (PU)		Unit-Price (Yuan/PU)	Procurement price (Yuan)
	Number of procurement (no.)	Weight of procurement (kg)		
Solar panels	N ≥ 1	–	250	250N
Generator	1	–	120	120
Condenser	1	–	100	100
Evaporator	1	–	100	100
Absorber	1	–	150	150
Pipelines	–	M ≥ 10	30	30 M
Total (Y)	–	–	–	470 + 250N + 30M

Table 70.2 The difference of raw material procurement costs of roofs

Categories	Unit size (mm)	Unit price (Yuan/Unit)	Quantity per m^2	Price per m^2 (Yuan)	Price for 40 m^2 (Yuan)
Metal roof	1335 × 420	24	2	48	1920
Concrete tile roof	364 × 303	2	10	20	800

2. The cost of metal roof and concrete tile roof

The cost of metal roof and concrete tile roof is composed of two parts, the cost of roof tile and the cost of cool roof coatings. The cost of metal roof and concrete tile roof for a 40 m^2 room is different. If we use the same roof coatings, the cost of cooling roof coatings is just the same. We chose two representative commodity from the electronic commerce website to calculate the purchase cost. The difference of raw material procurement costs of roofs can be find in Table 70.2.

From Table 70.2 we can find that the cost of metal tiles is much higher than the cost of concrete tiles. Through the investigation on the China mainland market, we found that the average price for roof coating is 240 Yuan/20 kg, and 20 kg roof coating can brushing 50 m^2 2 times, it's quite enough for a 40 m^2 room. So we can theoretically assumed that, whether using metal roof or concrete tile roof, the cost of coatings for a 40 m^2 room is 20 Yuan.

Through the above analysis, we can summary that:

the purchase cost of metal roof with coatings (S1) is P1

$$P1 = 1920 + 240 = 2160\ (\text{Yuan}) \tag{70.1}$$

the purchase cost of concrete tile roof with coatings (S2) is P2

$$P2 = 800 + 240 = 1040\ (\text{Yuan}) \tag{70.2}$$

the purchase cost of metal roof with intelligent cooling system (S3) is P3

$$P3 = 1020 + 1920 = 2940\ (\text{Yuan}) \tag{70.3}$$

the purchase cost of concrete roof with intelligent cooling system (S4) is P4

$$P4 = 1020 + 800 = 1820\ (\text{Yuan}) \tag{70.4}$$

70.2.2 The Cost of Logistics

In order to calculate the different transport cost of roof from Guangzhou to Newcastle, we should estimate the weight of roof tiles and refrigerator, then

Table 70.3 The weight analysis of metal roof and concrete roof tiles

Categories	Unit size (mm)	Unit weight (kg/unit)	Quantity per m^2	Weight per m^2 (kg)	Weight for 40 m^2 (kg)
Metal roof	1335 × 420	2.6	2	5.2	208
Concrete tile roof	364 × 303	4.2	10	42	420

Table 70.4 The weight analysis of intelligent cooling system

	Procurement unit		Unit weight (kg)	Component weight (kg)
	Purchase quantity	Purchasing weight (kg)		
Solar panels	N ≥ 1	–	9	9N
Generator	1	–	12	10
Condenser	1	–	8	6
Evaporator	1	–	10	8
Absorber	1	–	12	10
Pipelines	–	M ≥ 10	–	M
Total (kg)	–	–	–	34 + 9N + M

determined the logistics cost combined with various process rates. For the convenience of calculation, 40 m^2 room is chose to be a research object, different roof tiles transportation fee and smart cooling roof refrigerator logistics cost were calculated respectively. The weight analysis of metal roof and concrete roof tiles is shown in Table 70.3. The weight analysis of intelligent cooling system is shown in Table 70.4.

We can see from Table 70.3 that the weight of metal roof and concrete tile roof are Wm 208 kg and Wc 420 kg. Plus coating weight Wt 20 kg, the total weight of two kinds of roof should be 228 and 440 kg.

From Table 70.4 we can find that the weight of a set of intelligent refrigerator was $34 + 9N + M$, $N \geq 1$ and $N \in Z$, $M \geq 10$. When $N = 1$ and $M = 10$, we could get the minimum price of a set of intelligent refrigeration roof system, that was WI 53 kg. The weight of raw material or component for the solution Si is Wi, i = 1, 2, 3, 4.

$$W1 = Wm + Wt = 208 + 20 = 228\ (\mathrm{kg}) \tag{70.5}$$

$$W2 = Wc + Wt = 420 + 20 = 440\ (\mathrm{kg}) \tag{70.6}$$

$$W3 = Wm + WI = 208 + 53 = 261\ (\mathrm{kg}) \tag{70.7}$$

$$W4 = Wc + WI = 420 + 53 = 473\ (\mathrm{kg}) \tag{70.8}$$

The transport of raw materials or components from Guangzhou to Newcastle contains four aspects of expenses, including: packing charge delivery fee in China,

Table 70.5 The analysis of logistics cost for the four solution

Si	Wi (kg)	Packing charge	Delivery fee in China	Shipping cost	Delivery fee in newcastle	Total (Yuan)
		10 Yuan/kg	20 Yuan/kg	60 Yuan/kg	1000 Yuan/each time	
S1	228	2280	4560	13,680	1000	21,520
S2	440	4400	8800	26,400	1000	40,600
S3	261	2610	5220	15,660	1000	24,490
S4	473	4730	9460	28,380	1000	43,570

delivery fee in China, shipping cost, delivery fee in Newcastle. The packing charge delivery fee in China is 10 Yuan/kg, the delivery fee in China is 20 Yuan/kg, the shipping cost is 60 Yuan/kg and the delivery fee in Newcastle is 1000 Yuan/each time. The analysis of logistics cost for the four solution is in Table 70.5.

Table 70.5 shows that logistics cost of the four solution, the logistics cost for the four solutions can be expressed as Li Yuan, i = 1, 2, 3, 4. L1 = 21,520, L2 = 40,600, L3 = 24,490, L4 = 43,570.

70.2.3 Installation Fee

The cost of installation cost in the process of roof installation is composed of two parts: direct project costs and indirect project costs. The direct project costs include: labor costs and expenses of using construction machinery; the indirect project costs include: insurance premium, replenishment fee, upkeep fee and other expenses.

Roof tile is one of the most economical roofing options on the market. Due to their extreme durability, the cost of concrete roof tiles is distributed over an extended lifecycle. Depending on the weather conditions where the roof is located, a life expectancy of 10–20 years is common with tile roofs, a metal roofing system offers durability, lasting 2–3 times longer. Assume that the concrete tile roof repair cycle is 20 years, metal roof repair cycle is 50 years, and the single maintenance fees are 10,000 Yuan, two worker was selected to implement the four kind of solution respectively. Workers set up a 40 m^2 metal roof or concrete tile roof spent 8000 Yuan, brush paint cost is 2000 Yuan; customers can install the intelligent cooling system their own, no installation fee is needed. So the labor cost for the four solution are 10,000 Yuan, 10,000 Yuan, 8000 Yuan, 8000 Yuan. The investigation of the installation workers in Newcastle area shows that the installation cost of the four solutions are as follows (Table 70.6).

The cost of installation for the solution Si is Ii, i = 1, 2, 3, 4. I1 = 13,900, I2 = 14,200, I3 = 10,400, I4 = 9700. So we can find that the installation cost of Metal roof with intelligent cooling system (S3) and Concrete roof with intelligent cooling system (S4) are is more economical.

Table 70.6 The analysis of the cost of installation cost of the four solutions

Category	Charge	Explanation	S1	S2	S3	S4
Direct fee	Labor costs	Labor wages	10,000	10,000	8000	8000
	Expenses of using construction machinery	Mechanical construction cost	2000	2000	1000	–
Indirect fee	Insurance premium	Dangerous work accident insurance	1200	1200	1200	1200
	Upkeep fee	The average annual maintenance fee	200	500	200	500
	Other expenses	Overtime pay, lighting electricity etc.	500	500	–	–
Total	–	–	13,900	14,200	10,400	9700

Table 70.7 Comparison of three kind of cost

Cost	S1	S2	S3	S4
Procurement costs Pi	2160	1040	2940	1820
Logistics cost Li	21,520	40,600	24,490	43,570
Installation cost Ii	13,900	14,200	10,400	9700
Total	37,580	55,840	37,830	55,090

The comparison of raw material procurement costs, logistics cost, and installation costs are summarized in Table 70.7.

Table 70.7 shows that the solution Metal roof with coatings (S1) and Metal roof with intelligent cooling system (S3) is more economical for a 40 m^2 room. The average life of a non-metal roof is 17 years. Asphalt can require re-roofing every 10–20 years, often sooner. But a metal roofing system offers better durability, lasting 2–3 times longer (Residential Metal Roofing Resources 2014). So metal roof is a good solution for this case. Intelligent refrigeration system has the characteristics of cooling and heating, and can reduce the maintenance cost, the collocation of metal roof and intelligent refrigeration system would be the best solution for the 40 m^2 room.

70.3 Energy Saving Calculation

Houses in Newcastle Australia require cooling for providing comforts for their occupants. Normally one-third to half of the annual total electricity consumption is used for air-conditioning and refrigeration in the metropolis worldwide, with 80 % of electricity is still generated by burning fossil fuels, leading to the non-stopping emission of global warming gases (Fasfous et al. 2013; Fong et al. 2010).

Previous analysis showed that metal roof and intelligent cooling system are more economic. Usually, the 40 m^2 unit adopt an 2500 W air conditioner, cold demand per unit is 150 W/m^2, cold demand for 40 m^2 is 6000 kW. When using intelligent cooling system to cool a 40 m^2 room, Energy Efficiency Ratio (EER) will reflect the refrigeration efficiency.

$$\text{Energy Efficiency Ratio (EER)} = \text{Refrigerating output}/\text{Rated power consumption} \tag{70.9}$$

$$\text{EER} = 6000\,\text{W}/2500\,\text{W} = 2.40 \tag{70.10}$$

EER 2.40 shows that the refrigeration effect is not high. Because of the energy consumption is mainly determined by output power, the output power of air conditioner is generally 2.6–2.9 times of the input power, so the 2500 W air conditioner 0.9 kWh per hour. The investigation in Newcastle shows that the average tariff of this area is 1.8 Yuan per kWh. Using the 2500 W air conditioner, the power consumption per hour is 1.62 Yuan. The utilization of intelligent cooling system refrigeration system doesn't need electric energy, so this solution can help customs to save electricity expenses. If calculated in accordance with 1.62 Yuan/h, and 8 h per day, the total amount of electricity saving is for a month is 388.8 Yuan. The intelligent refrigeration roof can effectively reduce electricity costs.

70.4 System Description

The intelligent cooling system consists of a solar heat collector, a generator, an evaporator, an absorber, a cooling tower, and a data-acquisition system and the associated control systems, see Fig. 70.1. The working pair consists of LBPCM (LBPCM, Low boiling point phase change material) used as the refrigerant and HBPS (HBPS, High boiling point solvent) used as the absorbing medium. Because of the principle of the solar refrigerator is mainly Dalton's law of partial pressures and the Thermosyphon effect, the system operates exclusively with solar energy and no moving parts are required. In other words, the system collects solar energy to drive the refrigerator without electricity.

70.4.1 Principle of the Intelligent Cooling Roof

The intelligent cooling roof, shown in Fig. 70.1, uses two mechanisms to reduce the temperature of houses: one is to use phase change materials, absorption of solar radiation; the other is to use solar power radiation intelligent refrigerator, directly reduce the temperature of houses.

G is a generator, G solution absorption of solar radiation, part LBPCM will heat boiling, precipitate from the solution after boiling, steam bubble liquid column to

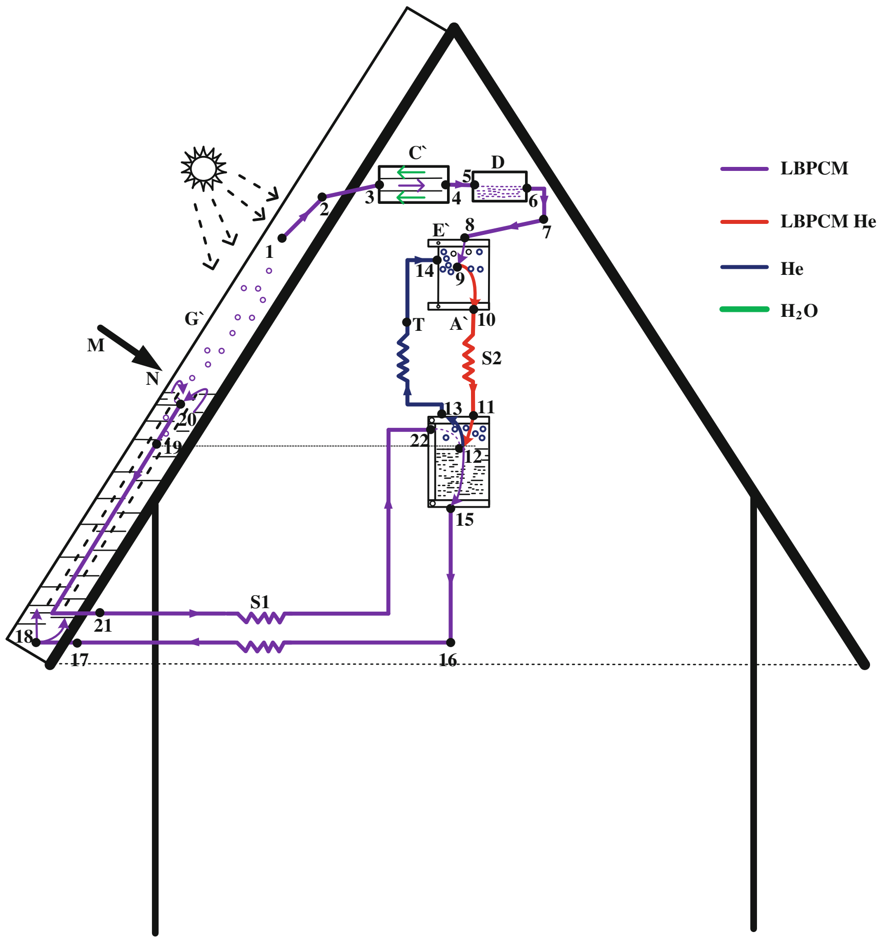

Fig. 70.1 The working principle of generator

20. Caused by the generation of air bubbles and the solution is heated, vertical density of concentrated solution of output are going down, according to the Thermosyphon effect (hot siphon phenomenon), concentrated solution is heated, expansion will become after will rise into the upper and the density of concentrated solution is returned to the bottom, thus G upper dilute solution, with the aid of G and A static head of the two container solution, forcing solution flows through the solution heat exchanger tube of S1 flow to A top (the path of 19, 21, 22). At the same time, will pass by A strong solution of heat (S1), make thick entering G soluble preheating. We’ve already talked about, radiant energy in intelligent machine includes three kinds of materials, LBPCM, HBPS and helium, because LBPCM easy to dissolve in HBPS, cause the gas pressure in A smaller, form the relatively low pressure, so 9 sites into helium and gaseous LBPCM mixture realize continuous suction, upstream (the path of 10, 11, 12, 22). In dilute solution (14) by

A top down by gravity flow, and from A top upstream of helium and gaseous LBPCM mixture (its path is 9, 10, 11, 12), absorption of gaseous LBPCM, make the solution concentration increasing. Formed A thick LBPCM solution into A bottom, again after the solution heat exchanger S1 in the G of thermosyphon differential pressure at the bottom of the G (15, 16, 17,18) for its path.

From G mix LBPCM more HBPS droplets, droplet within 2 due to gravity drop, gaseous LBPCM and gaseous HBPS rises, cause and the external environment for heat exchange, air temperature is reduced, more liquid HBPS will precipitate from LBPCM gas, condensate HBPS for liquid flow back into G. A high concentration of gaseous LBPCM after HBPS liquid blocker 2 into the air-cooled condenser with finned C, under C, the water cooling, condenses into liquid, and gaseous LBPCM C will make it an angle, depending on the inclination of the C itself, liquid LBPCM after flowing through the C, D to E (its path for 4, 5, 6, 7, 8), in upper E encounter with helium, is a mixture of helium and gaseous LBPCM gas in the E. According to Dalton law of additive pressure (Dalton's law of partial pressures), a gas in the gas mixture produced by partial pressure is it occupies the whole container produced by pressure alone, and the total pressure of gas mixture is equal to the sum of all the gas partial pressure, because of the low density of helium, floating in the upper part of the E, so at the top of the E, helium partial pressure is high, the corresponding LBPCM partial pressure is very low. LBPCM points down, the boiling point of the LBPCM is very low, so the liquid LBPCM in E start at the top of the evaporation, evaporation process absorbs a lot of heat from E around at the same time, achieve the goal of further cooling of the house. The top of the E, as a result of helium and gaseous LBPCM mixture of gaseous LBPCM partial pressure is low, so the evaporation temperature is very low. With a liquid LBPCM constantly evaporation and diffusion, in gaseous mixture LBPCM partial pressure slowly raise, evaporation temperature rise. Contain LBPCM more LBPCM at low temperature and helium mixture density is larger, sinking under the gravity, they through the lower S2 in A lower gas heat exchangers (its path is 9, 10, 11, 12). You've already talked about, in the top of A LBPCM is absorbed, form the relatively low pressure, therefore, gaseous LBPCM and helium mixture by A lower upward flow (the path for 11, 12), contact with the dilute solution of top-down, LBPCM overtaken by dilute solution absorption, gives off heat absorption process. Helium does not dissolve in water, density is small, so from A rise in the upper (its path for T, 11, 12, 13, 14), warm along T by helium gas cooling heat exchanger S2 (lower helium temperature, avoid influencing E refrigeration effect) into E and cycle starts all over again. Cold air come out from points 11 and 13, and it will reduce the temperature of the house.

The characteristics of intelligent refrigerator are its simple use and maintenance, safe performance, electrical energy saving, convenient energy storage, no environmental pollution, and so on. In addition, compared with the normal mechanical refrigeration, solar intelligent refrigerator system which makes use of Thermosyphon effect does not require pumps, compressors and other moving parts, and so there is no wear and noise. It does not require refrigerant so it will not produce environmental pollution, and it also use simple circulatory system of LBPCM(LBPCM, Low boiling point phase change material) and helium instead of complex transmission pipelines.

The concrete realization form of power are “light—heat—cold”. In order to achieve the purpose of cooling, the solar collector absorbs solar energy to drive the solar intelligent refrigerator. The working principle is mainly Dalton’s law of partial pressures and the Thermo syphon effect.

70.5 Conclusion

This study introduces the principle of an intelligent cooling and compares the life cycle costs of a concrete cooling roof, a metal cooling roof and the intelligent cooling roof. We conclude that the intelligent cooling roof is more cost effective than both the concrete cooling roof and the metal cooling roof. The intelligent cooling roof is friendly in installation and effective in producing cooling in summer without consuming any electricity, potentially it could be the next generation of roof for houses in Australia and many other countries.

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Chapter 71
Predicting Contractor's Behavior Toward Construction and Demolition Waste Management

Zezhou Wu, Ann T.W. Yu and Yigang Wei

Abstract Contractor's attitude and behavior towards construction and demolition (C&D) waste management can make significant influence to C&D waste generation. However, little research has been conducted to investigate the relationships between attitude and behavior. The theory of planned behavior (TPB) is a theory that links attitude and behavior, and it has been employed in many fields. The aim of this study is to investigate the contractor's attitude and behavior toward C&D waste management (CDWM) based on TPB. A conceptual framework is developed incorporating eight affecting factors, namely attitude toward behavior, social subjective, perceived behavioral control, behavioral intention, governmental supervision, beneficial consideration, project constraint, and behavior. Based on this framework, the interrelationships between attitude and behavior can be further investigated using structural equation model.

Keywords Construction and demolition waste management · Theory of planned behavior · Attitude · Behavior · Framework

71.1 Introduction

The construction industry generates numerous waste (Wu et al. 2013). Many countries or regions have published their construction and demolition (C&D) waste amounts. For example, the US Environmental Protection Agency (EPA) estimated

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the amount of building-related waste to be 136 million tons in the whole country, representing a generation rate of 2.8 pounds per person per day (EPA 2013). According to the publications of European Commission (EC), C&D waste accounts for approximately 30 % of all waste amount in EU (2013). In Mainland China, it is reported that the C&D waste generated from urbanization and city renewal represents more than 30 % of the municipal solid waste (Zhao et al. 2010). If the huge amount of C&D waste is treated improperly, negative environmental impacts can be produced, such as solid pollution, air contamination, etc. Thus, there is an urgent demand for effective C&D waste management (CDWM).

Nowadays, the construction stakeholders have recognized the need of alleviating C&D waste impacts. A prevailing hierarchy model for waste management has been introduced into the construction industry, which involves reduce, reuse, recycle, compost, incinerate, and landfill (Peng et al. 1997). Echoed with the hierarchy model, many CDWM strategies were proposed, such as on-site sorting (Poon et al. 2001; Wang et al. 2010), prefabrication (Lu and Yuan 2013; Tam and Hao 2014), material bar-code system (Chen et al. 2002; Wu and Yu 2014), etc. However, in China, the contractors rarely implement these management strategies in real-life construction, though many of them acknowledge that the contractors should take responsibility for protecting the environment. Thus it is essential to investigate why this happens and provide relevant countermeasures to improve the current situation. With the comprehensive and deep understanding of the interrelationships of contractor's attitude and behavior, CDWM can be promoted in real-life cases.

The aim of this study is to develop a conceptual framework that can be used to assist investigating the determinants for contractors to adopt CDWM in construction process. The next section of this paper introduces the theory of planned behavior (TPB). Based on the existing TPB model, a conceptual framework is further developed considering the context of construction industry; potential questions for measuring the affecting factors are presented as well. Finally, the paper is ended with a conclusion of the main findings.

71.2 Theory of Planned Behavior

The theory of planned behavior (TPB) was developed by Ajzen (1985), based on the theory of reasoned action (TRA). TRA was proposed by Fishbein (1967), it assumes that most of human actions are under the control of the main subject, the subject's attitude toward a behavior and subjective norm influence his intention and intention is the most instant determinant of a behavior. However, in real life, there are cases that the main subject cannot decide his behavior himself due to some external factors. It is thus regarded that attitudes probably could not predict behavior directly (Wicker 1969). Therefore, TPB was proposed by introducing perceived behavioral control into TRA to give a more comprehensive explanation of the determination process of a behavior. Perceived behavioral control is defined

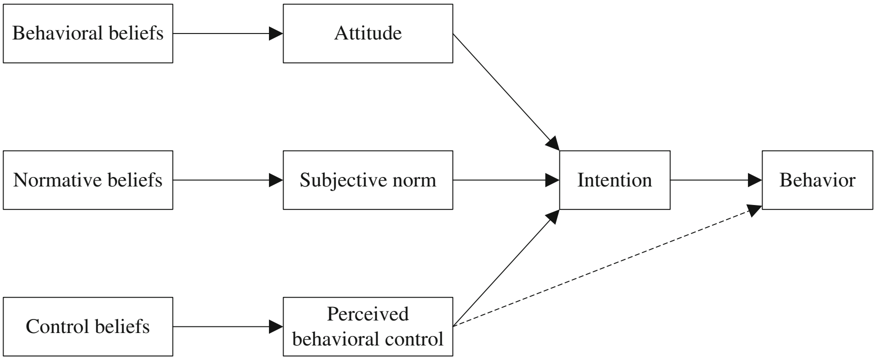

Fig. 71.1 Framework of theory of planned behavior (Ajzen 1985)

as people's perceptions of their ability to perform a particularly given behavior (Ajzen 1985). The framework of TPB is shown in Fig. 71.1.

From the TPB framework, it can be seen that intention and perceived behavioral control have direct effect on behavior. Meanwhile, perceived behavioral control is also having an indirect influence on behavior; it can perform an indirect influence on behavior through intention together with attitude and subjective norm. To give a general explanation, Ajzen (1991) claimed that, if a subject bears favorable attitude and subjective norm toward a particular behavior, he will have strong intention and very likely to perform the behavior if his perceived behavioral control is strong. Otherwise, the behavior may not be performed because of the weak perceived behavior control.

71.3 Establishment of the Framework

71.3.1 The Developed Framework

Currently, the TPB has already been implemented in numerous fields and studies, and has been proved to be effective. However, as the CDWM is a behavior in the context of construction industry, some particular external construction related factors can influence the behavior directly as well, such as governmental supervision, beneficial consideration, and project constraint. Thus a developed framework is established focusing on the CDWM field based on the existing TPB framework, as shown in Fig. 71.2.

In the framework, a total of eight affecting factors are involved, including attitude toward behavior (AB), subjective norm (SN), perceived behavioral control (PBC), behavioral intention (BI), governmental supervision (GS), beneficial capacity (BC), project constraints (PC), and behavior (B).

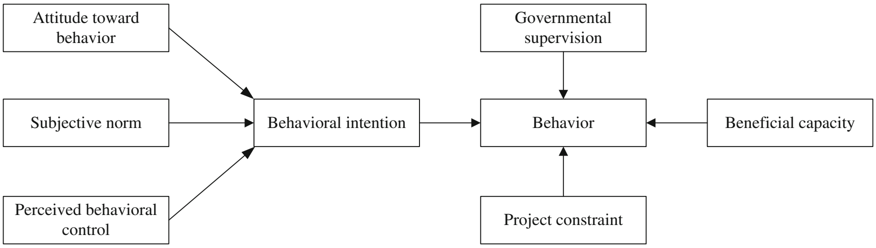

Fig. 71.2 The developed framework

GS is considered because governmental regulations and corresponding supervision can significantly affect the behavior of contractors. The influencing path is often direct: if something is forbidden by the government, the contractor must comply with the regulatory requirements. In terms of CDWM, if the government requires the contractors to dump C&D waste at landfills and impose hard punishment on illegal dumping, the behavior of illegal dumping will be decreased significantly.

BC is involved because contractors are companies that have the nature of benefit-earning. Thus the most prior objectives for contractors in a project are decreasing cost and making profit. If there is a conflict between environment and benefit, the project decision-makers often opt for the later one rather than the former one. In practice, CDWM measures are usually adopted incompletely in order to cut the construction cost, regardless of the potential environmental problems.

PC is also a direct affecting factor for adopting CDWM measures. In real-life construction projects, there are many practical and unpredictable constraints, such as time, money, material, labor, etc. Contractors must select the most appropriate measures based on the project constraints. For instance, if the construction duration is very limited, the contractor may implement less CDWM measures to save time. Similarly, if the number of construction workers is not adequate, less focus will be paid on adopting effective CDWM.

71.3.2 Measurement of the Affecting Factors

After establishing the framework, measurements are supposed to be determined to quantify and further investigate the relationships between each construct. In this study, the measurements are proposed according to the mature TPB measurements and previous studies on waste management. Specific measurements for each construct are listed in Tables 71.1, 71.2, 71.3, 71.4, 71.5, 71.6, 71.7 and 71.8.

Based on the proposed framework and measurements, the relationships between the constructs can be quantitatively investigated using a Likert scale and further analyzed using statistical analysis techniques.

Table 71.1 Measurement of attitude toward behavior

No.	Measurement
1	Implementing CDWM can improve the environmental quality
2	Implementing CDWM can promote the sustainable development
3	Implementing CDWM can increase the brand benefit
4	Implementing CDWM can improve the social recognition
5	I feel pleasant of implementing CDWM
6	Implementing CDWM should be advocated

Table 71.2 Measurement of subjective norm

No.	Measurement
1	The project manager expects to implement CDWM
2	My colleagues expect to implement CDWM
3	My family members expect to implement CDWM
4	The potential customers expect to implement CDWM
5	The local government expects to implement CDWM

Table 71.3 Measurement of perceived behavioral control

No.	Measurement
1	I have enough opportunity to implement CDWM
2	I have enough support to implement CDWM
3	I have enough time to implement CDWM
4	I have enough space to implement CDWM
5	I have enough experience to implement CDWM

Table 71.4 Measurement of behavioral intention

No.	Measurement
1	I intend to adopt measures that can reduce C&D waste generation
2	I intend to reuse or recycle the generated C&D waste
3	I would like to see the reasonable dumping of C&D waste
4	I intend to attend the training concerning CDWM

Table 71.5 Measurement of governmental supervision

No.	Measurement
1	The local government has specific regulation on CDWM
2	The local government has specific department for guiding CDWM
3	The local government has comprehensive supervision system for CDWM
4	The local government impose strict punishment to illegal C&D waste dumping
5	The local government has attractive incentive policies for C&D waste recycling

Table 71.6 Measurement of beneficial capacity

No.	Measurement
1	Implementing CDWM will increase the construction cost
2	Reducing C&D waste generation can decrease the construction cost
3	Implementing effective C&D waste recycling will bring benefits
4	The local landfilling fee for C&D waste is low
5	The current recycling market is not mature

Table 71.7 Measurement of project constraint

No.	Measurement
1	Implementing CDWM uses a large number of stuff
2	Implementing CDWM needs a lot of investment
3	Implementing CDWM costs too much time
4	Implementing CDWM occupies large construction space
5	Implementing CDWM uses machines that uncommon

Table 71.8 Measurement of behavior

No.	Measurement
1	Reducing C&D waste through reasonable design
2	Reducing C&D waste through effective on-site management
3	Reducing C&D waste through proper material procurement
4	Reducing C&D waste through advance technologies
5	Sorting C&D waste on site
6	Reusing C&D waste on site
7	Transporting C&D waste to recycling facilities
8	Recording C&D waste generation information
9	Implementing other measures to improve CDWM

71.4 Conclusions

Contractor's CDWM behavior is of significance for mitigating the negative effects of C&D waste. Thus, investigating the factors that determinate CDWM behavior can affect the level of CDWM. This paper proposes a framework for investigating the relationships between the affecting factors based on TPB. Except of the classic TPB constructs, three external constructs are involved in the framework as well, such as governmental supervision, beneficial capacity, and project constraint. In addition, corresponding measurements for the involved constructs are also given. This paper mainly focuses on the introduction of the framework. Future work can be conducted to collect data through questionnaire survey, and then the interrelationships between the affecting factors and the CDWM behavior can be investigated.

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Part VIII
Development and Management for Mountainous Towns

Chapter 72
Distribution and Determinants of Housing Prices in Polycentric Mountainous Cities: The Case of Chongqing

Meng-Wei Wang, Yong Liu and Xiu-Hua Liu

Abstract Based on 5410 sold residential projects, this paper used Kriging and the Geographically Weighted Regression (GWR) model to reveal the characteristics and determinants of housing prices in Chongqing. The results show that Chongqing's housing prices formed a clear polycentric pattern: peaking at the major Central Business District (CBD) of Jiefangbei and sub-peaking at several Secondary Business Districts (SBDs). The pattern of housing prices was found to be influenced by accessibility of urban centers, urban facilities (such as schools, hospitals, metroline), Yangtze and Jialing rivers. Considering spatial non-stationary of housing prices, GWR model was further employed to reduce spatial dependency of data. The results of GWR model show that the more accessible to the nearest urban center is, the higher housing prices are; the nearer to rivers is, the higher housing prices are; the more proximity to metrolines, the higher housing prices are. To sum up, polycentric urban development is regarded as the underlying factors shaping housing prices in mountain Chongqing.

Keywords Mountain city · Polycentric urban development · Housing price · Spatial pattern · Factors

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72.1 Introduction

Post-reform China has accelerated the commercialization of urban housing since 1998. Nowadays, soaring housing price has become a national economic issue concerned by the public and governments (Liu et al. 2011). Today, the spatial differentiation of urban housing prices is affected by macroeconomic factors (e.g. government policies), economic conditions and micro-factors (e.g. community environment and surrounding urban facilities). With the development of GIS, the impact of geospatial factors on housing prices attracts much attention from scholars. In 1998, Can stressed the importance of GIS technology in the research on real estate market. GIS method was widely used to disclose spatial distribution of housing price in first-tier Chinese cities, such as Beijing, Guangzhou (Yan et al. 2001; Bin et al. 2005; Haizhen et al. 2010). Meanwhile, in 1996, the British geographer Brunsdon et al. (1998, 1999) proposed Geographically Weighted Regression (GWR) model to investigate the effects of floor area on housing prices, revealing the spatial instability of housing prices, and they found that GWR was proved to be better than traditional OLS method, a feature of housing price model. Luo (2007) in China took a case study on Hangzhou, using GWR model to study the effects of location, neighborhood and architectural features on residential land price, which shows that residential land price has a property of spatial instability and confirms the superiority of GWR model in the study of spatial structure of residential land price.

In China, little attention has been paid on the issue of housing prices on the western cities. To fill the gap, we chose Chongqing as a case study. Chongqing, a typical mountain city, serves as the only municipality in Western China as well as the economic and cultural center of the southwestern area. Chongqing's urban development pattern is unique due to the impact of natural factors (river separation and terrain constrains) and anthropogenic factors (polycentric city) on housing prices. Since Chongqing city directly under the State Council in 1997, Chongqing urban area has witnessed a rapid economic development, with GDP in 2013 reaching 539 billion Yuan, ranking 23 in the National Urban GDP and surpassing the coastal cities such as Dongguan. What's more, it's urbanization rate reached 87.87 %. In 2013, housing price ranked 41 with the average price of 7527 Yuan/m^2 in the whole China. According to master plan, a polycentric urban structure has come into shape gradually in Chongqing. Based on sold house prices of residential projects in 2014, we used Kriging method to confirm the polycentric pattern of housing prices in Chongqing, and adopted GWR model to uncover the factors affecting housing prices.

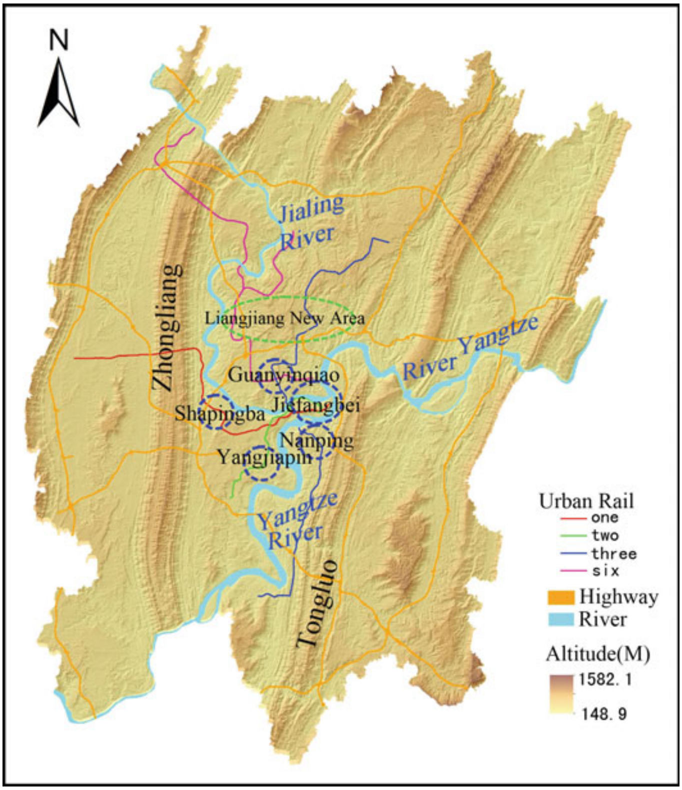

Fig. 72.1 The location of study area

72.2 Study Area, Data and Methods

72.2.1 Study Area

This paper chose the urban area of Chongqing as study area based on Chongqing Master Plan (1996–2020), including six districts (Yuzhong, Dadukou, Jiangbei, Nanan, Shapingba and Jiulongpo) and a part of Yubei, Beibei and Banan districts, with total area of 3716 km^2. The intersection (Chaotianmen) of the Yangtze River and the Jiangling River which has a superior shipping portal initiates the rise of Chongqing City. In 2013, the GDP in the study area reached 539 billion Yuan, accounting for 42.6 % in the whole Chongqing, and the per capita GDP reached 66,687 Yuan, higher than the national per capita GDP of 56.86 %. With the urban area expanding, "one urban core, five sub-centers, multiple groups" are finally formed due to the separation of Jialing River, Yangtze River, Zhongliang Mountain, Tongluo Mountain. In 2009, the State Council approved the establishment of "Liangjiang New Area", as a counterpart after "Pudong New Area" in Shanghai and "Binhai New Area" in Tianjin (Fig. 72.1).

72.2.2 Data

Data of sold housing price for 5410 residential projects of in 2014 were collected from the websites of Anjuke and SouFun. The spatial data was provided by Chongqing Urban Planning Bureau, Land Resources and Housing Authority and other relevant administrative departments, including the land use map, road map in 2014 (urban street, urban arteries, highways), Digital Elevation Model (DEM) of Chongqing in a resolution of 25 m. And points of interest for public facilities came from Chongqing Public Service Platform of Geographic Information, including railway, 36 primary schools, 27 key middle schools, 16 colleges, 18 hospitals, 27 city parks, 3420 bus stops, as well as metrolines 1, 2, 3, 6 and 96 metro stations.

72.2.3 Methods

72.2.3.1 Kriging

Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The Kriging tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. Kriging is a multistep process. It includes exploratory statistical analysis of the data, variogram modeling, creating the surface, and (optionally) exploring a variance surface. Kriging is most appropriate when you know there is a spatially correlated distance or directional bias in the data. The general formula for both interpolators is formed as a weighted sum of the data (Wang 2009):

$$\hat{Z}(s_0) = \sum_{i=1}^{n} \lambda_i Z(s_i) \tag{72.1}$$

where $Z(s_i)$ is the measured value at the ith location, λ_i is an unknown weight for the measured value at the ith location, s_0 is the prediction location, n is the number of measured values.

72.2.3.2 GWR Model

Geographically weighted regression is used to estimate locally linear coefficients and estimates of the dependent variable. The GWR model is formally defined as (Farber and Páez 2007):

$$P_i = \beta_{0i} + \sum_{k=1} \beta_{ki} x_{ki} + \varepsilon_i \tag{72.2}$$

where P_i is the ith observation of the dependent variable, X_{ki} is the ith observation of the kth independent variable, ξ_i is the ith value of a normally distributed error vector with mean equal to zero, β_{oi} is the constant estimated for local regression i, and β_{ki} is the regression coefficient estimated for regression i and variable k. This differs from ordinary least squares regression by utilizing distinct constants and regression parameters for each point, rather than a single set of global parameters.

The GWR model selected ten independent variables that would impact residential prices: (1) Accessibility to CBD: commuting time to CBD. (2) Accessibility to Sub-centers: commuting time to SBDs. (3) Road density: the length of road line within 1 km buffer from the housing sites. (4) Distance to Railway: euclidean distance to the nearest railway. (5) Distance to River: euclidean distance to Jialing River or Yangtze River. (6) Distance to Schools: euclidean distance to the nearest school. (7) Distance to Hospitals: euclidean distance to the nearest hospital. (8) Distance to Park: euclidean distance to the nearest park. (9) Density of Bus stations: the number of bus station within 500 m buffer from the housing sites. (10) Distance to Metroline: euclidean distance to the nearest metro station.

72.3 Findings

72.3.1 Kriging Analysis

72.3.1.1 Normal Distribution and Trend Surface Analysis

Based on 5410 sold residential projects in 2014, we used ArcGIS software to perform normal distribution analysis. The average of housing prices is 6998 Yuan/m^2 which is close to the median of 7088 Yuan/m^2. What's more, it generally shows a normal distribution. QQ Plot is close to a straight line distribution, indicating that the data shows normal distribution basically (Fig. 72.2a, b).

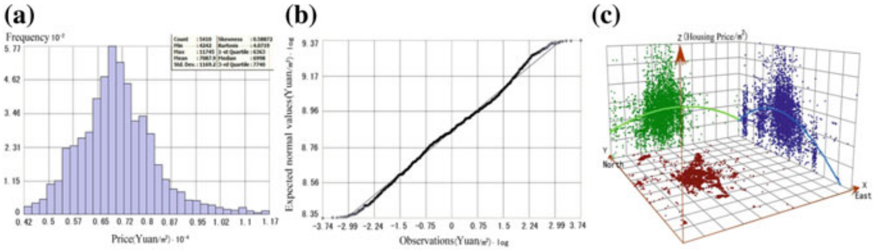

Fig. 72.2 Normal distribution histogram (**a**), QQ plot (**b**) and trend analysis (**c**) of housing price in Chongqing City

We used geostatistical analysis module (Trend Analysis) in ArcGIS to obtain the spatial distribution of trends in housing prices (Fig. 72.2c). The trend in North-south direction shows inverted U-shaped is more obvious than that in East-west direction. Besides, three significant housing price peaks are displayed in North-south direction. Above all, it reflects that the Chongqing urban expansion is mainly in north-south direction, while the east-west direction is subordinate.

72.3.1.2 Kriging Results

We used ordinary Kriging analysis, and got the model accuracy as follows: mean prediction error is 5.97; Mean standardized is 0.0056 (close to 0); Root-mean-square standard is 0.95 (close to 1); Average Standard Error is 1074.56 which is close to Root-Mean-Square 1021.65, indicating that the model is good for precision as shown in Fig. 72.3.

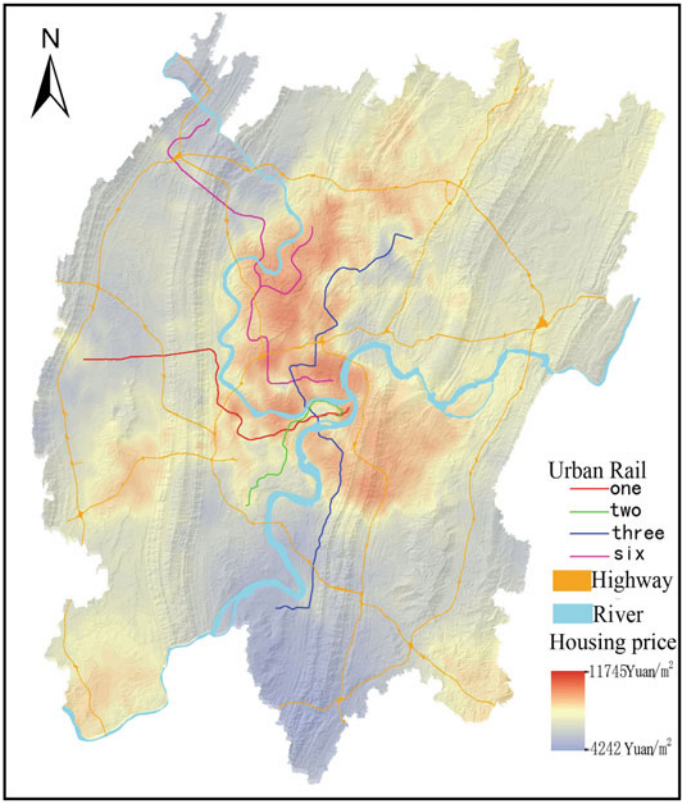

Fig. 72.3 Spatial interpolation of housing prices in Chongqing City

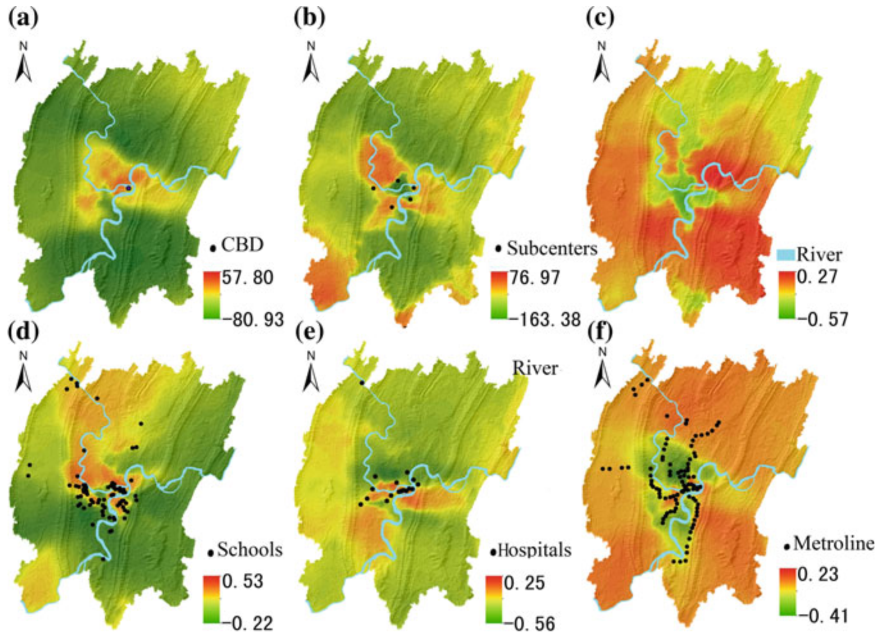

Fig. 72.4 Map of local parameter for selected independent variable factors of A-CBD (**a**), A-Sub-centers (**b**), D-River (**c**), D-Schools (**d**), D-Hospitals (**e**), D-Metroline (**f**) on housing price

Figure 72.3 shows that the spatial distribution of commodity housing price in Chongqing has the following features: (a) housing price has been gradually evolved into a polycentric form. Housing prices in the CBD and SBDs are higher than that in the surrounding area except for Yangjiaping. Some significant peaks of housing price are formed in Yubei airport industrial park and the Shapingba cluster, Xipeng cluster, Chayuan cluster proposed in Chongqing's Master Plan (1996–2020). (b) Housing prices in the north of the city are significantly higher than that in south area, while the sub-centers of housing prices has a northward expansion trend which also can be seen in Fig. 72.2c. (c) The rapid development of Chongqing rail transit rapidly pushed the housing prices up, especially along metroline 6.

72.3.2 Factor Analysis of Housing Prices Based on GWR

Spatial autocorrelation test is required before building GWR model. The Moran's I analysis by using GeoDa software indicates that the Moran's I coefficient for OLS model is 0.65 and the Moran points are mainly located in first and third quadrant, indicating a high level of spatial autocorrelation. After a diagnostic analysis of multicollinearity we ultimately identified A-CBD (Accessibility to CBD), A-Sub-centers (Accessibility to Sub-centers), D-Rivers (Distance to River), D-Schools

(Distance to Schools), D-Hospitals (Distance to Hospitals) and D-Metroline (Distance to Metroline) as influence factors affecting housing price. By using ArcGIS 10.1 software, we draw the map of local coefficient for each independent variable factors through kriging method (Fig. 72.4). The results are as follows:

(a) As shown in Fig. 72.4a, the coefficient of A-CBD is negative outside the urban core within one ring, which means that the longer commuting time to CBD is, the lower housing prices are. Besides, the coefficient of A-CBD positive in urban core area covered by five business districts, indicating that the four sub-centers are becoming mature, disrupting the CBD's affection on housing prices. (b) The maximum negative correlation coefficient and the ranges effected in Fig. 72.4b is larger and wider than that in Fig. 72.4a, showing that the five business districts' influence on housing prices is larger than only Jiefangbei's. What's more, housing price peak appeared in Xipeng Cluster which is located in the bottom left of the figure. (c) In Fig. 72.4c, only in the region surrounded by five business districts, the coefficient of D-River is negative, indicating that only the ordinary commercial housing located in the region of five business districts, these Riverview Room's price is higher than the rest. (d) As can be seen in Fig. 72.4d, e, the coefficient of D-School and D-Hospital are both positive and negative. Because the speculation of school-nearby house in the background of the "Admission to school by zoned area" policy introduced in Chongqing 2014, leading some artificially high price districts appeared. Meanwhile, the impact of healthcare on housing price has two sides. Healthcare can improve the price due to the convenience of medical equipment, but it also can reduce housing prices due to traffic jams and environmental problems. (e) In Fig. 72.4f, the coefficient of D-Metroline is negative in the areas covered by rail transportation apart from those are remote from city center which means the nearer to metroline is, the higher housing prices are.

72.4 Discussion

72.4.1 Housing Price Analysis

The distribution of housing price has been gradually evolved towards polycentric pattern in Chongqing 2014. Since the river and mountain separation by Zhongliang mountain, Tongluo mountain, Jialing River, Yangtze River, Chongqing also shows a polycentric urban development and reveals a north-south expansion. High price area in Chongqing is mainly located in "Liangjiang New Area", which is in the northern part of Chongqing city. In terms of Fengshui, "Liangjiang New Area" locates in north and face south, backed by mountain and surrounded by water. It is mostly converted from flatter farmland in order to save cost of development. What's more, it is closed to the Guanyinqiao SBD, the airport and north railway station so that it has convenient traffic conditions. In addition, some high-end real estate such as Lanhujun and Poly Golf located in "Lingjiang New Area", which further attracts the later developers of real estate. Government's investment in "Liangjiang New Area" and Yubei airport industrial park expands the sub-center to northwards. As a typical mountain city, suburban clusters such as Xipeng cluster and Chayuan cluster breakthrough the limits of Zhongliang and Tongluo mountain formed two price peaks in those clusters. This is because of the peripheral development of high-end house such as Hot Springs in Baishiyi and Townhouse in Chayuan Cluster, it reflecting the phenomenon of suburbanization. Through the GWR model, the pattern of housing price shows a cluster distribution around the five business districts. And the river-view advantage along the rivers becomes the "Bonus Space" of Chongqing development (Fengqing and Min 2011). Because of this, a large number of high-pricing districts gathers near the river, which also promotes the expansion of sub-centers.

Chongqing ranked 7th in terms of GDP in the whole China in 2013 while housing price ranked 41th with the price of 7527 Yuan/m^2, which is much lower than that in Beijing (37,439 Yuan/m^2) and Shanghai (29,947 Yuan/m^2), and even lower than other cities' price in the southwest of China like Kunming (8988 Yuan/m^2), Chengdu (9838 Yuan/m^2). Judging from the spatial distribution of housing prices, there are a causal link between polycentric structure and the phenomenon of "High economic outputs, low housing prices". In this polycentric structure, traffic organized efficiently to achieve "Job and Housing Balance", which means reducing commuter's travel distance and traffic pressure (Fengqing and Min 2011). So that to reduce the monopoly on real estate regional market in order to achieve a stable housing price. Due to high concentration of prefable urban facilities, Yuzhong peaked its housing price in the whole study area. Thanks to high level educational and medical services, Shapingba also had a high housing price. Chongqing, as the first city to have the rail transit in western China, several housing price sub-centers located near the metro station. Compared with Beijing (1969) and Shanghai (1995), Chongqing Rail Transit opened since November 2004 which is obviously backward. But it greatly promotes the real estate value beyond the latecomer advantage.

72.4.2 Comparison Between Mountainous and Plain City

Compared with Beijing, Shanghai, Hangzhou and other first-tier coastal plain cities, Chongqing's urban development has its own characteristics: (a) Sub-centers and SBDs in Chongqing developed rapidly, forming a polycentric pattern. For example, housing price of Crystal City located near Guanyinqiao SBD is very high, ranking the top in the study area. But most plain cities such as Beijing have a mono-centric urban pattern and suburbanization forms smaller sub-centers, what's more, the highest housing prices are mainly located in the city center. (b) Chongqing's polycentric urban development is mainly influenced by terrain constrains. Due to the rapidly developing, Yuzhong is limited. As a result, it's a trend to break through the landscape barrier and take more available land to develop. But in coastal plain cities, government involvement is the key to polycentric urban development such as the Industrial relocation and population decentralization. (c) Mountain cities are mainly distributed in western of China where the economic development is backward. Compared with the other first-tier coastal plain cities, Chongqing's economic development obviously lags behind. Therefore the polycentric urban development also lags behind plain cities. (d) Topography led a rapid transformation to polycentric development in Chongqing. But in first-tier cities like Beijing and Shanghai, through policy focus, polycentric city are after suffering from the traffic jam and environmental problems brought by a long time single center city.

72.5 Conclusions

In this paper, kriging and the GWR model were used to reveal the distribution and determinants of housing prices in Chongqing 2014. The results show that the spatial patterns of Chongqing housing's prices formed a clear polycentric pattern; one major CBD and four SBDs shows clear housing price peak and sub-peaks; there are significant association to the spatial pattern of sub-centers and urban transport facilities. Analysis of determinants of housing price based on GWR model shows that the commuting time to the nearest business district is the major factor affecting housing prices; Riverview advantage along the Yangtze River and Jialing Rive expand the distribution of housing price peaks and promotes the development of sub-centers; the coverage of urban rail transportation contributes a lot of rising housing prices in nearby area. This article has only studied on sold housing price's spatial pattern, based on the analysis unit of residential projects. We will do further study on the new housing prices in the future.

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Part IX
Advancement of Construction Project Management

Chapter 73
Why Continuous Improvement Program Fails—Lessons from the Toyota Production System

Peng Wu, Yingbin Feng and Xiaohua Jin

Abstract Continuous improvement plays a very important role for construction companies. For construction companies to achieve flexibility, responsiveness and the ability to adapt quickly to changes within its environment, the implementation of a sound strategy for continuous improvement is essential. However, there have been a significant number of failed continuous improvement programs in the construction industry, which are caused by lack of company cultures, lack of employee involvement to ensure persistency, etc. The Toyota Production System (TPS) was developed in Toyota. As one fundamental pillar in the TPS, continuous improvement has proven to be effective in helping Toyota to achieve cost reduction and waste elimination. Through a structured survey of 136 contractors, this research identified a comprehensive list of factors that can contribute to the success of continuous improvement programs. The findings suggest that continuous improvement is not an isolated application that can be implemented in construction companies to achieve immediate results. The underlying structure of continuous improvement and its relative importance to the successful implementation of continuous improvement programs in construction companies should be well understood by construction companies before implementation.

Keywords Continuous improvement · Construction companies · Toyota production system

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73.1 Introduction

Continuous improvement focuses on increasing the effectiveness and efficiency of an organization to fulfill its policy and objectives (Fryer et al. 2007). Although the term is often used within the context of quality control, continuous improvement has now been considered as a useful tool to help companies to achieve strategic objectives. It is critical for construction companies to survive in the ever changing construction environment. As there is more stringent regulatory controls over construction waste in the construction stage, the construction process that was acceptable in the past may not be acceptable now or in the near future. With the rising recognition of global climate change, clients expect to see designs and deliveries that can meet the new “green” standard and this cannot be achieved if construction companies remain unchanged. The concept of continuous improvement is to benefit the company for long-term development. It is a developmental process because applying continuous improvement will lead to change in every aspect of project and company management and this change in the mental model cannot be a one-off effort (Howell and Ballard 1998).

The Toyota Production System (TPS) was developed in Toyota. As one fundamental pillar in the TPS, continuous improvement has proven to be effective in helping Toyota to achieve cost reduction and waste elimination. There have been many successful attempts to apply the TPS for construction companies to obtain strategic advantages through continuous improvement. It should however be noted that there are also a significant number of attempts that failed to implement continuous improvement successfully. Shingo (1987, p. 152) stated that since improvement to a greater or lesser extend demands new procedures, 99 % of all improvement plans would vanish without a trace if they were to be abandoned after only a brief trial. Smyth (2010) found that there have been improvements in the construction industry, yet these seem not to have been continuous. The failure may be caused by lack of company cultures (Ahmed et al. 1999), lack of employee involvement to ensure persistency (Shingo 1987) and distant from direct value creation (Smyth 2010).

Continuous improvement is not an isolated application that can be implemented in construction companies to achieve instant results. The underlying structure of continuous improvement and its relative importance to the successful implementation of continuous improvement in construction companies should be investigated. Critical success factors (CSFs) are the limited numbers of areas which, if satisfactory, will ensure competitive performance for the organization (Rockart 1979). CSFs are the essential factors that must be endorsed by construction companies to achieve competitive advantages. This paper therefore aims to: (1) identify the CSFs for the successful implementation of continuous improvement in construction companies and (2) examine the readiness of Chinese contractors for the successful implementation of continuous improvement.

73.2 Continuous Improvement and the Toyota Production System

The Toyota Production System was developed by Toyota to deal with the problems arising from the oil crisis. The basis of the Toyota Production System is to achieve profit growth by reducing costs through completely eliminating waste such as excessive stocks or work force, which is supported by the following two pillars (Ohno 1988):

Just-in-time (JIT).
Autonomation (“Jidoka” in Japanese), or autonomous defects control in a loose interpretation.

The two systems are supported by continuous improvement (Kaizen in Japanese). The TPS initiatives that contribute to the successful implementation of continuous improvement include top management commitment, focusing on value, benchmarking, employee involvement and total quality control.

Top management commitment. Management’s efforts and time commitments are necessary to ensure that disciplined and correct operations are carried out in accordance with the lean concept. Without the support of top and upper management, it seems unlikely that the change can be successfully implemented (Ahire and O’Shaughnessy 1998). As top management plays a decisive role in paradigm shifts in critical areas such as production development and quality management, getting top management support is essential for the company to continuously improve. Another reason that top and upper management is essential for change is that employees need to impress upper management in order to advance up the corporate ladder (Ahire and O’Shaughnessy 1998). Therefore, when top management in a firm attempts to implement changes, such as continuous improvement, employees at all levels are more likely to invest time and effort in the change program (Cole 1993).

Focusing on value. In the TPS, there are two types of activities: conversions and flows. Conversions refer to activities that add value to the production or process while flows refer to activities that use resources but do not add value to the production or process. The term ‘value’ in the TPS can be interchangeably used with customer requirement, although in a broad sense, value can also refer to the requirement of downstream activities in a production process. There were a few practices that could be implemented to focus on value. Sousa (2003) found that creating customer relationships by emphasizing partnership arrangements, direct customer contacts and integration of the plant’s operations with customers were important to find and achieve values. Flynn et al. (1995) stated that once customer requirements were collected, mechanisms within the organization to disseminate and respond to information on customer needs should be established.

Benchmarking. Benchmarking is a useful stimulus to achieve continuous improvement. According to Cross and Iqbal (1995, p. 4), benchmarking is: “a continuous systematic process to evaluate companies recognized as industry leaders, to determine business and work processes that represent best practices and to establish rational performance goals". The process includes the identification of areas to benchmarking, establishing the benchmarks based on industrial databases, the use of comparative analysis to investigate the gaps and the implementation of action plans to reduce the gaps.

Employee involvement. The importance of employee involvement can be explained by the fact that organizational goals and personal goals can both be achieved if employees are treated with equity and respect in terms of being involved with decision making, being provided with meaningful jobs and being given the opportunity to learn (Stendel and Desruelle 1992). Front-line employees are directly responsible for construction activities such as delivery and installation. Disruptions in any point of the process will damage the entire construction chain and it is necessary for the workers, foremen, engineers and all firm's employees to take primary responsibility for identifying problems and aiming for continuous improvement (Low and Chan 1997). The TPS brings about new technological and philosophical innovations. However, as noted by Bayo-Moriones and de Cerio (2004), innovations alone are not sufficient for the firm to reap the potential rewards. The new way of production and operation proposed by the TPS requires an adapted role of workers, which may include increased discretion and scope of responsibility.

Total quality control. Total quality control is an effective system for integrating the quality-development, quality-maintenance and quality-improvement efforts of the various groups in an organization so as to enable production and service at the most economical levels which allow for full customer satisfaction (Rounds and Chi 1985). The term "total" refers to three extensions: expanding quality control from production to all departments; expanding quality control from workers to management; and expanding the notion of quality to cover all operations in the company (Shingo 1988).

73.3 Research Methodology

To identify the CSFs in continuous improvement for contractors, a fieldwork was conducted that aimed to include the top 60 Chinese contractors. The top 60 Chinese contractors were listed in the Engineering News Record (2011). From Mar 2013 to May 2013, the 60 contractors, including related branches, were approached by e-mail and telephone. A total of 452 copies of the questionnaires were sent to these contractors. In order to increase the response rate, a chain referral sampling method that relies on referrals from initial contractors was also used. A total of 136 responses were received. The response rate was 30 %.

In the field work, a comprehensive list of potential CSFs was obtained through literature review. Pilot studies were also conducted with two contractors to enrich the list. Several factors obtained from the pilot studies were also included in the list, including long term commitment from top management, compliance with ISO 9000, Six Sigma and other quality management methods, etc. A total of 34 CSFs were obtained, including:

Senior staff members are committed to continuous improvement are constantly searching for areas of improvements.

Long-term goals are clearly outlined by top management.

CSFs for long-term development are established.

Top management has identified follow-up actions to achieve long-term goals.

Adequate resources are provided by top management to achieve long-term goals.

Top management demonstrates its commitment to continuous improvement in formal and informal circumstances.

Top management makes continuous improvement as one criterion in performance evaluation of employees.

Top management has established mechanisms to recognize and reward successful departments or individuals who have made extraordinary contributions to the continuous improvement of the company.

The stakeholders of the company are identified, including shareholders, employees, suppliers and customers.

Stakeholders' requirements are explicitly outlined.

Stakeholders are involved when examining the requirements of the stakeholders.

Stakeholders' requirements are periodically reviewed to ensure that changes to the requirements can be quickly identified.

The fulfillments of values are listed in performance evaluation.

Internal benchmarks are identified.

Competitive benchmarks are identified.

Industry benchmarks are identified.

Process or generic benchmarks are set based on the best working processes.

A benchmarking team is established to analyze gaps.

Appropriate follow-up actions are taken to reduce the gaps.

Benchmarks are periodically reviewed.

Employees are involved in establishing plans on continuous improvement.

Mechanism is created so that employees' suggestions for improvements can be taken.

Delegation of responsibility to relevant employees.

Trainings are provided to employees.

The degree of training is matched with the roles of the employees.

Employees who make significant contributions to the continuous improvement are rewarded.

The reward system matches the degree of contribution.

The total quality control method complies with ISO 19000.

The total quality control method complies with Six Sigma or other quality management methods.

External consultancy is sought to improve total quality.

A total quality control team is appointed.

Adequate resources are allocated for total quality control.

Improvement in total quality is a long-term target.

Performance on total quality control is periodically reviewed.

The CSFs were then rated using two factors: the degree of current implementation (D) and impact (I). A five point Likert scale was adopted to assess the degree of current implementation on the CSF. The five point Likert scale was: (1) extremely unsatisfactory; (2) unsatisfactory; (3) neither unsatisfactory nor satisfactory; (4) satisfactory; and (5) extremely satisfactory. Accordingly, the impact of the CSF to achieve continuous improvement was assessed by a five point Likert scale, which was: (1) extremely insignificant; (2) insignificant; (3) neither insignificant nor significant; (4) significant; and (5) extremely significant.

Exploratory factor analysis was adopted to uncover the underlying structure of the CSFs based on their impact (I). Wilcoxon Signed Rank test was adopted to test whether the implementation and impact of these CSFs have significant difference at a 95 % confidence interval. The null hypothesis was that the difference between the two mean values was zero. If the ρ value was less than 0.05, the null hypothesis could be rejected. In other words, there is a significant gap between the implementation and the impact of the CSF and future improvement on this specific CSF is needed.

73.4 The Underlying Structure of Continuous Improvement

Cronbach's coefficient alpha was used to examine internal consistency of the CSFs. According to Pallant (2001), Alpha values greater than 0.7 can be considered as sufficient. The Cronbach's coefficient alpha of the CSFs (degree of implementation) ranged from 0.761 to 0.982. Similarly, the Cronbach's coefficient alpha of the CSFs (impact) was 0.951, which indicated high internal consistency. The survey therefore had adequate reliability.

The Kaiser-Mayer-Olkin (KMO) measure of sampling accuracy and Barlett's test of sphericity were conducted. The KMO value was 0.674, which is greater than 0.5 for a satisfactory factor analysis (Kaiser 1974). In addition, the significance level was 0.000, which shows that the variables in the population correlation matrix are correlated. The exploratory factors analysis of the CSFs is shown in Table 73.1. As can be seen from Table 73.1, seven factors can be extracted from the CSFs. These seven factors are: total quality control (TQC), benchmarking procedure (BMP), focusing on value (FoV), long-term commitment (LTC) to continuous improvement, benchmarks (BMs), reward system (RS) and performance evaluation (PE).

While some factors from the TPS can be directly used in construction companies to achieve competitive advantages, other factors should also be included to ensure that a complete continuous improvement system is adopted. For example, the benchmarking concept in the TPS can be divided into benchmarks (BMs) and benchmarking procedure (BMP). In addition, reward system (RS) and performance evaluation (PE), which are not directly derived from the TPS, seem to have an important role in the complete continuous improvement system.

Table 73.1 Factor analysis of critical success factors in continuous improvement

	Component						
	TQC	BMP	FoV	LTC	BMs	RS	PE
CSF 33: Improvement in total quality is long-term target	0.944						
CSF 34: Performance on TQC is periodically reviewed	0.931						
CSF 31: A TQC team is appointed	0.915						
CSF 32: Adequate resources are allocated for TQC	0.882						
CSF 30: External consultancy is sought to improve TQ	0.847						
CSF 23: Delegation of responsibility to employees	0.705						
CSF 29: TQC method complies with Six Sigma	0.691						
CSF 28: TQC method complies with ISO 9000	0.679						
CSF 21: Employees are involved	0.570						
CSF 20: Benchmarks are periodically reviewed		0.763					
CSF 17: Process or generic benchmarks are set		0.745					
CSF 18: A team is established to analyse gaps		0.739					
CSF 05: Adequate resources are provided		0.703					
CSF 19: Follow-up actions are taken to reduce gaps		0.537					
CSF 10: Stakeholders' requirements are outlined			0.847				
CSF 12: Requirements are periodically reviewed			0.733				
CSF 13: Fulfilments of values are evaluated			0.654				
CSF 04: Follow-up actions are identified for LT goals				0.807			
CSF 02: LT goals are established by top management				0.699			
CSF 01: Senior staff are committed to CI				0.615			

(continued)

Table 73.1 (continued)

	Component						
	TQC	BMP	FoV	LTC	BMs	RS	PE
CSF 15: Competitive benchmarks are identified					0.933		
CSF 14: Internal benchmarks are identified					0.632		
CSF 16: Industry benchmarks are identified					0.604		
CSF 26: Employees are rewarded						0.909	
CSF 27: The reward matches the degree of contribution						0.819	
CSF 08: Performance evaluation system is established							0.885
CSF 07: CI is one of the evaluation criteria							0.597
Percentage of variance explained	38.513	15.382	7.754	6.556	5.058	4.184	4.092
Cumulative percentage of variance explained	38.513	53.894	61.648	68.205	73.263	77.447	81.539

Notes
TQC Total quality control; *BMP* benchmarking procedure; *FoV Focusing on Value*; *LTC* long-term commitment; *BMs* benchmarks; *RS* reward system; *PE* performance evaluation; *CI* continuous improvement
Factors with loadings greater than 0.4 are shown in the factor analysis

73.5 The Readiness of Chinese Contractors

Mann Whitney U test was adopted to test whether the implementation and impact of these CSFs have significant difference at a 95 % confidence interval. The results are shown in Table 73.2.

As can be seen from Table 73.2, there were significant differences between the degree of implementation and impact of all CSFs. The results indicate that there were significant gaps in each of the CSF in construction companies to achieve continuous improvement. In addition, the impact was rated higher than the degree of implementation for all CSFs. It means that improvement in each of the CSF identified in this study should be made in order to reach the full potential of continuous improvement in construction companies.

Table 73.2 The disparity between the importance and the actual implementation of each CSF

CSFs	Asymp. Sig. (2-tailed)	CSFs	Asymp. Sig. (2-tailed)	CSFs	Asymp. Sig. (2-tailed)	CSFs	Asymp. Sig. (2-tailed)
CSF1(I)/CSF1(D)	0.000	CSF2(I)/CSF2(D)	0.000	CSF3(I)/CSF3(D)	0.000	CSF4(I)/CSF4(D)	0.000
CSF5(I)/CSF5(D)	0.021	CSF6(I)/CSF6(D)	0.000	CSF7(I)/CSF7(D)	0.000	CSF8(I)/CSF8(D)	0.000
CSF9(I)/CSF9(D)	0.000	CSF10(I)/CSF10(D)	0.000	CSF11(I)/CSF11(D)	0.000	CSF12(I)/CSF12(D)	0.000
CSF13(I)/CSF13(D)	0.000	CSF14(I)/CSF14(D)	0.000	CSF15(I)/CSF15(D)	0.000	CSF16(I)/CSF16(D)	0.000
CSF17(I)/CSF17(D)	0.000	CSF18(I)/CSF18(D)	0.000	CSF19(I)/CSF19(D)	0.000	CSF20(I)/CSF20(D)	0.000
CSF21(I)/CSF21(D)	0.000	CSF22(I)/CSF22(D)	0.000	CSF23(I)/CSF23(D)	0.000	CSF24(I)/CSF24(D)	0.000
CSF25(I)/CSF25(D)	0.000	CSF26(I)/CSF26(D)	0.000	CSF27(I)/CSF1(D)	0.000	CSF28(I)/CSF28(D)	0.029
CSF29(I)/CSF29(D)	0.009	CSF30(I)/CSF30(D)	0.004	CSF31(I)/CSF31(D)	0.009	CSF32(I)/CSF32(D)	0.001
CSF33(I)/CSF33(D)	0.000	CSF34(I)/CSF34(D)	0.000				

73.6 Discussions

Continuous improvement has a variety of advantages, and can theoretically bring benefits to construction companies. Continuous improvement originates from the Toyota Production System in Japan which has a significantly different culture. According to Ofori (2000), the project arrangements currently in use in developing countries have been inherited from Western Countries which have a different history, culture, collective experience and breadth of construction expertise. For Chinese contractors to implement continuous improvement, it is therefore necessary to understand the underlying structure of continuous improvement, an integral part of the continuous improvement culture.

Continuous improvement is not an isolated application that can be adopted by construction companies to achieve immediate results. There are two characteristics of continuous improvement that should be noted. Continuous improvement is not a stand-alone application. Various initiatives help continuous improvement to reach its full potential. These initiatives include total quality control (TQC), benchmarking procedure (BMP), focusing on value (FoV), long-term commitment (LTC) to continuous improvement, benchmarks (BMs), reward system (RS) and performance evaluation (PE). In addition, long-term improvements are the target of continuous improvement. While continuous improvement will inevitably bring changes to construction companies that may affect short-term performance, it will bring long-term benefits to the company. However, it seems that performance of Chinese construction companies on the CSFs of continuous improvement is not satisfactory. For example, according to the survey, 64 contractors (47.1 %) stated that there were no procedures or feedback mechanisms to include employees' contribution into quality control. 44 contractors (32.4 %) did not have generic benchmarks and 40 contractors (29.4 %) did not have benchmarking teams to evaluate the gaps. 72 contractors (52.9 %) did not establish follow-up plans to reduce the gaps. only 28 respondents (20.6 %) stated that they were satisfied with the reward system. There is a large implementation gap at the time of the study which may require immediate actions.

73.7 Conclusion

The primary contribution of this study is the investigation of the critical success factors of continuous improvement, which is originated from the Toyota Production System. Critical success factors drawn directly from the TPS will be useful for contractors to learn the culture where continuous improvement is rooted. The underlying structure of these critical success factors has also been examined. The underlying structure of continuous improvement includes seven components, which are total quality control, benchmarking procedure, focusing on value, long term commitment, benchmarks, reward system and performance evaluation. In addition, the performance of Chinese contractors on the critical success factors is not satisfactory as large gaps are identified in these seven areas.

The research findings of this study also provide some practical implications, especially for contractors that are seeking to implement continuous improvement. Most contractors have to improve on the following areas to implement effective continuous improvement initiative: the establishment of an evaluation team to analyse the gaps, employee involvement, the identification of stakeholders' requirements, the periodic review of stakeholders' requirements, the periodic review of benchmarks, the identification of industry benchmarks and the identification of competitive benchmarks. The research findings also imply that the degree of implementation would vary in different construction markets. For example, the fear of uncontrolled changes may impede the implementation of continuous improvement in the Chinese construction market. However, this problem most probably does not exist in mature construction markets, such as the Japanese construction market. Therefore, further research should be conducted in other geographical locations to find out their similarities and differences for international comparisons on the application of continuous improvement.

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Chapter 74
Understanding Enterprise Risk Management Maturity in Construction Firms

Xianbo Zhao, Bon-Gang Hwang and Sui Pheng Low

Abstract Enterprise risk management (ERM) has been practiced in a wide variety of industries, and construction firms have been seen as prime candidates for ERM adoption. The objectives of this study are to develop a computerized knowledge-based decision support system (KBDSS) for ERM and to investigate the ERM maturity in Chinese construction firms (CCFs) based in Singapore. The KBDSS allows users to assess the ERM maturity of their organizations using a fuzzy model and performs the perceptibly complicated mathematical calculations. By conducting a questionnaire survey with 35 Singapore-based CCFs and inputting the relevant data into the KBDSS, the ERM maturity of these firms was assessed. The results suggested that these CCFs had a low level of ERM maturity and that the weakest criterion was the application of a risk management information system. The results also indicated positive association between ERM maturity and firm size, and significant agreement on the ranking of the maturity criteria among all the survey CCFs. The ERM maturity of Singapore-based CCFs can serve as a benchmark, with which the other firms can compare, and the methodology adopted is applicable to other construction firms, thus contributing to the body of knowledge relating to ERM.

Keywords Risk management · Construction · Maturity · Knowledge · Decision support

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74.1 Introduction

Despite the widespread use of project risk management (PRM) in the construction industry, it is not the panacea because there may be problems resulting from over-emphasis on PRM (Zhao et al. 2013a, b). In recent years, a paradigm shift has occurred regarding the way companies view risk management. Holding a holistic view of risk management has become the trend and enterprise risk management (ERM) has been recognized as the fundamental paradigm in this trend (Gordon et al. 2009; Hoyt and Liebenberg 2011; Zhao et al. 2014b). According to the Committee of Sponsoring Organizations of the Treadway Commission (COSO 2004, p. 2), ERM is "a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives."

Given the complex and diverse risks in the construction industry, construction firms have been seen as prime candidates for implementing ERM (Druml 2009). In construction firms, PRM can be regarded as an integral part of ERM because project risks are within the entire risk profile of a construction company and ERM should be implemented at all levels of a company, including the project level. Effective PRM practices, which properly deal with project risks, can contribute to ERM effectiveness throughout a company. In turn, ERM provides a new way to improve PRM in construction firms (Liu et al. 2013) because ERM implementation could help management to make better informed decisions (Kleffner et al. 2003; KPMG 2010) and deal with project risks more effectively. ERM maturity reflects the sophistication of ERM implementation. To understand the ERM maturity of a company, a starting point can be the assessment of its current risk management practice (Loosemore 2006). It is therefore necessary for a company to assess and understand its ERM maturity.

The objectives of this study are to develop a computerized knowledge-based decision support system (KBDSS) for ERM and to investigate the ERM maturity in Chinese construction firms (CCFs) based in Singapore. The KBDSS allows the users to assess the ERM maturity of their firms and provides action plans for improving ERM implementation based on the assessment results. The assessment results can help a company to gain a clear view of the status quo, strengths and weaknesses of its ERM implementation, as well as the further action plans.

74.2 ERM Maturity Model

In the first phase of the on-going research program, Zhao et al. (2013b) identified 16 important ERM maturity criteria (see Table 74.1) and 66 applicable ERM best practices (i.e. sub-criteria), and developed a fuzzy ERM maturity model (ERMMM)

Table 74.1 ERM maturity criteria and weights

Code	ERM maturity criteria	Weights (%)
M01	Commitment of the board and senior management	7.21
M02	ERM ownership	6.59
M03	Risk appetite and tolerance	5.56
M04	Risk-aware culture	6.06
M05	Sufficient resources	6.36
M06	Risk identification, analysis and response	6.79
M07	Iterative and dynamic ERM process steps	6.29
M08	Leveraging risks as opportunities	5.72
M09	Risk communication	6.18
M10	A common risk language	5.40
M11	A risk management information system (RMIS)	5.97
M12	Training programs	6.22
M13	Formalized key risk indicators (KRIs)	6.16
M14	Integration of ERM into business processes	6.47
M15	Objective setting	6.75
M16	Monitoring, review and improvement of ERM framework	6.29

Source Zhao et al. (2013b)

for CCFs. The 16 criteria describe the key activities that constitute a mature or successful ERM program. As the importance of the 16 criteria varied from one to another, the perceived importance weights, ranging from 5.40 to 7.21 %, were assigned to them. The fuzzy set theory (FST), which can deal with the problems relating to the ambiguity and imprecision in human judgments, was adopted in the ERMMM. The FST can quantify the linguistic facet of available data and preferences for individual or group decision-making and allows the use of mathematical operators (Zimmermann 2001). The concept of linguistic variables, whose values are linguistic terms, lies at the root of the FST. Each linguistic term needs to be transformed to a fuzzy number, which enable these terms to be mathematically operable. The ERMMM adopts the triangular fuzzy number (TFN) to quantify the linguistic terms. A TFN denoted as $\tilde{A} = (a,\ b,\ c)$ is defined using the following membership function:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, x < a \ or \ x > c \\ (x-a)/(b-a),\ a \le x \le b \\ (c-x)/(c-b),\ b \le x \le c \end{cases} \tag{74.1}$$

where a, b, and c are the lower bound, the strongest membership, and the upper bound of variable x, respectively. The input data are implementation levels of the best practices. Thus, a linguistic variable, i.e. the implementation level of each best practice, is defined with the following linguistic values: very low, low, medium, high, and very high. These values were transformed into TFNs, respectively (see Fig. 74.1).

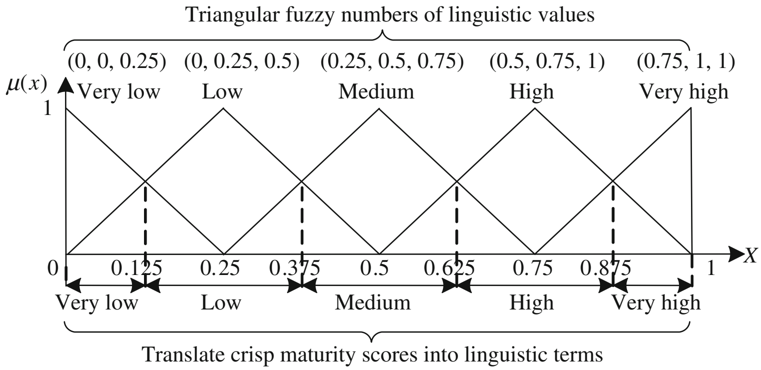

Fig. 74.1 Triangular membership function

When k people participate in the ERM maturity assessment, the implementation level of each best practice can be calculated as follows:

$$\tilde{L}_{ip} = \left(l_{ip1}, l_{ip2}, l_{ip3}\right) = 1/k \times \sum_{j=1}^{k} \tilde{L}_{ipj} \tag{74.2}$$

where $\tilde{L}_{ip}$ is the TFN of the implementation level of the best practice p under criterion i; l_{ip1}, l_{ip2}, and l_{ip3} represent the lower bound, the strongest membership degree, and the upper bound of $\tilde{L}_{ip}$, respectively; and $\tilde{L}_{ipj}$ is the TFN of the implementation level of the best practice p under criterion i collected from the individual j.

The ERMMM adopts the centroid defuzzification method to transform the TFNs into crisp values. This method intends to find the center of gravity of the fuzzy set (Negnevitsky 2006). As the fuzzy set in this study is a triangle, the crisp number of $\tilde{L}_{ip}$ can be calculated as follows:

$$L_{ip} = 1/3 \times (l_{ip1} + l_{ip2} + l_{ip3}) \tag{74.3}$$

where L_{ip} is the crisp number of $\tilde{L}_{ip}$. Thus, the implementation level (i.e. maturity score) of criterion i is measured by the average implementation level of all the best practices under this criterion:

$$L_i = 1/u \times \sum_{p=1}^{u} L_{ip} \tag{74.4}$$

where L_i is the crisp number (i.e. maturity score) of the implementation level of criterion i; and u is the number of the best practices under criterion i.

Therefore, the overall maturity score, defined as the ERM maturity index (ERMMI), can be calculated:

$$\mathrm{ERMMI} = \sum_{i=1}^{16} (W_i \times L_i) = \sum_{i=1}^{16} \left(W_i/u \times \sum_{p=1}^{u} L_{ip} \right) \tag{74.5}$$

where W_i is the weight of criterion i, as presented in Table 74.1. The ERMMI ranges from 0 to 1 and tends to fall into the regions of two adjacent linguistic terms. The ERMMI can be translated to the linguistic term whose membership value is higher, as indicated in Fig. 74.1.

74.3 Research Method

A questionnaire survey was performed to collect the data relating to ERM implementation in CCFs based in Singapore. In the questionnaire, the respondents were asked to rate the implementation levels of the 66 ERM best practices under the 16 criteria on a five-point Likert scale (1 = very low, 2 = low, 3 = medium, 4 = high, and 5 = very high), by comparing the similar current practices in their firms with the best practices.

A list of 46 CCFs registered with the Building and Construction Authority (BCA) of Singapore served as the sampling frame. The questionnaires were sent to the management staff of the CCFs in the list through either face-to-face interviews or emails. Finally, a total of 35 completed questionnaires were received from 35 CCFs, representing a response rate of 76.1 %. The profile of the 35 respondents and their firms is presented in Table 74.2. The BCA financial grade has been used as an indicator of the contractors' size (Zhao et al. 2013c, 2014a). 31.4 % of the CCFs were A1, A2 and L6 contractors as large contractors, while 20 % were B1 and L5 contractors as medium ones. The remaining 48.6 % were small ones. In the terms of designations, 17.1, 37.1, and 45.7 of the respondents held positions in the senior

Table 74.2 Profile of CCFs and respondents

CCFs		Number	Percent	Respondents		Number	Percent
Financial grade*	A1	10	22.90	Designations	Senior mgmt.	6	17.10
	A2	1	2.90		Dept. mgmt.	13	37.10
	B1	5	14.30		Project mgmt.	16	45.70
	C1	10	28.60	Work experience	5–10 years	12	34.30
	C3	5	14.30		11–15 years	8	22.90
	L6	2	5.70		16–20 years	11	31.40
	L5	2	5.70		21–25 years	1	2.90
	L1	1	2.90		26–30 years	3	8.60
	CR01	1	2.90				

**A1/L6*—unlimited tendering limit; *A2*—up to S$85 million; *B1*—up to S$40 million; *B2/L5*—up to S$13 million; *C1*—up to S$4 million; *C3/L1*—up to S$0.65 million; and *CR01*—minor construction related works management, department management and project management, respectively. Moreover, the respondents had an average of 13.7 years' experience in the construction industry, thus assuring the quality of the responses.

Given the complication of fuzzy mathematical operation, the survey data were input into the KBDSS, where the ERMMM was embedded. The KBDSS served as an easy-to-use computerized platform to assess ERM maturity, thus ensuring the accuracy of the perceptibly complicated mathematical calculations.

74.4 KBDSS for ERM

The KBDSS for ERM was developed using Microsoft Visual Basic 2010 (see Fig. 74.2). The specific objectives are to (1) assess the ERM maturity in a CCF; (2) to visualize the ERM maturity assessment results; and (3) to provide action plans for improving ERM practices along the maturity continuum. The assessment results and action plans output by the KBDSS play a supportive role in the decision-making relating to ERM. The KBDSS is not designed to make decisions for users, but rather it provides pertinent information in an efficient and easy-to-access format that enables users to make more informed decisions (Arain and Low 2006). The KBDSS for ERM consists of three main components: a knowledge base (KB), graphical user interfaces (GUIs), and a decision support engine (DSE).

The KB is a repository of the 16 ERM maturity criteria, 66 best practices, and specific action plans for improving ERM practices. Each best practice was assigned

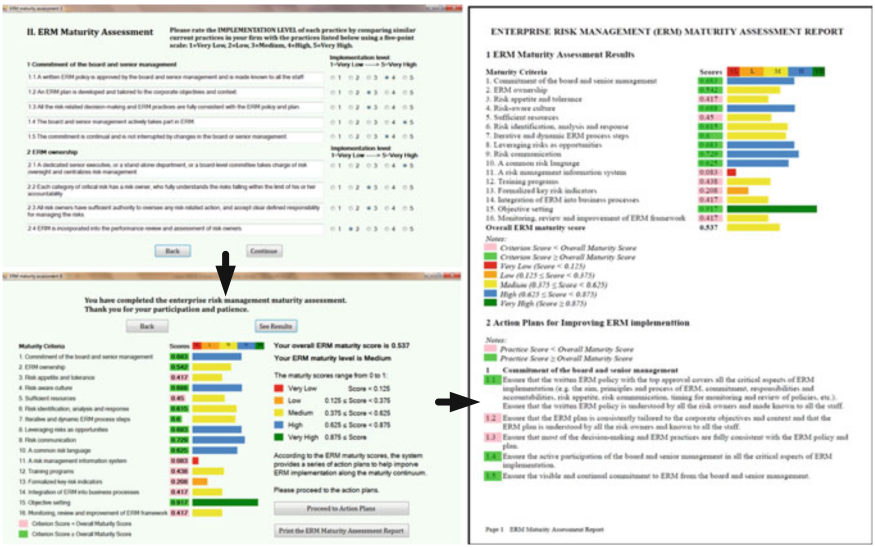

Fig. 74.2 The KBDSS screenshots

three action plans, which intend to help a firm improve the implementation of this best practice from a very low or low to a medium level, from a medium to a high level, and from a high to a very high level, respectively. As it was difficult to distinguish between the two adjacent implementation levels of some best practices, not all the best practices had three action plans. Finally, a total of 191 action plans were included in the KB.

The GUIs display ERM maturity criteria and best practices, and allow the user to input the implementation levels of the 66 best practices under the 16 criteria using the five-point scale (1 = very low, 2 = low, 3 = medium, 4 = high, and 5 = very high). Then, the DSE, where the ERMMM is embedded, transforms the input implementation level of ERM best practices into TFNs, and calculates the ERM maturity criterion scores and the ERMMI. Meanwhile, it sends commands to visualize the assessment results and selects the action plans from the KB for the user, according to the crisp implementation scores of the best practices. Finally, the GUIs display the assessment results and the selected action plans, and produce a printable ERM maturity assessment report, which includes the assessment results and specific action plans. The assessment results are presented in a histogram with bars in different colors (see Fig. 74.2). The bar length is in proportion to the respective criterion score. Thus, it is convenient for the user to understand the implementation status of the maturity criteria and to find weaker aspects represented by shorter bars.

74.5 Data Analysis and Discussion

The survey data of the implementation of the ERM best practices were into the KBDSS, and the ERMMMIs and maturity criterion scores were obtained.

74.5.1 ERM Maturity of CCFs in Singapore

As Table 74.3 indicates, 71.4 % of the surveyed CCFs had low-level ERMMIs (i.e. 0.125–0.375), while the remaining 28.6 % obtained medium-level ERMMIs (i.e.

Table 74.3 ERM maturity and firm size

Firm size	ERM maturity		Total	Mean ERMMI	χ^2
	Low	Medium			
Large (A1, A2 and L6)	3	8	11	0.449	15.497
Medium (B1 and L5)	6	1	7	0.309	(sig. = 0.000)
Small (C1, C3, L1 and CR01)	16	1	17	0.251	
Total	25 71.40 %	10 28.60 %	35 100.00 %	0.325	

0.375–0.625). The overall mean ERMMI of all these CCFs in Singapore was 0.325, implying that their overall ERM maturity level was low.

In addition, previous studies suggested that larger firms were more likely to implement ERM because they were more complex, faced a wider range of risks, and had more resources to support ERM implementation (Beasley et al. 2005; Hoyt and Liebenberg 2011). Gordon et al. (2009) found that the ERM-performance relation was dependent on the proper match between the firm size and the ERM system. Thus, it is worth investigating the relationship between the ERM maturity level and the size in Singapore-based CCFs. The χ^2 contingency table analysis was performed and the result indicated significant association between ERM maturity and firm size. Thus, larger firms were likely to have higher-level ERM maturity.

Most of the large CCFs in Singapore were the overseas subsidiaries of Chinese central enterprises (CCEs), which were state-owned enterprises (SOEs) owned by China's central government and had to comply with the ERM Guidance for CCEs issued by the State-owned Assets Supervision and Administration Commission of China (SASAC 2006). All the CCEs should formally submit a report of their ERM implementation status to the SASAC on an annual basis, and the information in the report should include the ERM implementation in their subsidiaries. Thus, the parent companies audited their overseas subsidiaries every year. In addition, the parent companies of the large CCFs based in Singapore were listed companies in either the Shanghai or Shenzhen Stock Exchange, and had to comply with the regulations relating to internal controls and information disclosure, thus including their ERM implementation status in their annual reports. Therefore, the large CCFs based in Singapore were more likely to implement ERM than the small and medium ones. Furthermore, the respective mean ERMMIs of large, medium and small CCFs were in a descending order, thus substantiating the analysis result.

74.5.2 ERM Maturity Criteria Scores

Using the survey data, the KBDSS also output the maturity criterion scores. As shown in Table 74.4, the overall mean scores ranged from 0.174 to 0.506. Five maturity criteria obtained the medium-level implementation in these CCFs, while the other 11 had low level.

"Risk communication" (M09) obtained the highest overall mean score, indicating that Singapore-based CCFs were relatively strong in communicating risk information across firms. As the communication mechanism is an important element of not only ERM implementation but also other management processes, risk communication would not be very difficult for the CCFs to implement. "Objective setting" (M15) was ranked second by all the respondents, suggesting that objectives at various levels were identified and linked with performance indicators in these CCFs. Similar to risk communication, the clear identification of objectives and

Table 74.4 ERM maturity criterion scores

Code	Overall		Small (S)		Medium (M)		Large (L)		S-M	M-L	S-L
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Sig.	Sig.	Sig.
M01	0.304	9	0.204	9	0.233	11	0.503	5	0.648	0.006*	0.000*
M02	0.298	10	0.196	10	0.253	9	0.483	6	0.165	0.002*	0.000*
M03	0.248	13	0.167	13	0.240	10	0.377	13	0.134	0.061	0.000*
M04	0.425	3	0.371	3	0.393	5	0.529	3	0.625	0.074	0.010*
M05	0.340	7	0.255	7	0.333	8	0.477	9	0.091	0.058	0.001*
M06	0.382	4	0.276	6	0.447	3	0.506	4	0.000*	0.274	0.000*
M07	0.326	8	0.209	8	0.367	7	0.482	7	0.001*	0.087	0.000*
M08	0.380	5	0.317	4	0.414	4	0.455	10	0.131	0.566	0.017*
M09	0.506	1	0.433	2	0.572	1	0.578	1	0.007*	0.921	0.006*
M10	0.257	11	0.191	11	0.149	14	0.428	11	0.464	0.002*	0.000*
M11	0.174	16	0.147	15	0.107	16	0.257	16	0.257	0.020*	0.030*
M12	0.366	6	0.289	5	0.375	6	0.477	8	0.198	0.122	0.003*
M13	0.185	15	0.131	16	0.146	15	0.294	15	0.681	0.086	0.024*
M14	0.255	12	0.166	14	0.230	12	0.409	12	0.164	0.016*	0.000*
M15	0.493	2	0.461	1	0.464	2	0.561	2	0.950	0.089	0.036*
M16	0.221	14	0.184	12	0.163	13	0.316	14	0.503	0.026*	0.037*
Spearman rank correlation									0.000**	0.000**	0.000**

*The independent-sample t-test result is significant at the 0.05 level (two-tailed)
**Spearman rank correlation is significant at the 0.01 level (two-tailed)

relevant performance indicators is also a common management process in various organizations. In addition, "risk-aware culture" (M04) occupied the third position, implying that these CCFs had a medium-level risk awareness within them. Although Singapore has a good social order and stable political environment, these CCFs still have to face the risks involved in their construction businesses and operation. Additionally, in the international market, contractors usually face a higher risk exposure and possibility of loss than those in the domestic market (Zhi 1995). Thus, the CCFs based in Singapore had started creating their risk-aware culture. Furthermore, "formalized key risk indicators (KRIs)" (M13) and "a risk management information system (RMIS)" (M11) were scored below 0.200, indicating that the CCFs had not developed KRIs or applied RMISs in ERM. These two weakest areas should be highlighted when the CCFs plan to improve their ERM practices. The result also echoed the viewpoint of Lu et al. (2009) that CCFs had low-level information and communication technology application in construction management.

The independent-sample t-test was conducted to check whether there were significant differences in criteria scores among large, medium, and small CCFs. The results indicated only three criteria obtained significantly different scores between small and medium CCFs, suggesting that medium CCFs had better practices in terms of risk identification, analysis, response, monitoring and review and communication. Additionally, six criteria had significantly different scores between medium and large CCFs, and all the criteria gained significant higher scores in large CCFs than in small ones. Specifically, large CCFs obtained higher scores of six criteria than both medium and small ones. Among these criteria, “commitment of the board and senior management” (M01) and “ERM ownership” (M02) obtained low overall scores but high scores in large CCFs, and thus merited attention. The large Singapore-based CCFs had senior-level commitment to ERM implementation and risk ownership because they were the subsidiaries of listed companies and/or CCEs, which had to comply with the guidance issued by the SASAC (2006). In contrast, the small and medium ones were the overseas subsidiaries of either provincial or municipal SOEs, and did not need to comply with the SASAC guidance.

Furthermore, the Spearman rank correlation was conducted and the results indicated significant agreement on the ranking of the maturity criteria among the three groups, despite the differences in mean scores.

74.6 Conclusions and Recommendations

This study develops a KBDSS for ERM in CCFs, which includes the ERMMM and performs the perceptibly complicated mathematical calculations for ERM maturity assessment. Through a questionnaire survey, this study intends to assess the ERM maturity in Singapore-based CCFs. The relevant survey data were input into the KBDSS and the ERM maturity assessment results were output. The statistical analysis results showed that Singapore-based CCFs had a low level of ERM maturity, and that there appears to be a positive association between ERM maturity and firm size. “Risk communication”, “objective setting” and “risk-aware culture” had the top three scores, while “formalized key risk indicators” and “a risk management information system” were the bottom two. Additionally, large CCFs obtained higher criterion scores than small ones. Despite the differences in mean scores, the results showed significant agreement on the ranking of the maturity criteria among all the survey CCFs.

As few studies have investigated ERM implementation in construction firms, this paper expands the literature by investigating ERM implementation in Singapore-based CCFs. Also, this paper allows other construction firms to compare with the CCFs in Singapore in terms of ERM practices and to use similar methodology to investigate their ERM implementation.

Future studies can focus on developing ERM practice benchmarking systems for construction firms in various regions, which allows these firms to compare their ERM practices with their counterparts and make better informed decisions to identify the measures to take to carry out their ERM implementation.

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Chapter 75
Enterprise Risk Management in Construction Firms: A Proposed Implementation Framework

Xianbo Zhao, Bon-Gang Hwang and Sui Pheng Low

Abstract Although the construction industry is project-based, risk management should cover risks at both project and enterprise levels because overemphasis on project risk management would lead to some limitations. As a holistic and integrated risk management approach, enterprise risk management (ERM), which agrees with the modern portfolio theory, deals with the entire risk portfolio of a firm and has been advocated in the construction industry. This study provides an understanding of ERM in construction firms and proposes an ERM framework for construction firms, based on the literature review. The components in this proposed framework represent the fundamentals of ERM. This framework could serve as a guide for ERM implementation in construction firms. As few studies have been focused on ERM in construction firms, it is believed that the proposed framework can contribute to the existing body of knowledge relating to ERM.

Keywords Risk management · Construction firms · Framework · Implementation

75.1 Introduction

The construction industry is a project-based industry and construction firms typically depend on their construction projects to earn revenues and profits. Thus, risks inherent in projects have been emphasized. However, construction firms are also exposed to

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the risks outside the projects, which tend to impact both project objectives and corporate objectives. Overemphasis on project risk management (PRM) tends to result in low efficiency in risk management, lack of transparency across multiple projects, inappropriate resource allocation among projects and difficulties in achieving the corporate strategic objectives (Zhao et al. 2013a). Therefore, risk management in construction firms should cover not only project risks, but also the risks encountered by being a business enterprise (Schaufelberger 2009; Zhao et al. 2013b).

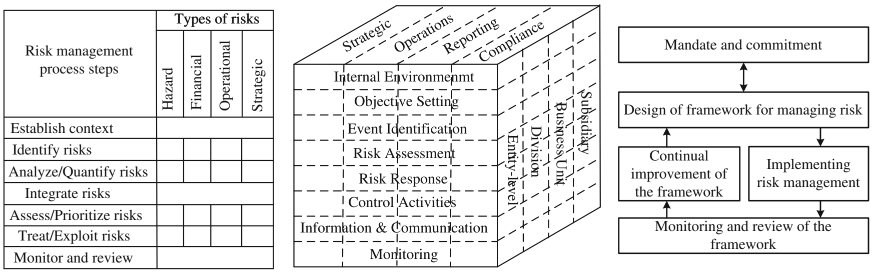
The way companies view risk management has experienced a shift in recent years, and the trend has moved towards a holistic view of risk management (Gordon et al. 2009). As the fundamental paradigm in this trend, enterprise risk management (ERM) has attracted much worldwide attention (Zhao et al. 2014b). ERM is most frequently defined with reference to the guidance document Enterprise Risk Management—Integrated Framework published by the Committee of Sponsoring Organizations of the Treadway Commission (COSO). COSO (2004) defines ERM as "a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives (p. 2)."

As ERM holds a portfolio view of risks and considers risk interactions, this approach agrees with the modern portfolio theory (MPT) (Markowitz 1952; 1959), which reveals that it is possible to build a portfolio that is reasonably safe even though it contains a number of uncorrelated or negatively correlated high-risk investments (Lam 2003). The concepts of the MPT can be generalized beyond financial risks to include risks of all kinds, namely beyond a portfolio of investments to the entire collection of risks that an enterprise faces (CAS 2003). Thus, an enterprise can be thought of as a collection of risky activities with various risk and return expectations. "Investments" in the MPT can be equivalent with "risky activities" in an enterprise. Lam (2003) argued that enterprise risk managers should think and act like a "fund manager" and set portfolio targets to ensure appropriate diversification and optimal portfolio returns.

Despite previous studies on ERM in various industries, few have attempted to investigate ERM in the construction industry. This study aims to propose a conceptual framework for ERM in construction firms. The components in this proposed framework represent the fundamentals of ERM. This framework could serve as a guide for ERM implementation in construction firms. As few studies have been focused on ERM in construction firms, it is believed that the proposed framework can contribute to the existing body of knowledge relating to ERM.

75.2 Existing ERM Frameworks

A framework serves as a guide, an outline or overview of interlinked items (activities) to facilitate an approach towards achieving a specific goal. An ERM framework is described as a specific set of functional activities and the associated



CAS framework (CAS, 2003) COSO framework (COSO, 2004) ISO 31000 framework (ISO, 2009)

Fig. 75.1 Existing ERM frameworks

definitions that define the ERM system in an organization and its relationship with the organizational system (Dafikpaku 2011). As Fig. 75.1 shows, there have been some ERM frameworks for various industries.

The Casualty Actuarial Society (CAS 2003) proposed a two-dimensional framework that covers four types of risks (i.e. hazard, financial, operational and strategic risks), which can be managed through seven iterative steps: establish context, identify risks, analyze/quantify risks, integrate risks, assess/prioritize risks, treat/exploit risks, as well as monitor and review.

In addition, the COSO (2004) developed a three-dimensional ERM conceptual framework. This framework specifies how the people from the four organizational levels (entity-level, division, business unit, subsidiary) across an enterprise implement the eight interrelated ERM components in order to achieve the four categories of corporate objectives (strategic, operations, reporting, and compliance). These components are internal environment, objective setting, event identification, risk assessment, risk response, control activities, information and communication, as well as monitoring. The effectiveness of ERM can be judged in terms of whether these eight components are present and functioning effectively (COSO 2004).

Furthermore, the International Organization for Standardization (ISO 2009) included a common risk management framework in ISO 31000:2009. This framework is also applicable to ERM. The framework includes: mandate and commitment, design of framework for managing risk, implementing risk management, monitoring and reviewing, as well as continual improvement of the framework. In this framework, risk management is implemented through a process including communication and consultation, context establishment, risk identification, risk analysis, risk evaluation, risk treatment, as well as monitoring and review.

These frameworks are similar and are applicable to any industries and could be considered as benchmarks. However, Liu et al. (2011) found that few Chinese construction firms adopted the above three ERM frameworks, and only 14.7 % of them had established and implemented the ERM frameworks. Hence, this study proposed an ERM framework for construction firms, and they can customize the framework to suit their own specific characteristics and to render integration of risk management easier and more effective.

75.3 A Proposed ERM Framework for Construction Firms

Based on the existing ERM frameworks and the project-based nature of the construction industry, an ERM framework is proposed for construction firms. As Fig. 75.2 indicates, this framework consists of (1) an ERM process; (2) commitment of the board and senior management; (3) training programs; (4) resources; (5) ERM ownership; (6) risk-aware culture; (7) objectives; (8) a common risk language; (9) PRM; (10) risk management information system (RMIS); (11) risk communication; and (12) monitoring, review and continuous improvement of the ERM framework.

The ERM process is the key component of this framework. In this framework, the ERM process adopts the process described in ISO 31000:2009. Construction firms are likely to have PRM in place. According to the Project Management Institute (PMI 2008), project risks can be managed through six phases, i.e. plan risk management, identify risks, perform qualitative analysis, perform quantitative analysis, plan risk responses, as well as monitor and control risks. Besides this process, there are other PRM processes in the literature (Fairley 2002; Hillson and Simon 2007; Kliem and Ludin 1997). Irrespective of the number of phases, risk identification, risk analysis and risk response are the generally recognized phases (Low et al. 2009). These three phases can be corresponded to the risk identification, analysis, evaluation and response in the ERM framework. The context establishment in the ERM process could seldom be found in the PRM process because the context typically concerns things at the enterprise level rather than the project level.

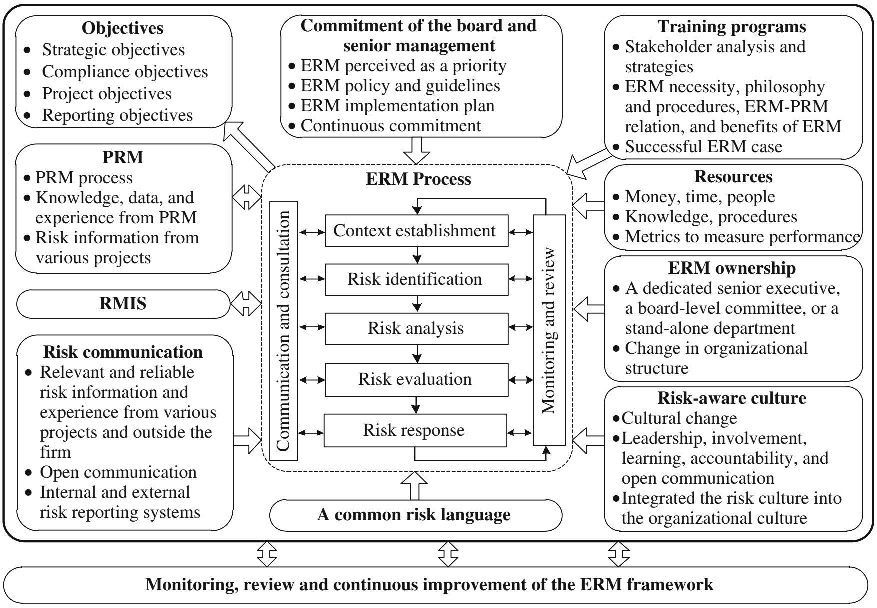


Fig. 75.2 An ERM framework for construction firms

The internal context establishment is crucial for ERM implementation in a construction firm because their existing internal context tends to fit only PRM. It is necessary for construction firms to change the internal context to make it fit ERM. Some of the remaining components of the framework, such as commitment of the board and senior management, resources, training programs, ERM ownership, culture, as well as risk communication and reporting mechanisms, concern change in the internal context of construction firms.

The commitment of the board and senior management is critical to implementing ERM across an enterprise (Abrams et al. 2007), and was considered as a prerequisite for implementing ERM (Barton et al. 2002). Without such commitment, the corporate culture or mindset at all levels within a firm would not be changed to be receptive to ERM (Zhao et al. 2014a). Such commitment can also signify the priority in implementing ERM to the personnel in a firm, and ensure that resources (including funds, people, time, expertise, procedures, tools, etc.) are allocated for ERM implementation. Hence, ERM policies, guidelines, and an implementation plan should be developed and made known to all the staff of a firm. The commitment of the board and senior management should be continuous, and ensures that the change in the ERM champion does not interrupt ERM implementation.

Resources are necessary for ERM implementation in construction firms because the ERM program that changes the accustomed way to manage risks concerns the need for funds, people and time input. Besides these inputs, resources should also include intellectual resources, such as knowledge, skills and expertise. In order to make people perceive the benefits or value of an ERM program, a set of metrics should be created to measure ERM performance. Such a set of performance indicators also contributes to the continuous improvement of ERM practices.

ERM should be implemented at all levels of firms, not just at the senior management level. However, during the initial stage of ERM implementation, management at the middle or lower middle level may view the impact of ERM as negative, such as an extra burden to their existing responsibilities, thus resisting the ERM programs. Hence, resources should also be allocated for training programs. These programs are necessary to help the personnel at all levels throughout a firm to clearly understand the necessity of ERM implementation, the ERM philosophy, the ERM procedure, the relationship between ERM and PRM, as well as the potential benefits of ERM. In order to make such programs effective, stakeholders' needs should be analyzed and training strategies should be developed. Successful business cases for ERM can be used to illustrate the values and benefits of ERM. Thus, misunderstanding of ERM will be reduced or even eliminated, and the commitment at all levels within the organization will form. It merits attention that the effectiveness of such training programs depends on the employee-manager relationships and mutual trust.

Similar to the ERM implementation in other industries (such as the financial or energy industry), implementing ERM in the construction industry also requires an owner. A senior executive may be appointed to be responsible for enterprise-wide risk oversight. Alternatively, a stand-alone risk management department or a board-level risk management committee may be set up to take charge of ERM. These methods all concern changes in the existing organizational structure.

In addition, because ERM implementation is viewed as an organizational change, change in the organizational culture is also necessary. Cultural elements unsupportive of ERM implementation should be changed. Cultural changes may involve discarding the "blame culture", a shift from "do not report bad news" to "report as early as possible", and from "how do risks affect my project" to "how do risks affect the entire firm" (IMA 2007). Thus, a risk-aware culture can be created. A risk-aware culture requires clear commitment of the board and senior management, involvement of all the stakeholders, learning, accountability, and open communication on all risk management issues and the lessons learnt (Hopkin 2010). Instituting clear accountability for risks has been identified as a successful approach to creating a risk culture (AON 2010). The risk-aware culture should be embedded into the organizational culture, which can encourage management at all levels to be aware of the potential project and enterprise risks. Hence, due to the pervasiveness of risk awareness throughout the firm, risk management becomes a critical part of the corporate culture (Barton et al. 2002; Kimbrough and Componation 2009).

Moreover, risk information is critical to manage risks at both project and enterprise levels. Thus, mechanisms need to be set up to motivate individuals to embrace ERM and share risk information across projects. Open risk communication across different projects enables each project team to obtain adequate risk information. The relevant risk information and experience in previous projects should also be collected for risk identification, analysis and evaluation. Risk information or historical data from outside the firm should also be collected, as long as the information or data is relevant and reliable. Risk communication also concerns risk reporting, which should be customized to gather and deliver the right information to the right people at various levels of the business, internally and externally. Benefiting from risk reporting, the board and senior management can have a clear perspective of the firm's entire risk profile to make better-informed decisions.

In order to improve the effectiveness and efficiency of risk communication and reporting, a RMIS needs to be set up and placed on the intranet of the construction firm with sufficient resources. A RMIS improves risk communication through providing an information platform, which facilitates risk information distribution from one project to another. In addition, a RMIS can facilitate data-based risk reporting, which leads to rapid and accurate evaluation of risk and timeliness of reporting (Duckert 2011). A RMIS can also record risk management activities, provide traceability of decisions and continuous improvement in risk management. Hence, it contributes to organizational learning through storing the valuable project data, experience and knowledge after the project completion. Besides these functions, some RMIS software packages can undertake risk identification and analysis, and provide response plans. Although the cost of a RMIS is relatively high, large firms can still gain enough marginal benefits from RMIS to offset the costs (Hopkin 2010).

Successful risk communication can also be attributed to the development of a common risk language. The risk language clearly explains terminologies and methods to be used universally in the organization, and contributes to a common understanding of risks. The risk language should be communicated to all risk management practitioners at all levels of the firm. To facilitate the acceptance of the risk language, a glossary that is a collection of key terms can be created and disseminated across the firm. The risk language also underpins the risk culture of the organization because it facilitates open communication, which is a component of a risk-aware culture (Hopkin 2010).

In construction firms, PRM is still necessary and can be considered as an integral part of ERM although ERM and PRM have different goals due to their different levels. Better PRM can assure the achievement of the objectives of the projects that the firms are engaged in, and thus further contribute to the achievement of the objectives at the enterprise level.

The ERM framework is also evolving continuously for improvement, so it also needs monitoring, review and improving. This is consistent with the ISO 31000:2009 risk management framework.

75.4 Conclusions

To embrace ERM, construction firms can customize the proposed ERM framework by selecting the components according to their stage in ERM implementation. ERM should be implemented step-by-step. In the initial stage of ERM implementation, the commitment of the board and senior management as well as training is essential. The ERM responsibility can be included in the CEO's function, because creating a stand-alone department or a board-level committee for ERM involves changes in the organizational structure, which is time-consuming. Change in the organizational culture unsupportive of ERM can be another thorny issue for the firm. Staff in construction firms tends to be accustomed to PRM practices and only care about the project they are engaged in, even though they possess risk awareness. To create a risk-aware culture throughout the firm and to embed it into the corporate culture, accountability at all levels needs to be instituted. Additionally, motivation mechanisms are necessary for staff to care about not only the project objectives but also the enterprise objectives. Thus, individuals would share risk information in their projects with their counterparts in other projects, which ensures risk communication. A common risk language should be developed to ensure the success of risk communication and to improve the risk culture. If possible, the construction firm can develop or purchase a RMIS, and embed it in the intranet.

The proposed ERM framework presents the fundamentals of ERM implementation in construction firms, thus providing an understanding of ERM in the construction industry. Based on this framework, customized ERM guidelines could be developed for specific construction firms. Considering that there has not been an ERM framework specifically for construction firms, this study expands the literature and contributes to the body of knowledge relating to ERM.

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Chapter 76
Game Theory Analysis on Credit Management of Personnel Qualification in Construction Market in Hainan

Chunjing Shang, Chang Xing and Xueqing Wang

Abstract The construction of Hainan International Tourism Island provides a broad market for construction industry. The credit management of construction enterprises and practitioners, which is the core, plays an important role both in the development of construction market and the quality of products. In the paper, mechanism of credit utility in construction market in Hainan was analyzed via Game Theory by establishing models of incomplete information, which was based on the complex agency relationship and the situation about lacking of good credit managements among actors. And some relevant strategies were put forward to improve the management efficiency of the construction market in Hainan, such as establishing actors' credit management system and incentives.

Keywords Hainan · Construction market · Credit management · Practitioners · Game theory

76.1 Introduction

Since Hainan International Tourism Island was constructed in 2010, the construction industry has sharply increased. In 2011, the growth rate of the construction industry output value was up to 28.07 %, accounted for 10.127 % of the GDP of Hainan province; The construction enterprises registered in Hainan province had been 3087 units, the number of which was 63.25 % more than that in 2009;

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Construction enterprise employees had reached about 55,000 people, and the value created by whom was 42,776 Yuan per person, the labor productivity in construction industry was 125.36 % more than that in 2009. As one of the construction market players, practitioners' action directly run through or influence these processes such as bidding, constructing, and operational management, etc. Some dishonest acts hidden in the project are constraints to the efficient development of the construction industry in Hainan. In the paper, reasons for credit-lacking among construction market in Hainan were analyzed via Game Theory so as to provide basis to help improve the management efficiency of construction market in Hainan.

76.2 The Present Situation of Credit-Lacking in Construction Market in Hainan

There are different market interest players in construction market in Hainan like the owner, the registered architect, the registered cost engineer, the registered survey and design engineer, the registered supervision engineer, the contractor, the project manager, the subcontractor, the supplier and the property manager, etc.

The phenomenon of credit-lacking in construction market in Hainan is not only confined to some certain body's behaviors, which means there may appear different degree of dishonest acts among all parties' acts. Mainly performances are as follows.

Project bidding activity is not regular in parts of Hainan province, such as setting irregular extra-giving points for bidding units, decomposing project tenders, secretly setting the winner, receiving security deposit for extra profit and even modifying the bid assessment method randomly; Owners break their word to contractors for their own benefit maximization, the default of construction funds in projects caused by whom leads contractors to construct by their own or to loan funds, the arrears transfer via owners, contractors, sub-contractors, project managers, labor contractors and supervisors, and this probably results in constructors having no money for builders. In turn, all kinds of labor disputes easily come about; For getting extra profits, some enterprises purchase cheap and shoddy building materials, which results in implied risks in quality and safety; Some registered engineers in intermediary organs like architects, cost and supervision, prefer to illegally lend or transfer qualification certificates to others, or even provide false reports in the construction activities.

Lacking credit among practitioners is the potential menace to safety and quality of construction products, there give some examples. In November 2010, a residential area in Hainan as the main part of the project were in arrears under the condition of passing the acceptance according to the law, the contractor owned the builders money cause builders to stop constructing for a long time. A highway was finished in January 2009 in Wenchang, but some potholes and breakages emerged soon after it put into use. This was caused by the fact that few materials were used during the construction. In September 2012, in the case of not passing the acceptance, a new school in Ledong came into use. Obviously, many cracks and land subsidence appeared.

76.3 Game Theory Analyses on Credit-Lacking in Construction Market in Hainan

76.3.1 Principal-Agent Relationship in Construction Market

In economics, principal-agent relationship refers to any kind of deal that involves asymmetric information, and those who have information advantages are agents and the others are principals (Zhang 2004). Information asymmetry on the one hand helps the parties focus their limited energies on the core business to help enhance their own advantages, but on the other hand may push agents to conceal the messages and behaviors that are bad for principals by making use of the information superiority under the opportunism motivation, the result of which is that principals suffer losses but agents realize the aim of self-interest.

Different market interest players like the owner, the registered architect, the registered cost engineer, the registered survey and design engineer, the registered supervision engineer, the contractor, the project manager, the subcontractor, the supplier and the property manager are included in construction market. Each party signs a dominant or recessive contract with each other to make up the principal-agent relationship. Take a project, for example. The owner, being as the project possessor, he also acts as the principal to respectively entrust relevant practitioners as agents by signing contracts in accordance with the law. For instance, the registered architect was entrusted to do design activities; The registered cost engineer was entrusted to be responsible for the cost valuation, pricing and management; The registered survey and design engineer was entrusted to give survey and design to the project; The registered supervision engineer was entrusted to do supervision and management works on both the construction project and the practice of its practitioners; The contractor was entrusted to undertake the project construction. Meanwhile the registered constructor was entrusted by the contractor to be the project manager and professional contractor was further entrusted by the latter. In this way, the whole project appears to have multiple levels of principal-agent relationships and therefore a complex information asymmetry is created as shown in Fig. 76.1.

76.3.2 Game Analysis on Imperfect Information

Game Theory is the study about how to make decisions and how to achieve a balanced result when decision makers do direct interactions (Ren and Chi 2009). In construction market, it can be regarded as a kind of game between the principal and the agent and the result depends on each body's decision-making behavior. Both sides expected to obtain the highest interests with the minimum costs in the transaction, so they could be assumed to be "rational men". There exists a common phenomenon that uncertainty and risk in construction market lead to information

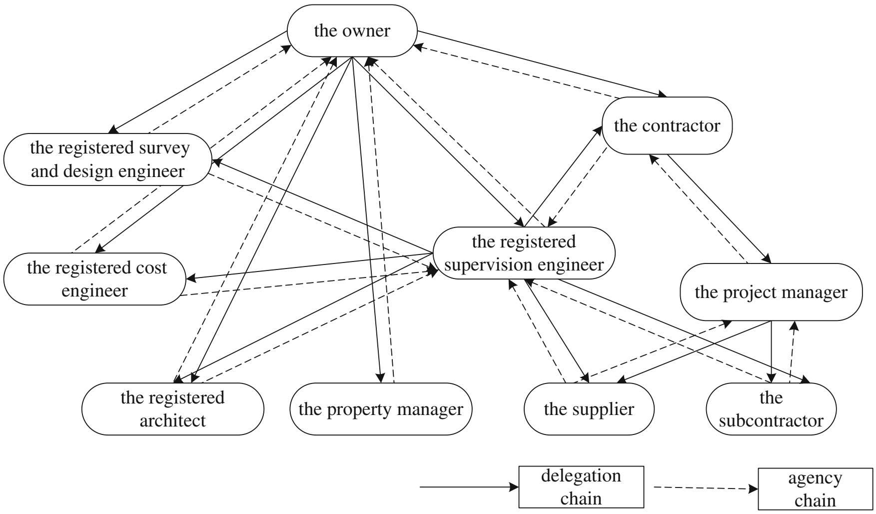

Fig. 76.1 Principal-agent chain in construction market

asymmetry, which makes the seemingly clear principal-agent relationship appear to be complicated under the drive of interests. That is, the side of information superiority usually tends to conceal the messages and behaviors that are bad for the information underdog by making use of the information superiority, which causes the information superiority to realize the aim of self-interest. Therefore, both sides strive to create the optimal strategy combination and give a formation of game equilibrium to achieve the benefit maximization. Then, game model for imperfect information are built to help analyze principal-agent avenues in construction market.

76.3.2.1 Establish Game Model of Incomplete Information

There often has information asymmetry among game players in construction activities due to a large number of uncertain factors exist in the real construction market. It can be seen that the agent has an absolute advantage in his own hidden information like technology and ability during a specific construction activities. On the contrary, the principal can only determine whether to cooperate with the agent or not according to the latter's past credit record or credit conditions. So a dynamic game model for incomplete information can be built to help analyze the credit mechanism of construction market.

First, assume that agents only have two cases of good credit and bad credit, and the credit type is centrally expressed as T = {p, 1 − p}, among which p represents for the good credit agent and 1 − p represents for the bad credit agent. Then, the principal makes further estimates and judgments to determine whether to give credit

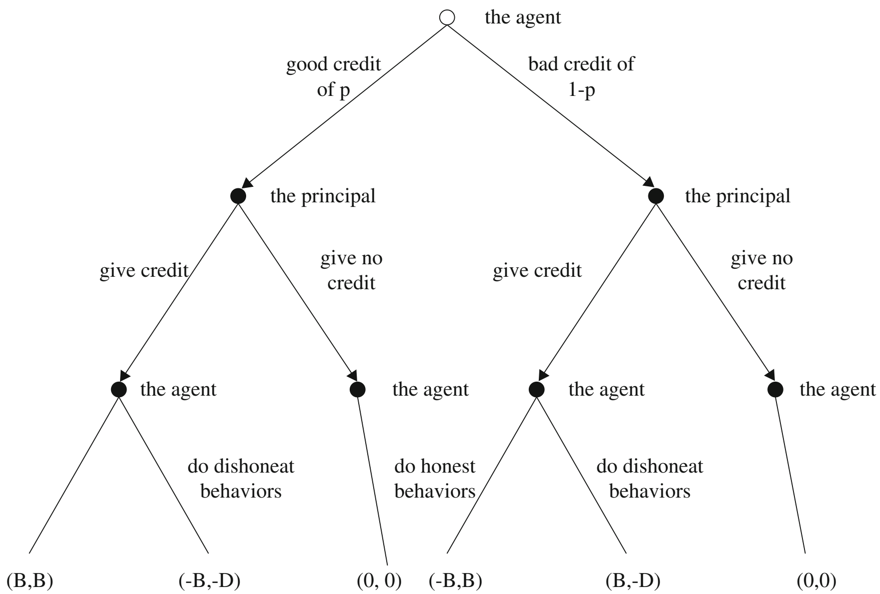

Fig. 76.2 Game process of incomplete information

or not on the basis of knowing above two credibility probability of p and 1 − p. Finally, agents with two different types respectively make honest or dishonest acts after observing their own credit type. It is worth mentioning that agents (including the good credit and the bad credit) may appear to have two different kinds of behaviors, honest or dishonest. But the possibility of a good credit agent makes the honest behavior is high and the poor credit agent is more likely to do dishonest acts. The whole game process can make up a game tree, which is as shown in Fig. 76.2. Assume that B and D are the amount of revenues that may got by the two game players in the end, the relationship of size between which is B > D > 0.

76.3.2.2 Game Analysis

In the game process of construction activities, if the principal doesn't give credit to the agent, both side will have no revenue or loss and the game will come into end regardless of the agent is honest or not. But if the principal chooses to give credit, it can be assumed that the following situations will exist: if the agent is of good credit, revenues of both side will be B when the agent does honest behaviors, but if the agent does dishonest behaviors, the revenue of the principal will turn into −D and the revenue of the agent will turn into −B; if the agent is of bad credit, the revenue of the principal will be B and the revenue of the agent will be −B when the agent does honest behaviors; or they will separately get −D and B instead.

It can be concluded that on the condition of the principal's giving credit, the revenue B got by the agent with good credit when he does honest behaviors is more than that does dishonest behaviors with −B, and the revenue −B got by the agent with bad credit when he/she does honest behaviors is less than that does dishonest behaviors with B. At that moment, the maximum revenue B got by both two types of agents is much more than revenue 0 in the case of no credit given. That is to say, in the whole process of the game, the optimum choice for the good credit agent is doing honest behaviors and the optimum choice for the bad credit agent is doing dishonest behaviors. The principal weighs up the expected revenue to make decisions on the basis of mastering above information and credibility probability for realizing his own effectiveness maximization. The expected revenue got by the principal can be

$$\mathrm{p} * B + (1 - p) * (-D) = p(B + D) - D$$

1. When $\mathrm{p}(B + D) - D > 0$ holds, that is $p > \frac{D}{B+D}$, the optimal choice for the agent is giving credit and there are two kinds of equilibriums of both (keep faith, give credit) and (break faith, give credit) at the same time. The equilibrium solution based on which depends on the amount of revenues got by the agent in the cases of keeping faith and breaking faith.

   As for the agent, when the revenue $\mathrm{p} * B$ got by keeping faith is more than $(1 - \mathrm{p}) * B$ got by breaking faith, that is $p > \frac{D}{B+D}$ and $\mathrm{p} > 0.5$ hold in the meantime, (keep faith, give credit) is the equilibrium solution, or when $p > \frac{D}{B+D}$ and $\mathrm{p} < 0.5$ hold in the meantime, (break faith, give credit) is the equilibrium solution.
2. When $\mathrm{p}(B + D) - D < 0$ holds, that is $p < \frac{D}{B+D}$, the optimal choice for the principal is giving no credit, so the equilibrium solution is (0, 0).

In conclusion, the equilibrium solution of incomplete information game relies on the principal's estimate to credit condition of the agent, and the estimate comes from the information obtained. So the key links of credit management system is the acquisition, evaluation and transformation for credit information in construction market. Nowadays however the number of credit institutions in Hainan province is only 45, a narrow scope of credit collection and credit data left collection, analysis and measurement for credit information in construction market in Hainan much to be desired. So the current construction market lacks the support of data and the operability to carry out the credit evaluation. Meanwhile, the credit information disperses over different sections in Hainan and even other provinces. Management departments related are lack of unified search platform and data transfer standard, which result in the difficulty for participants in obtaining the credit information from each other.

Since the credit information asymmetry caused by difficult information acquisition makes the principal easily give a relatively conservative estimate about the credit level of the agent under the condition of uncertainty and have errors in judgment further, the result turns out that the lower credit credibility of the agent by judgment, the lower credibility of giving-credit decision made by the principal. This blocks the construction activities among parties, causes huge waste of social resources and is not conducive to the efficiency development of construction activities.

76.4 Strategies on the Credit Management Among Practitioners in Construction Market in Hainan

76.4.1 Strengthen the System Construction and Clear the Government Functions

Being as a game rule, institution is the key to establish and maintain the credit system (Ma 2007). By referencing to legislation practice in terms of the parties' credit management in construction market, legislatures and regulatory authorities in Hainan should add a special provision of common credit evaluation system on the basis of the original system, which contains the construction market credit. The measures could not only solve the shortage of the information supply in construction market, but also prevent the excess supply from the system (Zhang et al. 2004).

Meanwhile, the clause should be based on the regulation system of the construction industry, the role of which is to further clear the status of government in constructing the credit system in construction market for playing its part in planning, guiding, organizing, coordinating and serving. This helps to promote establishing a credit mechanism that involves administrative management, discipline management, mutual supervision and cooperation. In this way, credit evaluation and regulation system and credit cooperation mechanism in Hainan can be formed gradually.

76.4.2 Build and Improve the Reward and Punishment Mechanism in Construction Market

Establishing a sound reward and punishment mechanism could encourage game players to make more effective choices. The construction administration department of Hainan province should utilize market means to reward trustworthy behaviors and punish dishonest acts by making relevant rules, focusing on letting each practitioner's revenue got by trustworthy behaviors is much more than that got by dishonest acts. Set up the credit information database and then establish a unified information reference standard according to both the regulation "recognized standards of bad behavior records for construction market parties" and the credit information comes from the field of industry and commerce, taxation, banking, and construction markets. Improve the reward and punishment mechanism in construction market, those with dishonest behaviors must be given high intensity of punishment by raising the cost of broken promises. By doing this, they on the one hand can't afford the punishment that may suffered after violations (Yu et al. 2010), on the other hand have risks in losing the support from banks and guarantee agencies and even risks in losing the large-area construction market share, which eventually force them to make choice of good credit behaviors for thoroughly eliminating opportunism tendency and excluding fluky psychology about choosing dishonest acts.

76.4.3 Build the Participants' Credit Management Platform on the Base of the Whole Life Cycle of the Construction Project, Strictly Enforce the Credit Standards-Based Entry and Exit Mechanism of Enterprises

Business entities and practitioners' behaviors work through the whole life cycle of projects. Tasks of design, construction, operation and maintenance are undertaken by registered engineers such as architects, cost, geotechnical, structural and supervision respectively. This is therefore the business entities and practitioners' credit management platform which is based on the whole life cycle of the project should be built to enhance the credit management mechanism of multidimensional practitioners. Strictly enforce the credit standards-based entry and exit mechanisms of enterprises, that is, give strict credit examinations to enterprises and then kick out the bad credit ones to achieve differentiated management, as shown in Fig. 76.3.

In the stages of the project design and project bidding, the practitioner with good credit will be selected if he/she meets the engineering requirement. Once wining the bid, credit behaviors of selected practitioners will be locked in the winning project until the project completion.

In the stages of the project implementation and the completion acceptance, the credit management puts emphasis on the credit behaviors of supervision engineers, project managers, suppliers and the quality inspection staffs from the government. For those who have dishonest acts like altering construction programs, defaulting on the labor costs would be included in the restrained list to exit the credit management platform.

Property managers and suppliers' credit behaviors would be especially strengthened in the stages of the project operation and the project maintenance.

The essence of establishing the business entities and practitioners' credit management platform based on the whole life cycle of the project is that solving the continuous credit problems caused by the parties in the way of strengthening the

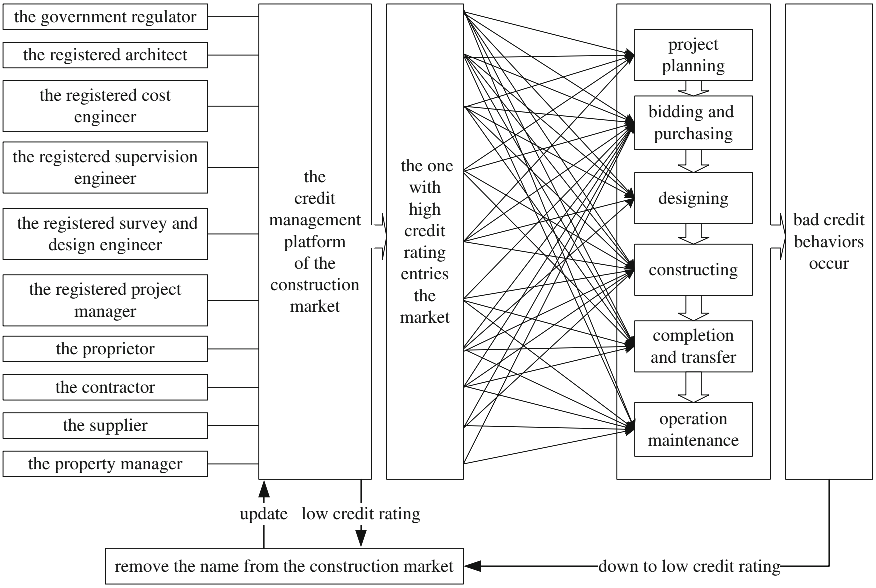

Fig. 76.3 The credit management platform based on project life cycle of participants

management of people's behaviors and improving the market management, which can also help to construct the credit guarantee of all participants during the whole project life cycle.

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Chapter 77
Managers and Craftsmen Perceptions of Operational Strategies Based on Lean Philosophy: The Case of a Large Swedish Construction Company

Jonathan Dahl, David Nordgren and Per-Erik Josephson

Abstract Organisations implement operational strategies in order to develop and stay competitive in a changing business environment. However, the strategy needs to be anchored and understood by the employees in order to become successful on a long-term basis. This paper is based on a case study of a large construction company specialised in new construction of multi-dwelling buildings. Five years ago, the company initiated Structured Production, which is an operational strategy based on lean philosophy. The aim of the paper is to identify how middle managers, lower managers and craftsmen perceive how operational strategies is implemented in the company. First, the strategy and the rational behind the decision to implement the strategy is presented. This section is based on document analysis as well as on interviews with upper managers in the company. Then, middle managers, lower managers and craftsmen perceptions of the strategy is presented. This section is based on a questionnaire study made 2014. The study shows that the strategy is perceived to focus on structuring and standardising products and processes, while less focus is on the organisation and its members.

Keywords Construction companies · Operational strategies · Strategy implementation · Lean construction

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77.1 Introduction

Construction companies are always striving for increasing their profitability, not least by improving their productivity by reducing unnecessary costs. This paper concerns how strategies for improved productivity are formed and implemented in a large construction company. Since the hierarchical levels of an organisation operate in different ways, strategies need to be translated into actions that are relevant for each level of the organisation (Clegg et al. 2011). The organisational strategy consists of three parts; a corporate strategy, a business strategy and an operational strategy (Johnson et al. 2011). Organisations often struggle with the connection between these parts, hence the strategies needs to strive against the same goals and at the same time be relevant for the operational work at each level. Therefore it is important to analyse how different levels of the organisation perceive the initiatives of the strategy and thereby understand that the organisation strive towards the shared goals. The aim of this paper is to identify how upper managers, lower managers and craftsmen perceive implementation of operational strategies based on lean philosophies in large construction companies. The paper is based on a study of a Swedish company, which initiated their operational strategy 2010.

77.2 Background to the Case of JM

JM AB, hereafter JM, is a house developer and contractor with an operational part focused on development and production of residential buildings and residential areas mainly in Scandinavia, but also in Finland and Belgium (JM 2014). JM was founded 1945 and has an annual turnover of SEK 12.6 billion (appr. €1.2 billion) and around 2200 employees. Currently, JM has approximately 5,600 apartments in production. This particular study focuses on JM Residential Sweden, which is the largest business segment. They contribute with around 60 % of the total income for the organisation and consist of six regions, where of three regions are located in greater Stockholm. One important factor for JM is that they run most projects from acquisition of land through the development and construction process to the selling of the product to the end customer. This gives an opportunity to make strategic decisions with a holistic view of the organisations processes.

In the beginning of the 21st century JM had for years faced a trend of increased production costs and post-market costs. Therefore, the board of directors took the strategic decision to start focus on improvements by structuring the organisation's processes. The decision was the beginning of a general strategy named Structured Project Development (SPD) (JM 2014). The vision was to generate value through quick and cost-efficient processes, create faultless products, improve cost control and standardise the end product and the construction processes. Since this decision was taken, SPD have been divided into several operational strategies, see Fig. 77.1.

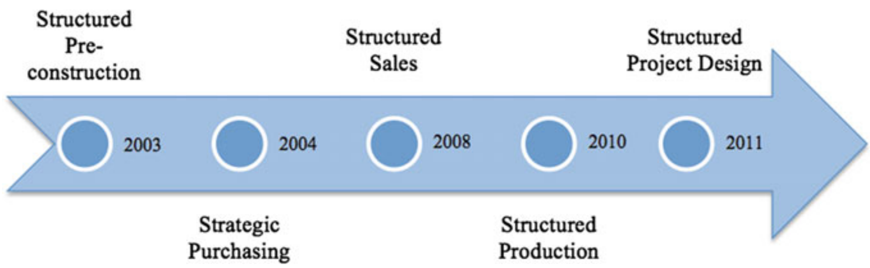

Fig. 77.1 An overview of the strategy structured project development including some of its operational strategies (JM 2014)

In 2010, Structured Production (SP) was launched in the business segment of production as a way to implement the overall strategy on construction sites. SP include four essential parts; manuals for standardised work procedures, descriptions for routines and instructions for unified time scheduling and finally education for all employees in the business segment. The process of building the product became equal through all projects. Experienced craftsmen and foremen developed the manuals together for all work moments in the process (Gíslason et al. 2013), simultaneously as a common cycle time was established. All employees were educated in SP and the reasons explaining why JM should work according to this operational strategy. Structured meetings, including daily morning meetings on site for foremen and craftsmen, were implemented. SP, which is inspired by the philosophy behind the Toyota Production system, gave JM a national award—"Lean builder of the year"—in 2011. To enable continuous improvements, all employees are asked to identify and suggest improvements, which are used to modify the manuals for standardised work procedures to fit best practise.

77.3 Literature Review

The competitive environment in the business market drives organisations to develop and change faster and more accurate than their competitors (Kaplan and Norton 1992). An organisation describes this change, which is driven by decisions to make the organisation more competitive, in their organisational strategy. Strategy is a complex term and should address all business areas of the organisation (Johnson et al. 2011). Strategy has been defined in various ways over time. Among these are "…the determination of the long-run goals and objectives of an enterprise and the adoption of courses of action and the allocation of resource necessary for carrying out these goals" (Chandler 1963), "…the long-term direction of an organisation" (Johnson et al. 2011) and "… a pattern in a stream of decisions" (Minzberg 2007). Hence, organisational strategies describe the long-term direction of an organisation, the scope of their activities, how to gain advantages, how to handle changes in the current business environment and how to handle their stakeholders. However, strategies are applied in different levels in the organisation and could be categorised into three levels: corporate-, business- and operational strategy (Clegg et al. 2011; Johnson et al. 2011). Operational strategies address the strategies to how the organisation works with employees, resources and processes (Slack and Lewis 2002). Furthermore, Slack and Lewis (2002) argue that the operational strategy must move the business towards the long-term goals, in order to align with the business and corporate strategy.

This study focuses on strategies aimed for the operational levels in the organisation. However, the operational strategies are closely linked to the other two types of strategy. It is the operational strategy, which should deliver the expected outcome of the corporate and business level strategy (Johnson et al. 2011). To make it possible for the organisation to fulfil the operative strategies, which the board of management has decided on, they are obligated to handle the right terms of tangible and intangible resources. Examples on tangible resources are the right amount of employees and capital to achieve the results. Intangible resources could be trust and brand image.

To successfully implement a strategy it is also important that the decisions taken is connected to the strategy and that upcoming activities are steps towards the operational strategy. On the other hand, it is difficult to develop an operational strategy, which suits and are relevant for the organisation's operational work and simultaneously supports the organisations business strategy and corporate strategy (Frizelle and Woodcock 1995). Even if it is in the operational level of the organisation the strategy is going to be implemented, it is occasionally middle managers that are involved in creating the strategy and the workers of the organisation are practically never involved in the strategic development (Mantere 2005).

A strategy is mainly evolved through two different processes in an organisation (Johnson et al. 2011). Either the strategy is accurate planned and meticulous thought out by the top management and launched as an intended strategy to the organisation. The emergent strategy, on the other hand, starts with a number of actions, which is performed over time with no intention of being a strategy and then, in a retro perspective, proclaimed to be a strategy in the organisation. However, it is the top management, who steer the strategic work and finally set the formulation of the strategies (Jarzabkowski and Paul Spee 2009).

In large organisations, the intended strategy is often based on the traditional and established theories on strategy development (Johnson et al. 2011). The strategies are developed from the organisation's vision and mission and by well-known methods launched in the organisation. To have a successful implementation of an intended strategy, a plan over the implementation process are a key aspect to have before the implementation starts (Grunert et al. 2011). Johnson et al. (2011) also argue that communication, coordination of resources and to provide common milestones are vital parts of the plans. However, while implementing a strategy the psychological aspects have an essential role too. Therefore, to involve the employees in the strategy development work helps them to feel that they are a part of the development and thereby feels more secure and engaged in the new strategies, which will change their daily work.

The case company in this study was influenced by the lean philosophy. Lean originates from the Toyota Production System (TPS), which was developed in the 1950s (Liker 2004). However, it was not until Womack et al. (1991) released the book "The machine that changed the world" as the term Lean production was familiarised (Holweg 2007). Lean production have then become a synonym for TPS and used to describe the philosophy of Toyotas successful production system (Liker 2004). The TPS is based on four main principles; long-term philosophy, the right process will produce the right results, people and partners and continuously solving root problems. However, Liker (2004) argues that all principles need to be accomplishing in order to follow "The Toyota Way". Gallagher (2005) stresses that TPS is not a toolbox; it is about the culture in the organisation and their ability to work towards their mission, the organisation's philosophy.

Research made in the UK industry indicates that about 90 % of UK industries fail to accomplish a successful Lean implementation (Bhasin and Burcher 2006). One contributing factor to the failure is the approach of interpreting Lean as a process instead of a philosophy (Bhasin and Burcher 2006). This creates a view of Lean as a toolbox of systems that can be implemented to increase profit while the mind-set of 'thinking Lean' gets ignored. Further, Kotter (1997) claims that strategy formulation represents only 10 % of the success while the remaining 90 % is related to implementation, which has to be driven by leadership. A successful long lasting implementation of Lean requires a consistent Lean management approach that involves a change in mind-set and behaviour of the organisations managers (Mann 2009). Based on a literature review, Bhasin (2012) concludes that the main barriers to implement lean are related to people.

An important characteristic of construction is that the majority of the work is performed in projects located at various geographical places. Temporary organisations are created to fulfil a special purpose, which often includes an element of change (Lundin and Söderholm 1995). Large construction companies annually form numbers of such temporary organisations to run their projects. A challenge concerns how to balance the centralised and the decentralised decisions. Samuelsson et al. (2006) found in their study of a large construction company a gap between operational and strategic operations at two organisational levels: lower management tended to prioritize operational criteria prior to strategic criteria, while middle managers prioritised strategic criteria. One reason for this gap seems to be the lack of incentives for lower managers for aligning with the strategic objectives. Frödell et al. (2013) made a similar conclusion in their study of purchasing in a large construction company and argued for a better balance between the strategic perspectives in the central purchasing department and the operational perspectives in the projects.

77.4 Method

In order to examine and evaluate how JM has been implementing SP, data was collected in two ways. First, interviews were made with eight upper managers, including region managers, production managers and department managers, in order to investigate the goals, visions and initiatives of SP. Main questions were sent to the interviewees in advance to give them an opportunity to prepare, since the time was limited to 30 min per interview. The interviewees were chosen by JM with the criteria of being in a leading position and operate in the case organisation. The numbers of interviews and the length of them were chosen by JM to reduce time consumption for the organisation. The first two authors made the interviews: one lead the interviews and the other took notes. Further, all interviews were recorded after permission from the interviewees.

Second, a questionnaire was distributed to middle and lower managers, including production managers, site managers and foremen, and to craftsmen. The managers responded via a web survey, while the craftsmen were approached via a number of site visits in all geographical regions. In total, 251 employees answered the questionnaire, whereof 127 managers and 124 craftsmen. Since the questionnaire were distributed and filled in during common meetings, the response rate was very high for craftsmen. The questionnaire was formed based on 31 recommendations for waste reduction, which were developed in collaboration with groups of practitioners (see Josephson and Björkman 2011). The managers and craftsmen were asked to comment to what extent they perceived that the company prioritised each recommendation on a ten-point scale in which 1 mean no priority at all and 10 means very high priority. Josephson et al. (2009) and Josephson (2013) have used the questionnaire for similar reasons. The latter restructured the recommendations in five groups based on a factor analysis. This structure was used in our study.

77.5 Results

77.5.1 The Driving Forces Behind Structured Production

The managers underlined that JM was in the forefront of their competitors in the construction sector when they decided to start Structured Project Development. A strong driving force was that JM always had the ambition to strive to become the most professional house builder. Other driving forces to start the SPD was cost runaway, insufficient cost estimations and a high degree of uncertainty in their design work. Together with these internal forces, a tough economic market in 2003 forced the organisation to take action. The external forces were the catalyst to perform the strategic development work within the organisation in a fast pace, however it would never have occurred without the internal driving forces.

In 2008, when JM suffered from the global economic crisis, once again the external environment acted as a catalyst to continue to standardise the processes in the organisation. SP was developed and launched 2010. At this point of time the production segment observed risen costs, the early phases of SPD had entered the managing phase and the organisation was ready for a new change process. Other internal forces were increased cost in the actual spending in the department of aftermarket and to continue with the work, which was started in the SPD and strive to utilise the strength of a standardised product and become a more competitive house builder. Further, the managers described how JM became inspired by the process industry and foremost the automotive industry to find inspiration.

77.5.2 The Goals and the Values of Structured Production

The managers described the goals of SP as to increase the competitiveness, lower the production cost, create a better product, work with health and safety and create a platform for continuous improvement. One manager described that one goal is to create a strong brand toward its stakeholders. The managers perceived that SP made it possible for the production segment to communicate its message and intention to its stakeholders. As an example, they underlined that SP made it easier to communicate to their material suppliers and sub-contractors concerning why, how and when their services were needed. They also saw SP as a communication tool towards its employees, potential employees, other departments at JM, the end customers and the society. The managers repeated that SP should cover many perspectives, but that the main goal of SP is to ensure a high and consistent quality of their product. All managers argued that the goals are achieved through a widespread involvement from all employees at the department of production, from craftsmen to upper managers. This broad involvement was described as one of the most vital part of the strategy and it is seen as essential for the success of the implementation.

The values of SP were described similar. One manager explained that the value of SP is the movement towards being less dependent on the individual. To focus the organisation towards the processes and not the individual, the managers argued that a higher level of lowest quality will be reached on their products and, make the processes in the projects overall smother. The lower dependency of the individual is achieved by increased amount of standardised work procedures, which ensures that all members of the organisation have a planned work procedure. Further on, with less dependency in the individual it argues that an increased quality of the end product to the customer, and this will be showed in lower aftermarket cost. Furthermore, one additional value of SP, according to managers, is the increased competitiveness, which SP gives JM. Consequently, the managers discussed around that the Swedish construction market is perceived as conservative and ineffective to be able to keep their share on the market, JM have to produce their product more efficient. With SP, JM can standardise their components and work procedures to create a foundation for future development of the production process. One manager reasoned in these terms and stated that "SP does not increase our productivity, it ensures our quality and create us a standard and a platform that make it possible to increase the productivity in the future". Another perspective is that SP changes the view of how their organisation works, from being a project-based towards being a process-oriented organisation. This is seen as added value for the organisation where ideas from one group can be applied and used in other groups.

77.5.3 The Implementation of Structured Production

The managers agreed on that the main challenge during the implementation was related to communication. A major challenge is to make sure that all employees understand the information, this includes aspects as; why we are changing, what will be changed and how the change process will occur. Another challenge is to make everyone understand the initiatives, to reach everyone in the organisation with the same information and message in an accurate time frame. One manager explained that rumours and uncertainties otherwise would grow in the organisation and lead to mistrust. Another challenge is to convince all employees that the change is mandatory and that there is no return to old procedures. One manager described the complexity in the following way; "It is always a struggle with the information flow to the employees. They give us a lot of feedback and questions. We are working with this input in different groups but it is a challenge to communicate and visualise for the employees that we are working with their questions. We are missing that information flow and transparency and that is a major challenge". Furthermore, the managers underlined the importance of consistency in decisions and activities around SP and they believed that consistency overall is one of the most important factors to succeed with the implementation. A higher consistency in the initiatives results in less uncertainties and misunderstandings. An additional challenge described by the managers is the importance to hold on to the strategy and never lose focus. They described that it has been a challenge to motivate the organisation to drive changes even when the organization has performed well financially.

The implementation of SP has inspired groups that support production to initiate new ways to improve. One manager described a closer collaboration with subcontractors and suppliers as an opportunity. SP supports this collaboration through the structured way of working and as a platform for continuous improvements. Another manager stated that the platform could, through similar communication procedures and working methods, help subcontractors and suppliers to develop into a more structured way of working. With increased structure among collaborators, JM can secure the flow of their working process. The structure of SP has given opportunities to further improve material logistics. Several managers stated that the next move of the strategy is to structure the logistics around the construction site to lubricate the flow of materials. One manager stated that they in three to five years "will definitely have a better logistic system, the work with logistic that we are about to start now was not possible to do before we had standardised the other parts of the processes. Every journey has its own time". The implementation of SP has, according to the manager, increased the possible gains of improvements in logistics.

The managers repeated several times that trust of the initiativeis crucial for successful implementation, referring to trust to the idea, which the strategy is based on, trust that the top management believes in the change and trust that this is the way the organisation is going to work. One factor that creates trust for SP is the broad understanding of the potentials, because all managers had a similar view of the goals. Another factor that creates trust in SP is the engagement in the development from all organisational groups. In the beginning of the implementation there were a lot of resistance to change, but the resistance later changed to engagement in the process. All groups of the production department are now involved in the process. The craftsmen engagement in handling in proposals for improvements was highlighted as one of the critical success factors.

77.5.4 The Lower Managers and Craftsmen Perceptions of the Strategy

In Table 77.1 all recommendations are presented along with the rank for each group of managers and craftsmen. The recommendations with the overall highest mean value (rank 1–3) are strive for order and neatness in the workplace, develop similar ways of working and define the factual customer requirements. The recommendations with the overall lowest mean value (rank 29–31) reward good work, minimise weather dependency by means of pre-fabricating and weather protected assembly, and plan in reflection and training. There are also differences to be found when comparing managerial levels, see the Discussion section.

77.6 Discussion and Conclusion

The aim of this paper is to identify how upper, middle and lower managers as well as craftsmen perceive implementation of operational strategies based on lean philosophies in large construction companies. The paper is based on a case study of a Swedish contractor, which mainly produces residential buildings.

Interviews with eight upper managers showed their strong commitment to the operational strategy, which was designed with a strong influence from the Toyota Production System and the lean philosophy. They further explained that focus has been to ensure high quality, through a well-known product and process. The managers enhance that strategy is a platform for continuously improvements, JM's way to secure high level of lowest quality and become less dependent on the individuals knowledge through the creation of standardised work procedures. This

Table 77.1 How managers and craftsmen perceive the companies' priorities

Recommendation	Prod. man.	Site man.	Fore-men	Crafts-men
Number of responses	18	37	72	124
(I) *Develop the organisation*				
Support the development of individual effectiveness	24	16	20	24
Encourage further training	17	10	9	23
Strive for aligned teams and project organizations	28	31	28	28
Select employees with the appropriate skills and attitudes	21	23	17	15
Consider new skills to meet new approaches	22	26	26	27
Plan in reflection and training	31	29	0	5
(II) *Manage improvements*				
Measure to control improvement work	8	19	18	17
Measure in order to uncover waste	23	22	23	21
Link all improvement initiatives to product characteristics or to the value-adding process	12	20	19	19
Collect and use best practices systematically	25	21	22	14
Set high demands that drive development	9	9	6	7
Give clear instructions, which cannot be misinterpreted	13	17	16	9
Reward good work	27	27	31	31
Strive for order and neatness in the workplace	2	1	2	1
Base management decisions on a long-term philosophy	14	13	15	22
Actively support suppliers in their development	29	28	27	29
(III) *Structure the process*				
Oversee that all project members know and understand the project goals	16	24	24	11
Define the factual customer requirements	7	12	4	2
Use all of the week's 168 h	26	25	25	20
Standardize information management tools	5	5	12	4
Minimize weather dependency by means of pre-fabricating and weather protected assembly	30	30	29	30
Establish disciplined information structures and meetings	19	3	3	8
Structure supply flows for efficient assembly	20	6	8	10
Plan accurately and follow-up continuously	15	8	10	18
Seek long-term customer-supplier relationships	6	7	7	5

(continued)

Table 77.1 (continued)

Recommendation	Prod. man.	Site man.	Fore-men	Crafts-men
(IV) *Standardise the products and the processes*				
Standardize components	3	4	5	6
Reduce the range of components	11	18	13	16
Develop technical solutions that can be used for several products	4	11	11	12
Develop similar ways of working	1	2	1	3
(V) *Create sustainable products*				
Base product definition on running costs	18	14	21	26
Prioritize sustainability in system choices	10	15	14	13

Rank for three managerial positions and craftsmen

is supported by the employees that express, through the questionnaire, which JM works with all of the 31 recommendations. However, the study concludes that the employees' perceive that JM has prioritised structuring and standardisation of the processes and the products over a development of the organisation and manage improvements.

There are three gaps identified which are of general interest.

First, lean is presented by for example Liker (2004) to mainly be a leadership issue, which involves and motivate employees to participate by continuously identifying improvements. In the case organisation, the upper managers explained the importance of good leadership, but the questionnaire shows that the employees perceive that this category is less recognised in relation to other more prioritised categories in the survey. The same experience was made by Bhasin and Burcher (2006) in UK construction.

Second, inspired by the lean approach the upper managers also argued for continuous improvements during the interviews. However, the personnel on site considered managing improvements having lower priority. As an example, they ranked the recommendations "collect and use best practices systematically" and "plan in reflection and training" very low in the questionnaire survey.

Third, sub-contractors do the majority of the work on construction sites (Frödell 2014). Of that reason, the upper managers argued for the importance to include their suppliers in fulfilling the operational strategies. However, the personnel on site consider that suppliers, so far, has had less focus. The recommendation "actively support suppliers in their development" is ranked very low.

These gaps show the challenge of implementing operational strategies initiated by corporate managers in large construction companies. It supports the idea of learning more about how strategies are developed on various managerial levels and how they are communicated within and between organisations and adapted on the operational level, i.e. on construction sites.

Even if there are obvious gaps between what the operational strategy includes and how the lower managers and craftsmen perceive it, it should be concluded that the case organisation has succeeded with their strategy from one perspective. Their vision was expressed as “being the most professional house builder, on all levels”. 2014 they received a national award for highest customer satisfaction in their business segment for the fifth year in row.

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Chapter 78
External Factors Affecting Managers' Safety Risk Perception in Construction Projects Decision Making

Pengpeng Li, Jiayuan Wang and Jiang Wu

Abstract The external environment that decision-makers are in have an effect on their perception, thinking, decision-making and behavior. Since risk perception is one of the most crucial factors in risk management, which largely depends on manager's subjective assessment, certainly will be affected by the influences from external environment. This paper aims to analyze the effect of external environmental factors on construction safety risk perceiving process from managerial perspectives. The external factors considered include safety culture, workers on-site behavior, law and regulation. Quantitative research methodology was adopted to test the theoretical model developed in this research. Data were collected via questionnaire surveys and the data collected were analyzed by using structural equation modeling (SEM) method. Except the relationship between relative laws and risk perception was not confirmed, the results support the hypothesis that construction manager's safety culture, and worker's behavior positively influences the perception of safety risks. In addition, both as methods to regulate manager's behaviors, safety culture has positive effect on laws and regulations. Furthermore, based on the one-way ANONA analysis, it is shown that risk perception will change due to individual's age, position and education, and the safety culture and laws and regulation have significant difference with different categories of working experience. This study contributes to the body of knowledge of construction project risk management by furthering the understanding of risks perceiving process. It is suggested that construction project managers develop a supportive working environment to help improve safety behavior of managers or workers.

Keywords Risks perception · Construction safety · External factors · Construction management

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78.1 Introduction

Construction remains as one of the most dangerous industries worldwide (Shin et al. 2014). Despite this industry make huge contribution in the development of whole society, the fatality and incidence rates of the construction industry are considerably higher than the all-industry average (Zou and Sunindijo 2013). For example, in China, there were 2437 people dead due to construction safety issue in 2012 and it is the first time the death was lager then that of coal industry, which has been considered as the most dangerous industry (Dawei et al. 2013). Furthermore, the ramifications of construction accidents are growing with trends toward larger-scale and more complex construction projects (Lee et al. 2011). Thus, it is imperative for the construction industry to manage its safety risks and improve its safety performance.

Heinrich et al. (1950) asserted that accidents are caused by an unsafe act (i.e., a person's behavior or activity that deviates from normal accepted safe procedure) or an unsafe condition (Heinrich et al. 1950). Based on this assertion and classification, Bird and Germain (1986) confirmed the ultimate reason of accident came from defective management in the theory of Accident-Causal-Chain (Bird and Germain 1986). Therefore, construction safety research needs to focus on managerial perspectives.

Risk management, has a broad range of applications to different industries and enterprises, as defend by the ISO31000 (2009), and it is one of the most useful ways in construction management, although there has been a large amount of researches devoted to developing methods to identify, analyze and evaluate the relative importance of risks associated with particular political, geographic, economic, environmental, regulatory and cultural factors (Chua et al. 2003; Dikmen et al. 2007), most of these analyses are heavily dependent on the risk perceptions of the top management of construction companies (Ramgopal 2003). Slovic et al. (1981) pointed that the efforts of management might go to wrong directions depending on the way she/he precept the risks. Mccomb and Smith (1991) also agreed with this statement, said the construction project would be more successful if the managers assess the risks more effectively by rational risk perception. Thus, a thorough understanding of how the risks are perceived by the management is of great importance for the construction accident prevention.

This paper made a comprehensive literature search by using "construction safety, risk perception" as the keywords, mainly focusing on the relevant journals (Construction Management and Economics, Journal of Construction Engineering and management, Safety Science, Journal of Construction Engineering and Management) from 2001 to 2014, and the result showed there were only a few papers on this topic, which mainly concentrated in the degree of safety risks perceived by people with different backgrounds, such as country, culture, positions and types of buildings. Relatively little effort has been devoted to analyzing the root cause of risk perception. But from another angle, it is because of people in different environment (different legal, social, culture, positions) that resulted in different perception of risks. However, this conjecture has not been explained until now.

Therefore, this paper aims to explore the effect of external factors on the process of safety risks perception from managerial perceptive. Specifically, this paper will:

1. Identify the key external factors influencing construction managers' safety risk perception;
2. Analyze the interaction relationships between these factors;
3. Based on the above, build the mechanism model of construction managers' safety risk perception.

It should be noted that while the above mentioned external environmental factors are important, the internal factors such as the person's knowledge, attitude, skills and experience are also important in shaping one's risk perception in decision making, but due to the space/length limits, such internal factors will be discussed in a separate paper.

78.2 Hypotheses and Model Development

A decision event generally includes three parts: the event itself, the decision-maker and the circumstances surrounded. In this paper, external factor means the circumstances, such as: culture, laws, peers or subordinates' behavior and so on. It is because of people in different environment (different legal, social, culture, positions) that resulted in different decisions and judgments. Based on literature review, this paper selected three factors as below.

Safety culture, as one of the most important external factors, which has been regard as crucial way in accident preventing (Sunindijo and Zou 2011). Mohamed (2002) indicated that safety culture have positive effect on worker's safe behavior whereas manager's behavior can also reflect the company culture. Zhou et al. (2008) based on the methodology of bayesian network, showed worker's behavior could be significantly affected by the culture. However, even though risk perception is the antecedent factors of decision behavior (Wang et al. 2014). There has little study to explore how safety culture affect risk perception based on literature review. Thus, taking existing researches into consideration, the first hypothesis is:

> H1: In the context of construction safety, safety culture will significantly affect manager's safe risk perception.

As to laws and regulations, in order to eliminate the happening of accident or injury, every government of each country have enacted relative laws and regulations which make it clear how seriousness of the violation of law. However, facing harsh punishment, there are still many construction accidents happened due to unsafe behavior or eagerness for quick success and instant benefits. Thus, there is a wonder about if the laws and regulations did affect individual's behavior? If they did, to what extent can they have effects on accident-preventing. Since risk perception is the crucial step for manager's risk-managing, the second hypothesis is:

H2: construction laws and regulations have significantly effect on manager's safe risk perception.

In theory, it seems no direct relations between worker's behavior and manager's safety risk perception, however, it can still find many unsafe behaviors among workers, such as: no helmets wearing, wires put everywhere, even though all the interviewees claimed they took safety very seriously and did plenty prevent measures for safe education. On one hand, manger's safety risk perception reflect their emphasis on safe problems, on the other hand, worker's behavior is heavily affected by those of the managers'. Thus, this paper aims to explore when manager saw the unsafe behaviors happening, would this phenomenon improve their safety risk perception or their sensitivity of safe problems, hence the third hypothesis is:

H3: construction worker's safe behavior has significant effect on manager's safety risk perception.

Another question to ask is the relationship between safety culture and law and regulations, as they are all environmental means that affecting manager's risk perception. Culture, as the soft ways, can influence individuals' mind, in contrast, laws and regulations, as the hard-and-fast rules, though everyone must obey them, there would still be someone temping to take a risk of acting oppositely, but cultural consideration may influence their views and action relation to laws and regulations. Thus, this paper proposed the fourth hypothesis:

H4: safety culture can help to promote the obedience of laws and regulations.

Fig. 78.1 demonstrates the hypothetical relationships between the external factors and risk perception.

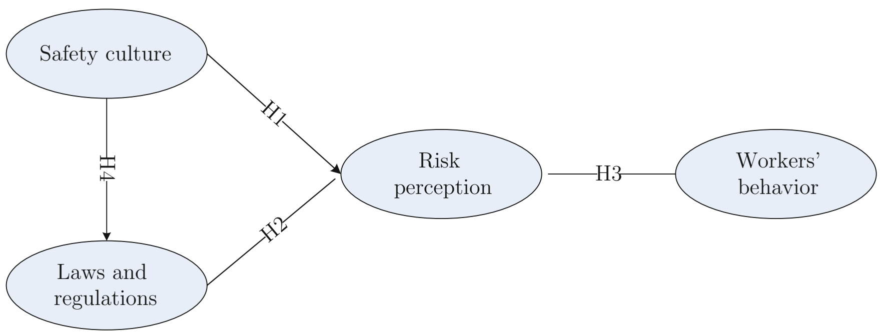

Fig. 78.1 The hypothetical safety risk perception model

78.3 Research Methodology

78.3.1 Data Collection

The survey questionnaire used to measure the variables included in the theoretical model are partly developed by the authors, and partly adapted from literature (Hunter 2006). The questionnaires are attached in Appendix.

This paper chosen eight construction sites in Shenzhen China and they are with similar scale. In order to ensure the authenticity and validity of data, the authors firstly had conversations with each top manager to make sure their willingness to take part in this research; then, distributed questionnaires to the subjects with help of top managers. A total of 300 experienced construction managerial personnel in Shenzhen, China, (from junior technical staff to the project manager, those who have direct or indirect guidance to workers) participated in the survey. Among this, 250 questionnaires were completed correctly and able to be used for analysis, including 74 project managers, 25 technical directors, 53 department managers and 98 technicians. 69 % of them were aged between 30 and 50 years and 78 % of them were experienced people in the construction industry with experience more than 5 years.

78.3.2 Data Analysis

The hypotheses were tested using structural equation modeling (SEM), a statistical methodology that takes a hypothesis-testing approach to the analysis of a structural theory which bears on some phenomenon (Byrne 2013). This SEM methods has been widely used in similar research, such as (Zou and Sunindijo 2013) and (Ji et al. 2011). Analysis of Moment Structures–version 18 (AMOS 18) was the SEM software package used in this research. Confirmatory factor analysis (CFA) was used to evaluate the measurement model and the fit of the hypothesizes posed above. Various fit indices were used to assess the fit of the model: goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI) and root mean square error of approximation (RMSEA). Values of GFI, AGFI and CFI of 0.9 or above, and an RMSEA of 0.08 or less also indicate a good fit (Hair Jr et al. 2006). Then One-way ANONA was applied to analyze the variances of external factors on personal attributes, such as: age, education, working experience, position and so on, to further explore causes of differentiation of information processing.

78.4 Results and Discussion

78.4.1 Results

While maintaining the theoretical model, some modifications were made to obtain superior goodness of fit. The best-fit model is shown in Fig. 78.2 and the final model has fit indices as listed in Table 78.1, which indicated that the proposed model fitted the data well (Table 78.2).

In Fig. 78.2, the numbers on the arrows are the path coefficients, which represent the proportion of change in dependent variable per single unit change in the predictor (independent) variable. For example, for every single unit of increase in safety culture, the level of risk perception is increased by 0.190. Except the path from laws and regulations to risk perception is no-significant ($p = 0.325 > 0.05$), for the rest four paths, their coefficients are statistically significant ($p < 0{:}001$), providing strong support for the hypothesized model, which state that (1) safety culture has significant positive influence on construction managers' safety risk perception (H1), and (2) worker's behavior can significantly affect manager's risk perception (H3), in addition, as supposed, (3) there exists mutually reinforcing effect between

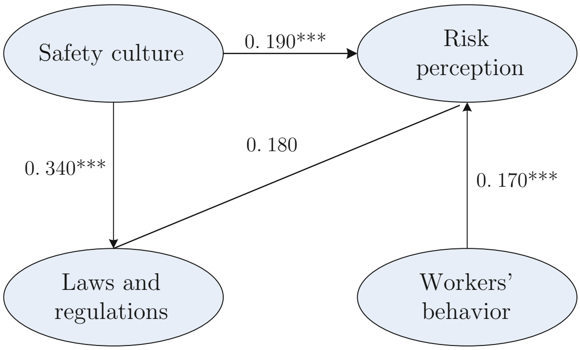

Fig. 78.2 Modified model of construction managers safety risk perception

Table 78.1 Fit index

x^2/df	RMSEA	GFI	AGFI	NFI	IFI	CFI	PGFI
1.485	0.050	0.922	0.893	0.876	0.901	0.900	0.706

Table 78.2 One-way ANONA of identified factors

Objective external	Age	Working experience	Education	Position	Salary
Risk perception	Significant	–	Significant	Significant	–
Safety culture	Significant	Significant	–	–	–
Laws and regulations	–	Significant	–	–	–
Worker behavior	–	–	–	–	–

Table 78.3 One-way ANONA of risk perception

Age factor	<30	30–40	40–50	>50	*p*	Significance test
Risk perception	4.4154	4.2234	4.1424	4.0889	0.002	Significant
Education factor	Senior high school	Junior college	Undergraduate	Postgraduate and above	*P*	Significance test
Risk perception	4.0692	4.1910	4.3740	4.3500	0.016	Significant
Position factor	Project manager	Technical directors	Department managers	Technicians	*P*	Significance test
Risk perception	4.2900	3.9100	4.2146	4.3105	0.038	Significant

safety culture and laws and regulations, which in specific, culture can promote the implementation of laws and regulations (H4).

Based on results of one-way ANONA, safety risk perception was affected by age, education and job position. Besides, culture, laws and regulations both are influenced by working experiences. Table 78.3 shows the trend of risk perception with changes of corresponding objective factors. Further exploration will be discussed in the next section.

78.5 Discussion

Interaction relationships between external factors and risk perception.

From the tested model, laws and regulations have no significant effect on manager's risk perception. This finding is beyond our expectation. Safety culture, laws and regulations, both as widely used methods to improve and regular individual's safety behavior, ought to significantly affect manager's assessment of safety risks. However, the reason why the former does and the latter does not could be explained from their purpose. Culture, as a soft method, aimed to improve people's safety awareness and emphasis on safety issues through a subtle influencing, such as, safe environment-creating, safety knowledge-educating, whose objects is individual's subject feelings. In contrast, laws and regulations, is a compulsory means to stop and punish unsafe behavior. As a result, they mainly help in affecting the actual behavior rather than people's subjective feelings. Due to risk perception is the antecedent factor of decision-making, safety culture could positively improve people's obedience of laws and regulations through the influence on risk perception.

The results show that manager's risk perception can be affected by worker's behavior. In fact, we can understand this relationship from two aspects: on one hand, the worker's behavior can remind managers who have higher safety risk awareness about the flaws in the management; on the other hand, if the managers did have lower risk awareness, the potential risks (workers' unsafe behaviors), acted as an urgent alarm, could enhance manager's emphasis on risk management.

The aim of one-way ANONA is to explore the effect of individual's personal attributes to their external factors. Based on the results, construction mangers' risk perception showed differences in different age groups, education backgrounds and positions. With the increase of age, perceived severity of risks is lower. It is supposed the older manages are better-informed compared to the younger ones, as a result, when they assess the risk, they always know how to response, thus, the risks they may not view the risk as severe as the younger people. Education, as the other significant factor showed the similar effect on risk perception. The higher the education degree construction managers have, the more severity of a risk they may perceive. In fact, there is no clear explanation on this issue, it may be explored in the future research. In addition, culture, laws and regulations are both affected by manager's working experience, it is understandable for the longer time a man worked, the deeper understanding of culture and relative regulations he/she may get.

78.6 Conclusion

This research highlights the value and influence of external factors for implementing safety risk perception. The findings of this research confirm that construction safety culture, worker's safe behaviors positively influences the perception of safety risks. In addition, both as methods to regulate manager's behaviors, safety culture has positive effect on laws and regulations. Furthermore, risk perception will change due to individual's age, position and education, and the culture and laws and regulation showed significant difference with different groups of working experience. Thus, construction management companies and its managerial personnel should pay more attention to monitor workers safe behavior and develop a positive safety culture, because it not only influence risk perception formulation but also in understanding and implementing safety law and regulations. However, this research has few limitations due to the data just collected from construction sates of Shenzhen, it needs further study to confirm its applicability in larger scale.

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Appendix—Survey Questionnaires Used in This Research

Risk perception: Assuming you are in the corresponding scenario, please score on the **severity of the security problem** caused by these risks.

Tick "$\sqrt{}$" on the corresponding figure.

Risk perception	Hazard	Explanations	Almost no effect	Not serious	General	Serious	Very serious
	Falls	When working high above the ground, the construction team invests inadequately on security and limb protection of construction site is not in place	1	2	3	4	5
	Mechanical equipment injury	Operators and equipment managers conduct the installation and demolition of tower cranes without systematic safety training	1	2	3	4	5
	Collapse	When excavation, a large number of earth is piled up next to the pit, and there is no experts argumentation before deep foundation excavation	1	2	3	4	5
	Electric shock	Distance between the outer edge of the field and electric voltage line is less than the minimum safe distance, no additional barriers, masking, pens or safety net	1	2	3	4	5
	Dormitory safety	Contractors use plates which fire-protection rating is not high for staff dormitory, for the purpose of saving costs	1	2	3	4	5

Please score on degree of the consent on the following discussion according to your company's and your own actual situation.

Tick "√" on the corresponding figure.

Indicators	Coding	Description (according to the actual circumstance of the individual)	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
Safety culture	SC01	Management often communicates with front-line workers on safety technology	1	2	3	4	5
	SC02	Company has established the perfect plans in view of the safety accident treatment	1	2	3	4	5
	SC03	Workers can get personal safety protective equipments marked in safety specification at any time (gloves, safety helmet, mask, ear plugs, etc.)	1	2	3	4	5
	SC04	Company posters very eye-catching safety propaganda wall newspaper on site (production safety standards, the accident lessons, etc.)	1	2	3	4	5
	SC05	When discovering potential safety hazard, company management would rectify quickly	1	2	3	4	5
	SC06	Company has set some rewards for workers who put forward safety recommendations or find potential safety hazard	1	2	3	4	5

(continued)

Indicators	Coding	Description (according to the actual circumstance of the individual)	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
	SC07	Company would conduct safety knowledge education for front-line workers regularly	1	2	3	4	5
Safety laws and regulations	SL01	The penalties for significant safety accident caused by illegal operations of criminal laws of our country have a great deterrent to you	1	2	3	4	5
	SL02	Standards and technical specifications related security are very perfect in Chinese construction industry	1	2	3	4	5
	SL03	Shenzhen safe and civilized construction rules have very good guidance significance for safe operation	1	2	3	4	5
	SL04	The production safety law of the people's republic of China makes great contribution to regulate the safety behavior of workers and to improve workers' safety consciousness	1	2	3	4	5
	SL05	When I see workers' unsafe behaviors, I would think of safety laws and regulations, and come up to stop them	1	2	3	4	5
	SL06	When I meet some security technology problems, there will always be a corresponding safety manual to help me solve	1	2	3	4	5
Worker's behaviors	WB01	Nor all the workers will comply with safety requirements to operate	1	2	3	4	5
	WB02	Workers would not take the initiative to inquire relevant safety and technical problems	1	2	3	4	5
	WB03	For some potential safety hazards which managers may not perceive, workers will usually not take the initiative to report to the superior	1	2	3	4	5

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Chapter 79
The International Entrepreneurial Dynamics of Pakistani Transnational Contractors

Ahsen Maqsoom and Chotchai Charoenngam

Abstract The construction industry has always played major role in the economic prosperity of any country. There has been very little variety of work regarding international entrepreneurship dynamics in the internationalization of contractors. This paper analyzes the drivers, motivations and top management characteristics of Pakistani transnational contractors with respect to the international entrepreneurship. A mixed method approach has been used to collect the data i.e. questionnaire survey and one-to-one interviews. The findings show that experienced workforce, top management decision and good contacts in overseas are the key drivers for the internationalization of Pakistani contractors. Sustaining the firm growth, effective usage of firm resources and increasing the profit margins are identified as key motivations for the internationalization. Further, the study shows that Pakistani contractors' internationalization is more influenced by three entrepreneurial characteristics of top management which include long time planning, ambition to succeed internationally and allocation of substantial resources to the international operations.

Keywords International entrepreneurship · Transnational · Contractors · Management characteristics · Pakistan

79.1 Introduction

The construction industry has always contributed generously toward the progress and economic prosperity of any nation. The developing economies have entered an era of globalization of construction, involving more companies to internationalize, as World Trade Organization (WTO) has lowered the barriers (Aulakh and Kotabe 2008). The local firms are unable to complete the major projects so they demand the help of the foreign firms and organizations for assistance (Gregori et al. 2008).

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Many studies have been conducted to examine the internationalization of construction companies by using different theoretical frameworks. However, there has been very little variety of work on international entrepreneurship dynamics that has uncovered knowledge about internationalization of construction businesses (Zahra and Gaevis 2000). Many of the contractors from Pakistan have been providing services in the foreign markets of Middle East, central Asia and Africa since long. Very few studies have routed out the international entrepreneurship dimension of contractors from the developing countries and particularly the research on the transnational firms from the Pakistani construction industry has not been probed in the literature (Maqsoom et al. 2013). Therefore in order to uncover the new insights, a study has been conducted to explore Pakistani transnational contractors in the light of international entrepreneurship. This study will identify the key drivers and motives for internationalization and it will also determine the influence of top management characteristics on the internationalization of contractors.

79.2 Literature Review

Over the past few years, scholars' interest on the influence of the entrepreneur on the internationalization of firms has gathered momentum. Instead of focusing on the internal resources (Peng 2001) or firm specific advantages (Dunning 1988) which helps the company to expand abroad, these scholars have changed their attention to entrepreneur specific drivers which spur the internationalization (Zahra et al. 2000). The internal resources concept originates from the Resource based theory by Barney (1991) and the firm-specific advantages concept coming from the Eclectic paradigm by Dunning (1988). Both models have been appreciated for being deterministic and not giving recognition to the important role played by the top management (Andersson 2000).

McDougall's (1989) study is known to be the first to explore the phrase "international entrepreneurship". His study which compared both the domestic and international new ventures opened new ways for further study in this area. Oviatt and McDougall (1994) proposed theoretical base for the study on international entrepreneurship. International entrepreneurship has importance not only for small and medium sized firms where decision making is in the hands of one or few persons who therefore have a special role in their organizations (Westhead et al. 2001), but it is also important for large firms (Zahra and Gramvis 2000).

The motives for internationalization have been studied by numerous scholars, these include to increase profitability, to explore market opportunities in host countries, to exploit asset opportunities in host countries, usage of firm resources, to sustain the firm growth and to counter the unstable business environment in the home country (Gregori et al. 2008; Abdul-Aziz and Wong 2010). Ditchtl et al. (1984), Leonidou et al. (1998) have divided managerial influences over firm internationalization into two categories: i.e. subjective characteristics (willingness to take risk, personal ambition, dynamism and flexibility) characteristics and objective characteristics (age, educational level and language). Management which takes risks is willing to place itself in an uncertain environment which results in a loss and has an optimistic view about possible consequences of its risky decision. A manager with personal ambition can take responsibility and motivate him and others. Flexible management does not strictly adhere to previous practices, traditions and mindsets in the face of new challenges. Some of the scholars pointed out that personal and business contacts and world mindedness are related to strong international objective or speed of internationalization (Zucchella et al. 2007).

79.3 Research Methodology

A mixed method approach that is self administered questionnaire survey and one-to-one semi structured interviews with consenting respondents has been used to collect the data. First method has been used to obtain quantitative data and second method was used to capture the nuance through understanding of international entrepreneurship aspects in question. By mixing both methods the limitations adopt in the respective methods are compensated by the strengths of the other.

To answer the research questions the questionnaire was designed. The questions were developed from previous studies related to the construction as well as other industries. Additional variables were included following pretesting of the questionnaire by the Chief Operating Officer of Constructors Association of Pakistan (CAP) and four executives belonging to the four different contractors. In order to make comments and observations, they went through the questionnaire in the presence of researchers. Their knowledge of the subject matter was invaluable to improve the questionnaire. Most of the questions were based on the five point Likert scale.

Construction Association of Pakistan (CAP) provided the mailing list of 126 Pakistani international contractors; also the chairman of CAP certified the research by way of a cover letter signed by him, thus providing the legitimacy to the study. The response rate in the current research was 66.7 % as total 126 questionnaires were sent to the contractors who have operated overseas and out of which 84 complete responses were returned. Moreover, telephone calls were made for the follow up on the questionnaire.

The data so collected was then analyzed using Statistical Package for Social Sciences (SPSS). With respect to internal consistency of the survey instrument, each factor's Cronbach alpha was greater than 0.7, corroborating the reliability of the items. The item-total correlation was used in order to check whether any item need to be excluded. Results showed that each item had value greater than 0.3, hence it was unnecessary to eliminate any item. Quantitative responses were extrapolated on the following scale: less than 1.49 = unimportant, 1.50–2.49 = less important, 2.50–3.49 = moderately important, 3.50–4.49 = important, 4.50–5.00 = very important. Such categorization has been used by various previous scholars including Kirby and LeBude (1998), Aziz and Wong (2010).

The next stage involved face to face interviews with the five executives who returned the questionnaires and indicated their consent. They were the representatives of the five different participating firms. Interviews were constructed on their responses in the returned questionnaires along with the information taken from the company documents and press releases. The interviews were used for the purpose of soliciting elaboration and clarification. The interviews served to highlight the data gathered from the questionnaires.

79.4 Findings and Discussions

The data in Table 79.1 below from the surveyed contractors in terms of number of employees and international experience indicates that the surveyed CCFs were having mixed profiles. Seventy six of the surveyed firms ((90 %) were private contractors whereas the rest eight firms (10 %) were publicly listed. Primarily, Pakistani construction industry is dominated by the private sector. The surveyed contractors were having specialization in multiple fields including building and civil, electrical and mechanical and petrochemical. Major portion of the firms (38 %) were having multiple specializations. Major amount of the contractors

Table 79.1 Profile of the surveyed contractors

Characteristics	Frequency	Percentage
Respondent's designation		
Top management	64	76
Middle management	20	24
Firm's legal status		
Public listed	8	10
Private limited	76	90
Specialization		
Building and civil	23	27
Electrical and Mechanical	16	19
Petrochemical	13	16
Multi specializations	32	38
Age		
≤10 years old	12	14
11–20 years old	22	26
>20 years old	50	60
International experience		
≤5 years	40	47
6–10 years	13	16
11–15 years	13	16
>15 years	18	21

Source Postal questionnaire survey

Table 79.2 Key five internationalization drivers

Variable	MIR	SD	Rank	Remarks
Experienced and capable workforce	4.57	0.590	1	V. Imp.
Top management decision	4.52	0.634	2	V. Imp.
Good contacts and networks in overseas	4.50	0.634	3	V. Imp.
Good assets and equipments	4.36	0.692	4	Imp.
Growing overseas markets	4.12	0.705	5	Imp.

Note Means <1.49 = unimportant; 1.5–2.49 = less important; 2.5–3.49 = moderately important; 3.5–4.49 = important; 4.5–5.0 = very important

(90 %) have more than 100 employees. Regarding international experience, they were having mixed nature as around 40–50 % of the firms have less than 5 years of international experience. It is to be noted here that the information provided above in Table 79.1 is until year 2012, as the survey was performed during 17 April 2012 to 11 July 2012.

The statistical results mentioned in Table 79.2 below reveal the level of importance attached to the key drivers in the process of undertaking internationalization by Pakistani contractors. The surveyed contractors ranked three factors as very important which included experienced and capable workforce (MIR = 4.57 and Standard Deviation = 0.590), top management decision (MIR = 4.52 and Standard Deviation = 0.634) and good contracts and networks in overseas (MIR = 4.50 and Standard Deviation = 0.634). The lowest standard deviation exists among the top three ranked variables, proving the least difference of opinion among the respondents.

Experienced and capable workforce is an attribute of an organization which determines its professionalism and efficiency significantly. Such workforce has experience in teamwork and problem-solving. The skilled and unskilled workforce with good experience yields higher productivity and dynamic efficiency, and consequently is very useful for the international operations.

Top management decision towards internationalization is an indication of the importance the top management attached towards the emerging opportunities in the international construction market. Having a top management team familiar with opportunities is an important competitive advantage for the firm. Though there are over 500 contractors registered with Pakistani Engineering Council (PEC), only 84 firms have been proactive and able to undertake internationalization.

Good contacts and networks in overseas are a result of relationships that are developed by the contractors in the host country. Overseas contacts and networks reflect the technical, social, formal and informal relationships (with host governments, clients and other international firms) which help in the management of the development process and are pivotal when undertaking internationalization. Good relationship with host country firms help in moderating and reducing risks in internationalization.

The fourth and fifth ranked drivers were good assets and equipment (MIR = 4.36 and Standard Deviation = 0.692) and growing overseas markets (MIR = 4.12 and

Table 79.3 Motives for internationalization

Variables	MIR	SD	Rank	Remarks
To sustain firm growth	4.67	0.526	1	V. Imp.
To make the effective use of firm resources	4.60	0.587	2	V. Imp.
To increase the profit margins	4.50	0.595	3	V. Imp.
To explore the opportunities in the foreign market	4.24	0.617	4	Imp.
To develop new market	3.86	0.926	5	Imp.
Unstable business environment in home country	3.81	0.890	6	Imp.
Liberalization of industry	3.69	0.897	7	Imp.
To increase the market share	3.43	0.914	8	Mod. Imp.
To exploit cheaper resources in foreign countries	3.40	0.885	9	Mod. Imp.

Note Means <1.49 = unimportant; 1.5–2.49 = less important; 2.5–3.49 = moderately important; 3.5–4.49 = important; 4.5–5.0 = very important

Standard Deviation = 0.705). Both of these variables were rated important and recorded the lower standard deviation which means, among the respondents, both the variables enjoyed a good consensus. Possession and maintenance of assets is an expensive affair and therefore the appropriate and effective engagement of such assets makes the overall difference to operations in international markets. The growing overseas markets are good opportunity for the firms to expand its business, especially for the firms who face barriers in terms of small domestic market and unfavorable business conditions in home country.

In this study, the second stage of analysis is related to the motives for the internationalization. Nine factors were taken from previous researches on motives (reasons) for internationalization. The results of findings are presented in Table 79.3 below.

Interestingly the internal motivations played major role in the internationalization of Pakistani contractors. Pakistani contractors considered three variables to be their most important motivations encouraging them to undertake internationalization. These included sustaining firm growth (MIR = 4.67 and SD = 0.526), to make effective use of firm resources (MIR = 4.60 and SD = 0.587) and increasing profit margins (MIR = 4.50 and SD 0.595). These top three motivations are all proactive actions to undertake the internationalization.

The expansion of the business provides a strong and sustainable financial footing to the firms in order to sustain their growth. Going overseas may reduce a firm's dependence on national and domestic markets i.e. declines in consumer demand at domestic market is compensated by upsurge in consumer demand in foreign market. Large markets have the potential for better profits, hence firms go overseas to search new business opportunities and even to expand the range of business i.e. goods and services they offer. Overseas operations are usually attractive for the firms who are seeking to lessen their budgets or overhead costs in order to raise the profit.

Pakistani contractors possess abundant amount of workforce, machinery and material due to the cheap availability of these resources in the home country and support from other industries associated with the construction industry. During the time of recession in domestic market and decline in the projects at domestic level, firms have to leave their resource idle which causes overhead costs and extra expenditure. Surveyed contractors ranked the need to increase profit margins as the third most important motive for their internationalization. Engaging in foreign development enables the opportunities for contractors to serve the construction markets that need expertise accumulated domestically.

The motivating factors that have been ranked important by the surveyed contractors include explore the opportunities in foreign markets (MIR = 4.24 and SD = 0.617), develop new market (MIR = 3.86 and SD = 0.926), unstable business environment in home country MIR = (3.81 and SD = 0.890) and liberalization of industry (MIR = 3.69 and SD = 0.897). Pakistani contractors unlike firms from other developing countries did not consider the increase in market share and exploiting cheaper resources in foreign countries as an important motivation for their internationalization, instead they ranked these three variables as moderately important variables for their internationalization.

The third stage of analysis in this study is related to the entrepreneurial behavior of the top management in undertaking the internationalization. Seven factors were taken from previous researches on entrepreneurial characteristics of the top management in internationalization. The results of findings are presented in Table 79.4 below.

Surveyed contractors considered three factors to be very important management characteristics towards internationalization. These three factors included top management uses a lot of time in planning international operations (MIR = 4.67 and Standard Deviation = 0.570), top management wants to succeed internationally (MIR = 4.62 and Standard Deviation = 0.539) and top management allocates substantial resources (MIR = 4.52 and Standard Deviation = 0.707).

Top management that uses a lot of time in planning international operations is flexible in nature. It does not strictly adhere to past customs, mindsets and practices in the face of new challenges. Top management which has high ambition to succeed

Table 79.4 Top management characteristics of the surveyed contractors

Variables	MIR	SD	Rank	Remarks
Top management uses a lot of time in planning international operations	4.67	0.570	1	V. Imp.
Top management wants to succeed internationally	4.62	0.539	2	V. Imp.
Top management allocates substantial resources	4.52	0.707	3	V. Imp.
Top management have different functional backgrounds	4.43	0.668	4	Imp.
Top management has higher education	4.38	0.661	5	Imp.
Top management has good international experience	4.21	0.813	6	Imp.
Top management considers international markets important	4.21	0.842	6	Imp.

Note Means <1.49 = unimportant; 1.5–2.49 = less important; 2.5–3.49 = moderately important; 3.5–4.49 = important; 4.5–5.0 = very important internationally is able to take responsibilities, is highly motivated and motivates other employees as well. Allocation of substantial resources to internationalization is the characteristic of innovative management who is ready to disentangle itself from existing norms, frequently adopting new management ideas, processes and products.

The fourth and fifth highest ranked factors were top management have different functional background and higher education of the management. These factors have MIR values of 4.43 and 4.38. Top management who has different functional background is dynamic in nature and acts proactively to adjust with the ever-changing situations. A top management team with a higher educational background is more open-minded, unbiased and more capable and knowledgeable in managerial responsibilities.

Two factors were jointly ranked at the sixth position by the Pakistani contractors. These factors included top management has good international experience and top management considers international markets important, both having mean value 4.21. International experience of the top management includes the previous experience with other international firms, international education experience of the members of the top management or work experience outside the home country Pakistan. Further, Pakistani contractors considered international markets to be an important growth path, which will increase their competitiveness in the future. A management team that considers international markets important allocates sufficient resources (workforce, capital and time) towards realizing those goals.

79.5 Conclusion

Previous literature has pointed out more established models of firm internationalization while ignoring the importance of entrepreneurs in the internationalization of firms. This research has gathered adequate interesting insights related to the international entrepreneurship dynamics of transnational contractors. The research found the centrality of construction entrepreneurs as the internationalization driver. The key internationalization drivers identified in this study were experience and capable workforce, top management decision and good contacts and networks in overseas. The entrepreneur's motives for internationalization were next uncovered. The primary motives included sustaining firm growth, making the effective use of firm resources and increase the profit margins. Lastly, the personal characteristics of the top management are demonstrated to have relevance to the internationalization behavior of the firm. The most important personal characteristics of the top management that enabled the internationalization of Pakistani contractors included long time in planning international operations, ambition to succeed internationally and allocation of substantial resources by the top management.

The findings of the study should be viewed in the limitation that only one developing economy i.e. Pakistan has been taken into account and also the sample represented only one service sector i.e. construction industry. As a result, the authors of the study call for future studies to be conducted which compare the international entrepreneurship behavior of firms from different sectors and markets as well.

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Chapter 80
Research on Project Cost of Overseas Power Plant—Take Acompany's X Power Plant Project for Example

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Abstract Traditional cost management starts with cost plan, goes through cost control, ends with cost accounting. As a special case in cost management, cost management in general contracting of overseas power plant project has dynamic and continuous features besides traditional cost management features. If Chinese power plants want to win in the international competition, they have to supervise the whole project process to ensure overall revenue; to minimize marginal cost by ensuring synergetic management of project schedule, safety, quality and cost control during project biding, design and procurement; to maximize project revenue through controlling project environment by laws and regulations, ethnic customs and etc.

Keywords Power plant project · Cost management · Case study

80.1 Introduction

80.1.1 Context

In recent years, developing countries have been building and expanding a number of power plants. Taking Southeast Asia market as an example, many countries including Philippines, Indonesia, Vietnam, are building a number of thermal power stations and hydropower stations. Chinese companies won bidding in several projects, therefore, Chinese companies have to strengthen project cost management to maximize revenue.

The research of general contracting cost management of overseas power plant has been an urgent topic. In order to benefit the implementation of the construction of overseas power plant, this article combines the general contracting management

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theory and practice together, aiming to improve Chinese general contracting enterprises' capability in general contracting cost management. As it is a very meaningful topic, we must have a better insight of overseas power plant general contracting cost management, implement the project in a better way and achieve more revenue.

80.1.2 Literature Review

Many scholars hold that project management is a process involving safety, schedule, quality and cost management, and it researches into how to give full play to management efficiency. Pan Kailing and Bai Liehu analyzed several major traits of management like the objective, integrality, nonlinearity, interactivity, governance, and synchronism in Managing Synergy. To maximize the function of system management and coordinated management via avoiding management bottleneck, which illustrates why synergic management of several factors is needed in general contracting management. Qiu Guolin and Gong Liming (2010) analyze the implementation process from different perspectives like schedule, quality, cost management and so on, emphasizing the roles of cost prediction, cost plan, cost accounting, cost control and cost analysis and assessment in cost management 2. Lu Qiuhong made a detailed analysis of international project development and implementation in EPC Project General contracting Enterprise Operation and Management Research, which demonstrates that project implementation process is complex and the factors are changeable, so that we need to make overall analysis from different perspectives like schedule, quality, plan and cost management. However, the effects of bidding management, design management, procurement management, cost management, risk and claim management and business management in the EPC (2011) project general contracting management need to be emphasized in undertaking the international general contracting project development and implementation.

Although the literature discussed above has analyzed and illustrated synergy management, project management, project general contracting implementation management and marginal cost benefit, overseas power plant general contracting project management is a process of systematic management, synergy management and cost benefit maximization, which deserves focused research. This article takes a company's X power plant as an example to make focused research on project general contracting cost management problems, breaking the way of cost research from cost itself, analyzing the correlative processes like bidding, design, procurement, traffic, construction and so on. Therefore, cost management becomes stereoscopic and linear.

80.2 Existing Cost Management Problems

The purpose of establishing a company is to make profit. In order to meet the legitimate rights and interests of shareholders and employees, company usually maximizes profit under the premise of without violating the business ethics, abiding by laws and regulations. However, it has been frequently reported that many Chinese overseas enterprises suffered loss when they implemented project abroad, all those things deserve our deliberation.

Judging from overseas power plant project cost management features, there are many differences between general contracting management and company cost management, project general contracting cost management has long periodicity, extensive coverage and dynamic management, therefore if general contractor wants to do a good job in cost management, he has to take the relationship of project's safety, quality, schedule and cost into full account during the project lifetime, to strengthen the management's coordination and rationality.

First, backward management methods. We all know the project cost management is a complex system which needs each subsystem, all aspects of coordination and cooperation, so the effective management of complex systems requires advanced management tools, however, the current project cost management lacks effective management tools, resulting in continued loss of project implementation. Second, cost accounting is out of control and cost information is distorted. Some projects can't know the progress of the project and cost settlement, resulting in project settlement revenue does not match cost, and project billing cycle is too long, some projects do not reflect gains and losses until the project is completed after the settlement. Third, the accounting period is out of control and cost and expenses are untrue. Cost accounting is not in strict accordance with accrual basis principle, cost accounting period is randomly changed, the project gains and losses are not reflected in time, the cost of finished projects and unfinished projects can't be reasonably divided, which are artificially adjusted for the completion costs index. Fourth, subcontract management is out of control, potential risks are serious. Enterprises fall into man-made legal dispute, affecting the normal operation of enterprises, undermining the good corporate image. Fifth, there is no in-depth understanding of the foreign environment. Timely preparation for political risks is not made, often caught by crises. In recent years, many Chinese large enterprises in Libya has been greatly affected because of its instability. Therefore, China's domestic corporate headquarters need to know more about Libyan local situation, taking into account the cost of losses due to local unrest.

80.3 Case Background

80.3.1 Basic Information of Power Plant

A company's X power plant is located in Jawa Tengah of Indonesia, coast of Indian Ocean. It is one of the first 10 million kilowatt Supercritical coal-fired power stations in Indonesia, its total scale is 600 MW a single unit, reserving for phase II, mainly including power plant project and wharf project, involving design, procurement, traffic, insurance, construction and installation. Among them, design includes power plant and maritime work, procurement includes three main engines, about 120 auxiliary engines, and about 120 materials, ocean transportation is the major traffic way.

80.3.2 Project Contracting Pattern and Capital Source

X power plant adopts EPC general contracting pattern (fixed total cost pattern), the total investment is about 4 billion yuan, of which 85 % comes from preferential buyer's credit of Chinese government loan guaranteed by the Indonesian government sovereign, and 15 % advance payment comes from client. The project contracting duration is 40 months, and it starts from the day that project general contractor received advance payment, 15 % of the client agreement total payment.

80.3.3 Project Milestone Node

X power plant general contracting project milestone nodes are in Table 80.1.

As X power plant adopts EPC general contracting pattern (fixed total price), project general contractor implements project according to EPC agreement, assuming sole responsibility for its profits or losses. This makes general contractor has more elastic power. If the cost of implementing the project is higher than agreement total price, the contractor shall bear the excess; if the cost of implementing the project is lower than agreement total price, the surplus belongs to the contractor. It is both opportunity and challenge for the general contractor to adopt such project general contracting pattern. Therefore, to formulate a scientific cost management pattern is vital for general contractor.

80.4 Project Cost Control Pattern

X power plant project adopts whole process cost management pattern to undertake project bidding and implementation, mainly including: cost management in bidding process, cost management in design, cost management in procurement and traffic, and cost management in construction. The following passages are going to illustrate X power plant's whole process cost management from the above mentioned perspectives.

Table 80.1 Project milestone nodes

Number	Name of project milestone node	Number	Name of project milestone node
1MS0010	Open letter of credit	1MS0160	Centralized control building for security check
1MS0020	Start work on pile foundation	1MS0170	Receive factory electricity
1MS0030	Start construction of east breakwater	1MS0180	Finish boiler hydrostatic testing
1MS0040	First can of concrete of power plant	1MS0190	Finish DCS charged recovery test
1MS0050	Boiler based on the zero meter	1MS0200	Produce qualified water chemistry
1MS0060	Boiler steel structure start lifting	1MS0210	Steam turbine box up
1MS0070	Main plant building zero meter	1MS0220	Coal conveying system ready for coal traffic
1MS0080	Main workshop steel structure begin lifting	1MS0230	Coal wharf project completion
1MS0090	Completion of boiler room big plate girder	1MS0240	Finish acid boiler washing
1MS0100	Start construction of west breakwater	1MS0250	Finish the boiler ignition
1MS0110	Boiler heating surface starts lifting	1MS0260	Whole set startup
1MS0120	Completion of chimney	1MS0270	Parallel unit grid
1MS0130	Wharf ready for security check	1MS0280	End 30 days reliable operation
1MS0140	Turbine bedplate is in place	1MS0290	Finish performance testing
1MS0150	Finish close of main workshop	1MS0300	Unit transfer

80.4.1 Cost Management in Bidding

In Indonesia power market, a company's bidding strategy is mainly affected by these factors: local laws and regulations, competitors and foreign exchange rate. Besides, the real project conditions, project client's condition, guarantee fee, the time and amount of agreement payment, performance guarantee fine, schedule fine, relative fine and bidding offering will have different degree of impact on it as well.

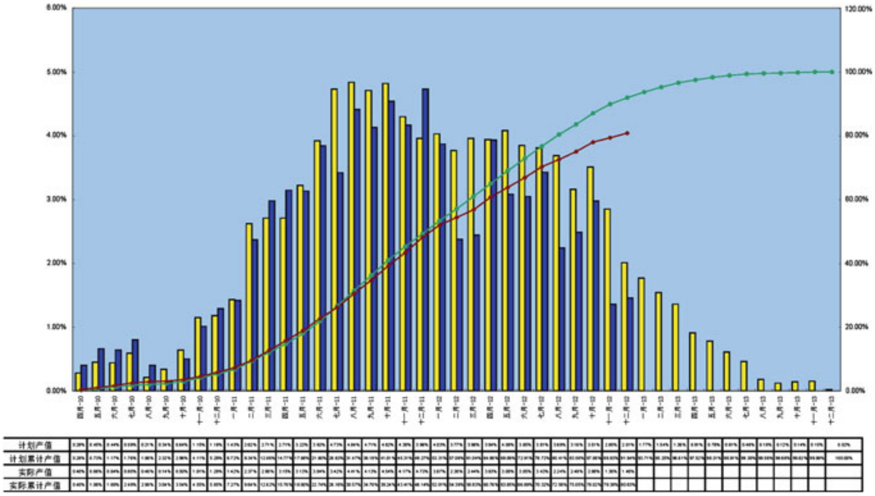

Fig. 80.1 Project overall rate of process curve

80.4.2 X Power Plant Project Cost Control Analysis

80.4.2.1 Project Overall Rate of Process

The project started from April, 2010 and ended in December 2013, lasting for three years and 9 months, the detailed schedule is shown in Fig. 80.1.

80.4.2.2 Cost Control in Design

As a project that is 85 % funded by Chinese government preferential buyer credit, X power plant project has stipulated in the agreement that the project adopts Chinese standard without violating Indonesian laws and regulations. Project design subcontractors strictly implement project initial design work according to Chinese standard. The design nodes are shown in Fig. 80.2. To complete formulating project initial design scheme through survey on domestic equipment manufacturers, and satisfy client's agreement requirement, procuring foreign equipment for key parts.

80.4.2.3 Cost Control in Procurement

X power plant general contracting project has three main engines: boiler, steam turbine and generator, it also includes procurement of over 120 auxiliary equipment and over 120 materials. Therefore, purchase quantity and purchase amount is huge. A company project department and equipment procurement department have co-

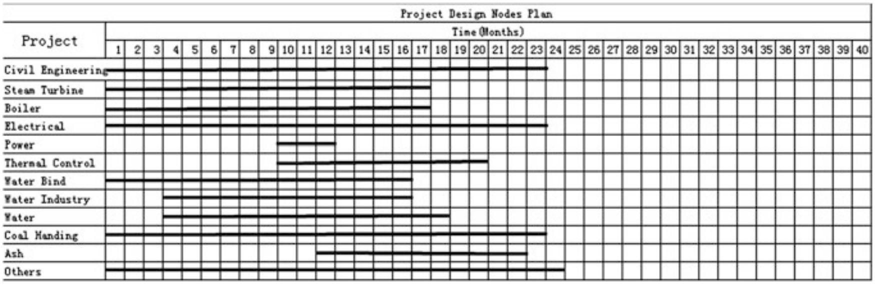

Fig. 80.2 Project design nodes plan

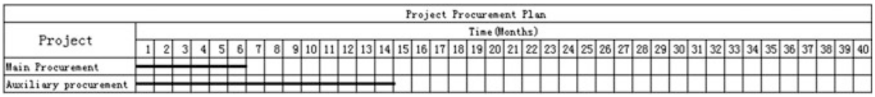

Fig. 80.3 Project procurement plan

responsibility for the procurement of main and auxiliary equipment and other materials. In the equipment procurement, we make procurement budgeting is an important assessment indicator for key equipment so as to reduce cost that may incur in future; for the general equipment, we introduce brand competition, so as to reduce the possibility of manufacturers' bidding collusion; meanwhile, we adopt payment pattern of 15 % advance payment, 75 % payment for goods, 10 % final payment, in this way, cost risk in agreement implementation has been transferred, and maximized profit for general contractor is ensured. Project procurement plan is shown in Fig. 80.3.

80.4.2.4 Traffic Process Cost Control

X power plant is located in Indonesia, project equipment and materials are mainly transported by ocean shipping, only the remaining small parts are transported by express and air. After analyzing the project schedule and calculating the transportation time, a company finally decides to set off a whole boat shipment per month, and the equipment and materials in urgent need are transported in container by liner ship. In the meantime, in order to try our best to reduce the losses caused by market unknown conditions, a company requires Chinese transport companies must cooperate with Indonesian local logistics companies to participate bidding, and for the key equipment, and for the overweight and over-height transportation, alternative transportation scheme is a must. So as to minimize traffic cost and unknown traffic cost in the transportation process. The project transportation plan is shown in Fig. 80.4.

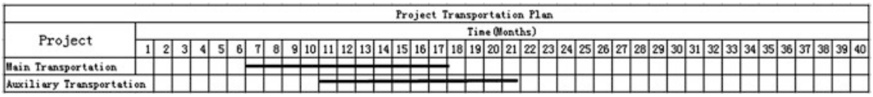

Fig. 80.4 Project transportation plan

80.4.2.5 Cost Control in Construction Process

Labor Cost Control

Labor cost in Indonesian market is lower than domestic market, a company requires sub-contractors employ Indonesian local labor in non-critical projects and non-critical procedures, so as to lower labor cost. During construction, to improve the skill level of workers and the operation management level and reasonably equip human resources according to project schedule and quality requirement, reducing ineffective labor work; to strengthen the cultivation of local labour skills, so as to achieve person-post matching.

Cost Control in Guarantee Period

EPC agreement of X power plant project stipulates that project owner will reserve 10 % project capital as project quality guarantee deposit. A company communicates with project owner that to replace 10 % agreement price with 10 % letter of guarantee of agreement price, in this way, a company can receive all the agreement price after project transfer, and improve a company overall revenue.

80.4.3 Cost Accounting

A company adopts annual assessment for X power plant project department, X power plant project adopts single project cost accounting besides annual cost accounting mode to calculate X power plant's foreign exchange amount and total profit. With a view to the current situation that X power is still under construction, therefore, cost accounting work for this stage can only be done according to company requirement and project plan.

80.5 Case Discussion

80.5.1 Cost Management Advantages

From the above cost management analysis in X power plant general contracting project, there are some valuable experience we can learn from a company in implementing X power plant project.

1. Strengthen Cost Management in Bidding Period
   X power plant general contracting project is a company's third bidding coal-fired power plant in Indonesia, it has concluded a set of cost prediction method fitting into project bidding after the first two bidding project. This method changes Chinese companies' traditional way of bidding: simply using Chinese power standard amount multiply by corresponding coefficient as the overseas project implementation standard amount. After measuring Indonesia local price level, construction sub-contractors and labor production capacity, the offer of X project is closer to X project's actual implementation estimation.
2. Procurement Work Focus on Resource Recycle
   A company changes public bidding into limited invitation bidding according to the equipment manufacturers' data bank established during the implementation of the first 2 power plant. This bidding only invites several companies with manufacture capacity. This way of bidding invitation not only meets a company's requirement but also guarantee procurement pace and cost. After comparing early stage procurement, a company's procurement finishes ahead of time by 2 months and reduces 2 % of cost, which is beneficial for the project implementation.

80.5.2 Shortcomings in Cost Management

As an overseas project, a company also meets some problems in tackling with some uncontrollable factors during the implementation of the project, which deserve our speculation and research, they are:

1. The understanding of bidding document is not thorough in the bidding stage
   During X project bidding stage, owner has stipulated in the bidding document that owner's feasibility report can't be used as general contractor's construction bases, however, in the similar projects, feasibility reports are used as agreement attachment which guides project implementation. This requires general contractor employs topographic survey team to conduct site measure again, which adds the implementation period, wasting project cost.
2. The standard is not clear in the design stage
   Although X project has stipulated that project applies to Chinese standard, but the standard must equal or higher than American standard, in the meantime, the

standard should not violate Indonesian local standard. All these has add difficulty to blueprint approval. When equipment manufacturer can't meet owner's requirement, owner will ask for standards comparison to demonstrate that Chinese standard is higher or equal American standard. As standards are so many that interpretation work will cost lots of labor and money, which increases implementation cost.

80.6 Suggestion

This article has employed project cost management theory, project synergy management theory, project marginal cost management theory and other relative project general contracting theory to make initial research on overseas power plant project general contracting. And this article takes a company's X power plant as an example for analysis, and it articulates that if Chinese company wants to win in international market in future, it must take cost management problems into full account. Therefore, this article give the following suggestion:

80.6.1 Cost Management in Bidding Stage

Project implementation cost analysis is of paramount importance in bidding stage. We can employ experts in this field to assist in cost prediction or form project cost analysis team. We can make the cost more reliable and avoid risks in implementation through actual research on target market and experience from implementing similar projects. Project's budget cost accounting can be made based on the research and experience.

80.6.2 Cost Management in Design Stage

Chinese design companies have accumulated rich experience from the development of Chinese power industry, and boast of a number of talented designers, however, thoughts may solidify. If X project could make plenty of analysis and comparison of differences between Chinese standard and International standard in its initial design and make plenty of explanation in communication with project owner, it's very likely that the blueprint approval will go smooth, reducing unnecessary cost.

80.6.3 Cost Management in Procurement Stage

Procurement work looks easy but it's actually very complex. The quality of equipment directly links to the operation condition of equipment in future, and it even will affect the whole unit's operation condition. In the meantime, equipment cost of power plant project account for nearly half of the total cost. Therefore the amount of procurement cost will have great impact on project process cost control. So that we should choose companies with good operation results and high reputation, for the key equipment and key materials we may consider the method of cost exchanges for quality, so as to avoid bigger problems in project actual implementation, which may produce greater impact on cost and schedule.

80.6.4 Cost Management in Traffic Stage

During transport of items of equipment or materials, customs clearance work is the key, the speed of customs clearance can affect the shipment batch and construction, installation time of the project, if there are problems in the transport process, be able to promptly adjust shipping batches and shipping equipment. For key equipment and other equipment that is likely to affect project duration, preparation in advance is necessary, once there is a problem in the actual operation of the transport work, to have remedial measures to ensure the smooth progress of the subsequent construction and installation work of the project, avoiding the situation that because the equipment does not appear leaving non-critical path becomes critical path, thereby extending the project duration, increasing the cost of project execution.

80.6.5 Cost Management in Construction

80.6.5.1 Strengthen Project Coordination and Management

In the course of project construction, we should control the project execution costs and make a good of quality, safety, schedule and cost, maximizing the marginal costs of the revenue.

80.6.5.2 Develop a Reasonable Construction Design

Construction design mainly includes construction methods, and construction equipment, construction plans and construction organization. The methods of construction must be economy and rationality, reduce costs with advanced technology, and construction scheme should be reasonable and economy and construction equipment acquisition and leasing costs are very high, equipment rental costs can account for about 5 % the delivery of rewarding owners if the total cost of, so developing a reasonable plan for the sets in the scene and construction equipment classes using the program could avoid increasing costs. Also, because the EPC contract will include the delivery of rewarding owners if the can be shorten, so the general contractor of the project should be make a scientific and rational construction plans, put the cost of speeding up the construction progress into the budget, generally consider the reward of the in advance of the schedule, and the costs of the material and other costs, and the target is maximizing the project benefits.

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Chapter 81
The Determinants for Safety Behaviors of Migrant Construction Workers

Jing Zhang, Jie Li and Jian Zuo

Abstract Based on the analysis of the cause of the accidents, nearly 90 % of the safety accidents are derived from the worker's unsafe behaviors. Therefore, it is imperative to improve their safety consciousness and behaviors. Through investigating the construction sites in Nanjing, Xuzhou and Taizhou, this paper makes an in-depth analysis of the determinants of security behaviors. Consequently, theoretical assumptions are made, followed by the validation via the SEM analysis. Results show that Man factors, Method factors and Management factors have significant impacts on safety behaviors of migrant workers in the construction industry.

Keywords Safety behaviors · Migrant construction workers · Determinants · SEM

81.1 Introduction

The development of the society has created significant demands for construction workers. According to the National Bureau of Statistics, the number of employees of construction industry amounted to 4267.24 million (2012). Vast majority of these employees are migrant workers. Meanwhile, there are a large number of accidents and casualties. Literature shows nearly 90 % of these accidents are derived from unsafe behaviors (Heinrich 1941).

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Lin and Huang (2003) researched and proposed the process of human beings' mental activities. First, objective knowledge is obtained by sensing organs. Afterwards, thinking, analysis and judgment are relied on to form ideas and behaviors. Xu (2003) suggested that human beings make decisions to avoid disaster based on motivation, experience and risk propensity. Cao et al. (2007) developed a model called "knowledge-ability-action" of the mining employees from the perspective of cognitive psychology. American scholar Barrie and Boyd Paulson (2000) argued that personal behavior and material are two of most critical factors for successful security management.

Although researchers have noticed that safety behaviors come for reasons, there are still little literature showing the determinants for safety behaviors had been explored, let alone the determinants of Migrant construction workers, who are the main source of construction manpower. To provide the basis of drafting intervention which aims to improve the safety awareness and behaviors of migrant workers and ensure the stable development of the construction industry, this paper identified the most influential factors for the safety behavior of migrant construction workers through the case analysis and the field study based on the safety behavior theory. SEM was adopted to validate results to verify the most fundamental determinants.

81.2 Identification of Determinants of Safety Behaviors of Migrant Workers

81.2.1 Concept and Characteristics of Safety Behaviors

Safety behavior refers to the rational reactions to dangerous external stimuli which conform to safety procedures to achieve the desired security objectives. It is connected with the standard of safety procedures, technical specifications and management system and using individual actions as the carrier which follows relevant operation mode (Ye et al. 2005).

81.2.2 The Determinants Analysis for Safety Behaviors of Migrant Workers

Based on the factor analysis framework "4M1E" (namely, Man, Material, Method, Management, Environment), this paper conducts an in-depth analysis of the typical accidents occurred in recent years (Table 81.1). As the result, sub-factors which may result in the accidents are drawn in Table 81.2.

Table 81.1 A list of typical accidents in construction projects

No.	Accidents	Time	Description	Casualties
1	The ground depression accident of Xianghu station of the Hangzhou Metro Line 1	November 15, 2008	The blind rush caused over-excavation pit, plus steel supports following up untimely, leading to the accident	21 deaths, 24 injuries, RMB49.62 million in direct losses
2	The collapse accident of Di Xi Tuo River Bridge in Fenghuang country,Hunan Province	August 13, 2007	Because of the failure to carry out the construction by work program, plus arcade effect, the bridge collapsed quickly	64 deaths, 22 injuries, RMB 39.747 million in direct losses
3	The collapse accident of Huangcheng Road-Fangzhi Road in first-stage project of the Xi'an Metro Line 1	August 2, 2009	The support of trench excavation is not timely, resulting in less support force. Then the soil wall collapsed suddenly	2 deaths
4	The template collapse accident of Fufengfamen Temple project in Baoji City, Shaanxi Province	March 13, 2008	Because of the failure to carry out the construction by work program, leading to less stability and carrying capacity. Template collapsed	4 deaths, RMB 1.5 million in direct losses
5	The lifting injuries accident in Mudanjiang City, Heilongjiang Province	September 10, 2006	When Construction workers take illegal goods lifts illegally, the rope suddenly snapped, causing the carrying cage's fall	7 deaths, 1 injury, RMB1.81 million in direct losses
6	The objects hitting accident of 10th tender of the Beijing Metro Line 10	February 27, 2006	The rope of crane in use snapped, causing bucket falling	3 deaths, 1 injury
7	The falling accident of the bridge across the Furong River in Wulong County, Chongqing Province	October 28, 2008	The workers took the hanging box to work the late shift. Because the rope suddenly snapped, the carrying cage fell to the bridge deck.	11 deaths, 12 injuries

(continued)

Table 81.1 (continued)

No.	Accidents	Time	Description	Casualties
8	The Particularly serious gas explosion accident Dong Jia Mountain Tunnel project of DuWen highway in Sichuan.	December 22, 2005	Due to landslides, gas leak abnormally. When the concentration reached the explosive limit, the gas met the spark which came from the circuits shortened, causing a huge explosion	7 deaths, 1 injury, RMB1.81 million in direct losses
9	The fire accident of teachers' apartment In Shanghai	November 15, 2010	The electric welder constructed illegally, Igniting surrounding insulation material. The fire spread through the whole building quickly	58 deaths, 70 injuries, RMB 500 million in direct losses
10	The poison accident of the combined sewage and flood mitigation project in Bayannur in Inner Mongolia	July 2, 2005	A man came to the observed well and sucked heady hydrogen sulfide and fainted. Then 4 people jumped into the well to rescue	4 deaths, RMB0.7 million in direct losses

Table 81.2 The determinants for safety behaviors of migrant workers

Man factors	1. Knowledge and skills
	2. Safety awareness
	3. Safety attitude
	4. Characters
	5. Psychological factors
	6. Physiological conditions
Material factors	1. Machinery and equipment
	2. Materials and tools
Method factors	1. Construction technology program
	2. Security measure
Management factors	1. Safety training
	2. Regulatory mechanisms
Environment factors	1. Operating environment
	2. Living environment

81.2.3 The Theoretical Assumptions of Determinants for Safety Behaviors of Migrant Workers

The analysis results in Table 81.2 shows the accidents in Table 81.1 were caused by combined factors, for example, the first case was caused by man factors, method

Table 81.3 The theoretical assumptions

H_1	Man factors have a significant impact on safety behaviors of migrant workers in construction industry
H_{1a}	Knowledge and skills have a significant impact on safety behaviors of migrant workers in construction industry
H_{1b}	Safety awareness has a significant impact on safety behaviors of migrant workers in construction industry
H_{1c}	Safety attitude has a significant impact on safety behaviors of migrant workers in construction industry
H_{1d}	Character has a significant impact on safety behaviors of migrant workers in construction industry
H_{1e}	Psychological factors have a significant impact on safety behaviors of migrant workers in construction industry
H_{1f}	Physiological conditions have a significant impact on safety behaviors of migrant workers in construction industry
H_2	Material have a significant impact on safety behaviors of migrant workers in construction industry
H_{2a}	Machinery and equipment have a significant impact on safety behaviors of migrant workers in construction industry
H_{2b}	Materials and tools have a significant impact on safety behaviors of migrant workers in construction industry
H_3	Method have a significant impact on safety behaviors of migrant workers in construction industry
H_{3a}	Construction technology program has a significant impact on safety behaviors of migrant workers in construction industry
H_{3b}	Security measures have a significant impact on safety behaviors of migrant workers in construction industry
H_4	Management have a significant impact on safety behaviors of migrant workers in construction industry
H_{4a}	Safety training has a significant impact on safety behaviors of migrant workers in construction industry
H_{4b}	Regulatory mechanisms have a significant impact on safety behaviors of migrant workers in construction industry
H_5	Environment factors have a significant impact on safety behaviors of migrant workers in construction industry
H_{5a}	Operating environment has a significant impact on safety behaviors of migrant workers in construction industry
H_{5b}	Living environment has a significant impact on safety behaviors of migrant workers in construction industry

factors, management factors and environment factors. Therefore, we assume chief factors and their sub-factors all relate to the unsafe behaviors and then contribute to the accidents.

The detailed assumptions are listed in Table 81.3.

81.3 The Validation of the Determinants Based on the SEM

81.3.1 Theoretical Framework of SEM

In this study, structural equation model is used to validate the determinants for safety behaviors of migrant construction workers. The common steps of SEM are: model specification, identification, estimation, evaluation and correction (Wu 2013).

81.3.2 The Administration of the Survey

Questionnaire survey was conducted to seek additional factors that affect safety behaviors of migrant workers in construction industry. The questionnaire was pilot tested. External and internal factors were drawn using a 5 point Likert scale. SPSS 19.0 and AMOS 17.0 were employed to analyze the data.

Through investigating the construction sites in Nanjing, Xuzhou and Taizhou, a total of 295 responses were received, of which 284 responses were valid. The sample involved 265 males and 19 females. This is appropriate according to the demographics of migrant construction workers.

The Cronbach's Alpha value of the questionnaire is 0.814. This indicates a high reliability of the survey instrument.

81.3.3 SEM Settings

Relevant theories showed that there are five evaluation indicators of safety behaviors, i.e. operate correctly, use personal protection equipment, ensure safe and reliable equipment, take safety precautions in dangerous positions, and master safe position. They are the observed variables of endogenous latent variables.

The paths of SEM are set as follows (Fig. 81.1):

81.3.4 SEM Results

According to "the rule of T", the degree of freedom of this model is calculated for $137 > 0$. It indicates this model is over identified so that estimation can be

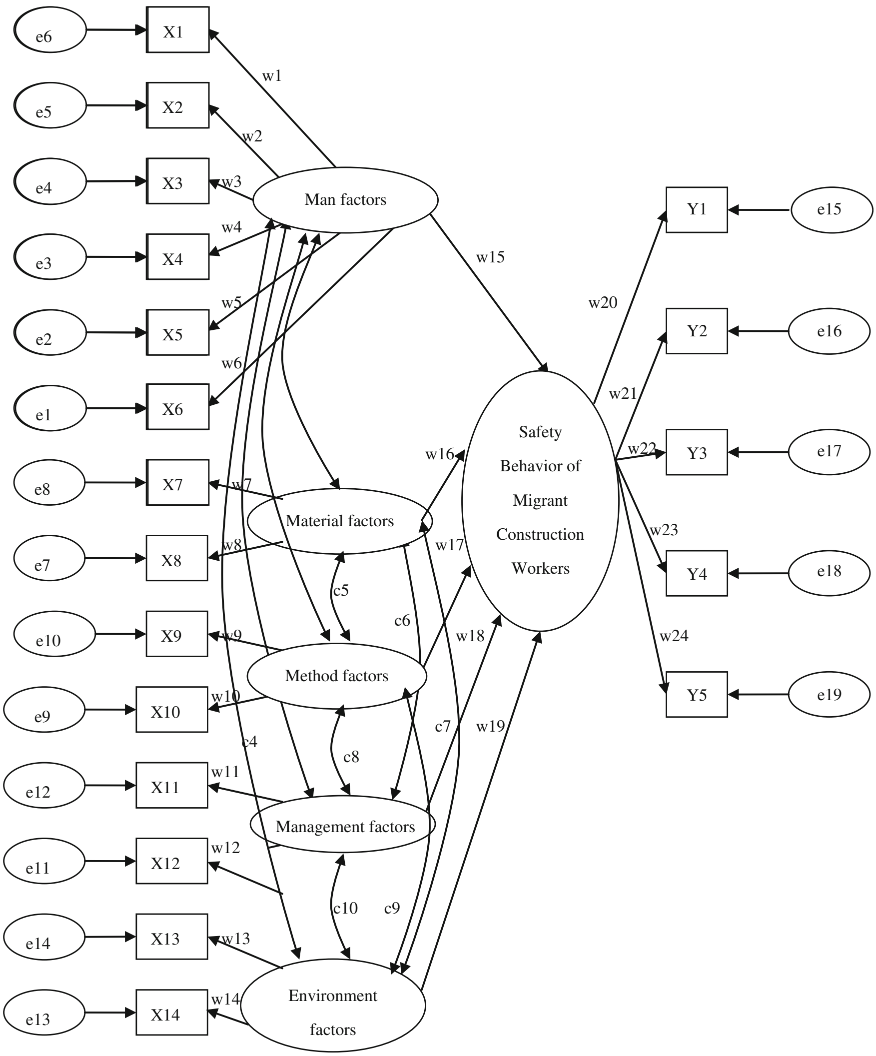

Fig. 81.1 The paths setting of SEM. Note: *e1–e19* are the errors of observed variables. w1–w24 are the path coefficients. *c1–c10* are the covariance between each exogenous latent variable. *X1–X14* are the observed variables of exogenous latent variables. *Y1–Y5* are observed variables of endogenous latent variables

undertaken. According to the survey, "Maximum likelihood estimation" was used to estimate by AMOS17.0. The outputs show that all path coefficient are significant at the 0.05 level (Fig. 81.2).

As shown in Table 81.4, the fitness of the assuming model was poor. Therefore, the model needs to be modified according to modification indices. After nine

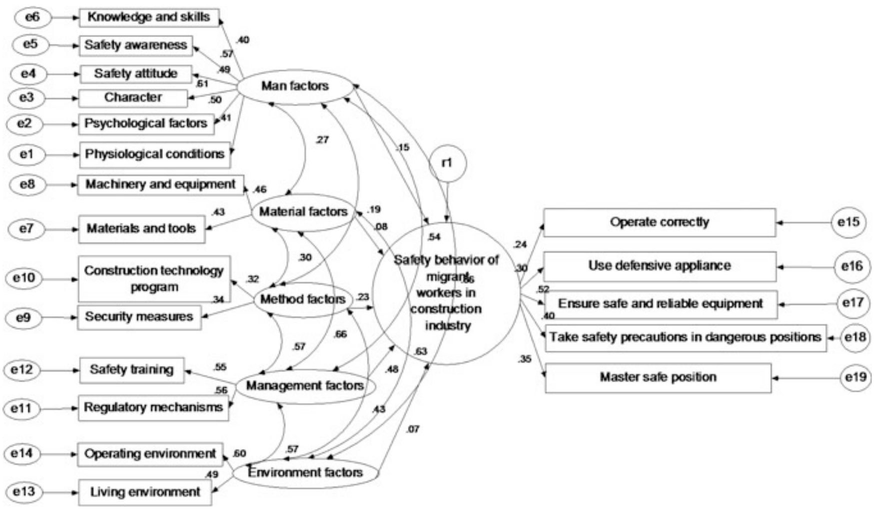

Fig. 81.2 The paths of SEM

Table 81.4 The fitness of structure of model (before modification)

Test indicators	Index value	Ideal value	Judgment
CMIN	277.805 (P < 0.001)	P >0.05 (not significant)	Yes
DF	137	/	/
CMIN/DF	2.028	>2	No
RMR	0.049	<0.05	No
RMSEA	0.106	<0.08	No
GFI	0.811	>0.90	No

iterations, the model achieves the desired fitness level. The results are shown in Fig. 81.3.

Due to the quality deviation of the sample, the revised model is very complex. However, it meets the requirement of the model assumption. Tables 81.5 and 81.6 show that path coefficients of latent variables are above 0.5 and the C.R. values are above 1.96. In addition, the significance levels of each path coefficient are all below 0.05. This indicates that the observed variables are reasonable. Similarly, contents of the questionnaire fully reflect each latent variable. As shown in Table 81.7, the fitness indicators of structure of model satisfy the requirements except PGFI. It suggests that this model is reasonable and can be used to test theoretical assumptions.

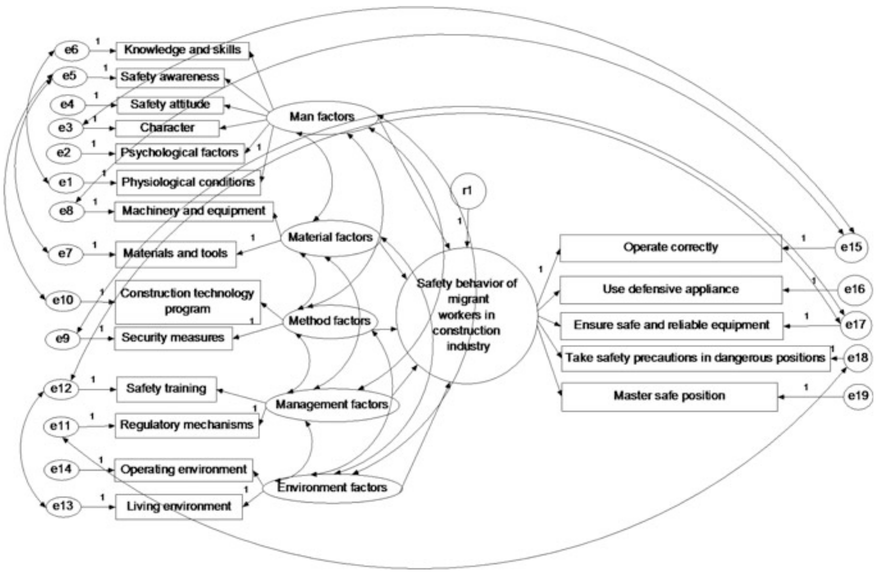

Fig. 81.3 The paths of SEM (after modification)

81.3.5 The Testing Results of Theoretical Assumptions for Safety Behaviors of Migrant Workers

The theoretical assumptions proposed in Sect. 2.3 whose standardized regression coefficient is over 0.5 can pass the test. Specific results are shown in Table 81.8.

Accordingly, the following conclusions can be drawn:

1. The Man factors have significant impacts on safety behaviors of migrant workers in construction industry. Among the Man factors, knowledge and skills, safety awareness, character and psychological factors are more significant than safety attitude and physiological conditions.
2. The material factors do not have significant impacts on safety behaviors of migrant workers in construction industry. Among the material factors, materials and tools are mostly significant.
3. The method factors have significant impacts on safety behaviors of migrant workers in construction industry. Among these factors, construction technology program and security measures are both significant.

Table 81.5 Regression coefficients

			Estimate	S.E.	C.R.	*P*	Label
Safety behaviors of migrant workers in construction industry	←	Man factors	0.291	0.099	2.939	0.004	par_14
Safety behaviors of migrant workers in construction industry	←	Material factors	0.086	0.019	4.526	***	par_15
Safety behaviors of migrant workers in construction industry	←	Method factors	0.330	0.125	2.639	0.008	par_16
Safety behaviors of migrant workers in construction industry	←	Management factors	0.201	0.090	2.229	0.026	par_17
Safety behaviors of migrant workers in construction industry	←	Environment factors	0.196	0.075	2.613	0.009	par_24
X6	←	Man factors	1.000				
X5	←	Man factors	1.211	0.240	5.037	***	par_1
X4	←	Man factors	1.400	0.265	5.280	***	par_2
X3	←	Man factors	0.928	0.191	4.861	***	par_3
X2	←	Man factors	1.625	0.319	5.089	***	par_4
X1	←	Man factors	0.946	0.180	5.254	***	par_5
X8	←	Material factors	1.000				
X7	←	Material factors	1.043	0.164	6.340	***	par_6
X10	←	Method factors	1.000				
X9	←	Method factors	0.595	0.115	5.170	***	par_7
X12	←	Management factors	1.000				

(continued)

Table 81.5 (continued)

			Estimate	S.E.	C.R.	*P*	Label
X11	←	Management factors	0.878	0.131	6.698	***	par_8
X14	←	Environment factors	1.000				
X13	←	Environment factors	1.683	0.324	5.191	***	par_9
Y1	←	Safety behaviors of migrant workers in construction industry	1.000				
Y2	←	Safety behaviors of migrant workers in construction industry	1.009	0.328	3.072	0.002	par_10
Y3	←	Safety behaviors of migrant workers in construction industry	1.915	0.544	3.521	***	par_11
Y4	←	Safety behaviors of migrant workers in construction industry	2.824	0.787	3.589	***	par_12
Y5	←	Safety behaviors of migrant workers in construction industry	1.425	0.428	3.329	***	par_13

4. The management factors have significant impacts on safety behaviors of migrant workers in construction industry. Among the management related factors, regulatory mechanisms are especially significant. However, safety training is not significant for safety behaviors of migrant construction workers.
5. The environment factors do not have significant impacts on safety behaviors of migrant workers in construction industry. Among these factors, living environment is not significant though.

Table 81.6 Standardized regression coefficients

			Estimate				Estimate
Safety behaviors of migrant workers in construction industry	←	Man factors	0.565	Y1	←	Safety behaviors of migrant workers in construction industry	0.209
Safety behaviors of migrant workers in construction industry	←	Material factors	0.485	Y2	←	Safety behaviors of migrant workers in construction industry	0.267
Safety behaviors of migrant workers in construction industry	←	Method factors	0.561	Y3	←	Safety behaviors of migrant workers in construction industry	0.449
Safety behaviors of migrant workers in construction industry	←	Management factors	0.541	Y4	←	Safety behaviors of migrant workers in construction industry	0.525
Safety behaviors of migrant workers in construction industry	←	Environment factors	0.381	Y5	←	Safety behaviors of migrant workers in construction industry	0.334
X6	←	Man factors	0.365	X7	←	Material factors	0.452
X5	←	Man factors	0.555	X10	←	Method factors	0.527
X4	←	Man factors	0.594	X9	←	Method factors	0.545
X3	←	Man factors	0.411	X12	←	Management factors	0.619
X2	←	Man factors	0.665	X11	←	Management factors	0.458
X1	←	Man factors	0.566	X14	←	Environment factors	0.456
X8	←	Material factors	0.582	X13	←	Environment factors	0.672

Table 81.7 The fitness of structure of model (after modification)

Test indicators	Index value	Ideal value	Judgment
CMIN	117.039 (P = 0.199)	P > 0.05 (not significant)	Yes
DF	128	/	/
CMIN/DF	0.914	<2	No
RMR	0.026	<0.05	Yes
RMSEA	0.020	<0.08	Yes
GFI	0.959	>0.90	Yes
AGFI	0.927	>0.90	Yes
PGFI	0.530	<0.50	No
NFI	0.909	>0.90	Yes
CFI	0.989	>0.90	Yes
PNFI	0.558	>0.50	Yes

Table 81.8 The testing results of theoretical assumptions

Assumptions	Relationships among variables	Standardized regression coefficients	Results
H1	Safety behaviors of migrant workers in construction industry ← man factors	0.565	Passing
H1a	Man factors ← knowledge and skills	0.566	Passing
H1b	Man factors ← safety awareness	0.665	Passing
H1c	Man factors ← safety attitude	0.411	Not passing
H1d	Man factors ← character	0.594	Passing
H1e	Man factors ← psychological factors	0.555	Passing
H1f	Man factors ← physiological conditions	0.365	Not passing
H2	Safety behaviors of migrant workers in construction industry ← material factors	0.485	Not passing
H2a	Material factors ← machinery and equipment	0.452	Not passing
H2b	Material factors ← materials and tools	0.582	Passing
H3	Safety behaviors of migrant workers in construction industry ← method factors	0.561	Passing
H3a	Method factors ← construction technology program	0.545	Passing
H3b	Method factors ← security measures	0.527	Passing
H4	Safety behaviors of migrant workers in construction industry ← management factors	0.541	Passing
H4a	Management factors ← safety training	0.458	Not passing
H4b	Management factors ← regulatory mechanisms	0.619	Passing

(continued)

Table 81.8 (continued)

Assumptions	Relationships among variables	Standardized regression coefficients	Results
H5	Safety behaviors of migrant workers in construction industry ← environment factors	0.381	Not passing
H5a	Environment factors ← operating environment	0.672	Passing
H5b	Environment factors ← living environment	0.456	Not passing

81.4 Conclusions

This paper employed the "4M1E" method to conduct in-depth analysis of the typical accidents and concludes five critical factors that are Man factors, material factors, method factors, management factors, environment factors and their sub-main factors. SEM method was adopted to identify the most significant factors for the safety behaviors of migrant construction workers. Results showed that the Man factors, the method factors and the management factors have significant impacts on safety behaviors of migrant workers in the construction industry. By contrast, the material and the environment related factors are found no significant for forming the safety behaviors of construction workers. However, the impact of factors which fail to pass the test of theoretical assumptions should not be overlooked as the significance is relative. With the improvement of management performance, their influence will gradually grow.

Meanwhile, according to the analysis of accidents and field investigation, the Man factors are the most significant. For example, the collapse accidents of Hangzhou Metro Line 1 and the Di Xi Tuo River Bridge in Hunan are mainly due to Man related factors. The migrant workers rushed the construction activities ignoring the work plan. The construction managers ignored the security risks. The accidents in Mudanjiang and t teachers' apartment in Shanghai are due to lack of safety consciousness and the lack of knowledge of safety risks. Therefore, the construction companies should pay more attention to Man factors, methods factors and management factors; and have a better understanding of the relationship among the need, motivation and behaviors. Similarly, incentive mechanism should be improved by putting more efforts to enhance security behaviors via accident prevention.

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Part X
Redevelopment in Disaster Areas

Chapter 82
The Reconstruction of Victims' Psychological Space and Life Inertia of Urban Residents in Beichuan County and Dujiangyan City After Wenchuan Earthquake—From the Perspective of Bridging Culture Lag

Lin Wang, Hui Xu and Lifang Huang

Abstract In recent years, some major unpredictable natural disasters frequently occurred in China, such as Wenchuan Earthquake. The process of post-disaster redevelopment is not only the necessary step of emergency response but also the national political responsibility. The redevelopment of Wenchuan Earthquake is "three years of redevelopment and basically completed in two years", which is very successful from the political and city construction angle. However, the success of post-disaster redevelopment of Wenchuan Earthquake in certain degree includes the phenomenon of "culture lag". The paper studies the reconstruction of victims' psychological space and life inertia during the post-disaster redevelopment. The two reconstruction processes are the bridging of the culture lag process. The argument support is from authors' field investigation in New Beichuan County and Dujiangyan city. Through the analysis of the reconstruction processes of victims' psychological space and life inertia, the paper aims to do some exploration of seeking for some methods to shorten the process of bridging the culture lag during the speeding post-disaster redevelopment.

Keywords Wenchuan earthquake · Psychological space · Life inertia · Reconstruction · Urban residents

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82.1 Introduction

On May 12, 2008 2:28 p.m., the Wenchuan Earthquake of 8.0 magnitude struck China,which caused great casualties and economic losses to China. There are 10 extremely severe disaster areas, the affection especially severe in Wenchuan County, Beichuan County, Mianzhu City, Shifang City, Qingchuan County, Dujiangyan city. Wenchuan Earthquake is a natural disaster that caused the most serious losses in China since the founding of the country.

After Wenchuan Earthquake, the redevelopment of the disaster areas gathered the attention of whole society. On September 19, 2008, the State Council issued "Wenchuan Earthquake Reconstruction Overall Planning", the redevelopment task was planned to use 3 years. Until September 2010, the aim "three years of redevelopment and basically completed in two years" was achieved. Until April 2011, 95 % of 41130 national redevelopment projects have been completed, the total investment reached to 885.1 billion. The quick speed and large scale of the redevelopment of Wenchuan Earthquake is unprecedented. The counterpart aid mode has been effectively explored and obtained great success during the redevelopment of Wenchuan Earthquake.

The redevelopment of Wenchuan Earthquake is not simple city landscape restoration, but the important step to promote the modernization level of western China. Beichuan County is one of the extremely severe disaster areas of Wenchuan Earthquake, and it is the only relocated county. Shandong province aided Beichuan County, the total investment was more than 10 billion, and the number of aided projects reached to 368. The redevelopment of the buildings entities of New Beichuan County is very successful from the speed, quality, planning, appearance and other aspects. The appearance and the layout of the city even surpass some central and eastern cities of the same level. However, the process of redevelopment is also the process of city change. During the process, the culture development must be considered besides the construction of material entities. The ultimate goal of city development is to satisfy people's living requirements. So the evaluation of city development is successful or not should from the perspective of "person", which is social influence evaluation. Through the field investigation of New Beichuan County, several problems can be found behind the rapid reconstruction of the building entities.

The residents of New Beichuan County include the original old Beichuan residents and the original Huangtu town residents. Living in the redeveloped New Beichuan County, the original old Beichuan residents faced dual changes, which are residential location and residential environment. For the original Huangtu town residents also faced changes of the residential environment from macro and micro level. So they all faced the dual challenges of reconstruction of psychological space and life inertia. Not only in New Beichuan County, the phenomenon also existed in many other redeveloped cities after Wenchuan Earthquake, such as Dujiangyan city. For the city redevelopment, the rapid reconstruction of building entities showed lack of inconsistency with the cultural adaptability, which can be translated by the theory of "culture lag" proposed by William Ogburn. According to the theory of "culture lag" and information obtained from field investigation in new Beichuan and Dujiangyan, the paper studies on the reconstruction processes of victims' psychological space and life inertia during the post-disaster redevelopment. The two reconstruction processes are also the bridging of the culture lag process.

82.2 Theoretical Overview

Chinese government proposed the "counterpart aid mode" in the post Wenchuan Earthquake redevelopment. 19 provinces aided 18 extremely severe disaster areas of Sichuan Province and extremely severe disaster areas of Shanxi-Gansu area. The total number of counterpart aid projects is 3645. The counterpart aid mode ensured the efficient completion of Wenchuan Earthquake redevelopment. The efficient completion of redevelopment illustrates the success of building entities construction. However, the process of post-disaster redevelopment is a huge process of social change. The rapid speed of building construction can't ensure the culture developed with the same step. The paper analyzes this phenomenon base on the theory of "culture lag".

In 1923, the American sociologist William Fielding Ogburn published the book "Social Change" and proposed the theory of "culture lag". Due to the inconsistency of social change speed, the change speed of different parts of the society is inconsistent, which is the phenomenon of "culture lag". The "culture lag" theory explains the culture adjustment processes of social change in different phases, which opens a new perspective of studying on the social change from sociology. Ogburn pointed out that culture includes material culture and spiritual culture. Material culture refers to the material entities used in the production, such as housing, factories, etc. Spiritual culture is also called adaptation culture, which includes the social consciousness, customs etc. The changing speed of material culture is always faster than spiritual culture, the distance between them is the culture lag. Influenced by the classical theory of productivity and production relations of Marx, the philosophical basis of cultural lag can be described as follows, material culture determines the spiritual culture, material culture changes before spiritual culture and in faster speed, the inconsistency caused cultural lag. Post-disaster reconstruction is a process that modernize city in a short period of time, which causes many phenomena of culture lag in New Beichuan County and many other disaster areas.

The performance of culture lag is that victims lacking of adaptation to the great-leap-forward development of the living environment. For example, the redevelopment of New Beichuan provides a new and modern living environment for the residents. However, residents adapt to the new living environment need time, which includes processes of psychological space and life inertia reconstruction.

The mentioned "psychological space" quotes the concept "psychological space" in cognitive linguistics. American linguists Fauconnier in the first place put forward the psychological space theory in his book "Mental Space" in 1985 and defined it as "the concept package built to achieve the purposes of partial understanding and action when people in thinking and talking". In addition, psychological space theory can be also defined as "A. temporary cognitive expression of the state of things based on language input; B. the background of the people who try to understand language". The psychological space theory is a very important part in cognitive linguistics. This paper defines "psychological space" as "Situational structure formed by social network and living environment map on the social subjects' mentality" as well as "the temporary cognitive expression of the situational structure based on social subjects' relationship in certain living environment." The above two definitions are the further application of the psychological space "information container" nature in sociology.

The concept of "life inertia" quotes the "inertia principle" in physics. The "inertia principle" has been proposed by Galileo, which has been published in the book "Dialogue about Ptolemy and Copernicus Two world System" in 1632. The inertia principle generally accepted by the modern society is from Newton's "Mathematical Principles of Natural Philosophy" in 1678, which defined the principle of inertia as "all objects will remain motionless or in uniform linear motion until some external force exerting on it to change the situation." The paper quotes the "principle of inertia" and put forward "life inertia". The definition of "life inertia" is "people's consistent living habits in their familiar living environment".

82.3 The "Cultural Lag" Phenomena in Post-disaster Redeveloped Cities of Wenchuan Earthquake

Due to certain historical reasons and restriction from natural conditions, the development of the western China is slow, so the degree of modernization falls behind many east-central cities. The western regions experienced a long process of natural development and formed a relatively stable living space and social consciousness. However, all of these were broken by Wenchuan Earthquake. Also because of the earthquake, the modernization development has been promoted in a large degree. Three years of redevelopment made the disaster areas achieved great-leap-forward modernization development.

During the process of redevelopment, the modern city development mode has been used. A lot of new modern cities have been built in the disaster areas. This is the great performance of government responsibilities in the face of sudden catastrophe. In this condition, victims tend to have higher and more urgent requirement for government than usual. The normal production, life and social order require be established rapidly. However, when the building entities' reconstruction obtained great success, local culture and social consciousness have not changed with the building speed. The pre-disaster culture outline still existed. This is the phenomenon of "culture lag", which includes three aspects.

Firstly, mismatch between evolution of city function and residents' values. Several relevant cases have been found in New Beichuan County through the authors' field investigation. In 2010, the investigation in the New Beichuan Mu Xi community showed that almost no one used the community planed public space. Most residents organized activities in the self-building space. The phenomenon reflected that there is gap between community function planning and residents' original values. Another case is about the residents' trip mode. Through observation, it can be found that residents' usual transportation means include cars, bicycles, electric cars, buses, and some people rent the electro-tricycle. However, the public bicycle service which located in the street only used by few people. For the public bicycles almost can't be seen on the street and the bicycles on the service was full. This phenomenon also reflected that residents had not accepted many new city functions, which indicated that mismatch between evolution of city function and residents' values.

Secondly, discordance exists between residents' original life inertia and modern city operation mode. The investigation in Dujiangyan One Block showed that there was some announcement issued by the One Block Project Office to inform the One Block owners. The announcement was about owners planting vegetables in public green space. The One Block Project Office announced this behavior is prohibitive. And there was another announcement issued by One Block Property Management Office, which was about piling up debris in community public corridor, fire access, emergency exit, etc. Also, this kind of behavior is prohibitive. These two announcements reflected that residents still maintain some original life inertia. The redevelopment cities have been modernized in a large degree and city operation is more precise. So, discordance exists between residents' original life inertia and modern city operation mode.

Thirdly, discordance exists between residents' original life orbits and city industry new development. The residents in New Beichuan County include original old Beichuan residents and the original Huangtu town residents, among which there were lots of landless farmers and unemployed. Thus, the government should not only consider the residents' housing problems, but also employment problems. The Shandong Province counterpart aided Beichuan County and built the Shandong Industrial Park. The aim of building the Shandong Industrial Park is to solve the employment problems and promote the economy development of New Beichuan County. However, the Shandong Industrial Park has not showed vigorous development as the original planning. In June 2013, for days the authors stood around the park and do some investigation from 8 o'clock. It can be found that just a few people went to the park to work. In some factories, there were just the gatekeepers in it. Then the authors communicated with many residents, the following are two cases.

Case 1 (the sanitation worker): (There seems not so many people go to the park to work?) Yes, haven't you seen some factories not in operation! (Were there many people come to work before?) Yes, when the park opened, a lot of people came to work, but some factories didn't operate well and many people felt unaccustomed. (Why they felt unaccustomed?) Many people were farmers lived on farm and let them work in the factory, they didn't willing to. For some young people, they felt work in this park can only make little money, so many of them go out to other cities to work.

Case 2 (the factory worker): (Do you go to the park to work?) Yes. (There are not so many people work in the park?) There were a lot of people work in the park last year and this year the number decrease. (Do you accustom to work here?) At first I didn't accustom to work here, but I think now I live in such good house and I will accustom to all of this step by step.

The Shandong Industrial Park hasn't developed completely as the original planning. On the one side, this is due to the development of the industry earnings. On the other side, the residents need more time to bridge the lag between residents' original life orbits and city industry new development.

82.4 "Cultural Lag" Bridging I: Victims' Psychological Space Reconstruction

Because of the cultural lag phenomenon, the reconstruction of psychological space is also the process of bridging the cultural lag and the process of reconstruction of victims' psychological adaptability for the new lifestyle. The study on victims' psychological space reconstruction may from two perspectives, one is people and the other is objects.

82.4.1 People: Victims' Psychological Space Reconstruction on Social Networks

The connections among people constitute people's social networks. To make sure the structure of social network, suppose the social network is regular network, random network and small world network separately. After the demonstration, the small world network is consistent with real life. Thus, this paper will study people's social network based on small world network. And citing the view of "pattern of difference sequence" proposed by Mr. Fei Xiaotong in his book "Rural China" to construct people's social networks. Mr. Fei Xiaotong considered that the social relations among Chinese people are just like "circles of ripples when putting a stone in the water." And "Everyone is the center of his or her ripples. The relationship is among the ripples, the farther the ripple, the weaker the relationship."

Based on the small world theory and the view of "pattern of difference sequence", the paper will construct people's social networks. Suppose the core subject is M, the subjects in his or her social relationship network include the inner contacts such as close colleagues, classmates, relatives, and the expanding contacts such as the close contacts' colleagues, classmates, relatives, and the social contacts such as government, enterprises, NGOs, etc. The above social network of M maps

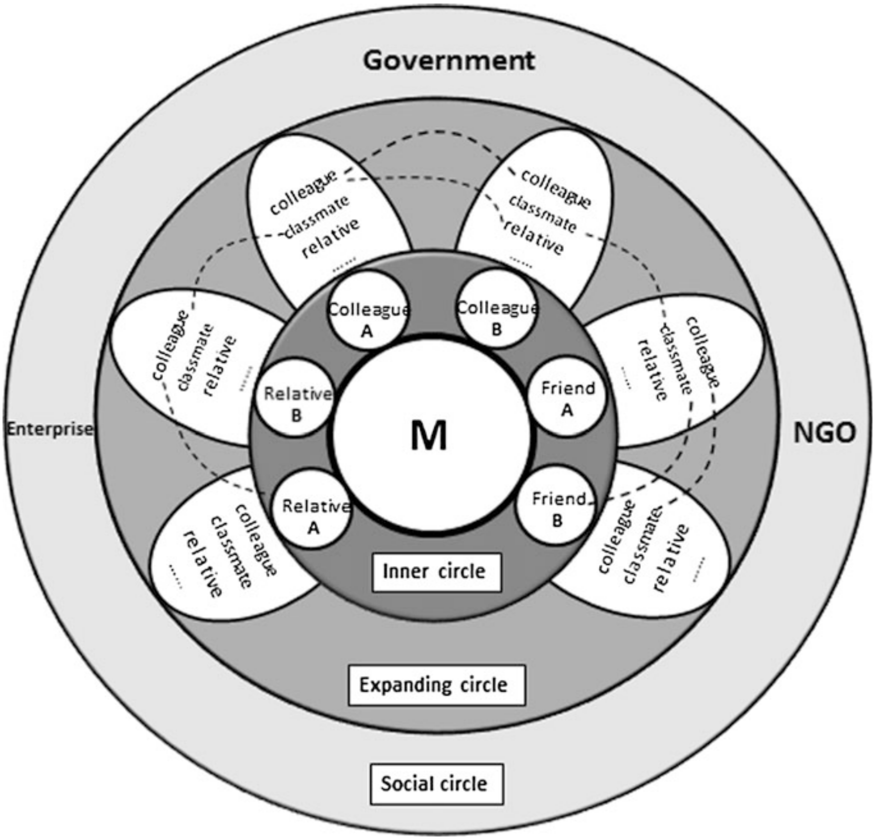

Fig. 82.1 Psychological space circles of social relationship subjects

on his or her mentality is the three circles of psychological space, which are inner circle, expanding circle, and social circle, as shown in Fig. 82.1. The inner circle constitutes the main body of the support structure of psychological space, which plays a very important role in supporting psychological space. The inner circle contains usually 6–10 people. The expanding circle contains usually 30–50 people, in which the connection is that in small world relationship networks some subjects connecting to other subjects with a certain probability—friends' friends know each other. This kind of connection will shorten feature path length in a large degree, in other words, the relationship between the subjects is relatively closer. At the same time, with the increased connection among subjects, the polymerization coefficient of some subjects in the network will also increase, which will show up as the high degree of aggregation and closeness of subjects.

In this paper, "psychological space" specifically shows as three relationship circles. The occurrence of Wenchuan Earthquake has torn victims' original psychological space circles. With the continuous change of residence places, the people around the victims also change a lot, which lead to the every circle of the psychological spaces go through repeated tearing and reconstruction. Until victims live in the permanent housing, the around people gradually immobilization and the social network will be formed. The relationship circles map on the mentality be reconstructed and the social support be strengthened, too.

Inner circle: The core subject M moves to the permanent housing. Most of the inner circle subjects are relatives and old friends. With the living gradually stabilized, M contacts more with neighbors and make new friends. So the inner circle will change, such as new friends or neighbors enter into the inner circle and some old friends out.

Expanding circle: The expanding circle is very weak when victims move to the permanent housing. In the new living environment, the social networks subjects are mainly inner circle subjects, the expanding circle should be reconstructed. After long time of living, the inner circle subjects change and every subject's social network extend gradually. Thus the subjects of expanding circle will become more and more.

Social circle: The government will change after post-disaster redevelopment, but it will not have much influence on the victims' life. The working environment will change with enterprises reconstructed. It needs a long time for the victims' psychology to bridge the lag generated from the adaption to the new working environment. Regarding to NGOs, after victims move to the permanent housing, NGOs will leave the disaster areas, which will tear the victims' psychological space in some degree. But with life gradually stabilized, such effects will be eliminated.

Social networks are the background of social support and social support is the function of social networks. As the network gradually stabilized, people get more social support, which is an important step for the psychological space reconstruction.

82.4.2 Objects: Victims' Psychological Space Reconstruction on Living Environment

In the new living environment, there are lots of new objects for the residents. They need time to familiar with them and then construct the psychological space. The paper analysis this process from static city function and dynamic city operation two aspects.

82.4.3 City Function

From the macro level, city function refers to the country's role in the economic, political and cultural life. For a certain city, city function includes many details of the three aspects. The post-disaster redevelopment cities have been constructed in short term and the cities go through great-leap-forward development. The original city function has been changed and new city function has been established, so the situational structure formed by these two aspects map on the mentality of the social subjects should be reconstructed. City function can really be applied only when residents accept them from the heart first.

The process of psychological space reconstruction for the city function can be divided into three steps, which are cognition, personal perception and shaping mental image.

There is big difference between post-disaster reconstructed cities and victims' original living environment. A very important performance of the big difference is city appearance. Victims' should first know the change of city appearance intuitively. After repeated observation, victims get used to the new city appearance. Such as for the construction of New Beichuan Library, to let large numbers of residents to use it in daily life, the first step is that residents should construct the psychological adaptability for the appearance of the library. This is the first step of psychological space reconstruction for the city function.

After the residents get used to the new appearance of the city, they need personal perception. Personal perception is sublimation of appearance cognition. Through touch, use, experience, the accustomed building appearance will be internalized by residents. This is the process for residents from the intuitive understanding to the senses and it is also the process to internalize the external things. Personal perception is an important step of psychological space reconstruction for the city function.

Through internalize the external things, the change of city function have clear definition and cognition on residents' psychological space, which will lead to the step of shaping mental image. These three steps are the process that residents accept the changes of city function and reconstruct their psychological space. For example, Banaqia Business Street is the business street in New Beichuan County. From the old business mode to Banaqia, residents should go through above three steps to know, to experience and then accept it in psychological space.

82.4.4 City Operation Mode

When the former New Orleans mayor Mark. Morel talking about the post-disaster redevelopment of New Orleans after Hurricane Katrina, he pointed out that "the redevelopment is not only the reconstruction of a New Orleans city and the Gulf Coast, but about the reconstruction of a culture and a human life system". Redevelopment is not simple reconstruction, but "Through the long-term planning and construction, the economy of disaster areas can operate in healthy condition and the overall society can be benefit from the redevelopment". This is also the aim of city operation. The key of normal operation of the post-disaster redeveloped city is the participation of people.

The process of victims' psychological space reconstruction for city operation includes four aspects, which are political, economic, social services and culture.

The four aspects connect with each other and are closely related with the life of city residents. The government management mode and decision-making action affects these four aspects, especially the economic development. The economic development includes industrial recovery and commercial recovery. The residents joint these two aspects of recovery directly. The operation of factories and the rent of the commercial apartment have been the part of residents' life. Thus, the "information container" nature of residents' psychological space is manifested for it contains the process of industrial recovery and commercial recovery, which is also the economic development mapping on the residents' mentality.

The social service and cultural construction are directly related to the lives of victims. Due to the urbanization process of the post-disaster redeveloped cities reaches to a very high level, the social service and culture development are comparatively perfect. For example, in Dujiangyan One Block, there was an announcement about the establishment of community unified messaging platform. The similar kinds of increased social service function are new to many residents. The implement of the new social service function requires residents' acceptation. The residents' inner acceptation is influenced by the level of culture development. The culture development is a guide to values, which lead residents integrate positive life experience, set up life consciousness in the new environment and participate in public services. The process of recognition and participation is also the process of residents' psychological space reconstruction.

The people reconstruction and the objects reconstruction interact with each other. The expanding social network promotes the subject to know more about living environment. In return, familiar with the living environment will also expand the subject's social network.

82.5 "Cultural Lag" Bridging II: Victims' Life Inertia Reconstruction

As mentioned,the definition of "life inertia" is "people's consistent living habits in their familiar living environment". The reconstruction of life inertia is the external performance of psychological space. Combining the virtual world (psychological space) and the real world (real life), the two reconstruction processes together constitute the cultural lag bilateral bridging process.

The life inertia consists of environment reconstruction and self-reconstruction. The environment reconstruction includes living environment and working environment reconstruction. The self-reconstruction includes the self-adaptive reconstruction for life and work.

The environment reconstruction is the external performance of the psychological space reconstruction for the city function, which constitute the cultural lag bilateral bridging process from the virtual and real world. After cognition, personal perception and shaping mental image three steps of psychological space reconstruction for city function, the residents complete the process of internalize the city new appearance and reconstruct the psychological space. The external performance of this process is the familiarity with the city environment and the formation of habits. The living environment includes community environment, medical environment, shopping environment, education environment, the public service etc. The working environment includes the external environment of working place and specific working environment. For the living and working environment, after the psychological space reconstruction process, the next phase is repeated familiarity process. In the redeveloped living and working environment, the repeated familiarity process created new habits of life and ultimately the environment reconstruction is completed.

The residents' self-reconstruction is the external performance of the psychological space reconstruction for city operation, which constitute the cultural lag bilateral bridging process from the virtual and real world. The residents joint in the industrial recovery and commercial recovery, which lead to the inner recognition for their own work. The external performance of the completion of the psychological space is the residents' self-reconstruction for their work. From the macro level, it is the economic development course. Through the process from recognize to familiar with the work, the colleague and the place, the working life inertia be reconstructed. For the residents, when they familiar with the external environment, the culture development changes their acceptation consciousness for the new life. The residents will experience more public social service, more and more social elements will enter into their

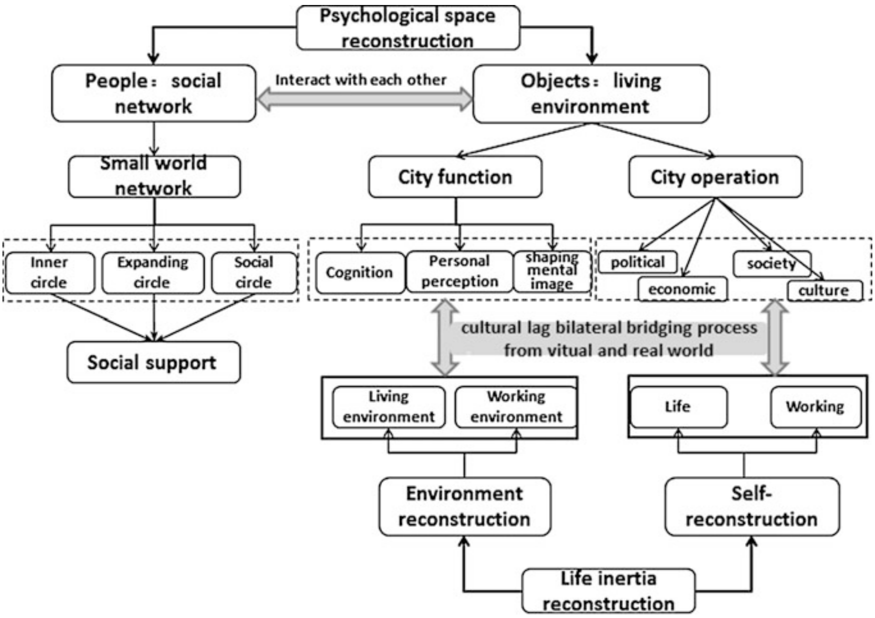

Fig. 82.2 Cultural lag bilateral bridging process from virtual and real world

lives. Thus, under the existing living environment frame, to recognize and be familiar and then form habits, this is the process of self-reconstruction.

The residents' psychological space reconstruction and life inertia reconstruction constitute the bilateral reconstruction process from virtual and real world, which is the cultural lag bilateral bridging process, as is shown in Fig. 82.2.

82.6 Conclusion

The "culture lag" phenomenon exists in many post-disaster redeveloped cities. After victims move into the redeveloped cities, they will experience the process of bridging culture lag, which include the reconstruction of psychological space and life inertia. The bridging process needs a long time. The paper studies on the reconstruction processes of psychological space and life inertia, the two reconstruction processes are the bridging of the culture lag process. The aim of the study is not to eliminate the "culture lag" phenomenon, but to shorten the bridging process. Some suggestions include government supplying assistance to build social support, paying more attention to the culture development, guiding residents take full use of the public service etc. Thus, more and more social elements will exist in residents' daily life and ultimately shorten the process of bridging "culture lag".

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Part XI
Law and Policies for Construction and Real Estate

Chapter 83
Problems and Solutions About Local Standard Informatization of Engineering Construction in Guangdong Province

Yi Zhang, Fangfang Liu, Yousong Wang, Aimin Wei and Yan Zhang

Abstract In order to investigate the informatization status of the local engineering construction standard in Guangdong province, 61 enterprises in 14 cities were researched through questionnaire survey. The result showed that the government gave strong support to the Survey & Design business, especially in Construction and Structure. However, there are still various problems in the process of local standard informatization in Guangdong province, which include poor popularization of software function information, adjustment of standard receiving feedback is not in time, the implementation after the promulgation of standards is lag and etc. For the sake of solving the problems mentioned above, we suggest that antecedence of software mentality should be established firstly. Next, information promotion responsibility should be cleared and then university-industry-government cooperation model should be implemented in the process of making promotion procedure. Finally, informatization resource databases resource should relate to local standard of engineering construction, more patterns of networks and communication systems and clear incentive mechanisms should be taken to achieve the informatization process in Guangdong province.

Keywords Local standard · Informatization, solution · Engineering construction · Guangdong province

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83.1 Introduction

Informatization was first put forward in 1963 by Tadao Umesao, a Japanese sociologist, in the book named Information Industry Theory: Dawn of the Coming Era of the Ectodermal Industry. In 1967, the Japanese Science, Technology and Economic Research Community proposed the concept of informatization, and held that informatization is a dynamic development process from the industrial society to the information society, and that the human society in the future would be an information-based society (Wang 2009). Jung et al. (2004) claimed that information constituted an information cooperation resource, which is widely assumed as a basis for effective project management, engineering and construction automation. Wang et al. (2002) believed that in today's world, the scientific and technical revolution is causing substantial changes in the economic structure, production mode and consumption structure of the society. And among various sciences and technologies, the computer-based modern information technology has imposed the broadest and most far-reaching influence. Information consultancy institutions on engineering construction standards have been a relatively perfect developed in the developed countries. As a knowledge-intensive industry, it had a considerable scale, and gradually become an important support for the operation and management of standards. The business of standard information consultancy institutions covers many fields such as engineering, technologies, policies, and management. They focus mainly on the comprehensive consultation and the application of the standards. Official, semi-official, business administration institute-based and non-governmental standard consultation institutions are presenting a trend of "advancing side by side" (Bi and Xie 2011).

Since the release of the Development Outline for Informatization of Construction Industry (2003–2008) and the Development Outline for Informatization of Construction Industry (2011–2015) by the Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD), local governments at all levels have been actively responded to them, and made their efforts to promote the development of informatization of the construction industry. Because of the reform in management style and implementation methods, and the reduction in construction costs which may be brought about by informatization, informatization of the construction industry has become an inevitable choice. Establishment of the national, industrial and local standards has laid a foundation for the construction industry. With no doubt, promoting the informatization of these standards will guide the informatization of the construction industry.

83.2 Generalized Current Situation About Local Standard of Engineering Construction in Guangdong Province

In order to understand current situation about local standard in Guangdong Province, we studied it about 61 enterprises in 14 cities through questionnaire survey. The design of the questionnaire adopted 7-point Likert scale. *1* very hard-working, *2* hard-working, *3* relatively hard-working, *4* general, *5* relatively sluggish, *6* sluggish, and *7* very sluggish.

A total of 656 questionnaires were issued, after rejected the invalid questionnaires there were 407. Then, SPSS was employed for the reliability and validity tests of the questionnaires. The reliability measurement index α and construct validity measurement index KMO were obtained as 0.900 and 0.945, respectively, suggesting that the questionnaire survey was valid and reliable.

To analysis the efficient questionnaires, according to the business unit Planning accounted for 10 %, Survey & Design accounted for 74 %, Construction (7 %), Supervision and Quality Management (5 %) and 4 % of others. It can also be seen from Fig. 83.1. A lot of the respondents are Survey & Design business. Among them, about 26 % thought governmental sectors were very hard-working; about 33 % thought they were hard-working; and about 23 % thought they were relatively hard-working.

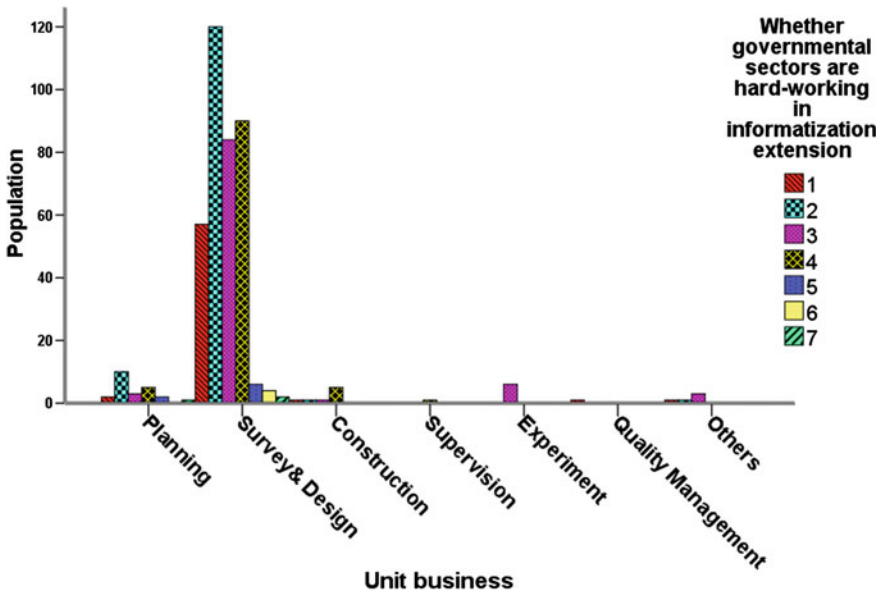

Fig. 83.1 The current situation of popularize of local standard which classified according to unit business

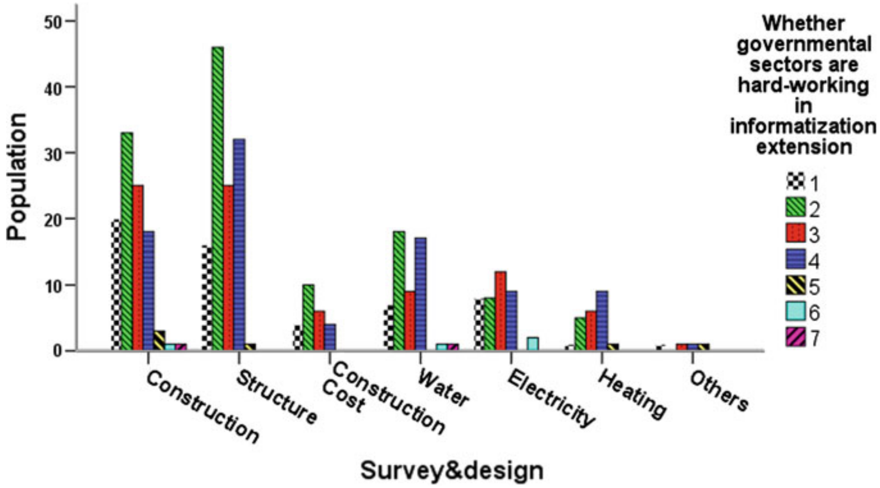

Fig. 83.2 The current situation of popularize of local standard which classified according to professional classification

While in Survey & Design business, Construction accounted for 43 %, structure accounted for 25 %, construction cost (7 %), water, electricity and heating combined (24 %) and the rest are municipal administration and urban planning. Figure 83.2 showed that Construction and Structure were better than other businesses. In the Construction direction, about 20 % thought governmental sectors were very hard-working; about 33 % thought they were hard-working; and about 25 % thought they were relatively hard-working. In the structure direction, about 13 % thought governmental sectors were very hard-working; about 38 % thought they are hard-working; and about 21 % thought they were relatively hard-working.

The results indirectly reflect the current situation of construction industry. Because of Survey & Design business is so important in engineering construction. Better Survey & Design will have a positive effect for the project itself, environmental and social benefits. Due to Construction and Structure businesses are the basis of the project, so the promotion of local standard in these two aspects is well.

83.3 Problems About the Informatization Process of Local Standard of Engineering Construction in Guangdong Province

Coefficient of variation is the standard deviation (also called difference coefficient or discrete coefficient). It is divided into the overall variation coefficient and sample variation coefficient. Sample variation coefficient is an important statistic to measure the degree of variation of each observation in the sample data. When comparing two or more data variation degree, if unit is the same to the average, you can compare with standard deviation directly. If they are different, the ratio of the standard deviation and average (relative) was used to compare the degree of variation, instead of a direct comparison of the standard deviation. Sample variation coefficient (Coefficient of Variance, referred to as CV) is defined as the ratio of standard deviation to the average (Wu and Gu 2010).

$$CV_j = \frac{\sigma_j}{\overline{X}_j} (j = 1, 2, \ldots, m)$$

A lower coefficient of variation value made the data more comparable and believable. As shown in Table 83.1, all coefficients of variations of evaluation index of informatization are low, indicating that the results are believable. Given the average of all in 5 floating up and down, so the following processing of the data (Table 83.2).

$$CA_i = (X_i - 5) \times 100$$

Table 83.1 Informatization evaluation index

Informatization evaluation index	Average σ_j	Standard deviation $\bar{X}_j$	Coefficient of variation CV_j
X1 The promulgation of standards in a timely manner, no lag	4.94	1.57	0.32
X2 Adjustment of standard receiving feedback is in time	4.86	1.58	0.33
X3 Supervision degree of implementation	5.03	1.44	0.29
X4 Promoting the construction of standard information service platform	5.05	1.39	0.28
X5 Procedure standard	4.99	1.31	0.26
X6 Software functions	4.86	1.39	0.29
X7 Transparency in the content	4.98	1.50	0.30
X8 Control standard quantity	4.98	1.41	0.28
X9 The highly complementary of provincial standards and national standards	5.37	1.36	0.25
X10 Promote the construction of modern information technology and engineering together	5.27	1.27	0.24
X11 Strengthen the standardization training work	5.17	1.44	0.28
X12 Promoting standardization research and consulting	5.20	1.47	0.28

Table 83.2 Results of evaluation index of informatization

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
CAi	−5.79	−14.05	2.75	4.68	−0.83	−14.33	−2.20	−2.48	36.64	27.27	16.53	19.83

It represents informatization process has a huge improve room when the CAi is negative and the lower index indicates that there are more problems. The positive CAi value represent that the informatization is going well, and the larger the value is, the better the informatization develop. Therefore, at present, there are still some problems with local standard:

Firstly, the popularization of software function information is very poor. The current characteristic model focuses on the requirements modeling and do not bind with software or do not achieve substantial mapping. In intelligent evolution of software, we should not only consider the demand of acquiring and modeling, but also consider the demand of implementation and change. The unified management of context, user requirements, and the specific function module can be achieved only by integrating the software requirement model, context model, and software application model (Wang 2012). How to use the interaction function sundry software to complete the shift between virtual and reality is the important reason of informatization promotion.

Secondly, adjustment of standard receiving feedback is not in time. The number of engineering construction standards had expanded from 180 in 1980 to 3800 items, including more than 2700 mandatory standard items. So many engineering construction standards require enterprises to improve the level of technology and invest enough money (Pan 2006). Standard promotion needs participants to solve the problems in voluntary consultation. Because of the monomer and regional of the main body of engineering construction made the adjustment of standard receiving feedback not timely.

Thirdly, the implementation after the promulgation of standards is lag. The promotion of engineering construction local standard should be the behavior by the parties implementing together. However, at present, under our country market economy system, all the promotional activities that are undertaken by the government will bring about financial difficulties. At the same time, because of the intermediary institutions and enterprises are lack of the responsibilities and obligations, this results in the problems of decentralization of information, little amount of information and delay of information transferring when engineering construction standards promulgated.

Fourth, local standard quantity should be improved. By querying the national information net of engineering construction standardization, there are 40 items recorded on the site of local standard in Guangdong province. In the list of Guangdong 40 items current engineering construction standards, 2 belong to system implementation details; 22 items belong to technical regulation; 6 items belong to design, construction, evaluation and acceptance procedures; 7 items belong to standard class; 3 items belong to specification class (Zhao 2013). Generally, these cover the whole process of engineering construction. But because of the differences in the geographical location, technical development level, specification requirements of various cities, the standard number needs to be improved.

Fifth, the transparency of standard content needs to be improved. At present, our country engineering construction standard GB, industry standard or local standard, are still obtained by buying or PDF vision through the professional purchasing channels. If the enterprise wants to get a complete building code, they must spend huge amounts of money. This is unfavorable for the popularity of standardization construction in small and medium enterprises.

Finally, the promotion of local standard procedure needs to be drawn up. The promotion of local standard is based on the enterprise actual project so that each one has its own features. Therefore, the standard promotion process is similar under the major premise, but it has slightly different between various projects. Because of this, we should take the differences when making process into consideration.

83.4 Solutions About the Problems Encountered in the Process of Local Standard Informatization of Engineering Construction

Since China had proposed informatization of Construction Industry, Guangdong province has spared no effort to promote the development on informatization of Engineering Construction, while the process is still at an initial stage of exploration. Proposals about the issues described above are as follow:

The antecedence of software mentality should be implemented, the core of which is "antecedence" and "transfixion". "Antecedence" means that large-scale software engineering courses are added to the college education cultivation project. "Transfixion" means that the training and using the large-scale software are throughout the whole process from basic course to graduation design (Ma et al. 2010). Nowadays, the commonly used software in the design domain are Autodesk CAD, PKPM, Tangent, 3DMAX and etc. The software used in the engineering project quantify aspect are Glodon, Rib, SJMS, etc. And those used in structural analysis field are Midas, SPA2000, ANSYS, etc. Our education system should let students study the software in their undergraduate course stage.

The responsibility of informatization promotion should be cleared. Informatization process is the popularization and application of technology. During this process, the responsibility among the governments, industries and enterprises should be identified. The model based on market and the assist mode of the government is founded. In order to maintain the healthy development of informatization promotion process, government should choose to spread the risk.

The procedure of informatization promotion should be drawn up the mode of university-industry-government cooperation. The procedure of local standard informatization of Engineering Construction should establish the interrelationship of university-industry-government to solve tough problems of scientific research in the single sector. At the same time, it need timely modify and feedback the comments and suggestions in the procedure development process.

Informatization resource databases should be built. The resource database related to the local standard of engineering construction (regional database of the construction enterprises, client resource database, market information database, law database, free online database of standard specific terms of engineering construction, etc.) should be established to provide support for the informatization of standard. The provincial "informatization standard normalization and coding system" should be established too. Ensure that each resource library can be used under this system.

More patterns of networks and communication systems should be established. Internet is basis on informatization. Internet information service should be developed to build Internet and communication system which are cored to national and industrial standard and supplemented by the Guangdong local standard, thus it will provide support for professionals to implement construction in accordance with standard. Simultaneously, Email, FTP, databases, www, videos, file sharing, special applications and other services should be used to enable participants share and exchange information about specific contents of standard quickly and easily. Network platform should include a series of longitudinal levels, such as national level, industrial level and provincial level, as well as a series of horizontal levels across various regions, such as Construction, Structure, Heating, Ventilation, Decoration, and Installation. LANs and WANs should be established among enterprises by business unit, such as Planning, Survey & Design, Construction, and Supervision. Taking these measures to assure that the coverage of informatization is broad and appropriate.

Clear incentive mechanisms should be established. Tax deduction and exemption, qualification rating, benchmarking demonstration, incentive mechanism and other measures should be set up to encourage the development of informatization construction among the enterprises. The huge problem of information construction is information the costs. Only through reducing introduce cost or making promotion incentive measures in pilot enterprises can promote information communication in big enterprises. Then this let's big enterprises drive medium/small enterprises and imposes a province-wide information construction.

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Chapter 84
National Construction Codes and Their Inadequacies: Australia's Arrangements and Difficulties

Mark Burgess and John Douglas Thomson

Abstract Research on building code development shows that there are critical factors relating to their development, and highlights that code development involves key trade-offs. In this research, we provide new insight into a condition that many countries face and where there is virtually no research. How should countries handle building code development when key trade-offs need to be made between the possible impacts of new technology, changes in the environment and social and cultural issues, and the systems and processes by which these challenges are met. A comprehensive empirical case study of Australia's building code arrangements and difficulties is presented. This unique data provides insight on the strategies used and difficulties faced by Australia in the review and development of its building codes. Implications for innovative new building code development success are identified.

Keywords Building code · Regulation · Standard setting · Trade-offs · Code development · Critical factors · Decision making · Public interest

84.1 Introduction

A building code, or building regulation, is a set of rules that specify the minimum acceptable level of safety for constructed objects designed to protect public health, safety and general welfare with respect to the construction and occupancy of buildings and structures (Australian Building Codes Board 2012c). A building code becomes law when enacted by the appropriate authority.

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While anecdotally termed ‘building regulation’, Australia’s National Construction Code is in effect a codification, or standardization document developed by the Australian Building Codes Board (2012c). This code is brought into regulation through adoption of a range of parallel State, Territory and Commonwealth legislation. The National Construction Code is revised annually with the latest version coming into effect each May. For practicality, the National Construction Code is published as separate volumes for the Building Code of Australia and Plumbing Code of Australia. This research examines only the Building Code of Australia, through an analysis of change processes used for each year’s revision and whether there are any opportunities for process improvement or refinement.

Australia’s nationally applied building code developed through transition from a series of disparate State based systems (Knox 1989). This evolution started in 1964, with the current code and its associated administrative processes the outcome of nearly 50 years of evolutionary and transitional development, including addition of requirements for energy efficiency, sustainability and disabled access provisions to be added to the original scope of safety, health and amenity (Australian Building Codes Board 2013). National unification was formally achieved with an Intergovernmental Agreement establishing the Australian Building Codes Board (ABCB) in 1994 (Australian Building Codes Board 2013). This Agreement provided for development of a uniform national building code, creation of a body to administer that code and a commitment by all Australian States and Territories to enact legislation adopting the resulting code (Australian Building Codes Board 2012b).

The establishment of Australia’s National Construction Code was paralleled by the development of administrative policy and decision making processes for its ongoing maintenance, revision and amendment. These are implemented through the formalised Proposal for Change process (Australian Building Codes Board 2012a) and driven, in part, by a broader government focus on deregulation (Productivity Commission 2006), and regulatory practices applied by the Office of Best Practice Regulation (Commonwealth of Australia 2007).

The academic study of regulation has not been restricted to the legal fraternity. Baldwin et al. (1998) identify academic study from disciplines as diverse as sociology, economics, political science, anthropology, social administration, psychology and geography. However, there has been little translation of theoretical work to the regulation of building and construction. In surveying five leading journals over ten years, Van der Heijden and de Jong (2009, p. 1038), found only 15 articles dealing with building regulation from 2800 published. In generalizing those articles, the authors found little attention given to ‘theory-building’.

84.2 Purpose

The purpose of the research is to extend understanding of the drivers of change to building regulation as technological, environmental, economic and cultural relationships develop synergistically and compete for recognition.

The scope of analysis is limited to the policy and processes used by the Australian Building Codes Board to facilitate the development of, and changes to the Building Code of Australia. This paper examines the philosophy of building code development and reform, and the Australian Building Codes Board's use of policy guidelines provided by the Council of Australian Governments (COAG). This Council is the peak intergovernmental forum in Australia, with members including the Prime Minister, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association (Council of Australian Governments 2014). They meet as needed, usually once or twice a year, with the role to promote policy reforms of national significance, or those which need coordinated action by all Australian Governments.

84.3 Critical Factor: Consultation

The Australian Building Codes Board (2013) has found that a policy of consultation is necessary to create a contemporary and relevant construction code that delivers good societal outcomes for safety, health, amenity and sustainability in the built environment. There are benefits to all stakeholders in a truly collaborative approach to considering key issues affecting building (Lovegrove et al. 1991). Meaningful consultation can promote trust between industry, the community and government, while transparency allows stakeholders to see and judge the quality of government actions and regulatory decisions (Croley 2008). Consultation also provides an opportunity for stakeholders to participate in the development of policy solutions and encourages broad ownership of solutions (Council of Australian Governments 2007). A proper consultation process can also lead to the revision and modification of preliminary recommendations before a final decision is made, thereby delivering better outcomes for all (Croley 2008).

It should be noted that a consultative approach is not always a straightforward pathway towards good regulatory process. Croley (2008) explains the challenge where consultation from parties representing broad interests is outnumbered by a disproportionate influence from interest groups. Accordingly, while consultation can lead to a better outcome, it can also introduce decision bias.

The National Construction Code draws input from consultation with government and industry stakeholders, while seeking advice and assistance from building professionals, research communities, industry peak bodies, local governments, special interest groups and the community. This feedback covers the breadth of strategic, policy, technical, administrative and societal issues. Key stakeholders are identified and approached for inclusion in relevant project-specific committees and working groups.

Early consultation is instrumental to the technical amendment processes and broader regulatory reform matters. Consultation assists in ensuring a clear understanding of 'what the problem is' and consideration of alternatives to regulation (Council of Australian Governments 2007). The Best Practice Regulation Handbook

(Council of Australian Governments 2007) identifies aspects of consultation including, trust promoted between stakeholders and decision-makers by allowing regulatory decision-making processes to be monitored; enhanced relationships with stakeholders by providing greater opportunities to participate in the development of regulations; input of specialist knowledge and timely involvement of stakeholders; and effective and transparent stakeholder engagement, communications and reporting arrangements.

84.4 Proposals for Change

The initialising step for any change to the National Construction Code is the preparation of a Proposal for Change document using a standardised question-answer template published by the Australian Building Codes Board (ABCB 2013). The Proposal for Change process is used by the Australian Building Codes Board to consider proposals to change the National Construction Code Series. The process is consistent with the Council of Australian Governments regulatory principles to ensure appropriate rigour is used in the assessment of proposals (ABCB 2013).

A Proposal for Change requires proponents to provide justification to support their proposal. This justification should be proportionate to the size of the proposed change or its potential impacts, and includes a description of the proposal; an explanation of the problem it is designed to resolve; evidence of the existence of the problem; how the proposal is expected to solve the problem; what alternatives to regulation have been considered, and why they are not preferred; who will be affected and how they will be affected; and any consultation that has taken place (ABCB 2013). This common proposal document is used by all proponents for initiation of any proposed changes to the published building code, whether from an individual, an industry or the Australian Building Codes Board itself. Once submitted, all proposals follow a common review and approval process (Fig. 84.1).

84.5 Translating Policy to Practice

Rein (1983, p. 113) explores the 'politics of implementation', providing perspective on the trade-off processes for translating policies into action. He argues that implementation must account for three competing imperatives, what is legally required, what is rationally defensible, and achieving agreement among parties who have a stake in the outcome (Rein 1983, p. 118). Sheehy and Feaver (2013), define regulation policy as 'a collective social political response to a problem', noting that whether the problem is important enough to warrant action is the result of complex socio-psychological phenomena, rather than a political task. It is therefore necessary to note that decisions to regulate, although driven by policy, are often not self evident, with Rein (1983) observing that purposes can be redefined through the process of implementation.

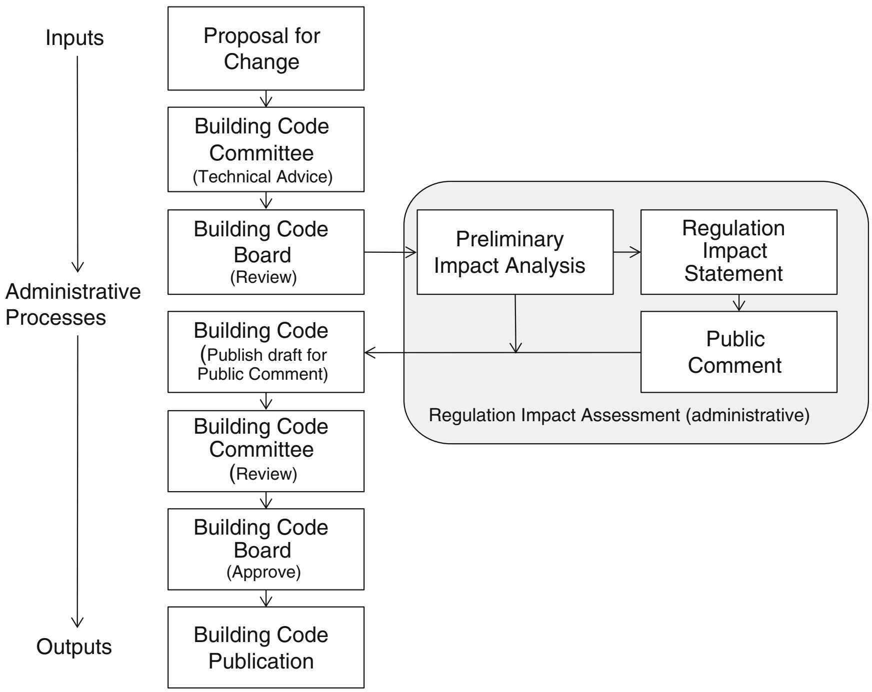

Fig. 84.1 Summary of the proposal for change process. *Source* Adapted from (Australian Building Codes Board 2012a)

In the case of building regulations, the process of translating policy to practice could be argued as being both complex and political, with its complexity necessitating spectrum of regulatory solutions. Breyer (1982) defines such a range of regulatory options, with a similar range reflected by the Australian Office of Best Practice Regulation, placing solutions from ‘self regulation’ through to ‘explicit government regulation’ along a spectrum (Commonwealth of Australia 2007) (Fig. 84.2).

Taking the example of bushfire protection, at one extreme, explicit government regulation places responsibility on government for defining and then taking responsibility for construction methods that will protect buildings and occupants in a bushfire (Commonwealth of Australia 2004). At the other extreme, self regulation provides flexibility and reduced implementation costs, but leaves open the

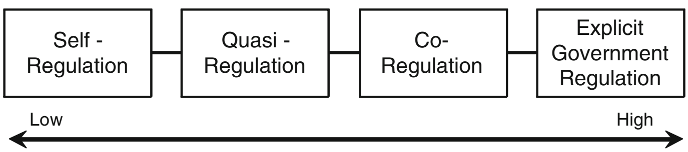

Fig. 84.2 A simplified spectrum of regulation. *Source* Adapted from Office of Best Practice Regulation Handbook (Commonwealth of Australia 2007)

possibility that individuals will assume a level of building and personal safety when little may in fact exist, or for charlatans in the market place to make false claims about the suitability of buildings.

84.6 Societal Risk

Rayner and Cantor (1987) discuss the concept of dealing with risk as a two stage process comprising the assessment of facts and then the evaluation of facts in a socio-political context. They argue that societal risk revolves around social relations as much as around evaluations of probability—conflict rather than probability is the chief focus of societal risk management. Their research indicates that procedures through which collective consent is obtained for a course of action must be acceptable to those who bear its consequences, that the principle used to apportion liabilities for an undesired consequence must be acceptable to those affected, and institutions that make the decisions to manage and regulate be worthy of fiduciary trust (Rayner and Cantor 1987).

The change processes employed by the Australian Building Codes Board provide for these multiple levels of review, including opportunities for technical, stakeholder, and public scrutiny. The first review stage is with the Building Codes Committee, a technical group comprised of representatives from industry stakeholders, specialist technical organisations, community stakeholders and State/Territory government representatives. This committee's recommendations are passed to the Australian Building Codes Board for review and approval. At this stage, the proposed change can take three pathways, depending on the impact of the change (Australian Building Codes Board 2011) (Fig. 84.1). Those with minimal impact, such as minor and editorial corrections may progress directly through to public comment stage. All others undergo Preliminary Impact Analysis, and in cases where this preliminary analysis identifies substantial impact, consultation with the Office of Best Practice Regulation. Where a Regulation Impact Statement is required, it is developed and subjected to a further series of Building Codes Committee review and public comment processes. The Office of Best Practice Regulation plays a central role in delivering the Australian Government's best practice regulation requirements by providing a 'one stop shop' to assist departments and agencies with regulatory impact analysis requirements, and monitors and reports on their performance (Office of Best Practice Regulation 2013).

In considering administrative regulatory decisions, Croley (2008) notes that citizen participation is rare, drawing his conclusion from the distance between the administrative agency making decisions and the elected representatives that provided the agency's authority. The processes to ensure consistency with the Council of Australian Government guidelines (Council of Australian Governments 2007), require all proposed changes to be provided in a draft of the Building Code and made available for public review and comment. It can be argued that the open nature of the Proposal for Change process and this opportunity for public review do much to address Croley's concerns for citizen participation and the management of risk.

It should be noted that consistent with the Proposal for Change methodology, a similar process is repeated at public comment stage, with a standard template used for all comments, whether originating from Government, industry or private individuals. All comments received are reviewed by the Building Code Committee, with recommendations made to the Building Code Board for final societal risk management, review and approval.

84.7 Trade-Offs Between Impact Assessments

A Regulatory Impact Assessment (RIA) is a formal process called for by the Council of Australian Governments and directed by the Office of Best Practice Regulation (Commonwealth of Australia 2007). This assessment calls for the drafting of a Regulatory Impact Statement (RIS) to explore regulatory options, categorising costs, benefits and risks of each. Requirements for this analysis are not restricted to regulatory decisions, or black letter law, but apply across the spectrum of regulation where societal impact is expected.

Table 84.1 Summary of results of illustrative quantitative model

Variable	Status quo	Non-mandatory information guidelines	Proposed BCA amendments
Value of a life	$3 880 000	$3,880,000	$3,880,000
Years to bushfire event	20	20	20
Net present value of a life	$1,003,000	$1,003,000	$1,003,000
Average number of people per shelter	3	3	3
Probability of survival without a shelter	0.97	0.97	0.97
Probability of a fire in the region	0.80	0.80	0.80
Probability of needing to rely on the shelter for survival	2.40 %	2.40 %	2.40 %
Financial costs of the shelter	$5 000	$10 000	$15,000
Probability of correct use	25 %	35 %	50 %
Probability of the shelter being structurally sound	40 %	65 %	90 %
Probability of survival in a shelter	10 %	23 %	45 %
Benefits of the shelter	$7 220	$16,430	$32,500
Actual benefit cost ratio	1.44	1.64	2.17
Net present value of shelter	$2 220	$6430	$17,500

Source Adapted from Bushfire RIS (Centre for International Economics 2011, pp. 68–74)

The Regulation Impact Statement is neither new, peculiarly Australian nor specific to building regulation. Breyer (1982) cites their requirement under an Executive Order by President Carter in 1978, specifying the Impact Statement to set about alternative ways of achieving an objective and justify the action as better than any alternative.

Proposed changes to the Building Code of Australia are subject to Regulatory Impact Assessment requirements. Implementation is usually an analysis through economic modelling of regulatory options, arriving at a Net Present Value (NPV) for each. An example is the proposal to include requirements for private bushfire shelters in the Building Code of Australia (RIS 2010-3). A range of alternative policy options were considered, with three subjected to economic modelling. The first was for no amendments to be made; the second for implementation of non mandatory information guidelines; and the final for the decision to construct a private bushfire shelter to be voluntary, but if constructed, must be in accordance with codified performance requirements. Table 84.1 summarises results from this quantitative modelling exercise.

The economic modelling results supported Option 3. This provided a non-mandatory option to install bushfire shelters related to a private dwelling, but where installed, requiring those shelters to conform with the performance requirements in the Building Code. This selected option reinforces the concepts of the regulatory spectrum and aligns with a policy of minimal acceptable standards.

84.8 Minimum not Optimum Acceptable Standards

When considering administrative processes to be employed by the Australian Building Codes Board, the Intergovernmental Agreement (2012) included a stated aim to provide *minimum* not *optimum* acceptable standards. This policy context is captured in the recitals of the Agreement, requiring a ‘National Construction Code setting the minimum necessary requirements for the design, construction and performance of buildings’ (Australian Building Codes Board 2012b, p. 2). Notwithstanding this requirement, the Chairman of the Productivity Commission’s regulation taskforce criticised the Building Code of Australia for setting standards above minimum levels (Banks 2006). Meacham’s (2010, p. 32) review of performance based building codes also notes this risk, offering a reminder that building regulations should not ‘represent levels of performance to which industry, society or the public aspire’. The compromise along the continuum between ultimate safety and minimum acceptable levels of safety will always represent a challenge for standards setting bodies, requiring vigilance by committee members when considering new proposals or changes to any regulatory code. This is particularly the case for bushfire regulation example—what is the minimum safety standard for a bushfire shelter and what is the optimum?

In light of the call for minimum requirements, the Australian Building Codes Board’s administrative system has the flexibility to opt for action outside direct regulation and prescriptive requirements in the National Construction Code. These options cover the regulatory spectrum (Fig. 84.2), implementing alternatives which can affect market behaviours, from low regulatory involvement through to explicit codification, and include industry notification, publication of handbooks or adoption of existing standards.

84.9 Policy Guidelines and Regulatory Solutions

In general, the Australian Building Codes Board's implementation of the Council of Australian Government's policy guidelines has arrived at a regulatory solution that is well suited to the needs of Australia's building sector. A fundamental aspect is the National Construction Code, now accepted across all States and Territories, providing efficiency benefits to building practitioners and building product suppliers. This success has been evidenced economically by a recent study finding the national code leading to attributable benefits of $1.1 billion annually (Centre for International Economics 2012).

The process claims to be open and balanced (Commonwealth of Australia 2004). Proposals for Change can be instigated by any party, including the general public, and pass through identical administrative review processes regardless of the proponent. Multiple avenues are provided for public input and stakeholder feedback. Additionally, the system allows change proposals to be satisfied using a range of non-regulatory options to affect market behaviours.

Regulatory Impact Analysis is integrated into the Proposal for Change process, with Productivity Commission (2012) benchmarking specifically citing the Australian Building Code Board as one of the standard setting bodies to have embedded the essential elements of this process.

The separation of technical and administrative review committees arguably provides a balanced forum for both engineering and value based decisions. The two committee process also provides forums for representative input from industry stakeholders and Government, including avenues for the sometimes diverse needs of the States and Territories to be debated.

84.10 Legal Implication of Informative Material

In line with the concept of minimum standards and the regulatory spectrum, a common policy alternative to strict codification in the Building Code of Australia has been the inclusion of informative materials in the Guide to Volume One of the Building Code. This Guide is a companion volume to the National Construction Code, intended to provide clarity to the normative Building Code of Australia provisions (Australian Building Codes Board 2010). However, industry and practitioner reliance on this informative companion has now been questioned by a New

South Wales (NSW) Supreme Court decision (*The Owners—Strata Plan No 69312 v Rockdale City Council & Anor; Owners of SP 69312 v Allianz Aust Insurance* 2012), which in a particular circumstance determined that '…the Guide is not relevant to a determination of the proper construction of the definition of effective height in the Building Code of Australia…'. This finding falls within the jurisdiction of the State of NSW and so that State (as do all States and Territories), has the authority to question the ability of a building practitioner or other entity to rely on the informative Guide to Volume One of the Building Code to ascertain conformity to the Building Code of Australia. Ramifications of this decision and further legal testing of the Guide to Volume One of the Building Code's status may impact on the currently understood and accepted regulatory spectrum.

While the policy of public consultation is identified as a benefit, it highlights potential conflict between the Intergovernmental Agreement's objective of minimum standards, and the public perception that conformity with standards implies a level of ultimate surety. This can lead to a mismatch between a change proposal and the public perception of that proposal. This confusion is compounded with evidence of the legal system using voluntary standards as a benchmark of compliance in establishing civil liability (Commonwealth of Australia 2004). This problem is not limited to the public, with the Productivity Commission (2004) also identifying widespread confusion among consumers and builders regarding the regulatory status of Australian Standards.

84.11 Regulating Industry Behaviours and Subsequent Administrative Risks

Breyer's seminal work on regulation (Breyer 1982) identifies standard setting, or codification in the case of the Building Code, as a classical policy for regulating an industry's behaviour. However, Breyer (1982) also warns that considering this solution from an idealised world may be misleading, citing a range of subsequent problems from sourcing information through to anticompetitive effects. Heeding Breyer's (1982) warning, this research would not be complete without considering potential failure modes within the current process. While not an exhaustive analysis, the following discussion highlights a number of potential administrative risks, with the aim of prompting further discussion and research.

In the area of building regulation, Cross (1952) is often quoted for his view that 'standardisation is a check on the fools and rascals'. Cross's quote can provide clarification with respect to potential failure modes by summarising them into two categories—those caused by 'fools' and those caused by 'rascals'.

Taking 'rascals' first, the transparency of the Proposal for Change process leaves it open to external influence. This influence could take the guise of simple lobbying to Building Code Committee members and administrators, or the longer term process of biasing the membership of committees. In discussing 'participation in administration', Croley (2008) highlights this risk of influence by interest groups. Additionally, direct influence on decisions either by, or through Government may allow interests to bypass the two committee process, forcing unilateral decisions at the Board level. While the effect of these 'rascal' actions is offset by the public comment and Regulatory Impact Assessment processes, the administrators of the system need ongoing vigilance against potential risks.

When considering Cross' (1952) concept of 'fools', the list of potential risks is much broader. The first risk would be the well intentioned, who drive Codification beyond the Board's objective of establishing minimum levels (Australian Building Codes Board 2012b). The extension of this drive would be to overreach the aim of translating policy into practice, leading to the potential for bottom-up policy making. A second risk is overzealous use of secondary reference standards, where adoption commits the industry to mandatory conformance against those standards. Where drafted outside the administrative processes applied to the Building Code, referenced standards may not be subject to appropriate levels of stakeholder consultation, public review and regulatory impact analysis.

Another risk arising from the well intentioned is the 'serial pest' bombarding the process with Proposals for Change. Driven by good intention, it would be unreasonable to consider this vexatious. Nevertheless, an unrelenting volley of proposals could bias the work or waste the time of the Building Codes Committee and administrating agency.

A final risk falls neither to 'fool' nor 'rascal', but impacts the concept of evidence based decision making. In its recent benchmarking of the Regulatory Impact Assessment process, the Productivity Commission highlighted the importance of an *ex post* review of actual outcomes, compared to those predicted by the analysis (Productivity Commission 2012). The Commission also highlighted the need for this analysis in cases where Regulatory Impact Assessment was deemed unnecessary. The extended construction times and long cycles in the building industry present challenges for this *ex post* analysis, where impact of changes in codification could be masked by economic cycles, technology change or other external factors. Notwithstanding these challenges, it would be a risk to continue making change without an evidence based approach to evaluate the resultant impact of that change.

84.12 Further Work Required

The Proposal for Change policy process has evolved in step with the development of Australia's national construction code, informed by Council of Australian Government guidelines and a number of Productivity Commission reviews in the last decade (Commonwealth of Australia 2004; Productivity Commission 2006), but the system is not flawless. The Council of Australian Governments has reinforced a view that further work is required, agreeing to establish an independent review panel to investigate costs in the construction industry (Council of Australian

Governments 2012). The terms of reference for this review panel include the administrative areas of regulation and compliance.

While this research supports the rigour of the Proposal for Change process used by the Australian Building Codes Board, it has identified an issue in the timing of those steps through the process. In reviewing a Proposal for Change, the various technical and administrative committees amass a range of information to inform the decision process. This is especially relevant when the decision is to be subject to formal Regulatory Impact Analysis, for example that of the requirements for safe private bushfire shelters (RIS 2010-3). The later a decision is made through the process, the higher the cost of decision making may be (Commonwealth of Australia 2004). This becomes an issue for status quo decisions, those where the outcome is to do nothing. Procedurally stepping through a formal process in these cases, while rigorous, may be inefficient. Following the submission of a Proposal for Change, the stages of committee debate and review will add information for decision makers. The Proposal will collect data which informs and strengthens the eventual decision.

Sometimes information collection can bias a decision rather than inform it. The Productivity Commission review of building regulation identified the risk that a Regulation Impact Statement 'becomes more an advocacy document than a balanced assessment' (Commonwealth of Australia 2004, p. 252). This position is reiterated in benchmarking work eight years later, observing cases where the Regulatory Impact Statement becomes an ex post justification rather than a decision making tool (Productivity Commission 2012).

84.13 Summary

Australia's national policy approach to building regulation has been in place since 1994. Since then it has been subjected to a number of reviews (Commonwealth of Australia 2004, 2006; Productivity Commission 2012), and reaffirmed through a new Intergovernmental Agreement (2012b). The continued support of this administrative arrangement by the Commonwealth along with all States and Territories provides evidence of a successful implementation. Annual revision and publication has both proven and refined the robustness of the process developed for management of the Code. These processes have been adapted to guidelines from the Office of Best Practice Regulation (Commonwealth of Australia 2007) and Productivity Commission reviews (Commonwealth of Australia 2004, 2006) while maintaining a system allowing input from governments, industry and the Australian public. When compared with other standardisation processes, the formal Proposal for Change process provides a transparent methodology for amendment. Wide stakeholder involvement, a robust public comments procedure and the volume of comments received indicate a high level of stakeholder participation in the process.

The Intergovernmental Agreement's aim to achieve 'minimum acceptable standards' is acknowledged by implementation of an impact analysis process, which incorporates formal application of the Office of Best Practice Regulation's

Regulatory Impact Analysis. The demonstrated application of these procedures (RIS, 2010-3) is evidenced by the Productivity Commission's (2012) recognition that the Regulatory Impact Analysis is firmly embedded in regulation development by the Australian Building Codes Board. However, this policy process can be lengthy and ambiguous in achieving outcomes, with little supporting evidence of *ex post* review of effectiveness. On this basis it could be argued that the process would benefit from further refinement.

84.14 Conclusion

The current policy and processes have been tested over 19 years of relatively calm and successful operation as measured by annual economic benefits exceeding $1 billion (Centre for International Economics 2012). While some may be of the view that the administrative processes have allowed the uniform building code to keep abreast of changing societal values, which has included the addition of energy efficiency, sustainability and disabled access provisions, the challenge remains—is the balance between scientific and economic analysis, environmental and technological change properly represented in the application of public perception and societal expectation in meeting the needs of Australian stakeholders?

Each annual revision of the building code highlights the delicate balance between scientific and societal mores. As yet, the decision making processes have not been subjected to extensive study, and decision making challenges remain unanswered. Improved understanding depends upon the extension of building knowledge and human interaction research of our changing environment. Further study, based on a case study review of Proposals for Change could serve to qualify key decision points through the process, balancing efficiency against rigorous, transparent process.

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Chapter 85
The Impact of Property Taxes on Housing Price: A Review of Literature

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Abstract Property taxes can increase local fiscal revenue and adjust the allocation of resources. In China, it is adopted to control the soaring housing prices over the past decade. While property taxes have been expected as effective tools to regulate housing price, there is no concrete understanding of the influence of property taxes on housing price. In this paper, we distinguish the concept of property taxes in China from other countries, and explore the effects of property taxes on housing price and the possible mechanisms. In reviewing the Chinese literature on property taxes, we found the definitions of property taxes have been distorted and included a series of real estate related taxes from all different stages of real estate development. In most recent practices in China, especially after the adoption of property tax in Shanghai and Chongqing since 2011, property taxes specifically refer to the tax levied in the retention stage, not those in the development and transfer stages. This is more comparable to the definitions of property taxes in other countries such as the U.S. So far, estimates of the impact of property taxes on housing price has been inconsistent due to the different research perspectives, including from the perspective of local public spending, tax shifting, cost-benefit and public anticipation.

Keywords Property taxes · Housing price · Effects · Relationship · Public service

85.1 Introduction

In China, the real estate industry is a core industry of the national economy now. The sustainability of real estate industry has important implications to the stability of the national economic growth as well as the improvement of people's living standards (Kuang and Ma 2010; Du 2009). In recent years, the problem of skyrocketing housing prices has become a popular topic for Chinese citizens, the government and developers. The housing price in many cities has been rising since the end of 1990s. In order

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to control housing price, the central government has introduced a series of measures such as tax relief, land premium reduction and housing supply structure adjustment, but all had achieved little success (Ding 2005). Housing price in many cities has risen more rapidly since 2000. In the first quarter of 2008, median housing price in 70 major cities of China increased by 11 % on average, while in April 2010, the prices rose by 12.8 % in one month, the fastest growth rate since 2000 (China Real Estate Market Report, 2009–2013). The price increase seemed to be out of control and mostly driven by speculations, bringing concerns about the huge economic risk and social unrest (Luo 2012; Zhu 2013). A healthy housing market is not only vital to the smooth operation of the national economy, but also related to the daily life of the residents. Since property taxes can increase government revenue, adjust resource allocation and potentially bring down the heat of housing speculation, property tax reform is gradually on the agenda. On January 28, 2011, the Central Government Economic Plan Conference in Beijing announced that Shanghai and Chongqing be the first two pilot cities to adopt property tax reform (China Real Estate Market Report, 2009–2013). This could potentially become the most influential local tax reform since the 1994 tax reform in China. So far, property tax revenue in both Chongqing and Shanghai is much lower than land sales revenue, accounting for less than 1 % of their annual fiscal revenue. Meanwhile the housing price in the two cities was still rising (China Real Estate Market Report, 2009–2013). It seems that property tax has not yet achieved its expected goals in these two cities, namely, to regulate housing price and increase government revenue. Nonetheless, property tax reform has been regarded as an important policy to control housing price, though researchers are still debating in terms of how large the effect of property tax on housing price can be. Through a comprehensive literature review, this paper aims to summarize important theoretical and practical evidences on this issue. In addition, we try to explore the in-depth mechanisms of how property tax reform could influence housing price in China.

85.2 The Definition of Property Tax

Most research mixed the term of property tax and tax related to real estate, both corresponding to “Property Tax”. A property tax is a levy on property that the owner is required to pay. The tax is levied by the governing authority of the jurisdiction in which the property is located. This definition includes three main points: first, the local government controls property taxes; second, the collection object is the property owner; third, the tax amount is based on the value of property (Rosen and Fullerton 1977; Dusanskey et al. 1981; Mc Donald 1993; Palmon and Smith 1998; Skidmore et al. 2012). There is no difference between property tax and tax of real estate in countries of private landownership. However, land system in China is socialist public ownership; state has land ownership while individuals own use-right. In China, tax of real estate is a comprehensive concept that encompasses property and real estate and property tax is only a part of it. Some scholars use property tax referring to taxes related to real estate and other property while others

Table 85.1 Taxes involved in real estate business activities

Stage	Taxes involved in
Development	Business tax; urban maintenance and construction tax; stamp duty; land-use tax of town and building tax; income tax on enterprises; land value increment tax; occupying farmland tax
Transfer	Business tax; urban maintenance and construction tax; deed tax; income tax on enterprises; individual income tax; land value increment tax; stamp duty
Retention	Property tax; urban maintenance and construction tax

may use it under the circumstance of property tax in China (Yang and Xu 2007; Xia 2011; You and Hu 2011). Some students may use it to express taxes related to real estate. We will accurately define the range of application of these two terms.

Tax of real estate refers to all taxes that have a direct relationship with real estate economy movement. Real estate business activities are generally divided into three part, development, transfer and retention; taxes involved each link shown in Table 85.1. Property tax is levied on houses; the amount of it is based on house tax residual value or rental income and the property owner levies. Many countries levy a property tax and China also regulated property tax in "Real Estate Tax Regulation" in 1986. According to the regulation, property tax are levied on business-use houses owned by enterprises and individuals in the cities, counties, towns and industrial and mining areas, and property tax free for personal non-business house. Thus, property tax in China is for operating houses, but not including houses in rural areas. The pilot for individual housing property tax beginning in 2011 in the case of rising housing price levies on those personal non-business houses or houses used to be tax-free (An 2012). In order to investigate the relationship between property tax and house price, we will sort out the existing literatures about the relationship between property tax or tax of real estate and house price. Related foreign researches didn't distinguish property tax and tax of real estate, only involved relationship between property tax and housing price. Property tax is new in China, so most researches in China about property tax are qualitative. However, the researches about tax of real estate have a long history and can provide reference for property tax. Domestic literature review includes how property tax and tax of real estate influence housing price.

85.2.1 Impacts of Property Tax on Housing Price

No consistent conclusions have been drawn about whether the impacts of property taxes on housing price are positive or negative. Such phenomenon may be related to the different hypothesis, methodology applying in researches and the different sample areas.

85.2.2 Positive Impact

Property tax has positive impact on housing prices through two ways; one is through increasing government revenue and then improving public service to raise house price. The researches in Massachusetts and New Jersey respectively have ascertained this opinion. In a research in Massachusetts, the demand and price of local real estate were found to be shrinking as the local revenue and the public services supply had been decreased due to the limitation of property tax at 2.5 %, though examining the relationship between housing prices, housing holdings and public services (Bradbury 2001). In Massachusetts, Lang and Jian (2004) also have found that communities that were able to increase their property tax more rapidly saw greater increases in their housing price under such limitation policy of property tax. A similar conclusion has been drawn by Oates in an empirical study in New Jersey that people here do appear willing to pay more property tax and withstand higher housing price to enjoy better public services supply provided by tax revenue (Oates 1969). Another empirical research in 234 counties in United States has also shown that the higher the property tax revenue was, the higher the housing price (Jurgen 2009). All these studies suggested that property tax can increase fiscal revenue variable, related to the quality of public service supply, and then stimulate housing demand and at the same time increase housing price.

Another way for property tax to increase housing price is through increasing the costs in developing and transferring. Chan and Chen (2011) demonstrated that high property taxes and fees had a significant impact on housing price in Sydney due to the increase in the cost of development. Yang and Xu (2007) believed that the property tax, together with other charges in the process of developing, transferring and holding stage related to real estate industry, made the purchase cost of a house much higher and then made the housing price much higher as the demand elasticity of buyers is relatively low. A simultaneous equation model, using the panel data of 25 years, had been set up to estimate the effect of property tax rate changes on housing price and its change rate, which showed that property tax had a significant positive impact on housing price (Hamilton 1975). These studies stand on a traditional view point, that property tax would raise the price in real estate market by increasing the costs related to real estate development.

85.2.3 Negative Impact

Different to the traditional view point on the impact of property tax on house price, some scholars believe that higher tax rates may produce the expelled effect on capital on one hand and reduce the expected revenue and net present value of real estate on the other hand. In consequence, the demand for house will decrease and so as to the housing price. Disagree with the traditional partial equilibrium analysis of property tax ignoring the differences of tax between regions, Zodrow and Mieszkowski (1986) believed that capital will flow from high tax area to the lower tax one, and then bring about the reduction of housing demand and housing price. Another research using the Cross Area Model had also proved such expelled effect of capital caused by property tax differences, which showed that the actual income could only increase by 6.6 % even if the property tax increased by 25 % (Case 1991). Not only the difference of tax rate but also that of tax system will result in the affore-mentioned effect. Using an OLS Model, Bai et al. (2012) discovered that the levy of property tax brought about housing price falling by an average of 15 % in Shanghai Municipality, but increasing by an average of 11 % in Chongqing Municipality. Further study revealed that it was the difference in tax system that brought about such interesting results; the property tax in Shanghai Municipality was directed against all the incremental houses except for the first house buyer, while the property tax in Chongqing Municipality had mainly focused on the high-end housing and then promoted the shift of house demand from the high-level to the low-end. As a result, in Chongqing, even though the high-end housing price decreased, the low-end housing price climbed up, and the latter lead the overall trend in housing prices.

The property tax increased the transaction and tenure cost, and then reduced the expected revenue and net present value of real estate, which may be the main reason that the property tax will curb the housing price. Bowman (2006) deemed the property tax affected the property values and holding cost, an important reason of Columbia, Maryland and Virginia's high prices, and suggested that the authorities used the tax to curb price. Kuang (2012) explored the property tax impact on housing price in the monopoly and competitive market by combining the Housing Flow Model and the Housing Market Partial Equilibrium Model and it showed that the different market structures property tax leaded to the decline in housing price, and also, the greater the monopoly, the heavier impact on price. Chen and Zong (2004) also held the opinion that the property tax reduced the expected value-added income and net present value which might curb the price rising. All these researches have shown the inhibition effect on housing price caused by property tax, which can be concluded as expelled effect.

85.2.4 No Significant Impact

Some scholars believed that although the property tax increased the local government revenue and guaranteed the supply of public services, it did not belong to the capital tax, and would not be capitalized into the value of housing, thus it will not affect housing price (Hamilton 1975; Fischel 2001). Chan and Chen (2011) found that the property tax together with related costs in Taipei had no significant effect on housing prices, and they deemed that the main reason lied in that by compared with Sydney, the ratio which the tax of Taipei occupies in the development cost of real estate was very small, mainly levied against the retain and transfer behavior. Based on an empirical research using related time series data from 1998 to 2011, Zhu (2013) found that the relationship between property taxes and housing price was not significant statistically and in addition, the regulation of China's property tax on the housing price was finite. After calculating the relationship between loan interest rate adjustment and real estate investment rate of return, Yue and Guan (2005) came to a conclusion that China's current property tax policy had little impact on the housing prices, while the interest policy was more effective to stabilize the housing price than the tax policy.

85.2.5 Other Opinions

Property tax may have impact on housing price, but the direction and the degree of its impact need specific analysis, in other scholars' opinions. First, the direction and degree of impact may be related to the elasticity of housing supply. Through reviewing the relevant study of property tax capitalization, Sirmans et al. (2008) hold that the housing supply elasticity determined the impact of property tax on housing price. In detail, the higher the elasticity was, the less the impact was; when the elasticity was perfect, property tax had nothing to do with housing price. Second, the kind of property tax may bring about different impact. Since there were different taxes related to real estate, Du (2011) applied the Partial Equilibrium Theory in her study to find out that the property tax and Land value increment tax had positive impact on housing price, while the urban maintenance and construction tax, the occupying farmland tax and the deed tax erected negative impact on housing price. Third, the specific conditions of the study areas, like the economic development stage, the level of real estate market development or the structure of fiscal revenue, may produce different impact. A regression analysis conducted by Guo et al. (2012) had ascertained this opinion. As mentioned before, the property tax will improve the local public service and infrastructure supply which adds to the value of house, meanwhile, increase the cost of house purchase which suppresses housing price. The overall impact of property tax on housing price is determined by which one can outweigh the other, Ding and Hu thought (Ding 2005; Hu 2007). All these studies indicate that the elasticity of housing supply, the kind of tax related to real estate, the conditions of study areas, and the double action ways, all together, bring about the diversified impacts of property tax on housing price.

85.2.6 Possible Mechanisms of Property Tax on Housing Price

As shown before, due to the different action ways, the impact of property tax on housing price has been inconsistent. So, to analyze the possible action mechanisms is of great significant to deep into the effects and their causes. Accordingly, we are going to analyze the mechanisms from the perspective of local public spending, tax shifting, cost-benefit and psychological anticipation.

85.2.7 Local Public Spending

Property tax will increase the local public spending and then have positive influence on housing price, which has been put out as early as 1970s. Based on that property tax was one kind of capital taxes, the local public spending would be limited in a low level of inefficiency as the local governments were reluctant to levy tax on floating capital, which was summarized as the competition in decreasing property tax between governments might lead to low level of local public services supply, by Break and Oates successively. In 1982, Yinger also found that the level of public services supply brought by the imposed property tax was much higher than the effective level. And then in 1991, Bucovetsky and Wilson proved that, compared to the small administrative region, the marginal public service level provided in the larger one was much closer to (but still below) effective level. The reason might lie in that the relatively high tax rate in big administrative region made the capital flow to small one and then the small administrative region could afford to provide high level of public services. It also came to the same conclusion in 21 century by analyzing the impact from the perspective of public spending. In 2005, the research conducted by Cornia and Walters also revealed that the increase of public facilities and public services assured by property tax expanded the housing demand and then raise the housing price. In 2009, Du's empirical analysis into the relationship between local public spending and property tax, and the relationship between property tax changes and housing price fluctuations, showed that local public spending had significant positive effect on housing price, and the that in the Eastern region was greater than that in the Mid-west region. In 2012, by applying the model of Local Public Services Supply to analyze the provincial panel data in China, Luo found that tax related to real estate had exemplified the supply of local public goods. As a source of local fiscal revenue, its increase would urge the government to improve public services. But interestedly, another empirical study on the relationship among property tax, public services and housing price, also by analyzing the provincial panel data in China, drew the conclusion that even the public services supply had positive effect on housing price, the tax related to real estate erected negative effect, no matter in the process of transfer or retention (Li et al. 2012). Even from the same perspective, it came to different even adverse conclusions.

85.2.8 Tax Shifting

Property tax referred to the tax levied in the retention stage, can be shifted in the housing price, but the degree of the impact on housing price depends on the relative size of the supply and demand elasticity in housing market. The researches on the supply and demand elasticity in housing market are quite common and comprehensive in English literatures, as they have constructed various theoretical models and done large quantity of empirical analysis under the support of actual data. Most of these researches show that the differences in the supply and demand elasticity result in the fluctuations of housing price. In Benjamin's study on the policy efficiency of property tax in transfer in Philadelphia, he found that due to the lack of elasticity in house supply, together with the entire borne of tax by the sellers, the property tax in transfer leaded to a short-time decline in housing price (Benjamin et al. 1993). In Cheshire and Sheppard's study on the supply elasticity in two cities' housing market in England, the Least Logarithm Square method was applied to found that the demand elasticity of these two cities were minus 1.4 and minus 0.6 respectively (Chesshire 1998). While in Loannides and Zabel's (2003) research by adopting the MHS database in American, the Regression Equation of Random Effects was established to found the demand supply here was positive, adverse to the previous research, between 0.19 and 0.66 (Loannides 2003). In Chinese literature, most of the researches got the conclusion that the elasticity is usually positive by applying various models to test the elasticity in housing market. By using a General Equilibrium Model, Peng and Wang (2009) believed that the impact of property tax on housing price depended on the ability of tax shift grafting and the flexibility of housing market elasticity. In Wang's study on the mechanism of the housing market supply and demand and the housing price in Beijing, the Variable Parameter Model was set up based on the function of housing market supply and demand to find out that the supply elasticity in housing market was more than 1.5 usually (Wang 2008). In Gao and Wang's (2008) study on the 35 large and medium-sized cities in China, they found that the demand elasticity in housing market was overall inelastic and had significant regional differences with largest in the Western region and minimum in the Eastern. The wealth effect outweighed the restraint effect in the Eastern region.

85.2.9 Cost-Benefit

Most Chinese scholars have done the researches from the perspective of cost-benefit analysis. Through analyzing from the perspective of living costs and asset returns, Yang and Xu (2007) believed that due to the rigid demand in housing market, the increase in property tax would raise the housing price undoubtedly in a short time no matter from the living cost analysis or the asset return analysis. By establishing the consumer-developer model and the investment-developer model, Kuang and Ma (2010) had done an empirical test to show that property tax brought a decline in housing price but it was quite different among regions as it worked effectively in the East while ineffectively in the Midwest. By setting up the Panel Logarithmic Model, Chen (2010) found the property tax played a positive role in housing price with 1 % increase in property tax resulting in 0.29 % in housing price by concluding that the levied property tax would increase the living cost.

85.2.10 Psychological Anticipation

It is the public anticipation changed by property tax that causes the fluctuations in housing price, in some scholars' opinions. Wang (2004) found that property tax had changed the anticipation of investment in housing market, and then affected the housing price trend. In a short term, the levy of property tax would push up housing price, but in the long run, it would suppress the housing price, demonstrated in their research. Such conclusion can also be found in Chen and Zong's research (Chen 2004). By including the uncertainty and speculation in the model, they found property tax would suppress the housing price in the long run, for it had increased the price for house renting. So property tax could be used as an effective tool to regulate the housing market, as it could decrease the public anticipation and speculative investment. By establishing a Micro Simulation Model, Wood (2006) studied the policy efficiency of property tax in Australia, and found that property tax would affect consumers' behavior in house purchasing and then affect the housing price. In other word, the property tax had changed the consumers' psychological anticipation. In Kuang's study, he had drawn a different conclusion (Kuang and Ma 2010). By setting up a Partial Equilibrium Model of housing market, he studied the impact by analyzing the investment and consumption demand of buyers and found the property tax had negative impact on housing price no matter the anticipation benefit existed or not. But when the psychological anticipation was considered into this model, the property tax would change the housing price greatly.

85.3 Research Methods

The current researches on the relationship between property taxes and housing prices are mainly statistical analysis and econometric analysis tools, mostly from an economic perspective, and also some from the management point of view. Correlation analysis and significance testing are the two common statistical methods applied to analyze the relationship. In a research in Massachusetts, Bradbury has done the correlation test on the relationship between house need and housing price after the implementation of a 2.5 % limit of property tax (Bradbury 2001). Also in a research in Sydney, the impact of property taxes and related costs on high housing price has been tested through significance testing (Chan and Chen 2011). Comparative analysis is often combined with statistical analysis to do the research, for example, case and grant has done a research on the expelled effect of the property tax increase by comparing the change of house demands and housing prices of different regions (Case and Grant 1991). Econometric analysis methods are mainly used to explore the mechanisms of how property taxes affect housing prices. Most studies have directly used the existing econometric models, of which OLS regression analysis is the most common one. The application of the OLS regression analysis can be seen in the empirical studies in Shanghai and Chongqing

Municipalities in China (Bai et al. 2012), two cities in England (Cheshire and Sheppard 1998) and so on. Some scholars have applied several classical econometric models, including the Tiebout model, the Partial Equilibrium model, and the Simultaneous Equation model. The Tiebout model is the earliest model which can be seen from Oates' study in New Jersey in 1969 (Oates 1969). The Partial Equilibrium model is the most common methods which can be seen in a research on the relationship of property taxes and housing prices in different market structures by Kuang and Ma (2010), the relationship in different taxation systems by Du et al. (2009), and the criticism of traditional way of using the Partial Equilibrium model by Zodrow and Mieszkowski (1986). The Simultaneous Equation model is a model appeared in recent researches. Hoyt has constructed a Simultaneous Equation model on housing price in 2011 to study the impact of changes in the property tax rates and changes in housing prices (Hamilton 1975). Some scholars have constructed special models dedicated to this study according to the actual situation and the theoretical analysis, of which the most prominent one is that built by a Chinese scholar, namely the consumer-developer model and the investment-developer model (Kuang and Ma 2010). Overall, the current economic model for the study of the relationship between property taxes and housing prices have been more mature, but for the management perspective, the spatial explanatory power of the model needs to be improved so as to set a reference to the management of taxes and other ways to regulate housing prices.

85.4 Conclusions and Discussions

In this review, we have combed the literature on the relationship between property tax and housing price, including the impacts and possible mechanisms, and dedicated to theorize the influence system. As few have done a comprehensive and systematic summarization on such topic, this paper is a useful attempt. Large controversy about the impact of property tax on housing price has been found, and no consistent conclusion has been formed. The opinions can be categories into four groups: public service, tax shifting, cost-benefit and psychological anticipation.

Since the 60s and 70s of last century, foreign literatures begin to focus on the relationship between property tax and housing price, while most of the Chinese literatures begin to emerge after 2000, because both the proposition and levy of levy are later than that in other countries. However, whether Chinese or foreign literature, the judgments for the housing price trend influenced by property tax are quite different from each other. This may lie in three reasons: first, the research perspectives and entry points are different, which may be the main reason as analyzed in this paper; second, the analysis for how the property tax acting on housing price is not in-depth, for the housing price can be affected by many socio-economic variables, and it is hard to peel out the influence from property tax; third, long-string data and dynamic analysis are lack in present researches, especially in China, the property tax in the strict sense has been levied in some pilot cities from 2011, so the time window is too narrow and the policy has been limited in several pilot areas, the lack of relevant data makes it difficult to do long-term and dynamic analysis.

However, these literatures still play a guiding role on the regulation of housing price using tax tool, especially when considering the complicated background and present situation. The mono revenue resource and the ever-increasing housing price have brought about the social instability, which has become a pressing need in our society. After reviewing and consideration, property tax may be one of the effective regulation ways which government can rely on. Meanwhile, more researches on this topic should be carried out both theoretically and empirically to guide the reality.

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Chapter 86
Market Expectations of Government's Measures to Promote Off-site Construction in Mainland China: Developers' Perspective

Hongjuan Wu, Chao Mao and Guiwen Liu

Abstract Off-site construction (OSC) has been recognized as a sustainable construction method with environmental and economic benefits globally. However, the promotion of OSC in China is lagged during the past twenty years, and without appropriated policies suited to the national condition. This paper aims to investigate the major differences between the government's role to promoting OSC in China and three developed countries, to further the understanding of market expectations of the most effective government measures to encourage OSC development in China. This paper adopted a combination of a comparative study and questionnaire survey. Firstly, comparative studies between three developed counties were conducted, and to explore the effective paths for reference in China. Secondly, a questionnaire survey was sent out to developers in China, which could collect market expectations of favorable measures that the Chinese government could promote OSC, 84 respondents of 200 were returned. Finally, based on the fundamental of comparative study and ranking analysis of questionnaire survey, incentive policies were found to be the most expected government measures while some reasonable technical policies were needed as well.

Keywords Off-site construction · China · Policy demand · Governmental policy

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86.1 Introduction

Off-site construction has been recognized as a sustainable mode of construction globally, with its numerous advantages, such as lower labor and material costs, higher speed of construction, enhancing building quality, higher tolerances, and reduced labor re-works on-site (Arif and Egbu 2010; Schuler 2003). And this innovation construction method has well developed and adopted in many countries around the world, for example, Japan is world's largest practitioner of manufactured construction with its considerable OSC market share (Gann 1996), the UK government commissioned reports have proposed OSM as an important contributor to progress in the construction industry since last century (Egan 1998), and the Australian construction industry has likewise more recently identified manufactured construction as a key vision for improving the industry over the next decade (Hampson and Brandon 2004).

However, the use of OSC is not widespread in mainland China compared to that of developed countries, although Chinese government has advocated OSC for over two decades. In fact, numerous factors hindering the diffusion of OSC in construction, existing both in developing and developed countries, have been investigated by a number of researchers and practitioners. For instance, cost, lead-in time, and the shortage of knowledge on OSC are well documented in previous research (Goodier and Gibb 2005; Blismas et al. 2005; Chiang et al. 2006; Blismas and Wakefield 2009; Kamar et al. 2009; Mao et al. 2013). And it is noted that lack of governmental regulations and incentives was seen as a critical element that hinder the generalization of OSC (Blismas and Wakefield 2009).

The aim of the study is to investigate whether there are any major conmen rules or differences in the Chinese Government's role in OSC promotion relative to that of developed countries. Furthermore, the market expectations of the most effective measures the Chinese Government could take to accelerate OSC development are further understood.

86.2 Different Government Roles to Promoting OSC Globally

Government behavior as a field of study has generated a number of useful critiques of the construction industry. Gann and Salter argue that government regulatory policies exert a strong influence on demand and play an important part in shaping the direction of technological change (Gann and Salter 2000). According to Dubois and Gadde (2002), this has generally been a negative influence internationally, with many government regulations and industry standards hampering innovation (Dubois and Gadde 2002).

Any new technology is inseparable from the support of governmental measures in its initial development stage, OSC is no exception. Many studies have suggested that government involvement is one of the most essential and effective means of promoting OSC. Pan (2007) claimed that the promoters including government

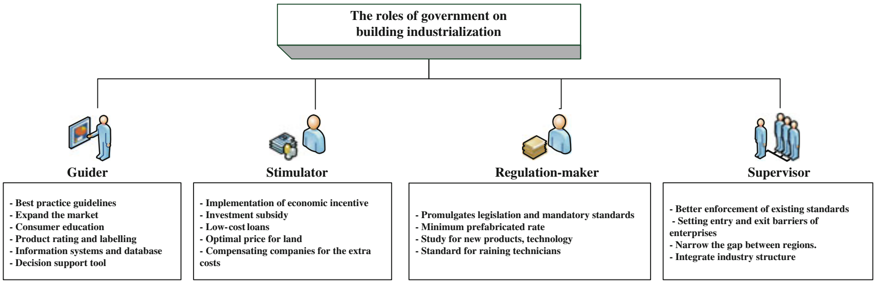

Fig. 86.1 Government's roles in the promotion of OSC

institutions, non-government organizations, private developers are crucial to the introduction and dissemination of prefabricated technology. As mentor, supervisor and facilitator, government should take measures, like making reasonable policies, to drive the development of OSC to into a healthy state (Zhang et al. 2014).

From a global perspective, government measure is the key to motivate the diffusion of OSC. In the UK, approximately £5 million had been invested by the UK government in research projects that included construction OSC between 1997 and 2001 (Gibb 2001). The Malaysian government has spared no effort to bring OSC to the drawing tables of all professionals involved in the built environment. Today, many private companies in Malaysia have teamed up with foreign expert to offer pre-cast solution to their project (IBS Survey, 2003). Singapore, the first country that formulated compulsory requirements for OSC promotion, guidelines for testing "buildability" and the regulation for assessing quality was made under its Buildable Design Appraisal System (BDAS) (Chiang et al. 2006).

However, in China, the development of OSC is not optimistic, both the nature and the scale of innovation in building industry are very conservative in comparison with other countries. Actually, most of the policies in China are lack of maneuverability, and the political system of OSC is still defective. Chinese government would do well to draw on these examples to compare and contrast its current measures with the international experience to explore effective measures that would suit the national situation.

Based on a literature review, we classified the government's role in OSC promotion into four categories: guider, stimulator, regulation-maker and supervisor. The review result is summarized in a pattern and the functions of each role of these governments are as follows (Fig. 86.1).

86.3 Methodology

The research methodologies involved in this article are literature review, comparative study and questionnaire survey. A comprehensive literature review was first carried out to identify the roles of government for the promotion of OSC and a field in-depth interview was then conducted. Subsequently, the comparative model was identified based on the analysis of the comments from interviewees, which was done to sum up the potential regular pattern of OSC development.

Then, a questionnaire survey was conducted to solicit opinions from the target respondents, who were mostly employed by property developer companies. The questionnaire consisted of 18 preliminary demands refined from literatures. And the data collected through the survey would be analyzed to find the importance degree of all these political demands. There might be some common trend be found when we combine the result of comparative study and questionnaire survey.

86.4 Comparative Study

The clarification of government roles in OSC promotion enables us to carry out a systematic comparison and critical review of existing OSC policies in the USA, Japan, Sweden and mainland China. There have been many experts tried to define the evolution phases of some countries that adopted OSC. Taking a panoramic view of the development of building industry in developed countries, this study divided the evolution process of OSC into typical three stages: initial stage, development stage and mature stage respectively (Table 86.1).

Based on a comparison of the four governments in terms of measures for OSC's promotion, the following list summaries the law of OSC development globally and situation in China:

1. The evolving of the government role basically followed the law of "guide-stimulator-supervision", and more governmental measures concentrated in the second development phase.
2. The main role of Chinese government in each stage is undefined and the stage of Chinese OSC cannot be confirmed yet. Technically speaking, the OSC of China entered the development phase (phase II), however, it is still in the primary stage from the results of industrialization and penetration of the whole country.
3. There is a severe lack of economic stimulators policy in China currently, which would hinder the progress of OSC development. The comparison shows that almost all the developed countries reached the point of evolution from initial stage to development stage by government incentive. Though this role of Chinese government restarts function these recent years, a systematic, widely applicable and mature financing scheme is still lacking.
4. Technical standards system is not thorough in China. There is a need for a representative and universal technical standard, like HUD-code in America, BL system in Japan.
5. Funding for new technology and R&D to improve industrialized techniques is limited in China.

Table 86.1 Comparative study of government role in OSC promotion in the USA, Japan, Sweden and mainland China

		Initial stage	Development stage	Mature stage
USA	Period	1930s–1940s	1950s–1970s	1980s–
	Government roles	Guider	Stimulator Regulation-maker	Stimulator Supervisor
	Political measures	• Government established the system of housing mortgage loans and guarantee system to encourage private construction and estate purchase	• Government established National Mortgage Association and Federal Resident Loan Mortgage Corporation • The Housing and Urban Development (HUD) promulgated *the national industrialized housing construction and safety standards* (1976)	• Government published the *energy star rating system* and *environmental design specification* to encourage the adoption of industrialized techniques
Japan	Period	1960s	1970s	1980s–
	Government roles	Guider	Stimulator Regulation-maker	Regulation-maker Supervisor
	Political measures	• Government formulated *five-year plan* for promoting the standardization of housing industry • Encouraging research on the uniform modulus standards for industrialized residences	• *The subsidy system for housing industrialization promotion* (1972) • *Exploitation grants system for the production technology of residential system* (1974) • Providing low interest loans for homeowners, private sector, and average annual interest rates were 30 % lower than that of commercial banks • Enacting and amending 115 Japanese Industrial Standards (JIS)	• Government published Law to ensure and promote housing quality (2000) • Government accredits Residential Part Center labelling "BL component"

(continued)

Table 86.1 (continued)

		Initial stage	Development stage	Mature stage
Sweden	Period	1950s–1960s	1970s–1980s	1990s–
	Government roles	Guider Stimulator	Guider	Guider Inventive
	Political measures	• Government made “million housing project” • Enactment of the *Residential Standards Act* Residences provided follow it can receive government loans	• Government increased the repairs, updates, and maintenance of the old residential buildings	• Established Ecological House pilot project (city of tomorrow) • Government provided dedicated funding to finance sustainable development projects since 1998 • Government set up research funding agencies (Formas) to support sustainable and environmental studies
Mainland China	Period	(1960s–1990s)	1990s–	
	Government roles	Guider	Regulation-maker	
	Political measures	• Formulate five-year plan for promoting the standardization of housing industry • Study the uniform modulus standards for industrialized residences	• Ministry of Construction set up the housing industrialization Promotion Center (1996) • Government published *pilot work of OSC modernization* and *Advices on promoting the modernization of housing industry to improve the quality of housing* (1999) • *Law to ensure and promote housing quality* (2000) • *CSI technical guide of residential construction* (2010)	

6. The obligation of Chinese government as a guider has not been fulfilled completely. No significant measures have been put in place to promote the adoption of OSC or to create a demand market.

86.5 Questionnaire Survey

To support the findings of the aforementioned comparative study, questionnaire survey data was collected and analyzed for a better understanding of the market demands of favorable political measures to further development of OSC.

The market data mainly collected from questionnaire survey. The target respondents of this formal questionnaire survey were someone mostly employed by the top 20 Chinese real estate companies in terms of annual output. The questionnaire survey was conducted in mainland China from March 18 to April 20, 2012. There were 200 questionnaires distributed via email and over the professional online questionnaire platform www.sojump.com, with 84 returned, for a valid response rate of 42 %. This study also conducts ranking and factor analyses using SPSS 17.0 software (Table 86.2).

The main question we focus on in this paper is "What are the favorable polities you need to develop OSC?", and they were asked to evaluate the degree to each item by a five-point Likert scale. The format of this typical five-level Likert item is: 1 (Strongly disagree), 2 (Disagree), 3 (Neither agree nor disagree), 4 (Agree), 5 (Strongly agree).

86.6 Data Analysis

Cronbach's coefficient alpha was used to measure internal consistency among the various factors to evaluate the reliability of the five-point scale. The value of this study's test was 0.923, which was higher than the 0.5 threshold, indicating that the five-point scale measurement was reliable at the 5 % significance level (Pallant 2010).

The mean score method was used in previous project management studies to rank the relative importance of specific factors (Chan et al. 2003). If two or more factors happened to have the same mean score, the one with a lower standard deviation (SD) was assigned a higher rank. The total average mean score was 3.58.

The mean scores and ranking of the 18 demands are shown in Table 86.3.

Table 86.2 The list of preliminary factors

Cluster	Code	Policy demands	Sources
Guiding policies	D01	Best practice guidelines	Goodier and Gibb (2005), Kamar et al. (2009)
	D02	Vigorously promote industrialized building among the masses	Pan et al. (2007)
	D03	Foster manufacturers and suppliers of prefabricated components	Blismas et al. (2005), Kamar et al. (2009), Pan et al. (2007)
Incentive policies	D04	Allowance for initial cost	Jaillon (2009), Lovell and Smith (2010)
	D05	Incentive financial policies	Blismas and Wakefield (2009), Kamar et al. (2009), Lovell and Smith (2010), Park et al. (2011)
	D06	Research founding for diverse structure study	Jaillon (2009)
Technical policies	D07	Design codes and standards for prefabricated components	Goodier and Gibb (2005), Kamar et al. (2009)
	D08	Project quota for industrialization building	Added after in-depth interview
	D09	Breaking monopoly of techniques	Chiang et al. (2006), Kamar et al. (2009)
	D10	Support from local R&D institutes and services	Blismas et al. (2005), Kamar et al. (2009)
	D11	Technologies and testing institute to prefabricated components	Kamar et al. (2009)
	D12	Regulation for storage of prefabricated elements	Blismas et al. (2005), Jaillon (2009)
	D13	Training technicians of assembly	Kamar et al. (2009), Pan et al. (2007), Park et al. (2011)
	D14	Detection prefabricated durability	Lovell and Smith (2010)
Management policies	D15	Expand the market	Jaillon (2009), Pan et al. (2007), Lovell and Smith (2010)
	D16	Integrate industry structure	Kamar et al. (2009), Pan et al. (2007)
	D17	Normalize design modify permissions	Blismas et al. (2005), Jaillon (2009), Pan et al. (2007)
	D18	Managing contractors on prefabrication	Kamar et al. (2009), Park et al. (2011)

Note The preliminary demand factors in the questionnaire are transformed from the obstructive factors which were refined from literatures

Table 86.3 Ranking of critical policy demands of developers

Code	1	2	3	4	5	MS	S.D.	Rank
D05	4	5	14	32	29	3.92	1.089	1
D04	2	5	20	35	22	3.83	0.967	2
D11	2	15	10	30	27	3.77	1.155	3
D15	3	5	27	28	21	3.70	1.027	4
D07	4	8	20	30	22	3.69	1.108	5
D17	3	14	14	28	25	3.69	1.172	6
D10	3	5	27	30	19	3.68	1.008	7
D18	4	8	18	35	19	3.68	1.077	8
D01	4	8	24	26	22	3.64	1.116	9
D16	2	11	26	25	20	3.60	1.066	11
D02	5	10	19	30	20	3.60	1.152	12
D06	2	12	25	28	17	3.55	1.046	13
D03	3	8	31	27	15	3.51	1.012	14
D08	5	10	24	29	16	3.49	1.114	15
D14	5	14	23	25	17	3.42	1.164	16
D09	7	14	24	25	14	3.30	1.180	17
D12	11	16	13	30	14	3.24	1.304	18
D13	9	12	27	23	13	3.23	1.196	19

86.7 Recommendations for Government Measures

The foregoing observations and discussion are the result of the comparative study and questionnaire findings, leads us to suggest that the following measures be considered for OSC promotion in mainland China: active government intervention is required in three main areas.

First, incentive policies should be formulated to meet the actual needs of China's building industry, which may involve both direct subsidies and different financial instruments: Subsidizing to improve OSC performance to attract users; Awarding the projects adopted industrialized technologies to stimulate the OSC market; Providing financial support to allow the industry to pursue technological innovations and R&D projects aimed at the continuous improvement of OSC; Optimal price of the construction land for OSC project or reward of constructed area; Tax credits and tax deductions.

Second, technical policies are indispensable in this developing stage in mainland China. Mandatory OSC standards should be established and implemented through legislation. Such legislation would clarify the legal liabilities of the parties involved and provide a level playing field for all players. Agreed common standards will encourage professionals to strive for excellence to capture greater market share and allow consumers to recognize genuine products. Only when consumers appreciate the benefits of energy efficient buildings will there be demand for OSC products.

Besides, the government should create demand for and appreciation of OSC products by making available OSC education programs for both building professionals and the public, widely promoting and supervising labelling programs, publishing OSC product information and implementing OSC assessment schemes.

86.8 Conclusion

This paper analysis the roles of government in enhancing OSC promotion by breaking that role into four categories: the roles of guider, motivator, regulation-maker, and supervisor. This framework has facilitated comparison of the OSC promotion measures adopted in mainland China and three developed countries (the USA, Japan and Sweden), with the aim of highlighting government OSC measures in mainland China. Some of the findings were further verified by statistical analysis of a market survey. Triangulating our analysis of the findings provided us with more reliable results, which led to a number of recommendations for measures that the Chinese Government could adopt to promote OSC. As it has been well established that the government's role is paramount in such promotion, China's Government should take the lead in developing policies and guidance to the OSC market and the public.

The findings presented in this paper demonstrate that the governments of different countries play different roles in OSC promotion in different developing stages. It is important to understand market expectations to ensure that corresponding government measures for OSC promotion are equitable and effective for the industry and consumers. OSC policy provides fertile ground for further investigation of the way forward in achieving sustainable industrialized development.

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Part XII
Information Technology for Construction Management and Real Estate

Chapter 87
The Study to Spatial Difference Modeling of Residential Land Value

Zisheng Wang and Yaohua Zhang

Abstract The residential land value management in project decision-making stage is a kind of prospective job in the course of the real estate construction. The problem of overspent construction engineering, additional investment even huge waste is universal in the field of construction investment at present. The fast and efficient method to real estate construction value calculation is especially important in order that the estimation evaluation to up-front investment is finished to large real estate projects group in a finite time. From the view of the dynamic, the research to spatial difference modeling and organizational management of real estate construction value is given in the paper.

Keywords Residential land · Value · Spatial difference modeling

87.1 Introduction

From the view of the dynamic, the research to spatial difference modeling and organizational management of real estate construction value is complex, so the research circle here is limited to "the first level residence land" and "the second level residence land" which are mainly urban residential land as state land that the right to use land is enjoyed by all owners in the urban residential areas.

The first link of real estate exploitation item is the purchase of land, which comes from two sources: the land from government must be given the land-transferring fee to the local land management department; the second one is the land purchased from other institutions whose land price is concerned here (Shao-ke 2010). The land value is the key element here no matter any forms of land sources.

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Spatial difference analysis to real estate engineering value based on GIS technology and multi-parameter dynamic mapping model through internet is advantageous to space planning and analysis to real estate large projects group (Turner and Simister 2000), decreasing the huge waste of money and the scientific project planning and management. Due to the complex constitute of the real estate construction value, in order that the government can organize and manage the real estate scientifically, the spatial difference modeling to the real estate construction value must be given based on effective data which is gotten by the system for measuring and evaluating combining quantitative and qualitative analysis (Bo and Miao 2007) based on space. The system comes from the multi-parameter dynamic mapping model (Zhao et al. 2007) by the fuzzy mapping theory (Wang et al. 2004) and the identification to mapping process basic reason.

The value of residential land, as an important part of the real estate value, is generally 30 % of the total value. Land transfer fee and floor price are different among different place, different area and different project (Jun and Wang 2010), based on which design by analysis to spatial difference modeling of residential land value may play the advantage of GIS technology, give real-time processing to the multi-domain dynamic data, forecast the preemptive investment benefit to real estate in different region, and compare the benefit of investment from different stages of different schemes.

87.2 Spatial Difference Modeling

Engineering value management in project decision-making stage is premise of project design (Li et al. 2012), from which the right value forecast can make real estate enterprises in an invincible position in the fierce competition. It is the spatial difference model of the residential land and analysis of some other construction value in the future study in the different stages of different areas that will provide the forward-looking data for the spatial planning of real estate.

The mapping mathematical models of real estate project value projection and quantitative mathematical expressions and their Error detection methods to each parameter factor make full use of multi-parameter dynamic mapping model, especially subsection modeling index (Spohrer et al. 2007) in the models can give the budget of investment returns to real estate in different stage and restricted area, which provide a broad space for the scientific organization and management to real estate. There is no recognized method among experts for the quantitative analysis to impact factors themselves which forecast real estate value, among which lie the intricate relations and influence with each other, so the real-time analysis to dynamic process (Chesbrough and Spohrer 2006) for the forecasting research of real estate value can grasp the market pulse and promote the rapid and sound development of real estate engineering value management.

Table 87.1 Value statistics of residential land in 2010 in Jinan City

Factor	A	B	C	D	E	F	G	H	∑/8
Highest	3510	3410	3410	3300	3300	3300	3250	3250	3341.25
Highest frequency	3300	3250	3240	3215	3220	3250	3200	3200	3234.375
Lowest	3120	3120	3130	3130	3140	3140	3150	3150	3135
AVG	3310	3260	3260	3215	3220	3230	3200	3200	3236.875

87.2.1 Initial Processing to Static Value Data

Due to complex factors of the residential land value (Sirmans and Slade 2012), the multi-parameter dynamic mapping model will be elaborated in other research achievements. The confidence interval and spatial differentiation analysis of residential land value in the meantime are calculated from regional land value (Hanink et al. 2012) in the paper. The data in the paper is from the investigation to dozens of residential quarters, such as Luneng Brought Show City, China Golden Sunlight Garden, Fellows Heights and Calendar Mountain Ming County, etc. Initial analysis to eight sets of survey data is given as following (Table 87.1, Units: 10,000 yuan/mu).

The data in Table 87.1 can be divided into four intervals with "quarter-separated method", where the data should be filtered with spatial difference modeling method, so that the spatial difference distribution map can be drawn. The positions where the quartiles lie are decided based on the frequency matching along with the unit value (2.1.1).

$$\left.\begin{aligned} Q_1\,position &= \frac{\sum f}{4} \\ Q_2\,position &= \frac{\sum 2f}{4} \\ Q_3\,position &= \frac{\sum 3f}{4} \end{aligned}\right\} \tag{2.1.1}$$

The next step is the calculation to cumulative frequency. The variable value in the group of accumulative total frequency where the quartile lies is exactly the quartile. The four groups of data is thus given from the minimum land value to the highest land value: 621–1240, 1240–1580, 1580–1921 and 1921–2500.

87.2.2 Basic Steps to Spatial Differentiation Modeling

Residential land value based on the survey data is obviously regular in the spatial distribution. According to the given data (Table 87.1), the model is given first as far as the value between 621 and 1240 yuan RMB per mu, which can "filter" some superfluous data which can influence modeling.

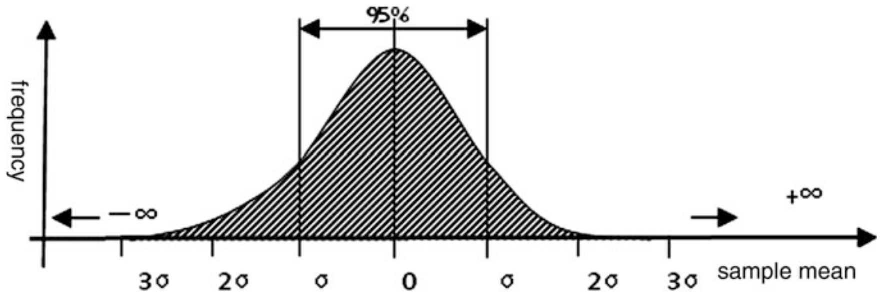

Fig. 87.1 Sampling standards schematic

Sampling standard

The Interval is estimated with Standard Deviation and Sample Mean. The upper and lower limits of the Interval (Fig. 87.1) to sampling area are made sure in the restriction that 95 % of the sample data in the given circle is choosen and standard error of the mean is σ.

- Overall average valuations of residential land value based on the sample drawn

$$\bar{x} = \frac{1}{n}\sum_{k=1}^{n} \mu_k = 1006 \tag{2.2.1}$$

The residential land value from 2.2.1 is the quantitative evidence of regional differences to residential land value in a specific time and regional conditions.

- The interval estimation of the residential land value.

The confidence interval in the none repeated sampling precondition:

$$\begin{aligned} \bar{x} + t_{\frac{\alpha}{2}}\delta_{\bar{x}} &= \bar{x} \pm t_{\frac{\alpha}{2}}\sqrt{\frac{s^2_{(n-1)}}{n}\left(\frac{N-n}{N-1}\right)} \\ &= \left(\bar{x} - t_{\frac{\alpha}{2}}\sqrt{\frac{s^2_{(n-1)}}{n}\left(\frac{N-n}{N-1}\right)},\ \bar{x} + t_{\frac{\alpha}{2}}\sqrt{\frac{s^2_{(n-1)}}{n}\left(\frac{N-n}{N-1}\right)}\right) \end{aligned} \tag{2.2.2}$$

In the 2.2.2,

$$\mathrm{s_{n-1}} = \sqrt{\frac{\sum (x_i - \bar{x})^2 f_i}{\sum f_i - 1}}, \quad t_{\frac{\alpha}{2}} = 1.96,$$

N stands for Overall sample, n stands for sampling sample.

The value range of residential land in the sampling area is (640, 1229) based on 2.2.2. Overall, the value range of the residential land in the sampling area is based on the 95 % confidence level. The data in the interval is regarded as the foundation of spatial difference modeling, which can exclude the influence to residential land value from the irregular factors.

87.2.3 Spacial Difference Distribution Map

The data analysis of spatial distribution modeling to the data which is outside the scope of the 621 and 1240 is given based on the basic steps in spatial differentiation modeling, which leads to the space difference distribution map (Fig. 87.2) of residential land value. The sampled data whose region can be divided into four levels is limited to Jinan city. The bigger research area, the more obvious spatial difference to residential land value, it's more advantageous to the organizational management of the real estate large projects group.

The overall average valuations of residential land value in other months can be gotten based on the spatial distribution modeling method. Furthermore, the history value to the residential land can be given with the method so that the value trends can be forecasted. If the variation trend to residential land value is calculated accurately, It's necessary to analyze the weight of some factors, such as economic cycle, government policy, political factor, social factor, seasonal factor,

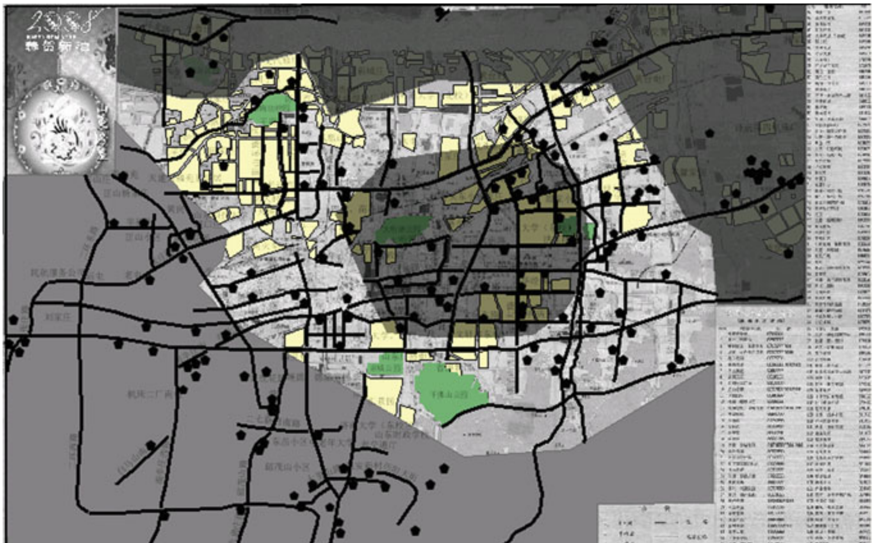

Fig. 87.2 Space difference distribution. Map of residential land value in 2010 in Jinan City

psychological factor, financial and monetary factor, etc., so that the calculating result here can be adjusted dynamically through a dynamic data platform for the spatial distribution modeling to the large real estate engineering group, and the forecast accuracy to the land value trend can be improved greatly.

87.2.4 The Real-Time Calculation to Land Value Based on the Dynamic Data

The budget model of multi- parameter dynamic mapping is given based on dynamic parameters, and a dynamic data platform is provided for the spatial difference model of the residential land in a large real estate projects group. It's only the first step that the investigated data are calculated directly to analyze the spatial difference model to the residential land value. It's indispensable to find main factors to influencing ones so that forecast the residential land value (Wang and Bian 2007). Some influence factors themselves are not stable, so the weight of every element should be adjusted continuously, based on which the value interval to residential land is not fixed value, the same as the spatial data difference modeling, but relatively stable in short periods, which can get the trend of the residential land value. The realization of accurate forecasting function depends on that the model to the spatial difference model can scan the calculation result of every dynamic sub module consistently, thus the high-quality forecast to the value can be realized and the error can be pared down to a bare minimum.

87.3 Conclusion

The system of the assessment combined quantitative and qualitative analysis have much more pertinence and effectiveness. First of all, the accurate Confidence Interval can be calculated to maximum realization based on the mathematical method of probability and parameter estimation; secondly, the space difference distribution map to each part of construction value can be overlapped into space difference analysis results of the total real estate construction value, so that unified tax administration and supervision can be implemented to large real estate projects group. Furthermore, the expanding the range of abnormal trading land pieces means that the Land Department will monitor land price changes of each county city, which can be realized based on the spatial difference modeling to large projects group. At present, the perfection to spatial difference modeling method may present a forewarning timely for the fluctuation of the real estate value in the third and fourth line of the city.

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Chapter 88
Opportunities of Building Information Modelling in Australian Offsite Manufacturing

Sherif Mostafa, Nicholas Chileshe and Jian Zuo

Abstract Offsite Manufacturing (OSM) is a modern construction method for the future of Australian house building due to its potential capacity in meeting the growing housing demand. Previous studies have proved the benefits of OSM in housing supply and quality. However, the application of OSM in Australia is limited to some challenges which could be classified into three groups: managing two working locations, house customer preferences, and house builder's capacity. With the recent development of the Building Information Modelling (BIM), these challenges could be overcome through using BIM within the OSM supply chain. This paper aimed at discussing the opportunities of applying BIM in OSM in Australia in the light of existing literature using a systematic approach. As a result, the following five main OSM barriers have been identified and analysed with respect to BIM: (1) low level of OSM knowledge, (2) initial cost, (3) negative perception on OSM products, (4) longer lead times and (5) freeze design and specification at early stages. The discussion of integrating BIM to OSM conducted in this study could lead to future research on the five barriers and validity of the integration. Overcoming the barriers could expand the opportunity of OSM adoption in future Australian house building.

Keywords Australian house building · OSM barriers · BIM-OSM opportunities

88.1 Introduction

The offsite manufacturing (OSM) involves two working sites: off-site factory and onsite construction. It is considered as a key innovative method for the future of Australian house building due to its potential capacity in meeting the growing housing demand. It has been revealed that the opportunities of OSM in Australia are

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centred on detached and semi-detached housing, high-density multi-residential complexes, and public facilities such as hospitals and schools (Blismas and Wakefield 2009). Previous studies have proved the advantages of OSM in house productivity and quality. However, the application of OSM in Australia is limited due to some challenges which could be classified into three groups: managing two working locations, house customer preferences, and house builder's capacity. Dealing with factory and construction sites provides potentials of lack of coordination between the two sites activities and jumbled on-site processes. The house customers is vague and dynamically change which leads to slow response to achieve the demand in short time (Chang and Lee 2004). The Australian house builder's capacity includes skilled labour force, machinery and construction methods and techniques. Some conservative builders are not adopting OSM as it needs a structural variation of the house building supply chain. This means a high level of information technology is required to stream the OSM processes. Some builders and customers have a negative perception about OSM products as it freezes the house design at early stages (Manley et al. 2009).

With the recent development of the Building Information Modelling (BIM), these challenges could be overcome through integrating BIM into the OSM supply chain. The National BIM initiative report recommended that Australian Government should mandate full collaborative BIM based on open standards for information exchange from July 2016 (buildingSMART Australasia 2012). The results of the survey conducted by Newton and Chileshe (2012) indicated the benefits of BIM in the Australian construction industry. These benefits include better design, improve information sharing, productivity, quality, and customer services. This paper aimed to analyse the impacts of BIM integration to OSM in Australia in the light of existing literature using a systematic approach. Five OSM barriers have been identified and analysed with respect to BIM. The barriers are low level of OSM knowledge, initial cost, negative perception on OSM products, longer lead times, and freeze design and specification at early stages. Promoting BIM to OSM provides a framework for future research to further explore the validity of these barriers.

88.2 Research Methodology

The research aims at discussing the impacts of BIM to the OSM house building supply chain. To achieve the aim, the study employed the literature review methodology. A review of background studies was conducted through exploring the opened online databases. The databases included Emerald, Elsevier, Taylor and Francis and American Society for Civil Engineers. Moreover, some published reports from Australian government and housing industry alliances were included in the search including cooperative research centre for construction innovation, national housing supply council, and *BuildingSmart* Australasia. Data collection from the databases focused on the OSM barriers and BIM drivers in Australia. The research processes were as follows:

Stage 1: Screening the collected data to classify the limitations of adopting OSM in Australia housing building environment and understanding the BIM benefits for house building in Australia.
Stage 2: Discussing the BIM benefits to the OSM to understand the house building process.
Stage 3: Explaining how BIM could overcome the OSM limitations in Australia.

88.3 Research Findings

The search process revealed a total of 115 relevant publications dated from 2002 to 2014. The term OSM has been used interchangeably with Off-Site Production/Fabrication (OSP/OSF), preassembly, modularisation, and off-site fabrication (PPMOF) (Pan and Goodier 2012), and the industrialised building systems (IBS) (Shukor et al. 2011). The drivers and barriers of OSM were summarised in Table 88.1 from different construction contexts including China, Hong Kong, japan, Malaysia, New Zealand, Sweden, UK, and US. The drivers and barriers of OSM in Australia were highlighted in few research studies. Most of the literature on BIM in the AEC, in Australia, were focused on providing awareness on the benefits of BIM (Newton and Chileshe 2012), project cost management (Smith 2014), and accident prevention (Kamardeen 2012). Adopting BIM in OSM for Australian house building was found minimal in the selected materials. Therefore, this study contributed to overcoming the OSM barriers with the use of BIM. The research findings are discussed as following.

88.3.1 Offsite Manufacturing in Australia

OSM refers to the fabrication of house components in an offsite factory and their subsequent activities on a construction site (Goulding et al. 2012). It provides several benefits including improving onsite safety by providing cleaner and tidier construction site as well as enhancing quality of the house components under factory production. Moreover, OSM reduces environmental effects by reducing waste generation, shortening lead time and increasing the efficiency and productivity (Zhai et al. 2014). Previous studies positively addressed OSM in the Australian built environment. Hampson and Brandon (2004) suggested OSM as a key vision for improving the performance of construction industry with in the period from 2004 to 2019. Two construction research projects carried out by Blismas (2007) and Manley et al. (2009) confirmed that OSM has capability to produce high-volume and high-quality houses based on the efficiencies of the manufacturing principles. Three major challenges arise from the management of two working sites concurrently. These challenges are the potential for lack of

Table 88.1 Summary of OSM drivers and barriers stated in the literature

		OSM drivers									
		Time	Quality	Final product cost	Productivity	Human skills	Logistics and process	Customer preferences	Environmental	OS&H	Waste removal
Arif and Egbu (2010)	China	*	*		*				*		*
Blismas et al. (2005)	UK	*									
Blismas et al. (2006)	UK										
Blismas (2007)	Australia	*	*		*	*			*	*	
Blismas and Wakefield (2009)	Australia	*	*		*	*			*	*	
Goodier and Gibb (2007)	UK	*	*								
Larsson and Simonsson (2012)	Sweden	*	*	*			*		*	*	
Manley et al. (2009)	Australia	*	*		*	*			*	*	
Elnaas et al. (2014)	UK			*					*	*	
Javanifard et al. (2013)	US		*	*	*						
Johnson (2007)	Japan		*	*				*	*		

(continued)

Table 88.1 (continued)

		OSM drivers									
		Time	Quality	Final product cost	Productivity	Human skills	Logistics and process	Customer preferences	Environmental	OS&H	Waste removal
Russell et al. (2012)	Australia		*		*						
Shukor et al. (2011)	Malaysia										
Tam et al. (2006)	Hong Kong		*	*							*
Prefab (2013)	New Zealand	*	*	*	*		*			*	*
Zhai et al. (2014)	China			*							

		OSM barriers							
		Process	Initial cost	Regulatory	Industry market and culture	Leadership	Supply chain and procurement	Skills and knowledge	Logistics and site operations
Arif and Egbu (2010)	China		*	*			*	*	
Blismas et al. (2005)	UK	*		*	*		*	*	*
Blismas et al. (2006)	UK						*		
Blismas (2007)	Australia	*	*	*	*	*	*	*	*
Blismas and Wakefield (2009)	Australia	*	*	*	*	*	*	*	*
Goodier and Gibb (2007)	UK		*		*			*	

(continued)

Table 88.1 (continued)

		OSM barriers							
		Process	Initial cost	Regulatory	Industry market and culture	Leadership	Supply chain and procurement	Skills and knowledge	Logistics and site operations
Larsson and Simonsson (2012)	Sweden	*	*						
Manley et al. (2009)	Australia	*	*	*	*	*	*	*	*
Elnaas et al. (2014)	UK	*	*	*				*	*
Javanifard et al. (2013)	US		*	*	*			*	*
Johnson (2007)	Japan	*	*				*	*	
Russell et al. (2012)	Australia								
Shukor et al. (2011)	Malaysia		*	*	*			*	
Tam et al. (2006)	Hong Kong								
Prefab (2013)	New Zealand				*	*			
Zhai et al. (2014)	China	*	*				*	*	*

* Presence of the OSM driver within the study

coordination between the offsite and onsite activities, the jumbled on-site processes due to difference between the production flow at offsite factories and construction flow on-site, and the vague demands from undecided customers (Chang and Lee 2004). These challenges might leads to slower response to achieve customer order. Some attempts has been carried out to overcome these challenges by suggesting transferring successful concepts from other industries like manufacturing (Blismas 2007; Mostafa et al. 2014). However, adopting Information and Communications Technology (ICT) such as BIM applications were found minimal.

88.3.2 Building Information Modelling in Australia

Building information modelling (BIM) is an information technology which facilitates storing, managing, sharing, accessing and updating all data related to a project throughout the project life cycle (Yan and Damian 2008). BIM is a set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a facility (Succar and Sher 2014). The adoption of BIM is widely recognised as having the potential to change the managing and executing the construction projects (buildingSMART Australasia 2012). Newton and Chileshe (2012) mentioned that BIM has capabilities to foster the cooperation and understanding between stakeholders in the Architecture/Engineering/Construction (AEC) industry. It helps to reduce design errors and omissions which results in minimising the lead time (Aibinu and Venkatesh 2014). BIM employs visualisation tools for a building model which embedded of smart elements. As a result, it enables the extraction of information about each element. BIM is not restricted to three dimension (3D) graphical model. But, a building model can be 3D graphical model, fourth dimension (4D) time model, fifth dimension (5D) cost model, sixth dimension (6D) facility management model, or nD model which combines multi-issues of design information (e.g. energy savings, acoustic, thermal) throughout a building project lifecycle (Kamardeen 2012). This allows eliminating the inconsistent design concepts (Greenwald 2013). In house building, using BIM models provide builders with more flexibility to achieve the customers demand (CMHC 2013). House customers can select the house design using 3D visualisation with time and cost estimation using 4D and 5D models. Furthermore, BIM simplifies the prefabrication or preassembly of building elements which can minimise work needed on site, and therefore, reduce risks by allowing complex tasks to be undertaken in more controlled environments (Philipp 2013).

88.3.3 Drivers and Barriers of OSM

Adopting OSM in producing building components has numerous drivers as demonstrated in Table 88.1. According to Gibb and Isack (2003), reducing the construction time was the first highly rated benefit and have impact on the construction costs. Improving the quality of the construction product is considered as a major benefit of applying OSM (Blismas and Wakefield 2009). Reducing construct/design cost could be reduced by adopting OSM (Jaillon and Poon 2010). As the OSM includes modular design and standard prefabricated elements that save time and cost. The OSM has a major role to improve the productivity by allow parallel activities taking place onsite and offsite. Therefore, it reduces the disturbance of onsite construction (Gibb and Isack 2003). The human resource category includes labour force working onsite and offsite, and safety of their work environment. Blismas and Wakefield (2009) highlighted the skills shortage is a prominent benefit to adopt OSM in Australia. The OSM can provide a controlled work environment onsite and offsite. This results in reducing the occupational health and safety (OS&H) risks. OSM manages the logistics and onsite operations through fewer trades and interfaces between the two working sites. Therefore, Manley et al. (2009) stated that the transport and logistics operators are the key stakeholders for OSM organisations. OSM provides customers with a high customisation for their products. Customers have flexibility to select or modify the design the prefabricated elements (Goodier and Gibb 2007). Furthermore, environmental sustainability is a major driver of OSM particularly after the increase of the environmental awareness (Goodier and Gibb 2007). The take up of OSM in the construction industry contributes to a high level of environmental sustainability (Zhai et al. 2014).

On the other hand, there are some barriers affecting the adoption of OSM. Identifying these barriers is significant to promote its application of OSM in the construction industry. It can be seen in Table 88.1 that the barriers stated in the literature are highly varied because of different construction environment characteristics. Goodier and Gibb (2007) concluded that the resistance to adopt OSM in the UK is deeply rooted to the unsuccessful past experiences associated with the OSM. The rigidity of design modifications and higher initial construction cost are the main barriers to the application of OSM in the Hong Kong housing construction (Tam et al. 2006). The customers and consultants show a reluctant to apply OSM because of freezing the design in the early stages. The factors impeding the OSM of housing construction in China were reported by Zhai et al. (2014) and Arif and Egbu (2010). The main challenging factor is related to the cultural shift nature from the customers' perspectives. Moving towards new types of construction products, customers are not familiar with, is possibly a shift in culture and attitude. The barriers to the application of OSM in U.S. construction industry including consumers and marketing, labour, builder resistance to change, and regulatory process (Javanifard et al. 2013). In spite the OSM barriers, it is believed that OSM has a potential to benefit the construction industry and has potential in the wider context of housing supply (Blismas and Wakefield 2009; Pan and Goodier 2012; Zhai et al. 2014). Supervision can lead to achieving better environment and quality. As a result, long-term construction costs can be reduced.

88.4 Discussion of OSM Barriers in Australia in the Light of BIM

88.4.1 Barriers of OSM in Australia

Some studies identified the OSM barriers in Australia. The research project conducted by Blismas (2007) identified the main barriers of OSM based on the outcome of seven case studies. Another study of Blismas and Wakefield (2009) covered the commercial and residential construction across the four Australian States (Victoria, Queensland, New South Wales, and Western Australia). Manley et al. (2009) highlighted two most important barriers: skills shortages and inadequate understanding of OSM in Australia. OSM needs higher onsite precision, than tradespeople are accustomed to, due to low tolerances of prefabricated elements interfaces. Therefore, OSM requires specific training for onsite operations and trades. Most of the stakeholders have limited expertise in OSM as it is a new method of construct a building.

Figure 88.1a summarises the significance of the OSM barriers in the literature review of the following eight housing contexts: Australia, China, Japan, Malaysia, New Zealand, Sweden, UK and US. It can be seen that the five most significant OSM barriers are (1) process; (2) initial cost; (3) industry market and culture; (4) supply chain and procurement; and (5) skills and knowledge. Australia has similar OSM barriers to other housing contexts as shown in Fig. 88.1b. The description of the five main categories of OSM barriers in Australia is provided in Table 88.2. The first category covers the OSM process which includes longer lead time, and freeze design at early stages. The cost category contains the initial cost and seeing OSM expensive compared to traditional construction. The third category describes the resistance of the housing industry and market in Australia. This includes the perception of low quality for pre-built products and lack of customisation. The fourth category is the logistics and onsite process. The final category is the covering the lack of professional and trades skills and knowledge of OSM in Australia.

88.4.2 OSM Supply Chain

For successful integration of BIM with OSM, it is significant to understand what consists the OSM supply chain, and material and information flows. A supply chain consists of all parties that directly or indirectly try to fulfil a customer demand. Chen and Paulraj (2004) simplifies the supply chain as a network of materials, information, and services processing links with the characteristics of supply, transformation, and demand. Therefore, OSM supply chain includes the suppliers, manufacturer, transporters, warehouses, distributors, retailers and customers. Successful. Management of OSM supply chain includes coordination and integration,

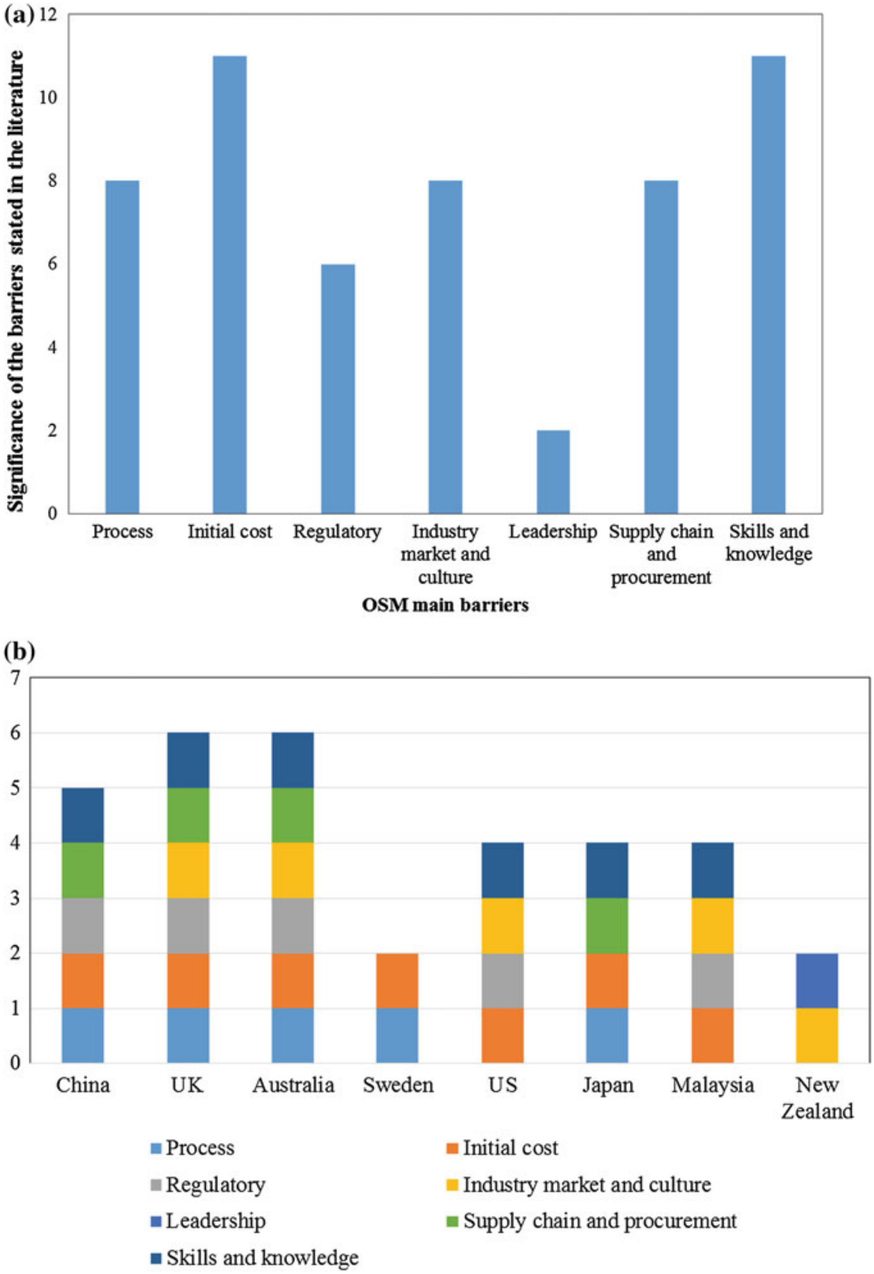

Fig. 88.1 **a** Significance of OSM barriers. **b** Association of OSM barriers within the eight housing contexts

Table 88.2 Description of main OSM barriers categories in Australia

Barrier category	Description
1. Process	Longer lead times
	Inability to freeze design and specification at early stages of the house building
	High fragmentation in the construction industry
2. Cost	Seen as expensive when compared to traditional methods
	High initial cost
	Obliged to accept element-specific costing
	Clients having difficulties understanding the benefits
3. Industry market and culture	Deep rooted pessimism over past mistakes rather than a determination to learn from history
	Clients view OSM as standardised and lacking any customisation
	Strong client perception that OSM, quick-built products are of lower quality
4. Logistics and process	Onsite ergonomics through site layout and obviating raw material storage
	Difficulties in stock/inventory control
5. Skills and knowledge	Lack of skills by professionals in OSM
	Lack of skills in manufacturers/suppliers to enhance OSM efficiency
	Lack of industry R&D
	Lack of knowledge repository portal

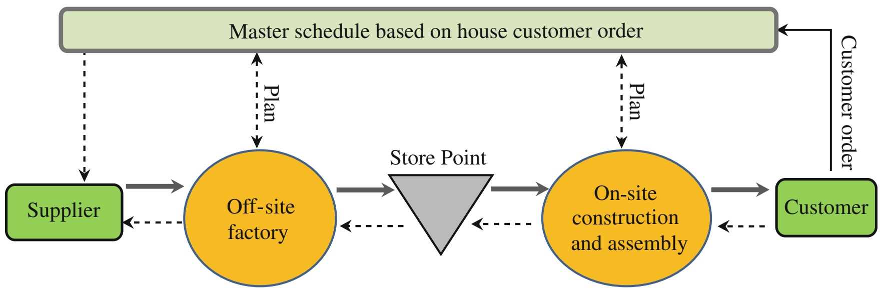

Fig. 88.2 Material and information flow between the OSM two working locations

cooperation among chain members, and the movement of materials to the final customer. The OSM house building supply chain could be visualised as shown in Fig. 88.2.

The OSM supply chain must be managed to achieve the house customer demand. This can be achieved through maximising house quality, service level (customer/product support, product service and flexibility to meet customer demands), safety, and sustainability. Whereas, minimising the house completion time and construction costs.

88.4.3 OSM Barriers in the Light of BIM

Both OSM and BIM are considered as innovative methods for enhancing the construction industry performance in Australia (Manley et al. 2009). OSM has the capacity to increase the supply of housing to meet the growing housing demand. The OSM built-in a high quality within the delivered houses. However, the OSM activities might carry some uncertainties (i.e. changes in customer demand, stakeholders and site conditions) which result in unpredictable delays to achieve the customer demand. Employing BIM with OSM would proactively enhance the reaction towards these uncertainties. BIM models the elements of a house (e.g. wall and floor panels, and roof trusses, windows, doors), attributes and relationships. Therefore, this study is rooted on this association and focused on promoting advantages from BIM implementation to OSM in Australia. This study acknowledged the works of Ezcan et al. (2013) for promoting BIM to the OSM in the UK construction industry and Nawari (2012) for providing BIM standard for off-site construction in Malaysia. However, this research scope is focuses only on OSM in Australia. A literature review covered all the OSM studies carried out in Australia to identify the OSM barriers. The following is the discussion of the main five barriers of OSM in Australia in the light of BIM benefits stated in the literature.

88.4.3.1 Inadequate Level of OSM Knowledge

As OSM is non-traditional building, the stakeholders might have inadequate level of experience (Manley et al. 2009). This includes designers, contractors, and trades. The stored information on each house element in the BIM environment and the capacity to utilise 3D and 4D models are considered helpful for contractors and trades in the manufacturing and assembly process. Moreover, BIM has the capacity for run simulations for each model which can be used for training purposes. As a result, it can improve the limited experience of the stakeholders involved (Gray et al. 2013; Gu et al. 2007; Yan and Damian 2008).

88.4.3.2 Initial Cost

The initial cost of employing OSM is considered high due to the limited skilled workforce and resources, transportation of elements, and onsite costs. BIM has capabilities to monitor and control the costs and the cash flows through all stages of completing a house. In addition, training and improving the labours would reduce the construction costs (Nawari 2012; Yan and Damian 2008).

88.4.3.3 Negative Perception on OSM Products

OSM products has a negative image in Australia due to the past mistakes (Blismas and Wakefield 2009). Therefore, house customers and some builders have a resistance to change the traditional houses and construction methods. BIM could contribute to change this conservative view of customers and builders. The pre-construction simulations using BIM virtual environment would enhance the adoption of OSM in Australia. Moreover, the utilisation of BIM models (3D, 4D, nD) would help to reduce costs optimising schedules, satisfying customer on house design. This will built a solid ground for OSM (Ezcan et al. 2013; Nawari 2012; Yan and Damian 2008).

88.4.3.4 Longer Lead Time

Managing with factory and construction sites provides potentials of lack of coordination between the two sites activities and jumbled on-site processes (Chang and Lee 2004). The utilisation of the BIM 3D visualization and 4D time models provides accurate scheduling. As a result, it helps to smooth the manufacturing processes of house elements, better logistics for transportation between the two sites and improved cooperation among all stakeholders (Nawari 2012).

88.4.3.5 Freeze Design and Specification at Early Stages

It is difficult to modify the design of the house elements during the manufacturing processes. Usually, the modification is due to changes in customer demands or difficulties at the construction site (Blismas and Wakefield 2009). The 3D visualisation model of the house embedded all the information about each element. This means customers have flexibility to see the 3D model of their houses and can change the design before the manufacturing process. Moreover, the BIM models for a house are able to discover design inconsistencies, clashes and omissions and give users the chance to solve possible conflicts before occurrence. This helps to reduce rework and lead time by eliminating any alteration needed during the construction (Gray et al. 2013).

88.5 Conclusion

Integrating BIM with OSM could enhance the housing-supply performance in Australia to meet the growing demand. BIM has capabilities to store and share the information among the stakeholders involved in the house building process. Moreover, it provides the extraction of different models (3D, 4D, 5D, 6D, nD) for a building. These advantages provide a platform for combining BIM with modern methods of construction. OSM is an innovative method for delivering houses with low cost and completion time, and high quality. According to this study, the adoption of OSM in Australia is limited to the five main barriers through the existing literature. These barriers are low level of OSM knowledge, initial cost, negative perception on OSM products, longer lead times and freeze design and specification at early stages. The study argued that the OSM barriers in Australia could be overcome through the implementation of BIM. The integration of BIM to OSM conducted in this study could lead to future research on the five barriers and validity of the integration. Overcoming the barriers could expand the opportunity of OSM adoption in future Australian house building.

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Chapter 89
A Preliminary Study on the Framework and Technologies for Bridging BIM and Building

Ke Chen, Weisheng Lu and Yi Peng

Abstract Currently, Building Information Modeling (BIM) has been increasingly used in the Architectural, Engineering and Construction (AEC) industry, and the exploration of BIM focuses on the design and some parts of the construction process. One of the major problems that limits the usage of BIM is that it generally contains up-designed information which is time-consuming and error-prone to manually update in the following stages of the construction project. The virtual model without real-life information can hardly support decision-making throughout the lifecycle of the project. This paper develops the framework for bridging BIM and buildings, and discusses the use of some technologies including radio frequency identification (RFID), laser scanner, webcam, local area network (LAN), and personal area network (PAN) to collect and transfer real-life information. It is emphasized that the availability of real-time information is essential for lifecycle management. BIM will be an ideal platform to provide real-time information if it is well connected with real-life processes through those technologies.

Keywords Building information modeling (BIM) · Physical processes · Auto-ID technology · Real-time information · Project management

89.1 Introduction

Project management is always a complex and critical part in a construction project as it not only determines efficiency, safety, and cost control but also affects precision and clients' satisfaction (Love et al. 1999; Tserng et al. 2006; Xue et al. 2007).

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Information, which continuously flows throughout the project life cycle, is of vital importance in the management practices and decision making process (Chau et al. 2003). For example, establishment of the construction plan needs various information such as the surrounding environment, orientation of the building, details of material, the delivery time of each material, and the status of equipment or machinery. Besides, facility management, during the operation stage, requires information such as the location and historical maintenance record of each facility.

As one of the most promising technology, Building Information Modeling (BIM) has been introduced to the Architecture, Engineering and Construction (AEC) industry to facilitate project management. According to the National BIM Standard (2012), 'a BIM is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition'. This is to say BIM is an information-rich and object-oriented 3D digital representation of the building, which integrates the architectural model, structural model and Mechanical, Electrical and Plumbing (MEP) model.

Many researches have been carried out to explore the utilizations and benefits of BIM in construction projects, including the adoption of BIM as a learning tools in the real-life construction works (Lu et al. 2013), the simulations on BIM to improve the project design (Azhar et al. 2008), a BIM-based system intended for assessing the energy performance of the building (Schlueter and Thesseling 2009), and the use of BIM to achieve lean construction (Sacks et al. 2010).

However, in current practice, the use of BIM in a construction project is limited because the information contained in the BIM model cannot always reflect the actual situation. Disconnection between the BIM model with the physical building make the model unable to support decision-making throughout the project life cycle. The reason may reside in the lack of a conceptual framework highlighting the theoretical perspective of bridging BIM and buildings.

In order to make BIM more powerful in the construction project management, this research aims at developing that framework and discussing the use of some technologies which help to connect the BIM model and the corresponding physical building for several management practices at various stages of the construction project.

89.2 Methods

The study mainly consists of three steps.

The literature review is conducted which focuses on the use of BIM to support project execution and approaches to acquire real time information at different stages of a construction project. The function and applications of various information and Auto-ID technologies adopted in the AEC industry are studied.

The next step is the development of the framework. The authors have participated in several workshops and carried out brainstorming activities, in addition to the literature review, to get a comprehensive understanding of the information needed for decision-making and possible technologies.

The final step is to evaluate the validation of the framework. Feedbacks from stakeholders and experts in the AEC industry act as the reference for further improvements of the framework. Thus, its feasibility can be better explored. Currently, the evaluation test conducted in an actual project is in progress.

89.3 Framework

As shown in the Fig. 89.1, the framework contains three layers and two directions of information flow. The three layers are integrated together to optimize decision making.

The physical layer consists of physical activities at different stages of the project. Generally, the implementation of those activities requires inputs such as material, labour, machinery, and time. Meanwhile, each activity can generate a certain amount of information, such as the quantity of waste, the status of machinery, total cost, quality and schedule overruns. The real-time information with satisfactory level of accuracy is of vital importance for effective project management. Therefore, the site and construction operation by individuals are required to be continuously

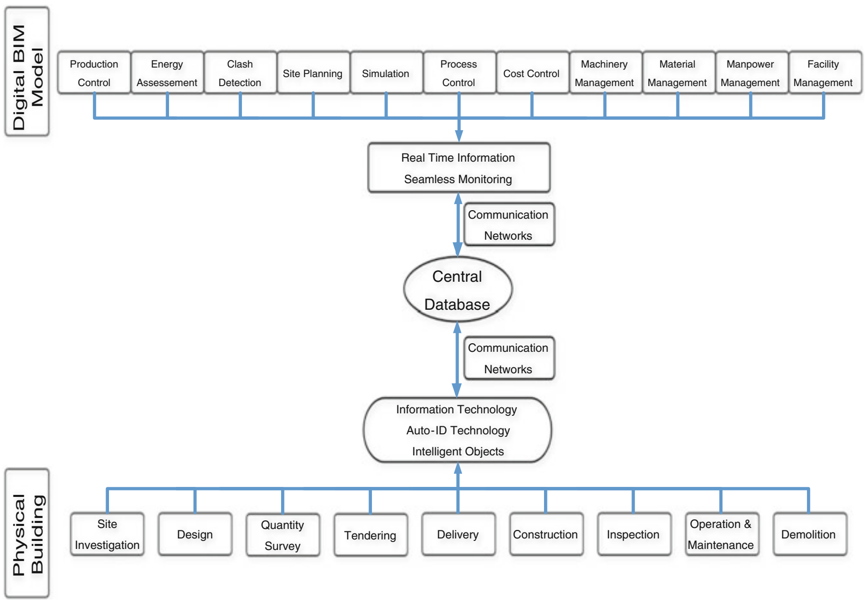

Fig. 89.1 Framework

monitored and the building components will be automatically tracked by information-capturing technology and Auto-ID technology.

The BIM layer contains the shared BIM model and decision support system. The original BIM model that is developed in the conception and design stage will be kept updated throughout the project. Based on the real-time information from the physical layer, the BIM model will assist decision support systems to carry out a number of project management practices such as Simulation or Manpower, Material, and Machinery Management (M3M). Conversely, if there is a need for design change, the change will be demonstrated in the BIM model, where the affected building components can be highlighted and noticed. Additionally, the change is recorded in the central database and transferred to the physical layer for instructing the construction work.

The information captured from the physical construction is firstly transported to the central database. The advantages of the central database are: firstly, it eliminates overburden of BIM through not putting all the information and data in the BIM model; secondly, only authorized stakeholders can obtain and modify their corresponding information. Thus, the central database in the framework ensures efficiency and security of information management. In order to maintain fluent data exchange and meet the needs for various assessments, the format of the data should be regulated and accepted by diverse stakeholders.

89.4 Essential Technologies

This section envisions how the current technologies can be used to support bridging BIM and buildings.

89.4.1 Bar-Code and Radio Frequency Identification

Bar-code and Radio Frequency Identification (RFID) are two typical Auto-ID technologies that have been utilized for identification and tracking in many industries (e.g. manufactory industry and medical industry). While in construction industry, even though the bar-code is cheap and easy to use, it is often too vulnerable to function under dynamic and dusty environment. Thus, RFID is introduced to overcome the disadvantages of bar-code technology.

A complete RFID system consists of an antenna, a transceiver, and a tag. The antenna can work with the transceiver and decoder in order to read and write the information in the tag. Compared with the bar-code, the RFID technology uses radio waves to identify objects, which eliminate the need for a direct line of sight. In addition, there are different types of RFID systems with a wide range of frequencies and two kinds of RFID tag (passive and active) in order to meet various requirements and work under different conditions.

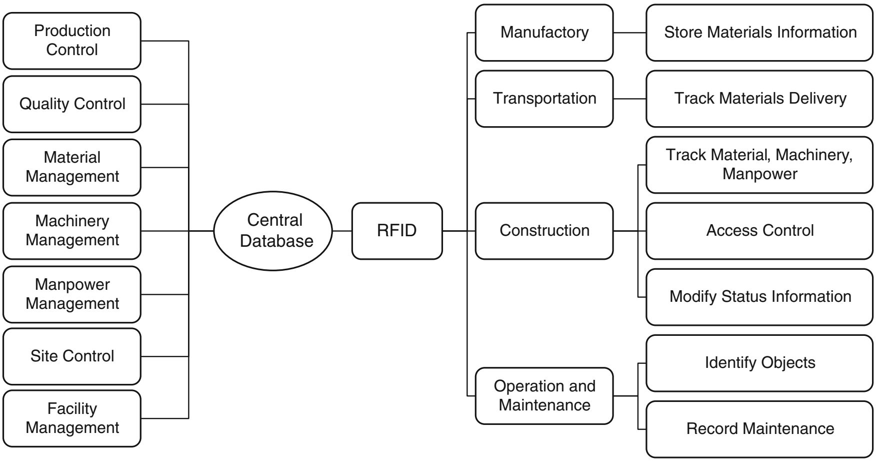

Fig. 89.2 Uses of RFID

Current studies on RFID in construction industry mainly focus on supply chain management (Goodrum et al. 2006), tracking workers (Friedlos 2008). Lu et al. (2011) notes that RFID has potential to improve construction project management and the management of materials, manpower, and machinery.

As shown in Fig. 89.2. The information and status of materials and machinery are stored in RFID tags and can be easily obtain by corresponding RFID readers. Besides, the use of RFID can achieve the purpose of life-cycle tracking and identification, which facilities life-cycle management of the project.

89.4.2 *Laser Scanner*

The laser scanner is the technology that use laser light to digitally capture the information of geometry, dimensions and spatial relationships. It has been used in surveying field to collect site data since it is capable of measuring a large amount of geometry data in a relatively short period. Additionally, compared with the conventional method (e.g. total-station), the measuring results are more accurate (Trupp et al. 2004).

It is usually impossible to scan all surfaces of a building by a single laser scanner from single location. Therefore, the scan should be conducted from multiple locations. After each scanning process, the output is a point cloud image. The following works are aligning the data in one coordinate system and manual or automated filtering (Tang et al. 2010) before the data can be further utilized for management issues (Fig. 89.3).

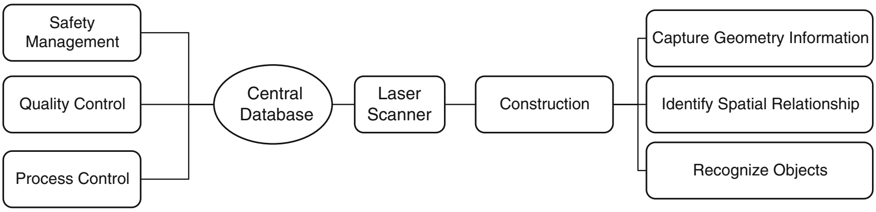

Fig. 89.3 Uses of laser scanner

The laser scanner can be adopted to collect data such as geometry information and spatial relationship, which are important for safety management. Besides, the as-built model can be compared with the as-planned one to check the quality and process of the project.

89.4.3 Webcam

The webcam is a video camera proposed to provide streaming images or still pictures through the network. Individuals can access those images or pictures by the web browsers or other software on their own devices. So far, the webcam has been applied in many industries for security and monitoring purposes.

Regarding the potential of webcam in this study, it is a cheap and flexible technology to be installed at different spots which provides convenience for stakeholders to remotely monitor the construction progress. Besides, the real-time situation from construction stage to demolition stage can be captured to support decision making. The location and number of webcam should be carefully considered since not enough webcam or installation at improper spots leads to insufficient information to be captured, but too many webcams may bother the daily construction works (Fig. 89.4).

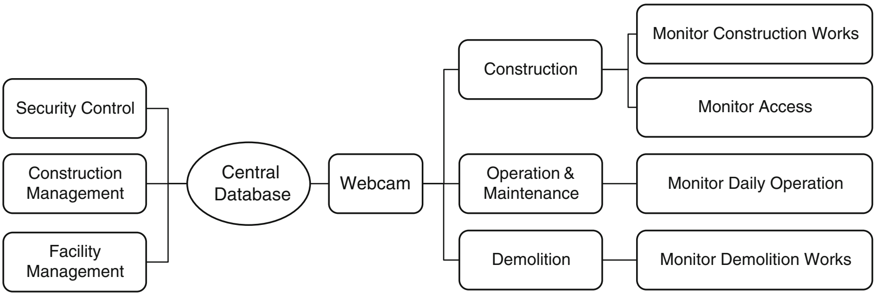

Fig. 89.4 Uses of webcam

89.4.4 Mobile Devices

Mobile devices are basically handheld devices and handheld computers which are intended for portability. Typical examples are RFID readers, smart phones, personal data assistant (PDA), tablet computer, and personal navigation assistant (PNA).

The mobile device provides much convenience for data processing, and it can also contribute to timely information sharing. In the construction industry, the mobile devices have been utilized to establish the environment for information exchange between various stakeholders (Penã-Mora and Dwivedi 2002) and displaying the digital 3D design model of building components (Lipman 2004). In this study, RFID reader is used to obtain and modify the data contained in the RFID tag, and tablet computers that can connect to the central database ensure timely and fluent information acquisition regardless of time and the location of stakeholders.

89.4.5 Communication Networks

The communication network is another key technology in this study. As illustrated in the conception model in the Sect. 89.3, communication networks provide the channel for information transferring from the bottom layer to the top layer or vice versa.

With the help of the local area network (LAN) (e.g. Wi-Fi) and the personal area network (PAN) (e.g. Bluetooth and ZigBee), tablet computers, smart phones, and PDA can share information over short distances, and all desktop computers in the construction site are able to be interconnected. Otherwise, it will be much difficult for seamless information exchange among different working teams, even individuals.

In order to develop a suitable communication network between users and users, users and devices, devices and devices, factors including the cost, the distance to be covered, the speed and rate of data transfer, and the capability should be taken into consideration.

89.5 Conclusion

Building information modeling has been accepted by the AEC field, but its usage is limited to some specific phases such as design instead of the whole lifecycle of a project. The reason may lie in the lack of a framework guiding the researchers and practitioners to develop such a bridge between BIM and physical building. As a result, this study proposes a framework, which consists of physical layer, central database, and BIM layer, to connect the BIM model and the physical project. The physical layer involves a series of actual practices in the project. While the BIM layer refers to the virtual model which will enable effective project management. Between these two layers, the central database provides a flexible and secure management of project information and data.

The integration of BIM and physical building cannot achieve without essential technologies. The function of radio frequency identification is to automatically identify and track machinery, materials, and building components. While laser scanning and webcam can capture the as-built geometry information and real-time situation respectively. In addition, communication networks, especially the wireless network, act as the channel for information transfer and exchange. With real-time information, BIM makes it possible to optimize the project management in various aspects.

Further research is suggested to study the interoperability of data collected by different data-acquisition technologies and BIM software, and the way in which all kinds of data can be integrated in the BIM environment. Additionally, the method to manage a full-scale information and data should be explored in order to gain more efficiency and effectiveness throughout the life cycle of the project.

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Part XIII
Other Topics

Chapter 90
A Study on the Method and Contents of Construction Management Education in UK and Japan

Hitoshi Mihara, Takuro Yoshida, Tetsuo Hojo and Masato Urae

Abstract This study aims to survey the method of CM education and its curriculum at several British universities (educational institutions) that have established partnerships with British construction organizations such as the Chartered Institute of Building (CIOB) and the Royal Institute of Chartered Surveyors (RICS), analyze and compare them with the construction education curriculum used in Japan's universities, and identify issues related to introducing the CM method in Japan. The survey took place between August 9 and September 20, 2013 at some British universities and covered topics related to the CM curriculum. Interviews were also held. Based on this information, the education methods used at British universities to train students in the knowledge required to undertake CM tasks in the British construction industry, as well as the contents of those methods, will be summarized. Furthermore, the collaborative education and partnership initiatives with CIOB and RICS will be summarized. Based on the information collected from the survey on the British university curriculum, and the related interviews, the study will make comparisons with the construction education offered at Japanese universities, and discuss how the CM method can take root in Japan, along with other issues.

Keywords Construction management education · General contractors · Partnership

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90.1 Introduction

In Japan, the history of construction management (CM) education is shallow by comparison with countries like the UK. It may be possible to accelerate progress in Japanese curriculum design by drawing from UK examples. However, such a task requires prudence, taking into account the major differences in the way that construction is organized in the two nations. A basic assumption of this research is that differences in CM programmes in higher education between Japan and UK are largely related to the wider industrial context. The aim of this research is to develop a conversation between British and Japanese academics, professional institutions and civil servants about what constitutes construction management and how it may be developed in both countries, while respecting the crucial contextual differences in each country. In this paper, the context of CM programmes in UK is investigated, and the difference in higher education curricula between UK and Japan is considered. Published research that has been carried out in this area indicates that there is much to be done in understanding what constitutes a worthwhile CM programme. In a country like UK, such programmes have clearly evolved over decades of interaction between industry, professions and both further and higher education establishments.

90.2 Methods

The interview data were analysed to identify the participants' major concerns in relation to the design of the curriculum, which differs in each university. Following the analysis of the UK universities, the fundamental differences from Japan were considered. Participants' concerns about the background institutions in the UK were useful in considering what background institutions might influence the curriculum in Japan. The curricula of three different types of Japanese higher education institutions are briefly introduced from the lead author's previous research. From the comparison of the two countries' curricula as well as the impact of the background institutions, CM education in Japan and UK is further compared.

To develop an overview of UK universities' approaches to designing their CM curricula, interviews were conducted with faculty members of the universities in September 2013. Open-ended questions were asked in order to allow the interviewees to talk freely about their concerns. Four universities were targeted due to their high reputation in the CM area. Also, the curricula and the aim of the programme were collected from the universities' websites, fliers as well as through direct contact with university administrators.

90.3 Survey Results

The interview data gained from the UK were analysed to seek common themes. It was found that the participants' main concerns about the industry context were mainly two-fold: First, there were concerns about the relationship with professional bodies such as Royal Institution of Chartered Surveyors (RICS) and Chartered Institute of Building (CIOB). These are also related to entry requirements of each university. Second was their concern about students in terms of the types who come to the university and their future employment after graduation. Table 90.1 summarizes identified particular features of each university in relation to the design of curricula. (Universities have been anonymized and are referred to as A, B, C and D.)

In University A, The majority of graduates become consultants. With the partnership with RICS and CIOB, as well as building surveying and property management companies, industrial placements are provided as a career development module. A broad range of curriculum is offered in this university, including the management of property, construction procurement and construction operations. Not only management skills, but students' technical skills are also developed, especially in relation to building surveying. This includes the provision of knowledge about the maintenance and repair of buildings. Building Information Modelling (BIM) was recently incorporated into the curriculum as providing opportunities to develop the students' capability to integrate technical knowledge and management skills.

In University B, the aim is to produce students who become senior managers in the construction industry, including those in the public and private sectors. In relation to the partnership with RICS, the curriculum of quantity surveying was especially emphasized, as this profession requires intense theoretical knowledge. In contrast, the management of construction process needs rather more practical experience. The relationship with practitioners is not only seen in the partnership with professional bodies. Some practitioners come to learn in the university. These practitioners often aim to attain Higher National Certificate (HNC) through part-time study, which is roughly equivalent to one year of university. After successfully

Table 90.1 Features of the UK universities

	University A	University B	University C	University D
Identified features of the design of CM programme	Broad area of construction management	Including part-time HNC programme	Broad area of construction management	Emphasis on construction techniques
Partnership with professional bodies	CIOB/RICS	CIOB/RICS	CIOB/RICS	CIOB/ABE
Entry requirement	360 UCAS points	320 UCAS points	260–300 UCAS points	240 UCAS points
Graduate employment	Consultancy, construction companies	Consultancy, construction companies	Consultancy, construction companies, subcontractors	Regional construction companies, subcontractors

completing the HNC, it is often possible to complete a degree with one further year of full-time study.

In University C, the aim is to develop students who become leaders in the industry in the various areas including construction management, property management, and commercial management. The university is proud of the variety of graduate destinations from consultancy to subcontractor companies. Through the partnership with RICS and CIOB, professional opinions are incorporated into the curriculum with different emphasis. Some subjects reflect the wishes of RICS more, while other subjects reflect the wishes of CIOB.

In University D, the programmes are accredited by CIOB and Association of Building Engineering (ABE), but not RICS. This is because the minimum level of entry requirement dictated by RICS is above the level that that University can recruit. Due to this restriction and the particular emphasis on the development of industry-relevant, practical skills, there are students with various backgrounds including construction operatives. Due to active partnerships with local employers, some graduates are employed by the regional contractors, as well as by subcontractors.

90.4 Findings and Discussions

From the interviews with the UK universities, it was found that the professional bodies, types of student and graduate destinations play a major role in the way that universities design their programmes. In this section, first, CM education in Japan is introduced. Then, the CM curricula in Japan and the UK are compared. Finally, CM education in Japan and the industrial context are discussed, which leads to the future directions for this research.

90.4.1 CM Education (Japan)

To discuss the difference in CM education between UK and Japan, the curricula of three higher education institutions are briefly introduced in this section. These are

Table 90.2 Features of Japanese higher education institutions

	University E	University F	University G
Emphasis of the programme	Architecture and Planning	Architecture	Construction technique
Background institution	Government ministry	Government ministry	Government ministry
Graduates' employment	Construction, housing, architecture, real estate	Construction, housing, architecture, real estate	Construction, builder architecture, real estate

University E, University F and University G. None of these has schools or departments of construction management, as such. However, the emphasis on areas is slightly different in each institution. Table 90.2 shows the features of Japanese institutions.

The CM curriculum in Japan is encompassed in schools or departments of Architecture, which is normally in a Faculty of Science and Technology. In University E, management and planning is one area in architecture among architectural design, structural engineering and services engineering. This implies an emphasis on the management area. In University F, management is not particularly emphasized. University G, practical construction techniques can be learned.

In all the universities, construction management tends to be a small part of the general area of Architecture, among other subjects including architectural design, structural design, services engineering design and architectural laws. Architectural laws in Japan are more wide-ranging and specific than in the UK, where the profession is self-regulated. Also, subjects related to general science such as mathematics, physics and chemistry, as well as general subjects such as foreign language and physical education are required.

The subjects that seem to be related to construction management in these higher education institutions are as follows. In University E, there is a broader range of subjects related to management, construction methods, construction process, building economics, building industry, housing process planning and urban design. In University F, there are subjects related to building economics, facilities management and process planning. This implies that the kinds of management areas included in each university vary, such as facilities management and building economics. However, in both of the universities, these are optional subjects and not required for graduation. On the other hand, in University G, the development of technical and practical skills is emphasized. Management skills are gained from practical experience which is incorporated into the curriculum, including mock-ups of real construction processes. Internship is a required subject for graduation. A particular aim is to develop students' practical skills that will be immediately applicable in the industry upon graduation, which makes a distinct feature from the other two universities.

90.4.2 Comparison of the Curriculum of the United Kingdom and Japan

In Japan, construction management is a small area in architectural education. Therefore, the development of the CM curricula is restrained by the curriculum in Architecture. The curriculum in Architecture is mainly designed under the influence of the Ministry of Education, Culture, Sports, Science and Technology. Significantly, the Ministry sets the requirements for the curriculum in higher education as eligibility requirements for examination of attaining a professional license, such as first class architect (Kenchikushi) license and Engineering Operation Management Engineer certificate. Students mainly aim to attain the license of first-class architect, which is of significant importance for career development.

In comparison with the UK curriculum, there are some subjects that are not included or emphasized in Japan. For example, broader knowledge about the construction industry and human resource management are not taught in Japanese programmes. Construction economics and law do not figure highly in Japan. However, in the UK, these may be considered as essential for graduates who are to become leaders in the construction industry. Also, contemporary industry needs, such as BIM, are not seen in Japan. This is because there is no mechanism for updating the curriculum based on industry's current needs. The conversation about what is needed in undergraduate education appears to be exclusively between universities and government.

On the other hand, the accreditation of professional bodies is significant in influencing the curriculum in the UK. Students aim to attain membership of the professional bodies through receiving the education in the universities. The professional institutions tend to restrict entry to the professions to suitably qualified graduates. The particular benefit of this partnership is that this allows the curriculum to be updated according to contemporary industry needs. This is mutually beneficial for both education institutions and practitioners. Also, Japanese education is restricted to a focus on architecture. In contrast, the wider focus of built environment is provided in the UK. In other words, what both countries have in common is that the degree is needed in order to enter a professional career. The key difference is the direct government control of the relevant profession in Japan, by comparison with self-regulation of the more diverse UK professions.

Clearly, this background context does not motivate the development of CM education in Japan.

90.5 Conclusion

For the future direction of this research, the role of the professional institutions in influencing the curriculum in the UK will be further investigated to provide insights into the way that CM education might take root in Japan. It is hoped that this is the beginning of a more involved conversation between the CM communities in both countries. In this research, the concerns of UK academics in designing CM curricula were investigated. From the identification of their main concerns about the partnership with professional bodies and student types as well as future employment, the gap in the curriculum between Japan and the UK was analysed and discussed in relation to the background institution. The relation between higher education institutions and professional institutions in the UK was found to contribute to the design of CM curricula around meeting contemporary industry needs. In contrast, the relationship between Japanese higher education institutions and the Ministry was found to restrict the development of CM education in Japan.

Chapter 91
An Empirical Study of Urban Trade Area Evolutionary Mechanism Based on Gray Correlation Analysis—A Case Study in Nanchang

Liu Qun-hong, Zhong Pu-ping and Li Min

Abstract The rapid development of economy and society has brought the prosperity of commerce with the rising of commercial real estate and expansion of urban trade area. The study of evolution of urban trade area is of great importance to the commercial real estate investment and urban commercial planning. In this paper, we analyze the factors affecting the evolution of urban trade area and the impact mechanism of them by taking Nanchang city of Jiangxi Province for example. The paper also illustrates the relative importance of the factors affecting the urban trade area evolution by means of grey correlative degree analysis. The empirical study provides the foundation for the decision-making and planning of the relevant real estate corporations and the local government.

Keywords Urban trade area · Evolution mechanism · Gray correlation analysis

91.1 Introduction

The past three decades witnessed the rapid development of China's economy. China's per capita disposable income has exceeded US$3000, and the capacity of residents' commodity consumption has been greatly improved. Meanwhile commercial real estate has seen a rapid rise while the urban trade area continues to expand. Urban trade area is characterized by spatiality, clustering, hierarchy and dynamism. The changes of external environmental and internal market will influence the evolution of urban trade area. The urban trade area is evolved on the certain rule. The impact of different factors on the evolution of urban trading area varies from one another. The research on the evolution mechanism of urban trade area could provide a basis and reference for the relevant planning of government and the investment decision of the enterprises in real estate development and retail enterprises.

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91.2 Urban Trade Area and Its Evolution

91.2.1 The Concept of Urban Trade Area

The concept of trade area initially was proposed by Christaller, a German economic geographer in the central place theory. Central place theory explicated that trade area was the service range of goods, as the space boundary of goods from the center place to the consumers (Christaller 1933). A widely accepted concept refers to the scope of customers attracted by a retail store in a certain direction and distance extension. In a word, trade area is the geographical range where the customers lived.

Based on different perspectives, trade area can be divided into enterprise trade area, urban trade area and regional trade area. The following are their specific concepts and features.

91.2.1.1 The Enterprise Trade Area

The enterprise trade area is a commercial radiation zone of a single retail store from the perspective of individual retail enterprises. In the early reference in commercial, trade area is defined as the space range of customer who is attracted by an individual retail enterprises. Its nature is a consumer demand ring ranging of a retail enterprise. The enterprise trade area is defined from the view of microcosmic level of the company. Many theoretical models such as the central place theory created by Christaller and the multi factor model of Black are the exploration to the relevant mechanisms and rules of enterprise trade area.

91.2.1.2 The Urban Trade Area

The urban trade is a common space formed by the cluster of a number of commercial enterprises to attract customers. It has a regional value in a city. Compared with the micro enterprise trade area, the urban trade area has a medium property. At present, only Half's model and its modified model by MITI possesses a medium urban attribute considering the probability of residents' visit to an urban area.

91.2.1.3 The Regional Trade Area

The regional trade area is the affected scope of commercial of the two adjacent cities in a macro perspective (Reilly 1931). Reilly (1931) proposed the Retail Gravitation Rules and Converse's (1948) Breaking point model are the exploration of radiation law between the cities (Converse 1949).

At present, the urban trade area is a kind of concept widely used in the field of city planning and the layout of commercial. The evolution mechanism of trade area in this paper refers in particular to the urban trade area (Qi 2007).

91.2.2 Characteristics of Urban Trade Area

91.2.2.1 Spatiality

Urban trade area is a specific region of space. It is not only a specific sales space, but also a specific space of purchase. It also can be roughly defined as geographical area. Consequently, urban trade area has the characteristic of spatiality.

91.2.2.2 Clustering

Clustering of urban trade area means that stream of people, commodity flow, capital flow and information flow which tends to gather in the market center. The market center has great attraction and aggregation effects on the surrounding owing to its commercial gathering, large population density and convenient transportation. As a result, the market center turns into a radiating source of urban trade area. Urban trade area has a clustering property.

91.2.2.3 Dynamic

Due to the various changes of internal and external factors in the system, urban trade area is constantly changing. This change is affected by the changes of the external environment factors as well as the internal market factors. The former factors include policy environment, economic environment, and natural environment. The latter factors include market administration, the adjustment of management policy and the change of service functions of market. Changes in the external environment and internal market and other factors would fuel the constant development of the urban trade area.

91.2.3 Evolution of Urban Trade Area

Chou (2002) considered that the functions of clustering and diffusion of urban trade area were the main reason for its evolution. Chou (2003) pointed out that shopping cost fundamentally determined the size of a store. Tang (2008) made an empirical study of the causes of urban trade area's agglomeration in space from the perspective of the institutional economics, the external economic theory and space economy (Tang 2008). Liu et al. (2007) studied temporal and spatial evolution mechanism of urban trade area from the perspective of external environmental factors, commercial enterprises factors and combined with life cycle theory of the urban trade area (Liu et al. 2007). These studies have certain expositions to the evolvement mechanism of the urban trade area more or less. However, quantitative research is rarely made on the influence which was brought by the urban trade area to the mechanism of its evolution.

91.3 Factors Influencing the Evolution of Urban Trade Area

The factors influencing urban trade area's evolution can be divided into external environment factors and internal market factors. The former can be divided into natural factors and social economic factors while the latter included the size factor and the quality factor of commercial real estate. Social economic factors, mainly take into account the aspects of population, economy and traffic. The details are as follows.

91.3.1 Natural Factors

Although urban trade area belongs to the economic and social fields, it is closely related with the natural factors. Topography, climate, soil, hydrology and other natural factors played a great role in promoting the early human aggregation, the rise of city civilization and commodity trade activities. Even now in modern civilized society with highly advanced science and technology, topography, hydrology and other natural factors still have a restrictive function of human activities and expansion of urban trade area.

91.3.2 Demographic Factors

The urban trade area refers to the spatial scope of customers. As a result, the size of the population and its spatial distribution, age structure, quality would have a significant effect on the size and distribution of urban trade area. The larger the population are in size, the greater the distance between them, the more widely influenced region. The age structure and the quality of the population and other factors would affect consumer behavior, and then affect the size and distribution of urban trade area.

91.3.3 Economical Factors

Development of social economy is closely related with the expansion of urban trade area. The rapid development of economy and the continued of per capita GDP and per capita disposable income would improve the annual per capita consumption and change consumption structure, which will affect the evolution of urban trade area.

91.3.4 Factors of Transportation

Shopping cost is a decisive factor in consumers' shopping decision. And the time cost is an important index of measuring the cost of shopping. Such factors as spatial distribution and accessibility of roads, public transport service have a huge impact on the shopping cost of consumers. Therefore, the traffic factor is one of the important factors affecting the evolution of urban trade area.

91.3.5 Commercial Scale Factors

Because of the gathering effect, the expansion of commercial real estate and the aggregation commercial scale can have a bigger attraction to consumers, leading a greatly expanded range of urban trade area. As a result, commercial scale is of great importance in the evolution of urban trade area.

91.3.6 Commercial Quality Factors

The commercial quality factors such as the complete degree of business status and kinds, the image and the grade of commercial real estate is one of the most important factors influencing the consumers' shopping decision. Consequently commercial quality factors will have an impact on the evolution of urban trade area.

91.4 Grey Relational Degree Analysis of the Evolution of C Urban Trade Area

91.4.1 Brief Introduction of Grey Relational Degree Analysis

Grey system theory is a new theory created by Professor Deng Ju-long in 1982 mainly aiming at solving the problem of "small sample, poor information". Grey correlation analysis is a system analysis method in the grey system theory. It can make the estimate of the link based on the similarity degree of the sequence curve's geometry. Grey relational degree analysis aims to find the relationship among the various factors in the system through the quantitative analysis focusing on the influential factors of the target value to master the main characteristic of objects. It can provide useful information and reliable basis for system-forecasting, decision-making, system control (Zhang et al. 2008).

We have a preliminary analysis of the key factors influencing the evolution of urban trade area, but some uncertain factors affecting urban trade area still exist and the relevant information is difficult to obtain. Consequently, Grey relational degree analysis is appropriate for the study of the influencing factors and the evolution mechanism of urban trade area.

91.4.2 The Calculation Process of Grey Relational Degree Analysis

Correlation described the relative changes in size, direction and speed between the various factors in the process of system development. If the relative change of them is basically consistent in the process of development, we consider them of a high degree correlation (Xiao 1997). Those are the specific operation steps of gray correlation analysis method.

Firstly, determining the reference sequence and comparative sequence.

Secondly, calculating the initial value of each sequence.

$$X_i' = \frac{X_i'}{x_i(1)} = (x_i'(1), x_i'(2), \ldots x_i'(n)) \quad i = 0, 1, 2, \ldots m$$

Thirdly, calculating the sequence of differences.

$$\Delta_i = \left| x_0'(k) - x_i'(k) \right|$$

$$\Delta_i = \Delta_i(1), \Delta_i(2), \ldots \Delta_i(n)$$

$$\mathrm{i} = 1, 2, \ldots \mathrm{m}$$

Fourthly, calculating Te-maxD and minimum differential of two stage.

$$M = \max_i \max_k \Delta_i(k)$$

$$m = \min_i \min_k \Delta_i(k)$$

Finally, calculating the correlation coefficient and correlation degree.

$$r_{0i}(k) = \frac{m + \xi M}{\Delta_i(k) + \xi M}$$

$$\xi \in (0,1); \quad \mathrm{k} = 1,2,\ldots,\mathrm{n}; \quad \mathrm{i} = 1,2,\ldots,\mathrm{m}$$

$$r_{0i} = \frac{1}{n}\sum_{k=1}^{n} r_{0i}(k)$$

$$\mathrm{i} = 1,2,\ldots,\mathrm{m}$$

Due to the high correlation between the extension of urban trade area and the total amount of retail industry, this paper takes Nanchang City, Jiangxi province as an example. The volume of retail sales (denoted as X_1; unit-billion RMB) was not only taken to be the size index of urban trade area, but also the grey relational analysis reference series. The natural factors were not considered because they cannot be quantified. We selected the resident population (denoted as X_2; unit-ten thousand) as a representative population index. The annual per capita disposable income was selected (denoted as X_3; unit-10 million) as the representative indicators of economic factors. The quantity of city bus routes (denoted as X_4; unit-A single) were selected as the representative index of traffic factors. Annually completed floor space of commercial real estate (denoted as X_5; unit-million square meters) were selected as the representative index of the scale factor of commercial real estate. The quantity of retailing formats and kinds of Business (denoted as X_6; unit: a) as the representative of commercial quality factor. X_2, X_3, X_4, X_5, and X_6 belongs to the reference sequence.

We have got a reference sequence and comparative sequence table by means of querying the statistics yearbook and the related data, combining years of field survey data to the factors of urban trade area. As it is shown in the following Table 91.1.

91.4.3 The Results of Methods of Grey Correlation

Calculation of the grey relational degree.

$$\mathrm{r}_{12} = 0.5277;\ \mathrm{r}_{13} = 0.7527;\ \mathrm{r}_{14} = 0.6905;\ \mathrm{r}_{15} = 0.9484;\ \mathrm{r}_{16} = 0.6265$$

Through the calculation of gray correlation degree, influence degree of the influence factors on the evolution of urban trade area are as shown in Table 91.2.

Table 91.1 A table of reference sequence and comparative

N (year)	X_1	X_2	X_3	X_4	X_5	X_6
2003	201.18	445.50	7793	75	31.850	67
2004	234.90	448.60	8744	79	39.250	73
2005	307.49	451.61	10,301	88	62.050	79
2006	358.40	454.54	11,243	120	55.723	84
2007	426.69	458.06	13,076	126	61.445	91
2008	528.89	461.52	15,112	132	82.884	98
2009	634.43	464.89	16,472	147	92.185	107
2010	769.94	502.23	18,276	145	92.032	113
2011	910.00	504.95	20,741	157	128.447	117
2012	1116.54	507.87	23,602	171	156.483	123
2013	1270.01	518.42	26,151	188	199.905	129

Sources of data "2003–2013 statistical yearbook of Nanchang City", survey data of commercial real estate in Nanchang

Table 91.2 Rank of the incidence in gray correlation degree

Influencing factors	R correlation	Rank
The size of commercial real estate	0.9484	1
Economy	0.7527	2
Traffic	0.6905	3
The quality of commercial real estate	0.6265	4
Population	0.5277	5

91.5 Conclusion

As a result, degrees of association of the influencing factors are relatively large, suggesting that these factors have a close link with the evolution of urban trade area. Correlative sequence is as follows: commercial scale, economy, traffic, commercial quality and population. While according to its associated order, the influence degrees of each factor on evolution of urban trade area are not identical.

91.5.1 The Evolution of Urban Trade Area Was the Most Impacted by the Size of Commercial Real Estate in Those Influence Factors

This was defined by the innate character of urban trade area as a space of the customers attracted by the clustering of commercial real estate. The expansion of urban trade area was brought by the growth of completed floor space of commercial real estate and the expansion of commercial scale.

91.5.2 The Economic Factor Has a Great Influence on the Evolution of Urban Trade Area

Owing to the expansion and development of urban trade area cannot do without the prosperity of the economic and social development and the increase of per capita disposable income. Economic development, increase of individual income will further promote the prosperity and development of commodity trade, promoting the evolution of urban trade area.

91.5.3 The Traffic Factor Is an Important Factor Affecting the Evolution of Urban Trade Area

Accessibility convenience of traffic would save consumers' shopping cost, promoting the market transactions and the prosperity of urban trade area.

91.5.4 Quality of Commercial Real Estate Evolution Has Great Influence on Evolution of Urban Trade Area

The variety of retailing formats and kinds of business, the promotion of the image and the grade of trade area are attractive to the consumers, bringing the prosperity of the commercial and the expansion of urban trade area.

91.5.5 Comparing to the Above Four Factors, the Evolution of Urban Trade Area Has Been Less Affected by the Population Factor

However, the population factor still cannot be ignored. Continuous agglomeration in space and growth of population would trigger the expansion and evolution of urban trade area.

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Chapter 92
Monetary Policies and Bank Lending to China's Real Estate Industry

Yigang Wei and Zezhou Wu

Abstract This research seeks to answer the question of whether the provision of bank loan is constrained in China's real estate industry, when encountering a monetary stringency policy, and to comment on the effects of government's financing controls on the property industry. This research is conducted mainly based on an examination of a mixture of banking and real estate related indicators from 1998 to 2010. A narrative approach is presented. Empirical findings confirm that bank lending to developers is driven by real estate investment—the demand for credit; rather than the traditional belief that supply of credit drives real estate investment. Further, it is found that housing price has a long-term bi-directional relation with development loan, which explains the incentive of bank lending behavior to the property industry. A narrative analysis indicates that restrictive monetary policies fail to constrain the abusive lending to the property industry. The futileness of monetary policies is mainly attributed to two aspects: the rapid increase of deposits and the development of the financial market, for example, the use of foreign loans and the issue of bonds through which banks increase liability under the backdrop of the tightened monetary policy. Since tightening the availability of bank loan is the main strand of approaches for the control of real estate activities in China, this research suggests the government to improve the policy by monitoring ongoing changes in financial development and the problems of affluent excessive deposits.

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92.1 Introduction

An examination of the literature indicates that the real estate industry constitutes substantial weights in the real economy. The cyclical boom-bust nature of the property market has a close connection with stability of the financial market and the overall economy (Herring and Wachter 1999; Case al et. 2001). For example, some indicators in the housing sector, such as housing starts and housing price, are proven to be leading measures of economic activities in the US, with forecasting power on inflation, real growth, or both (Stock and Watson 2003). The importance of the industry to national economy is markedly attested to by historical evidence. Herring and Wachter (1999) summarize a common feature of many important financial crisis plagued around a great variety of emerging economies and industrial countries that the crunch of the national economy is generally preceded with the bust of property price bubbles and the consequential deterioration of the banking system, before the impact is magnified to the exchange rate crisis, and economic recession. Some painful lessons learned from Japan, the US, Thailand, Nordics' property and subsequent banking crises testify that regulators and bankers should cautiously control lending and other types of exposures on real estate business. Noticing this economic significance, the Chinese government always vows to take prudent attitudes to rein in the property market. The effects of real estate control have long been a perennial concern among the central authority and scholars.

Real estate variables have a close link with monetary policy. Carlos (2008) advocates that housing investment represents an important macroeconomic variable. Bernanke et al. (2005, the Chairman of US Federal Reserve) articulated that 'central banks routinely monitor literally hundreds of economic variables in the process of policy formulation, providing motivation for conditioning any analysis of monetary policy on a rich information set.' Green (1997) proved that housing investment can Granger cause GDP growth in the United State. Given this importance, the Conference Board succinctly includes housing permits among its major economic indicators (Fratantoni and Schuh 2003). In China, there are also potent reasons to expect the real estate industry to play a similar important role in formulating its monetary policy. Abundant Chinese literature reiterates the views that real estate policies are centrally important policy germane to economic stability (e.g. Lisheng 2010; Wei et al. 2014).

Since the late 1990s, the People's Bank of China (PBOC), acting as the central banking authority, has promulgated a series of macroeconomic policies to curb the real estate market from overheating by tightening the credit. Most striking are the stricter mandates instigated: raising the ratio of self-owed capital to total funds raised in development projects up to 35 %, hikes in lending rates to raise the cost of capital, increases of the reserve ratio to reduce banks' liquidity, credit rationing on real estate development, tight lending terms, and severe credit supervision (Ye and Wu 2008).

Leung and Lu (2011) argue that since the current financial market in China is bank-dominated, monetary policy is essentially transmitted through the bank credit.

A tight monetary policy with higher interest rate and less credit supply can impact the industry outputs through both the interest rate effect and the credit channel including bank lending channel and the balance-sheet channel (see Bernanke and Gertler 1995). For simplicity, the tightening policy impacts the economy by making credit less affordable (interest rate effect) or less available (the credit channel). According to the 'credit availability effects' views Rosa (1951), although investment is not sensitive to the interest rate, monetary policy still can exert its impacts through the channel of the availability of credit. In China's property market, there are reasons to expect the 'credit availability effects' are more noticeable. Since the property industry is unduly dependent on bank lending, access to credit seems a more urgent need for China's developers than the cost of capital, which can be transferred to purchasers by the soaring property prices. Recent research on the bank credit channel mainly focuses on two lines: the behaviors of borrowers or the banks under tight policy. Will certain bank-dependent borrowers' investment and spending be immediately impacted by changes in banks' lending attitudes? And, do monetary policy actions directly constrain bank lending? Recent research has yielded conflicting evidence.

Acting as conventional financing intermediaries for development backing, banks play a special role in the transmission channel. Since policy effects emanate from bank's willingness for lending, the ineffectual policy impact on the property market may be attributed to the perverse incentives of banks. Against this background, the focus of this research is on the lending behavior of banks and its reaction with the property industry, because banks acting as the main provider of credits and as an intermediary between policy and credit borrowers take a special role in the transmission of monetary policy. Whether bank lending is constrained by constrictive monetary policy, together with an analysis of their lending incentives, have rich implications for regulators and professionals. In the theoretical ground, a special emphasis on bank lending channel research is also pressingly needed. Bernanke and Gertler (1995) have argued that bank lending channel is more controversial relative to balance sheet channel which is arguably evident. Therefore, sidestepping the balance sheet channel for the time being, this research focuses on evaluating some evidence on the lending channel operating in China's property market since 2003. To be specific, this study is aimed at answering two questions: (1) whether the vast array of restrictive monetary policy actions have restrained banks' abusive lending to the real estate developers; if not, how banks eschew the policy shocks and underpin the growth of real estate lending?; and (2) whether the incentives of bank lending behaviors are motivated by the uprising housing prices? The research findings help to unravel the complexity of policy transmission channels, and more importantly, give some insights for the government to ameliorate the policy effect on the property industry.

92.2 A Bank-Dependent Industry

One key premise for the existence of the credit channel focuses on a certain category of bank-dependent borrowers, who cannot insulate shocks from abrupt reduction of loan supply by switching to other types of external financing. Real estate industry in China is a highly leveraged industry and bank lending is an irreplaceable financing means to sustain its development (Panagopoulos and Vlamis 2009). From the national aggregate level, bank loans contributes to one-fifth of the total capital for development financing, representing the second largest share, only behind the self-raised capitals. Many researchers also addressed that nearly 60–90 % of so-called ‘self-raised capital’ are de facto sourced from bank credits (e.g. Wang 2008). Therefore if taking into account mortgages, bank loans take an important role in the developers’ financing chain, up to 80 % of the real estate investment. Panagopoulos and Vlamis (2009) claimed that real estate investment is sensitive to monetary policy changes, especially in China where loans are subject to floating rates. Therefore, the real estate industry is a fertile ground to investigate the role of bank lending in the transmission of monetary policy-bank lending channel.

92.3 Tight-Credit Periods

Tight credit periods refer to episodes of ‘relatively high interest rates as well as periods of reduced availability because of greater non-price credit rationing’ (Owens and Schreft 1995, p. 63). How to define the episodes of monetary stringency is an open question with no consistent agreement. There are no officially stated criteria to precisely identify the policy stance. However, four different practices, namely, variations of interest rate, changes of nominal reserve rate, ‘Romer and Romer period’,[1] as well as real fund rate are prevailingly adopted for research in the US. Many researches support the use of reserve rate as the best indicator for a constrictive stance of the monetary policy. The reserve ratio is a leading policy tool frequently used in China. The adjustments in the reserve ratio can release or drain liquidity across the banking system, bringing about monetary expansion or tightening credit (Leung and Lu 2011). According to Fig. 92.1, reserve ratio and lending rate in China have moved in tandem. This paper has selected these two variables to identify the stance of monetary policy. Figure 92.1 depicts the focal episodes of the restrictive and expansionary policy, which shows the government’s intention to guide the development of the real estate market. The shaded areas (Sept 2003–Nov 2008; Dec 2009–Sept 2010) is the ‘policy windows’ indicating that the monetary authorities were implementing tight monetary policy to reduce inflationary pressure. Accordingly, the monetary control can be differentiated into two crossroad periods: expansionary

[1]Romer and Romer (1989), by reading the narrative history of the Federal Reserve in the US, defined seven disinflationary periods.

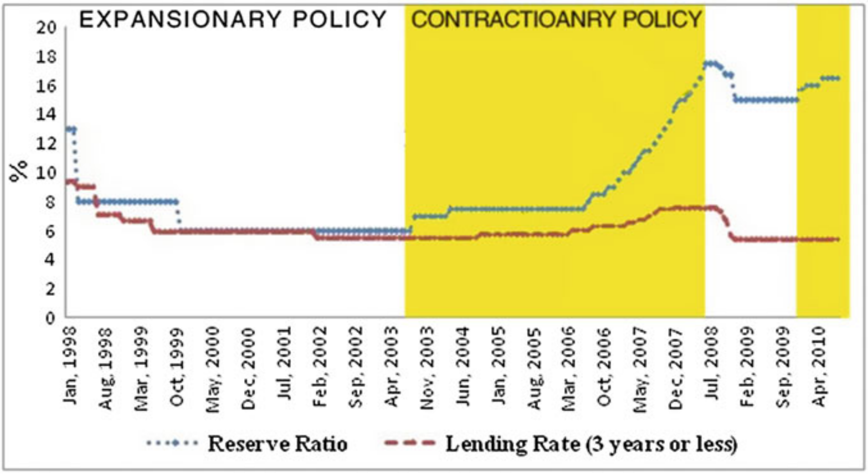

Fig. 92.1 The monetary policy and real estate lending control policy in China. *Source* China Statistic Bureau

phase (1991–2003 and 2008–mid 2009), and tightening phase (2004–2008 and Sept 2009–till now). Despite some short episodes when supportive policies were promulgated to improve the development, monetary constringency has been the main policy stance dominating the last decade.

92.4 Further Discussion

Figure 92.2 shows the balance sheet data of banks' lending to property development purposes. The 'policy windows' highlights the bank's lending behaviors during tightening episodes. Figure 92.2 shows a continuous and substantial increase of development loan supply in the last decades, despite several rounds of remarkable monetary constringency measures. The findings indicate that the tightening policy failed to drain off banks' excess reserves and to restrain banks' abusive real estate lending. The little evidence of an operative bank lending channel leads to another question of how bank can replenish the liquidity loss and capital-asset ratio under the monetary constringency. This turns to the analysis of bank portfolio behavior.

From 1989, the Chinese government discarded the practice of setting credit quantity scale, and turned to implementation of the maximum credit control. Commercial banks can use funds at their own discretion after depositing statutory required reserves with the Central Bank and purchasing policy bonds. The rationale of this policy is to 'control on the maximum lending, and lending depends on deposit'. Each bank is set a maximum loan ceiling, according to the bank's deposits. However, when banks have excess reserves, an increase in the reserve

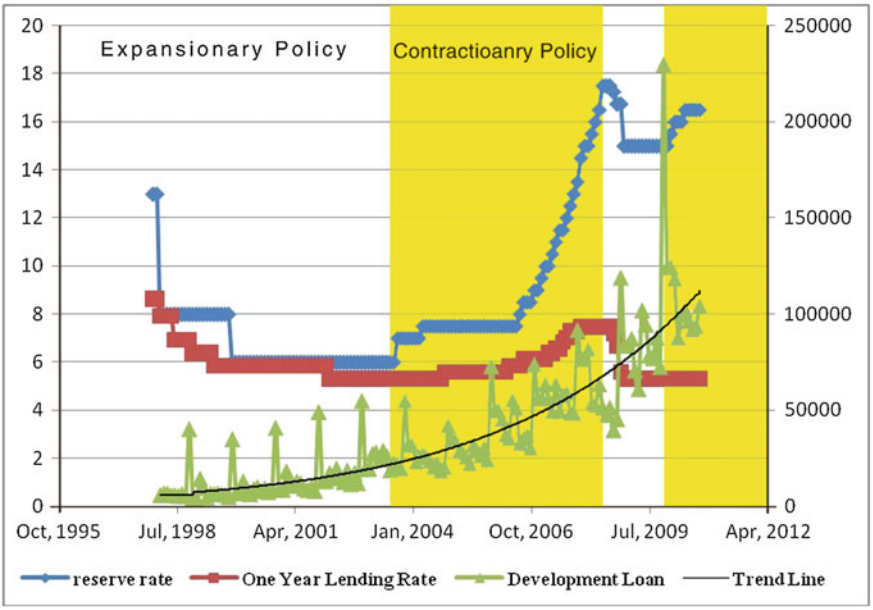

Fig. 92.2 The supply of real estate development from Apr 1998 to Sep 2010. *Source* China Statistic Bureau

ratio will not tighten banks' lending capability (Leung and Lu 2011). Laurens and Maino (2007) ascribed the less efficient control over banks' high excess reserve as one important obstacle to the policy effects. With the rapid growth on foreign currency reserves and household incomes, the excessive liquidity in banks is commonplace in China. With a low loan deposit ratio relative to the legally prescribed rate of 75 %, these banks hold excessive reserves and have considerable room for loan expansion.

Although deposit increases and excess reserves are the main contributors to the clog of bank lending channel, the ongoing structural changes of the financial market is another important factor. Promoted by the improvement of interbank markets, both the interbank credit lending and bond purchase have grown rapidly and become the preferred way for banks to secure short-term capital. The interbank transactions improve the flow of excess liquidity from large state owned-commercial banks (the net provider of capital) to others (Leung and Lu 2011). In addition, as Fig. 92.3 depicts, bond issues by state-owned commercial banks were increased, which offset the tightening effect of reserve ratio increases.

The results indicate that even under the backdrop of monetary control, banks are able to maintain their development lending by several measures: adjusting the liquid asset such as bond repo, inter-bank credit borrowing, bond issues, and the increase of deposits. These measures supplement the part of liquidity loss induced by the tight policy, thereby obviating them from the policy control.

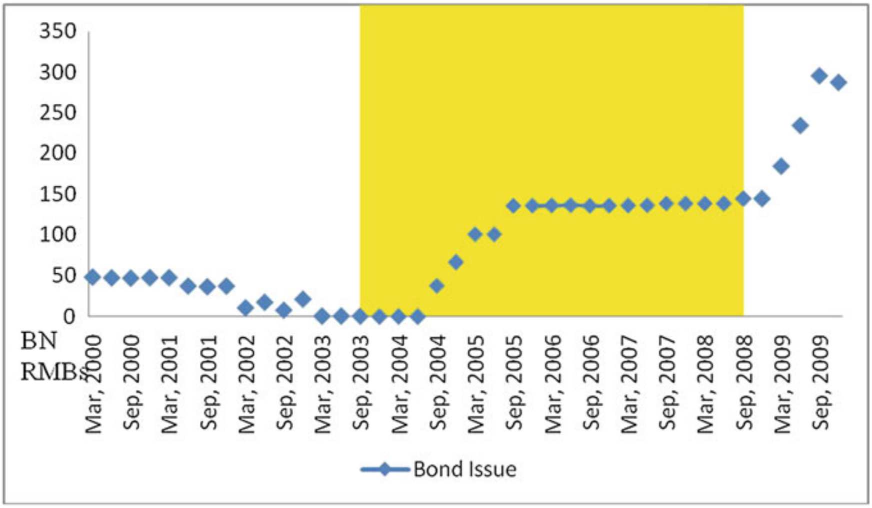

Fig. 92.3 Bond issue of state-owned commercial bank. *Source* China Statistic Bureau

Another divergent view for credit channel research is whether lending is driven by loan demand or supply. For example, due to the pressure from excess liquity and the purposes of maintaining their relationships with clients, banks are forced to offer additional credit rather than restricting the supply.

In the end, a closer analysis of the link between property price on bank lending is essential to explain perverse incentives between bank lending and policy intentions. Some research has yield similar conclusion that property price is an explanatory factor on driving bank credit (e.g. Davis and Zhu 2004). In China, real estate prices have experienced rapid and continual run-ups nationwidely since the housing reforms initiated in 1998. The boom of China's real estate has increased the credibility of the bank credits which lend for real estate purposes or use real estate as collaterals. Therefore, real estate price inflations are an important inhibitor for the effective implementation of real estate lending controls.

92.5 Conclusions

As the property industry sees it, tightening bank credit supply has been the main strand of political rationale for real estate control. The monetary constringency is reinforced by interest-rate tools and issues of 'window policy' to instruct banks to constrain their lending behaviors. However, these policy actions still fall short of restricting the abusive real estate lending. Empirical findings also suggest that aggressive lending is an important culprit for the soaring property prices. By examining bankers' incentives for real estate lending, this work helps to answer why the bank lending channel fails to operate.

A narrative analysis on the banks' portfolios indicates that three factors are attributable to the mitigation of policy effects on property prices and transactions, i.e. the rapid increase of deposits, bonds issues, and interbank transactions. These practices offset the liquidity drain from tight monetary policy. Empirical findings from previous studies also confirm that exuberant real estate loan demand is a key contributor driving the credit supply. Besides, the rapid increase of housing prices is a special attraction leading to the divergent lending behavior against the policy motive of remedying real estate lending.

A bank lending channel does not seem to be part of monetary transmission in the property market. However, as real estate is a well-defined industry dependent on credit, bank credit is arguably a powerful tool to manipulate the development of the industry. Some policy suggestions are provided to ameliorate the real estate control effect. The ongoing evolution of banks and the financial market may change the monetary transmission mechanism and increase the difficulties for regulators to implement monetary policy. Besides, as the monetary authorities have to balance multiple objectives, changes in the financial market and the use of policy tools may generate conflicting outcomes in different sectors (Leung and Lu 2011). Special concerns should be placed on the potential impact on the property sectors to reconcile the inadequate influence. Besides, the regulators should try to drain or sterilize excess liquidity within the banking industry, especially the state-owned banks. Lastly, corresponding to the monetary policy, administrative-based directives should be designed to better supervise lending performance and to prevent banks' excessive exposure to volatile real estate prices.

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Chapter 93
Market-Oriented and Bank-Oriented Corporate Governance Models Research Base on Construction Management Companies

Yongyong Zhu

Abstract Affected by economic, political, historical, cultural and other factors, the governance model taken by construction management companies within countries has some differences, but with the development and integration of global capital market, the worldwide governance model are tending assimilated, and developing toward the shareholder interests-dominated, profited-oriented model, paying attention to the interests of stakeholder. This paper starts from the market-oriented mode and bank-oriented mode of construction management company, considers their respective positions, clients and services, and then explores the governance objective features, values orientation and objective convergence trend of the construction management company under the two modes, so as to lay the foundation for corporate governance of the construction management company.

Keywords Construction management companies · Market-oriented · Bank-oriented

93.1 Introduction

The study of comparative advantage between bank-based and market-based systems is mainly carried out in four major countries, take Germany and Japan as the examples of market-based system, and take England and the United States as the example of bank-based system, market-based and bank-based research mainly focus

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on financial system, however, corporate governance and financial system which belong to different areas are increasing linked with the enhanced extension and control of corporate governance at present (Tinoco and Wilson 2013). Although there are many differences between the market-oriented American and British model and the bank-oriented German and Japanese model, they have their own advantages and disadvantages, and all serve for economic development.

93.2 Biopharmaceutical Enterprises Comparative Research Base on Market-Oriented and Bank-Oriented Corporate Governance Models

93.2.1 Market-Based Model for Construction Management Company

The market-based construction management corporate governance model is characterized with the shareholder's equity and competitive capital market, belonging to external governance (Bourletidis 2013). With the action of decision usefulness, the equity is highly dispersed, the relation between shareholders and the enterprise declines, the dispersed shareholders are not able to exert effective influence on corporate decision, the strong liquidity of board members weakens the control of the operator, and the direct management has large external effects restricted by laws (Ruokolainen and Mäkelä 2007). Due to the maturity and perfection of capital market, intense competition existing in product market, manager market, buyout market and other external markets, the external resource providers rely on the capital market, if the company was badly managed, the investors would sell huge stakes, and the construction management company would face the danger to be acquired, the senior managers would be fired, which brings big pressure to the control and restriction of managers and corporate operators. To be consistent with the corporate governance model, the corporate accounting is mainly targeted on the external information demanders, the company managers are regarded as the insiders who are able to obtain the accounting information through their own capabilities, the shareholders are considered to be the external information demanders for their strong liquidity and frequent changes (Mohamad et al. 2013). The accounting information of construction management corporate is used to help shareholders deal with their equity holdings. When the construction management company is in poor performance, the disclosure of accounting information will act on the stock prices of the capital market, drive the synergistic effects of external governance mechanism, and form the accounting target of decision usefulness. In the corporate financial reporting of No. 1 financial accounting concept announcement, the Financial Accounting Standards Board thinks that: the general goal to make financial reports is to provide useful business information for enterprises on the formulation of economic policy-making, the amount of cash flow and time distribution are uncertain, the decision-making is always oriented to the future, the most relevant information with decision-making is the future of the enterprise, so what the decision usefulness focuses is the relevance of accounting information.

93.2.2 Bank-Based Model for Construction Management Company

The concept of fiduciary duty for construction management firm considers the accounting objective is to faithfully reflect the management and use of entrusted resources by the resource trustee, financial reporting primarily reflects the objective information of corporate history, and emphasizes the reliability of information. Fiduciary duty theory targets on the traditional role of financial accounting, and should reflect the operator's performance obligations of the financial accounting, effectively reflect the fulfillment of fiduciary duty and objectively reflect the business performance in the past, the information is mainly characterized with objectivity and historicality, the evaluation of the resource trustee about the performance of entrusted responsibility puts more emphasis on authenticity and reliability of information (Nitithamyong and Skibniewski 2014).

The capital of bank-based corporate governance model is mainly from one or a few large shareholders with relatively concentrated sources. Investors pursues short-term share price differences under the market-oriented construction management model, while the large shareholders control a large stake in the company, pursue long-term business profit, and equity transfer will not happen within a long time. The weak equity flows make the external market mechanism not be able to play a major role in the construction corporate governance, the manager market is not active, the construction management company mainly uses internal governance based model, and focuses on internal corporate control, board and the supervisory board are set in the organization structure mutually tied and restrained from each other (Liou 2014). Major shareholder of the construction management company may take effective measures and decide the placement of the managers according to the performance of the operators at any time. Major shareholders, managers and external stakeholders can not only learn from the annual report about the financial situation, operating result and cash flow, but also obtain information from the routine board meeting or internal management, which make the external stakeholders unappreciated to require the accounting information and the openness of accounting information. The construction management company targets to provide the resource provider with the resource trusteeship, making the accounting standard system of construction management company tends to lower level of public disclosure and provision of less public accounting information, pay less attention to the interests of policy-making and more emphasis on the adjustment of interest relationship, the company management objective tends to contract execution.

Bank-based and market-based construction management companies all takes the separation of resource ownership and right of business as well as the production of fiduciary responsibility as a precondition, being required to provide external information with different positions and serving breadth. Bank-based company will exercise their duty by lifting economic responsibility from the perspective of administrators, the accounting entity will actively report the main information involving asset management and performance achievements, without considering if such information is useful for investors. The market-oriented company stands in the position of external information user with investor as the main part, and make a request on the accounting entity, the accounting entity is passive and required to provide information useful for decision-making, including not only the trusted results of operation and asset management information, but also the manager information, marketing share and other non-financial information, as well as other future-oriented forward-looking information. From the perspective of client, the bank-based company thinks that the object of information service is asset principal, the market-oriented company thinks that the information user has been transformed from single to multiple, including investor, creditor, potential investor, management, the board of director, employee, competitor, competent authority, academic institution, media etc. who are legal person or natural person, and information users, the information provider should meet the needs of these users (Corkin 2012).

93.3 The Governance Objective of Construction Management Company Under the Market-Based and Bank-Based Models

93.3.1 Target Properties of Construction Management Company

Environment of construction management company includes internal environment and external environment. Internal environment mainly refers to the enterprise system, while the external environment refers to the political and economic environment. With the improvements in measurement technology, the company continues to optimize its system, and improve its management techniques. Different management circumstances give birth to distinct management objectives, which depend on the corporate circumstances, and reflect the corporate social nature. Targets of construction management company vary with the company environment, and the environmental dynamics determine the target dynamics of the management company, thus, the targets of construction management company may reveal different orientations and features in different period of development. When capital markets are underdeveloped, a direct relationship between the distinct trustor and trustee allows an easy implementation of direct supervision. Regularly report the management performances to the trustor, so as to ensure the capital preservation and appreciation. Along with the development of capital market, the diversification of the main investors has obscured the trustor and trustee responsibilities, and the construction management company shifts its target into a useful decision-making concept due to higher cost of supervision and more rational investors. Construction management company has divided its targets into elementary objectives, general objectives and specific objectives. The elementary objectives are intended to improve the economic and social benefits simultaneously; the general objectives include the offer of accounting information and the use of accounting information; the specific objectives have been divided into financial accounting objectives, decision-making accounting objectives and responsibility accounting objectives. The financial accounting objectives of construction management company provide decision-making information; the decision-making accounting objectives make decisions according to accounting information, and the responsibility accounting objectives provide social responsibility information.

93.3.2 Governance Target Values of Construction Management Company

How to guarantee the most effective operation of management company and how to satisfy the interests of all participants is a standard to evaluate the governance system and governance structure of the construction management company. The governance of a construction management company is not limited to the supervision of shareholders on operators, but includes a wide range of stakeholders, such as shareholders, creditors, suppliers, employees, government, communities and other groups. Construction management corporate governance is intended to coordinate the interests of the company and all stakeholders, guarantee the scientificity of the corporate decisions, and protect the interests of all parties through a set of formal or informal, internal or external systems and mechanisms. Its purpose is to maintain the corporate integrity, motivate employees and control the corporate growth. The board members are responsible for establishing and maintaining the power basis, mechanism basis and reputation basis, appointing corporate members based on the critical enterprise resources, and promoting them to become firm-specific complementary investments.

The governance target of construction management company is to ensure the maximized interests of shareholders and other stakeholders, and prevent the operators from deviating from the interests of the owners and relevant groups (Han et al. 2010). A narrow conception of corporate governance refers to a supervision and balance mechanism of the shareholders on the operators, and it is internal governance based on a corporate governance structure composed of shareholder meeting, board of directors, board of supervisors and the management. It aims at reasonably allocating the rights and responsibilities between the owners and operators through the institutional arrangements. Broad corporate governance is not limited to the counterbalance of shareholders on the operators, but involves a wide range of stakeholders. It aims at coordinating the interests among the company and all stakeholders through formal or informal, internal or external systems or mechanisms, in order to ensure the scientific decision-making and protect the interests of all aspects of the company. At this point, the construction management company is not only the shareholders' company, but rather a community of interests, and its governance mechanism is not limited to the internal governance based on the governance structure, but shared governance implemented by stakeholders through a series of internal and external mechanisms. According to features, investment substitutability, additively and complementarily of key resources, the governance targets determines the members with access right through the allocation of accesses of key resources; organize individuals or teams with access right, create the complementarily for enterprises, separate the industry-specific technical specialization and corporate-specific technical specialization; set procedures to enter and allocate decision-making resources, ensure scientific decision-making, create motivating circumstances, cultivate corporate cultures, and gradually promote them to become critical resources among the members, as well as the members and the enterprises, and effectively avoid decision-making mistakes caused by the understanding, cognitive preference model and rigidity of the top management personnel.

93.3.3 Convergence of Accounting Targets and Governance Targets of Construction Management Company

The overall accounting goal of the construction management company is to be accomplished step by step, the overall goal of the company activity is to improve the economic efficiency, ensure the continued profit grow through the improvement of enterprise efficiency so that the interests of shareholders or stakeholders can be guaranteed. From the perspective of financial goal, both bank-based and market-oriented models have the common premise, that is to separate ownership and management. The target of financial accounting is to provide the enterprise shareholders and other related groups with financial information about future economic decisions, when the right of ownership and management are separated, interests drive between owners and operators are not identical, the operators are inside the company, have better acknowledgement of the company's financial information, and able to make relatively quick and accurate decisions, while the shareholders and other interested parties are away from the business, whose judgment made on the basis of the financial information is relative imbalanced. The distortion of financial information results in the decision-making mistakes of shareholders, the company's strategy goes in wrong direction, and all business strategies are away from the company's actual situation, leading to investment mistake and operational failure, downturn in economic efficiency, and difficult to maximize the interests of shareholders.

Under the market-oriented model, the target of financial accounting is to accurately calculate revenue and summarize the state of operation, reflecting the fulfillment of their fiduciary responsibilities. When the ownership and operation right are separated, to ensure the operators will do the due diligence for the owner, both parties should sign contract stipulating obligations and responsibilities. The financial activities of the construction management firm focus on the reliability of information and the accurate measurement of net operating income, so that the owner can carry out reasonable assessment to the operators and make incentive mechanism, or the distortion of accounting information will affect the evaluation of the results and the enthusiasm of operators, which will not be conducive to achieve the goal of corporate governance.

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Chapter 94
Contrast Analysis of Standardization Economic Contribution Rate

Hong Zhang, Zhu Qiao and Fengjiao Sun

Abstract Standardization can improve the economic efficiency, and promote the comprehensive development of the economy, and lay a solid foundation in the scientific management. The results of standardization economic benefit evaluation can be used as a national important reference basis for setting out standardization strategy and policy. And countries have researched standardization economic efficiency to guide the standardization work of their own country. However, since there is no unified and fixed standardization economic benefit evaluation method, comparative analysis of the research results can't be conducive to further cognitive the role of standardization. In this paper, through the enterprise level, industry level, and nation level, we compare the contribution rate of international and domestic standardization economic benefits, in order to more intuitively show the standardization of significant contribution to the economy, making guidance to the decision for enterprises, industries and countries.

Keywords Standardization · Economic benefits · Contribution rate · Contrast analysis

94.1 Introduction

Standardization economic benefits have been payed close attention by the international standardization organization and national experts and scholars. Germany, Britain, Australia, Canada and other countries have studied the standardization economic benefits, and draw the same conclusion: standardization has a positive role in promoting the economy. In recent years, the research progress on the standardization economic benefits is quick, and research scope expands unceasingly.

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The research direction turns to empirical studies from the perspective of the theory (SSIT 2012). “China standardization development research report in 2011”, which is based on the basis of describing and analyzing the standardization of industry development and local standardization development from point to area, selects the “standardization economic evaluation methods and case studies” as a topic to analyze and discuss further. This suggests that the study of standardization economic contribution rate has become hot and frontier. And it is very important to do standardization economic contribution rate up. Although all studies have shown that standardization can bring positive economic benefits or other benefits, these results are difficult to compare because of these studies using different methods to measure.

Statistics and calculations in some countries abroad show the multiple between standardization benefits obtained and standards developed and implemented investment: the United States is 50 times, Japan is 10 times, Germany is 7 times, France is 18 times, and the former Soviet Union is 7.5 times (Tang and Liu 2009). We can see the economic benefits of standardization are enormous from these data. These studies are made from the angle of the ratio between input and output, and the analysis of the evaluation result is more intuitive, which can make policymakers in decision-making more clear understanding of the benefit of the standard, and attach great importance to the standard input and execution. However, although the results are intuitive, we don’t clearly know the size of standardization economic benefits the contribution rate, and we can’t understand the importance of the standardization on the whole, causing standardization can’t been mentioned on the strategic height. Therefore, based on the existing research at home and abroad, respectively from the different levels such as enterprise, industry, national, we analyze the contribution rate of standardization economic benefit.

94.2 The Contribution Rate of Enterprise Standardization on Economic Growth

Enterprise standardization is a kind of organized activities to develop, implement, manage and maintain standards, which is aimed to improve the economic benefit, with the main content of doing a good job in production, management, technology and marketing, etc. Enterprise standardization is the pillar and foundation of all the standardization, and improving the enterprise standardization is of great significance to improve the quality of enterprise management level.

Enterprise is the main part of the standardization work, “Third-rate enterprises do the products, second-class enterprises do technology, and first-class enterprises do standards”, which is a vivid summary about the importance of enterprise standardization work. The comprehensive contribution of enterprise standardization reflects on these aspects, which is beneficial to improve the enterprise benefits, work method, and the enterprise core competitiveness. The ultimate goal of enterprises standardization, however, whether it is in order to improve work method, or improve enterprise core competitiveness, is to improve the efficiency of the enterprise. Therefore, the enterprise standardization benefit is one of the important problems which the enterprise managers and standardization workers focus on, and is directly related to the implementation of enterprise standardization. In recent years, many scholars both at home and abroad do the research on the enterprise standardization economic benefits, and all agreed that the standardization brought huge economic benefits into the enterprise.

94.2.1 Research on the Economic Benefits of Enterprise Standardization in Our Country

In 2007, "Research on standardization of several major theoretical issues" published by the China institute of standardization, uses two methods, which are the analytic hierarchy process (APH) and based on the angle of management innovation, to study enterprise standardization efficiency.

They measure the standardization efficiency of Beijing Changkong co., Ltd, Wanxaing Qianchao co., Ltd, Shanghai tobacco industry, Yangye Electrical Appliance co., Ltd by the analytic hierarchy process (APH), and the standardization rates are 12.89, 13.08, 11.92, 13.08 % in 2003 (CNIS 2007).

They calculated the contribution rate of enterprise standards for production from the perspective of management innovation, and the average of standardization benefits in Bao Steel, Haier in Qingdao, Tsingtao Beer, Shanxi Coking, Saic Motor, TianShiLi, Tasly, Inner Mongolia Yili Industrial Group and China International Marine Containers, are 2.18, 13.3, 5.27, 28, 22.2, 26.66, 2.55, 13.04 % from 2000 to 2003 (CNIS 2007).

The results of the contribution rate of enterprise standardization for production, based on the analytic hierarchy process (APH) and the perspective of management innovation, show that standardization has brought great economic benefits to the enterprise. The former establishes the same index system applicable to enterprise benefits evaluation and standardization benefits evaluation, which is used to evaluate enterprise benefits and standardization benefits respectively, then calculating the ratio of the standardized index N and enterprise benefits M (N/M), and finally quantifying the contribution rate of the enterprise standardization benefits. Thinking of the proportion of the contribution rate of management innovation in the output value based on the generalized technology progress, the latter materializes the management innovation into enterprise standardization, and a set of evaluation indicators of enterprise standardization for output value contribution rate is given, and estimates the contribution rate of standardization for the enterprise output value. The former measures efficiency by the method of integrated scoring, and it has a strong subjectivity. The latter calculates efficiency through the company specific data, and it has a strong objectivity. The economic benefits of the former to estimate are for the contribution rate of the ratio between GDP and the cost of production. The latter is for the contribution rate of output value. Therefore, the comparability of these methods is poor.

94.2.2 Researches on the Economic Benefits of Enterprise Standardization in ISO

In March 2010, ISO issued standards economic benefit evaluation methods for the use of the ISO member states in designs and researches. ISO standards economic benefits evaluation methods can help the industries and enterprises to determine the value of standards creating, and grasp the method of standards to make value maximized. This methodology is based on value chain analysis method, and the research result—"the economic benefits of the standard-global case studies" has been published. Researches have shown that, for most cases, the overall benefits of standards account for 0.5 % of the company's annual sales to 4 % (SSIT 2012).

The economic benefits contribution rate of standardization in the book, according to different comparative objects, can be divided into three aspects: the influence of standardization for sales income of the enterprise, earnings before interest and tax (EBIT), and the enterprise turnover. Enterprise standardization economic benefits influence is shown in Table 94.1.

It is noteworthy that the scope of cases evaluation is different. Analysis scope of some cases is restricted to a business functions (e.g., production), analyzing the influence of the standards in the business function. Several business functions of other cases are analyzed (such as research and development, procurement, production, marketing and sales). Obviously, involving more business functions, the standards' impact is bigger.

By the table, we can see the research achievements of ISO aim to use the same methodology to quantify the enterprise economic benefits of standards. But not all the research objects are the whole process of value chain, and most of selections are

Table 94.1 The economic benefits contribution rate of enterprise standardization (%)

Company name	EBIT	Sales revenue	Turnover
PTT Chemical Public Company Limited (PTTCH), Thailand	–	3	3
Electric Company Joint Stock Company No. 1 (VINAKIP), Vietnam	21.3	10.4	–
Nanotron Technologies GmbH, Germany	–	33	–
Pretoria Portland Cement Company Limited (PPC Cement), South Africa	–	2.5	–
PT. Wijaya Karya (WIKA) Beton, Indonesia	6	0.43	–
Siemens AG, Germany	1.1–2.8	–	–
Xinxing Ductile Iron Pipes co. Ltd in China	13.92	–	–
Festo Brasil, Brazil	–	–	1.9
Gerfor, Colombia	56.25	–	7.7
DanPer Trujillo and Association Frio Aereo, Peru	–	–	1.7
Lobatse Clay Works (PTy) Ltd, Botswana	4.96	–	2.63

several business functions. So they can't fully reflect the standard economic benefits. In addition, the initial research idea is that all evaluation indexes for EBIT to measure, but EBIT, sales revenue and sales are mix in the actual measuring results. Due to the difference of evaluating reference objects, it's adverse for the transverse comparison of enterprises.

94.3 The Contribution Rate of Industry Standardization to Economic Growth

At present, the analysis research of industry standardization economic benefits evaluation is still very lacking. Standardization economic benefits evaluation of macro level, because of involving too wide range, is difficult to provide specific guidance for enterprise standardization activities. The evaluation of micro level for a specific enterprise is difficult to offer some guidance with strong universality for other enterprises standardization activities. Results of examining standardization activities from the perspective of the industry make the understanding of the position and role of the standardization specific and not narrow. It can provide foundation and basis for the standardization of the various enterprises in the same industry on the investment decision-making, the standard setting and the standard planning (Liu 2004).

Western economists, according to the order of the object of labor, divided sectors of national economy into three industries. According to the division of the three times industrial structure in our country, we select the agricultural industry as a representative of the primary industry, construction industry as a representative of the secondary industry, service industry as a representative of the tertiary industry, to analyze the economic benefits of industry standardization.

In 2011, in the journal article "economic effect analysis of agricultural standardization implementation-based on an empirical analysis of the 74 demonstration counties", Zhou Hong analyzed the effect by the comparison of the standard implementation before and after, by the national 74 standard demonstration county of survey data, designed endogenous variables of standardization, used the generalized C-D production function, and calculated standardization economic effect. It is concluded that the agricultural economic growth contribution rate of agricultural standardization implementation is about 30 % (Zhou and Zhu 2011).

In 2009, Wang Chao, a doctor of Beijing Jiaotong University established a Computable General Equilibrium (CGE) model to calculate the economic benefits of engineering construction standardization in his doctoral thesis—"The research on engineering construction standardization of influence to the national economy". He concluded that engineering construction standardization boosted GDP growth by 0.4 % points. The study was aimed at the whole engineering construction standard system to the national economy, and it's easy to integrally understand the influence of engineering construction standard's contribution to the national economy (Wang

2009). In 2010, Wu Xudan, a master of Beijing Jiaotong University, established a Cobb-Douglass Function model to calculate the economic benefits of engineering construction standardization in his master paper—"the engineering construction standardization research on evaluation method of the impact of the national economy". He concluded that the number of standards of engineering construction changes 1 %, the correspondingly changing 0.28 % in GDP (Wu 2010). In the same year, Liang Xiaozhen through the research results based on the National Natural Science Foundation of China (NSFC)—"the empirical research on the impact of engineering construction standardization on economic growth of our country-based on the theory of co-integration theory, Granger causality effect examination and ridge regression" which is also based on C-D production function model, concluded that, from 1978 to 2006, the GDP contribution degree of engineering construction standards is 0.222: Under the condition of other factors remaining unchanged, the number of standards increase 1 %, and the GDP will increase correspondingly by 0.222 %. The latter two studies are based on standard stock changes to reflect the contribution of standards in the new increasing GDP, which can accurately reflect the contribution of standard quantity to the national economic growth (Liang 2010).

In 2013, Guo Zheng, through an journal article "Contribution of services standardization to economic growth," quantitatively measured the contribution of service standardization, and established a new quantitative model—Composite Matrix methods. Starting from the survey of the micro-enterprise, using assertions of the enterprise to contributions of services standardization, finally, he concludes that its contribution rate in the national economy is 1.0408 %, which means that the work creates a total of 414,220,700,000 yuan of new GDP growth (Guo and Jin 2013).

Empirical studies of the economic benefits of these three industry-standards, fully explain that the development, promotion and implementation of standardized industry has a significant role in promoting China's economic growth. Now, our country needs to develop standardized construction energetically, and the implementation of industry standardization needs support, promotion and popularization of the government.

94.4 The Contribution Rate of National Standardization to Economic Growth

At the national level, many studies on the economic benefits of standardization have been done at home and abroad. Most research methods are based on the C-D production function model, which is originally developed by Germany. In 1997, the German Institute for Standardization (DIN) launched the "study of standardized overall economic" for two years in Germany, Austria and Switzerland. They adopt economic methods to analyze the economic development situation in 1960–1996, and analyze the data of business sector according to the capital, labor force production factors and three technological progress indicators (the number of registered patents, costs of adopting foreign patent in Germany, the number of standards and

Table 94.2 National standardization for economic contribution rate list

Nation	Research objects		Research results (%)	Content
	Independent variable	Dependent variable		
China	Standard stock variation	Economic growth variation	0.79	Yu Xinli, who is the former vice president of China Standardization, and now chief engineer at the National Standards Committee, compiled a book in 2008, "Standardization and economic growth—theories, demonstrations and cases", and studies showed that: in the past 30 years, 0.79 % increase in economic growth for every 1 % increase in standard stock (Yu 2008)
Germany	Standard system	Economic system	1	In 1999, DIN studies showed: Standardization contributed 0.9 % in annual economic growth rate (3.3 %) in Germany, which accounted for about 30 % of the average annual real GDP growth, and they estimated that the economic benefits of standardization were about 1 % of GDP. DIN tried to update and improve the initial findings of economic benefits related to standardization study in 2011, and the study showed: after German reunification, the standard stock increased by 1 %, and the economy grew in 0.7–0.8 % (Fan 2013)
	Standard stock variation	Economic growth variation	0.7–0.8	
England	Standard stock variation	Labor productivity rate variation	0.05	UK used the British statistics from 1948 to 2002, and analyzed and got the following three conclusions: First, 0.05 % increase in labor productivity forces growth for every 1 % increase in standard stock; Second, standards contribute about 0.28 % in labor productivity rate growth, which means standards contribute about 13 % of productivity forces growth in Britain from 1948 to 2002; third, the standard for technological progress contribution rate is over 25 % (SIS 2007)
	Standard system	Labor productivity forces variation	0.28	
France	Standard system	Economic system	0.81	In 2009, Association Francaise de Normalisation (AFNOR) launched a macroeconomic research on the impact of standards for economic growth, and the data about macro economy from 1950 to 2007 were analyzed. The study showed: the contribution rate of standardization to the French annual economic growth was 0.81 % (CNIS 2012). In addition, the findings also showed that 0.12 % increase in TFP growth for every 1 % increase in standard stock (Fan 2013)
	Standard stock variation	Total factor productivity rate (TFP) variation	0.12	

(continued)

Table 94.2 (continued)

Nation	Research objects		Research results (%)	Content
	Independent variable	Dependent variable		
Canada	Standard stock variation	Labor productivity rate variation	0.356	In 2007, Conference Board of Canada measured the impact of standards and the capital-labor ratio for the Canadian labor productivity rate from 1981 to 2004. The study showed that: 0.356 % increase in labor productivity rate growth for every 1 % increase in the standard stock (Fan 2013)
New Zealand	Standard stock variation	Total factor productivity rate (TFP) variation	0.10	In 2011, New Zealand implemented a two-stage evaluation program, and studies showed: 0.1 % increase in TFP growth for every 1 % increase in standard stock, and labor productivity rate increase by 0.054 % (Fan 2013)
	Standard stock variation	Labor productivity rate variation	0.054	
Australia	Standard stock variation	Productivity forces variation	0.17	In 2002, Australia launched the study "standards, innovation and the Australian economy". Based on 40 years data before the deadline in 2002, the study results indicated that 0.17 % increase in the productivity of the entire economy growth for every 1 % increase in standard stock (CNIS 2012)

technical regulations), and regression analysis is used to calculate the various factors of production to the contribution rate of economic growth (Zhang et al. 2007). Since then, the study of standardization economic benefits has been launched in succession. The research results of various countries are shown in Table 94.2.

From the table, we can see the standardization economic contribution rate is divided into two aspects: one is standardization impact on the economy, such as Germany (0.7–0.8 %), France (0.81 %), China (0.79 %); the other one is standardization impact on productivity, such as British (labor productivity rate 0.05 %), France (TFP 0.12 %), Canada (labor productivity rate 0.356 %), New Zealand (TFP 0.10 %, labor productivity rate 0.054 %), Australia (0.17 % increase in productivity forces). From these data, we can find that although the impact of standardization on productivity is not the same, ultimately the contribution rate to economic growth is around 0.8 %. This shows that whether it is developed countries or developing countries, standardization can bring huge economic benefits to the country.

China, as a developing county, has a large gap on the standardization work compared with developed countries, so we should pay more attention to the standardization work. Therefore, we should increase the investment of standardization, and perfect the execution of the standard process, making standardization to make greater contribution to the development of our country's economy.

94.5 Conclusion

Quantitative benefits of standards have major significance for monitoring and prioritizing standardization activities. And standardization economic evaluation results can be used as an important reference to formulate standardization strategies and policies. And it can raise awareness, promote exchanges, promote the use of standards and encourage stakeholders participating in the standardization work at the same time. Over the past few years, many national standards bodies, and other research teams had carried on some researches on this subject.

Through contrastive analysis of enterprise, industry, nation on standardization economic contribution rate, this paper systematically and objectively demonstrates the significance of standardization work to economic development, and makes a guide for decision-making to the enterprise, the industry, and the nation. However, due to lack of uniform methodology about the standardization economic evaluation and quantification methods, it is difficult to compare the results obtained, and not conducive to obtain the baseline and general trends from studies (SSIT 2012). Therefore, to find a universal suitable method capable to transversely compare standardization economic benefits of different companies, different industries, and different nations is very important. Because there are contrasts, we can have a more objective understanding of the standardization work, and find deficiencies of work in order to better implement standardized work.

Standardization work is not just to study the enterprise, industry, national standardization, and standardization itself should be standardized. The economic evaluation methods, indicators, and objects standardization will be more conducive for standardization work, and they will bring greater contributions to economic development.

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Chapter 95
Comparative Study of Engineering Construction Standardization Economic Benefit Evaluation Methods

Zhu Qiao, Hong Zhang and Fengjiao Sun

Abstract With the economic globalization, the function of standardization strategy is prominent, and many countries make standardization as one of the important strategic goals, in order to improve capability of independent innovation and core competitiveness. At present, the research on the evaluation of standardization economic benefit is hot and frontier. However, not unified evaluation methods make it difficult in comparing and analyzing the results of standardization economic benefit. This paper compares and analyzes the application scope, advantages and disadvantages of the method, in order to find the most appropriate research methods, providing the guidance for the research of standardization economic benefit.

Keywords Standardization · Economic benefit · Engineering construction · Evaluation methods

95.1 Introduction

With the rapid development of economic globalization and information technology, the standard has become one of the best tools to promote the industry development and foreign trade, and standardize market economic order. Many countries make it as one of the important strategic goals in order to improve capability of independent innovation and core competitiveness. Therefore, the problem of standardization economic benefit draws attention to the international standardization organizations and experts and scholars from all over the world. In recent years, the research progress on the standardization economic benefit is rapid at home and abroad, and the research scope expands unceasingly. At present, economic benefit evaluation models of standardization at home and abroad mainly include: investment income theory evaluation system in China (GB/T 3533), the production function method

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represented by England and Germany, ISO methodology that taking “value chain” as core theory. However, as the evaluation methods haven’t unified and fixed standards, the standardization economic benefit can’t be compared and analyzed. This is not conducive to further understand the role of standardization. Combining with economic benefit evaluation methods of the engineering construction standardization in our country, this paper compares and analyzes the application scopes and advantages and disadvantages of the standardization economic benefit evaluation methods, in order to find the most appropriate research method, making guidance to the research of standardization economic benefit.

95.2 Research Situation of Engineering Construction Standardization Economic Benefit Evaluation

Currently, standardization economic benefit evaluation can be divided into two levels: one is the macro level, namely from the perspective of the whole country evaluating standardization economic benefit. The other one is the micro level, namely from the perspective of enterprises evaluating standardization economic benefit. Due to the scope of the macro level of standardization economic benefit evaluation is too wide, it is difficult to provide specific guidance for enterprise standardization activities. The micro level evaluation result for a specific enterprise is not suitable for other enterprises, and the guidance provided hasn’t a certain universality. Examining standardization activities from the perspective of the whole industry makes the understanding of standardization position and role specific but not narrow. It can provide companies in the same industry with foundation and basis for standardization investment and decision-making, formulating and planning standards. Above all, we should attach importance to the industry standardization economic studies (Liu 2004).

Engineering construction is the important pillar of the national economy, and the research on the industry standardization economic benefit is of constructive significance. Engineering construction standardization, as an important part of standardization, has a significant contribution to the economic development. At present, the research of standardization economic benefit is mostly based on experience and theoretical analysis, and system and quantitative analysis should be studied further (Feng et al. 2012). Therefore, combined with existing research results in our country, this paper introduces the situation of engineering construction standardization economic benefit evaluation.

In 2007, “some important theoretical problems in standardization researches” compiled by China institute of standardization was published, systematically revealed the standard’s role in the development of social economy, the contribution rate of the standard for comprehensive national strength, and the standard economic benefit evaluation methods and other major theoretical issues. The book put forward two methods to study the economic standardization benefit: one is enterprise standardization economic benefit analysis based on analytic hierarchy process

(AHP), the other one is from the perspective of management innovation measuring the contribution of enterprise standards for production. The former builds the evaluation index system from the perspective of the mechanism about standardization benefit in enterprises. This method synthetically evaluates enterprise standardization benefit contribution rate through introducing "contribution coefficient", the fuzzy membership degree valuing assignment, and expert scoring method. The latter is regarding the standard as a management innovation of enterprises, which can be included in the general technological progress. In the evaluation of the contribution rate of enterprise standards to output value: firstly, the effect of general technological progress in the production value contribution rate should be broken down, considering the share of the management innovation in general technological progress contribution rate in output value; secondly, management innovation should be translated into enterprise standards, considering its contribution to the output; finally, we can explore relatively feasible calculation methods to measure enterprise standards' contribution rate (CNIS 2007).

In 2008, "Standardization and Economic Growth—Theory, Demonstration and Cases" written by Yu Xinli, who was the former vice President of the national institute of standardization, used Cobb-Douglass Function model, systematically and comprehensively estimated the standardization economic benefit. In order to estimate "standards in the contribution rate of economic growth", the book firstly takes the long-term growth of GDP as an indicator of economic growth, converting "researches on the relationship between standards and economic growth" into "a study on the relationship between standards and long-term GDP growth". The book sets up a GDP growth model through Cobb-Douglass Function model, and then translates into the statistical regression model to estimate parameters of the model (Yu 2008). In the same year, Song Tao, a Hunan university master, studied the standardization economic benefit through a modified Cobb-Douglass Function model in his master thesis "Empirical Analysis on Standardization and Economic Growth". Since then, the study in this model becomes more and more, and turns into the mainstream method to measure standardization economic benefit in all walks of life.

In 2009, Wang Chao, a doctor of Beijing Jiaotong University established a Computable General Equilibrium (CGE) model to calculate the economic benefit of engineering construction standardization in his doctoral thesis–"Researches on the Influences of Construction Standardization to the National Economy". In the paper, by designing questionnaire, he received specific affect parameters in engineering construction standardization of CGE model, and simulated the parameters calibration influence to Chinese economy. Finally, the influence of engineering construction standardization to the national economy was concluded.

In 2010, Wu Xudan, a master of Beijing Jiaotong University, established a Cobb-Douglass Function model to calculate the economic benefit of engineering construction standardization in his master paper—"Research on Evaluation Method of Construction Standardization Effect on National Economy".

In 2011, Liu Yang, a master of Northeast Forestry University, calculated the economic benefit of engineering construction standardization in his master's thesis—"Engineering Construction Standards Research Based on the Enterprise Level", which adopted the Cost-Benefit Analysis. In view of the research of engineering construction standards for the enterprise economic utility, he firstly determined the composition of costs and benefit of the engineering construction standardization, and then established the cost efficiency's mathematical model of profit and loss. Finally, he, according to the model, obtained the critical quantity of standards, marginal cost and marginal revenue. According to the financial index to measure the evaluation index which the model needed, the enterprise can get size of the marginal effect of engineering construction standardization for the enterprise.

95.3 The Comparative Analysis of Engineering Construction Standardization Economic Benefit Evaluation Method

In view of the effects of different areas and different levels on the engineering construction standardization, you should select specific and appropriate calculating methods. In the micro level, you should use the micro-economic method, such as

Table 95.1 Comparative analysis of standardization economic benefit evaluation methods

C-D production function	Levels of evaluation	Nation	Applicable
		Industry	Applicable
		Enterprise	Applicable in theory
	Advantages The model has been widely used in the economics of growth, and the theory of research on standardization economic benefit through this method has been relatively mature at home and abroad		
	Disadvantages It takes standards and other indicators as the influence factors of technological change, and measure the influence degree of standardization on the economy by the technical change in economic production function. So the standardization contribution rate is not accurate reaction (Yu 2008; Wu 2010)		
CGE model	Levels of evaluation	Nation	Applicable in theory
		Industry	Applicable
		Enterprise	No research
	Advantages It has a clear economic structure, and reflects the relationship between the macro and micro variables. This is the combination of input-output model and linear programming model, and results are more intuitive		
	Disadvantages It has a high requirement to the data, and engineering construction standardization in our country is lack of the basis of international general data, making difficulty in using the CGE model. In addition, the software system of the model is relatively high-end, and the personal computer operating system is difficult to run (Wang 2009)		

(continued)

Table 95.1 (continued)

ISO methodology	Levels of evaluation	Nation	Applicable in theory
		Industry	Applicable in theory
		Enterprise	Applicable
	Advantages The core of the method is the value chain theory. It distinguishes the influence of the standard and the other factors (SSIT 2012). The economic benefit of standards calculated is more accurate		
	Disadvantages To distinguish the influence of standards and other factors is difficult. It needs enough data		
Enterprise standardization economic benefit analysis based on analytic hierarchy process (AHP)	Levels of evaluation	Nation	Not applicable
		Industry	Not applicable
		Enterprise	Applicable
	Advantages This method, to a certain extent, avoids difficulty in the collection of original data, and the obstacles lack of the unified evaluation index. The method on the evaluation of engineering construction standardization in the enterprise level is more applicable		
	Disadvantages Due to the engineering construction standardization with wider range of influence, and not the simple sum of relevant factors, the qualitative indexes for engineering construction standardization of factors that influence the national economy can't be intuitively judged. In addition, if the relevant statistics are lack, it can make the calculation of quantitative indexes extremely difficult (CNIS 2007)		
From the perspective of management innovation calculating the contribution ate of enterprise standards for production	Levels of evaluation	Nation	No research
		Industry	No research
		Enterprise	Applicable
	Advantages To recognize the contribution of the enterprise standard on output growth with innovative thinking is an important part of a complete evaluation to the enterprise standard, making the standard benefit evaluation more comprehensive		
	Disadvantages Based on the endogenous growth model, some factors influencing the business performance and income may be left out. To analyze a case or a micro enterprise operation has a certain limitation, and it is difficult to guarantee the enterprise management innovation including standard alone operation in a period (CNIS 2007)		
Cost-benefit analysis (CBA)	Levels of evaluation	Nation	Applicable
		Industry	Applicable
		Enterprise	Applicable
	Advantages The calculating results are relatively straightforward		
	Disadvantages There are some artificial parameters and a lot of intangible benefit without measuring. And it did not consider the effect of standards to the comprehensive behavior ability (Liu 2011)		

(continued)

Table 95.1 (continued)

Investment income theory evaluation system	Levels of evaluation	Nation	Applicable
		Industry	Applicable
		Enterprise	Applicable
	Advantages It stipulates a series of index systems of the standards economic benefit evaluation and calculation methods, and the index system includes standardization economic benefit, investment payback period, rate of return on investment, economic effect coefficients and so on. And the measuring method is relatively simple		
	Disadvantages The evaluation objects of this method mostly are product standards. It is lack of considering the system of standardization and the enterprise external environment, and neglects the detailed description of the qualitative analysis of economic benefit. And when evaluating comprehensive standardization economic effect, the qualitative evaluation method is often more than the quantitative evaluation method, and it is difficult to quantify		
Data envelopment analysis (DEA)	Levels of evaluation	Nation	No research
		Industry	No research
		Enterprise	Applicable
	Advantages It can avoid the influence of the interaction relationship in the indicators, and position it from relative effectiveness of the evaluation objects, avoiding ensuring the weight coefficient of each index at statistical average meaning, excluding the subjective factors. It has the internal objectivity, and ensures the accuracy and effectiveness of evaluation		
	Disadvantages Due to the non-parametric technique of DEA, the statistical hypothesis test is very difficult, and it isn't able to know the theoretical maximum. In addition, the method to calculate is multifarious, and the enterprise benefit evaluation index are numerous, increasing the difficulty in application of the enterprise standardization benefit evaluation (Song et al. 2003)		

Cost-Benefit Analysis (CBA); in the industry level, you should choose meso-economic method, such as Econometric Approach; in the macro level, you should choose macro-economic analysis methods, such as CGE model or Cobb-Douglass Function model, etc. If you want to measure all-round, multi-angle and multi-level standardization economic effect, you should establish the multi-model integrated measuring system, and choose the appropriate mathematical model on the basis of choosing combination of macro, middle and micro level in economic measuring methods, finally use a scientific method to measure the effects of engineering construction standardization in different areas and different levels (Wang and Li 2013).

Combined with engineering construction standardization economic benefit evaluation methods in our country, contrastive analysis of the standardization economic benefit evaluation methods is sorted out as shown in Table 95.1.

Table 95.2 Evaluation methods suggested

Levels of evaluation	Evaluation method suggested	Suggested reasons
Nation	C-D production function	Whether the industry or country, theories and researches of the method have been relatively mature. Through the change of standards stock to reflect its influence on economic benefit is relatively objective, and the data source is accurate which comes from official statistics
Industry	C-D production function	
Enterprise	ISO methodology	Taking the value chain as the core, through the analysis of the company's value chain, the standard influence of each link is derived. And then the influence of the economic benefit is directly measured, and the data source is accurate. This evaluation method is objective

95.4 Conclusions

Through comparative analysis of standardization economic benefit evaluation methods, we can clear and definite their respective advantages and disadvantages. In order to make an accurate evaluation and quantification of standardization economic benefit, comparing and analyzing results among different countries, the industry, the enterprise, domestic and foreign experts are trying to develop an evaluation system, which can evaluate standardization economic benefit on different levels. But so far, we haven't accurately evaluated the standardization economic benefit from different aspects through one method. Therefore, combining with the advantages and disadvantages of various methods, as well as the existing research results, recommendations to evaluate standardization economic benefit of different aspects are listed as in Table 95.2.

The table shows that "C-D production function method" and "ISO methodology" are relatively mature and widely used evaluation methods in the world, but the two methods still have some shortcomings applied to the engineering construction standardization economic benefit evaluation. Due to incomplete data in the field of engineering construction in our country, results of adopting the C-D Production Function model may be not accurate. In addition, this method, which is based on the medium of technical progress, takes the standard, together with other indicators as the influence factors of technological change, and the deflection of estimating results is larger. So the method still needs further perfection. ISO methodology is mainly based on the enterprise micro level for quantitative analysis of standardization economic benefit. It needs to conduct a comprehensive consideration and research at the industry and national levels. So the evaluation method also should be studied further. We should absorb the advantages of the two methods to explore a more accurate evaluation method from the angle of establishing the econometric model and the evaluation index system, and refining standardization economic benefit.

Faced with the situation, we should have the courage to explore, and dare to rush and try. On the basis of the predecessors, combining with the engineering practice of our country, we can explore a more accurate scientific method to quantitatively measure the engineering construction standardization economic benefit. This is conducive to further understand and recognize the significant role of standards for engineering professionals, and make standards better contribute to the project construction quality, safety and economic benefit.

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Chapter 96
Common Illness that Affect the Performance of Residence: A Case from South Africa

Chikezie Eke, Clinton Aigbavboa and Wellington Thwala

Abstract Sophia town residence is one of the residence in University of Johannesburg and this paper present a findings of common illness that affects the performance of the students in the residence. The purpose of the paper is to evaluate the common illness that affects the students' performance. The data were collected during October and November 2012; and was with the aid of a structured questionnaire. Out of the 150 questionnaires that were distributed, 135 were received back from the students that reside in the residence. Findings from the survey reveal that fatigue/tiredness was the commonest illness students experience and was ranked first from the mean item score table while nausea was ranked last.

Keywords Common illness · Performance · Residence

96.1 Introduction

Most of the illnesses or sicknesses experienced in the residence are caused by poor indoor environmental quality (indoor air quality, lighting, thermal comfort, noise, ergonomics). Poor indoor air quality is a serious health risk factor and causes diseases such as cancer, respiratory diseases, and so on. Incorrect temperatures may have serious consequences for the occupant's body because different people have different body metabolism and if not addressed properly and timeously, it may

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affect the occupant's performance, which may drop significantly as a result of constant tiredness due to a too high temperature; or through shivering and coldness caused by a too low temperature in the residence (Eke 2014). Special interventions are required, as the poor-quality indoor air environment has serious health implications for the lives of resident users. The poor indoor air quality increases the chances of sick-building syndrome, and respiratory illness, resulting to sick students being absent from school, which in turn may lead to a reduction in the residence and also affect there academics (Antikainen et al. 2008). If the indoor air quality is not taken seriously, it may affect the occupants by causing irritation of eyes, noses, throats, headaches, dizziness and fatigue. These effects may be made worse by an inadequate supply of good-quality indoor air (Hassanain 2008). The common illness that can be experience in the residence are headache, cough, fever, nausea, fatigue or tiredness, common cold, influenza, dizziness and others. The bad aspect of some of these illnesses is that some of them are contagious like cough and influenza and it will affect the students' performance both academically and other wise. If the residential building offers poor resting conditions, it will affect the health of the occupants, which will ultimately reduce their performance. A poor resting environment will affect the occupants' lives and those of their families, because when a student is affected by a serious illness, their family members will have to take care of them or obtain medical assistance for the patient (AL-Anzi 2009). The study place is critical to the occupants' lives because they spend the most part of their day studying. It is of vital importance that the institution creates an environment that is healthy for users of the building. Occupants may be affected by health hazards that are harmful to their bodies and even their lives. These study-related illnesses have many effects on the occupants' lives and will ultimately result in loss of concentration in academics, pain and suffering (AL-Anzi 2009).

Health issues are the big worry of all institution around the globe in terms of effective academic excellence; therefore institutions must take this health problem very serious so as to avoid poor quality of work because of unhealthy occupants (students). Institutions have to make provision for resources that will cater for periodic visits from health specialists to come and determine whether occupants are still healthy and fit. If diseases are diagnosed at an early stage, corrective action can be taken to ensure that occupants stay healthy (AL-Anzi 2009: 39).

96.2 Methodology

The research was conducted between the months of October and November 2012 and a quantitative research approach was used in this research. A 150 well-structured questionnaire was sent out in the collection of the data from the occupants of Sophiatown residence and 135 were received and are useable. The 135 useable questionnaires represent a 90 % response rate which is considered adequate for this analysis.

96.3 Findings and Discussion

Findings from the usable 135 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 was blacks (97 %), followed by (3 %) whites. Majority of the respondent status (97 %) were full time and (3 %) were part time. Majority of respondents level of study were (34.1 %) first year, followed by (30.4 %) second year and the minority were (2.2 %) fifth year. Majority of respondents highest education qualification were (76 %) grade 12 (matric), followed by (11 %) post graduate degree(s) and the minority were (2 %) diploma or certificate. 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 were (44.8 %) less than 1 year, followed by (38.8 %) 1 year and the least was (16.4 %) more than 1 year.

Respondents were asked the health frequency of the students. The result from the questionnaire indicated that fatigue/tiredness (MIS = 2.90; R = 1) was ranked first, followed by headache (MIS = 2.61; R = 2) which was ranked second, common cold (2.36; R = 3), cough (MIS = 2.18; R = 4), influenza (MIS = 1.95; R = 5) dizziness (MIS = 1.94; R = 6), fever (MIS = 1.92; R = 7), and nausea (MIS = 1.73; R = 8) was ranked last (Table 96.1).

Respondents were also asked the illness experienced from the residence. Nausea was ranked first (MIS = 1.72; R = 1), dizziness was ranked second (MIS = 1.61; R = 2), cough was ranked forth (MIS = 1.40; R = 4), and common cold was ranked fifth (MIS = 1.29; R = 5), while fever was ranked second to the last (MIS = 1.20; R = 7), and fatigue (tiredness) was ranked last (MIS = 1.19; R = 8). Literature reviewed indicated that occupants may be affected by health hazards that are harmful to their bodies and even their lives. These study-related illnesses have many effects on the occupants' lives and will ultimately result in loss of concentration in academics, pain and suffering (AL-Anzi 2009) (Table 96.2).

Table 96.1 MIS of student health frequency

	MIS	Rank (R)
Nausea	1.72	1
Dizziness	1.61	2
Influenza	1.58	3
Cough	1.40	4
Common cold	1.29	5
Headache	1.21	6
Fever	1.20	7
Fatigue (tiredness)	1.19	8

Table 96.2 MIS of student health frequency

	MIS	Rank (R)
Fatigue (tiredness)	2.90	1
Headache	2.61	2
Common cold	2.36	3
Cough	2.18	4
Influenza	1.95	5
Dizziness	1.94	6
Fever	1.92	7
Nausea	1.73	8

96.4 Conclusion and Recommendation

The findings from the study revealed that occupants experience all the common illness that affects the students' performance. However, fatigue (tiredness) is the most commonly health frequency (MIS = 2.90; R = 1) and also affect the students' performance. In the aspect of illness experience, findings from the study revealed that majority of the occupants frequently had nausea (MIS = 1.72; R = 1) more than other common illnesses that affect the students' performance. Recommendation is that the institutions have to make provision for resources that will cater for periodic visits from health specialists to come and determine whether occupants (students) are still healthy and fit because unhealthy students produces poor academic performance.

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Chapter 97
Application of the Precast Staircase and Balcony in the Residential Building

Huanhuan Wu, Yajun Cai and Yilong Zhang

Abstract Currently, the construction of staircase and balcony relies mainly on traditional wet operations. With the development of green building and sustainable development concept in residential construction, the traditional mode of residential construction has been in need of reform and precast components can settle the problem effectively. This paper introduces the research status of precast components domestic and overseas and analyses the different characters between the precast staircase and balcony and traditional construction components in the construction process, cost construction, etc. The paper also analyses the cost variances in labor, material, machinery by the method of fixed set of price and the value variances under the two different production mode by Life Cycle Cost theory and Value Engineering theory. Some recommendations for the application of the residential components such as the precast staircase and balcony are proposed.

Keywords Precast staircase and balcony · The life cycle cost · The value engineering · Residential components

97.1 Introduction

The level of the housing industry in our country is low and the residential construction is extensive on the whole. Traditional old technology is still applied on the large scale. The advanced technology and technical innovation are excluded on account of short-term conduct. Precast components can be constructed by green technologies of construction and be recycled after the demolition of buildings. The application of precast components can shorten the work period, save labor, reduce construction waste emissions, reduce the noise of the construction and emissions of harmful gas and dust substantially through factory production and prefabricated construction at the scene. Precast staircase and balcony (PC staircase and PC bal-

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cony) are the staircase and balcony whose components of the staircase and balcony are prefabricated in the in prefabrication field or the locale and installed on the scene and they are small and medium-sized prefabricated parts which has high frequency in the prefabricated housing system. Prefabricated housing components develop slowly currently in our country, the main reason is that the construction cost of housing components in the initial stage is higher than the traditional production residential products (Que et al. 2010). We choose the PC staircase and PC balcony as the breakthrough point and analyze the superiority of the PC staircase and PC balcony in the construction cost and value to transform the traditional construction mode and promote the application of the residential components.

97.2 Literature Review

The development of the residential components at abroad has a long history. It is reported that there are 5 ten thousand residential components on the content of the American residential components, 1 ten thousand on the content of the Japanese residential components (Li 2014). Housing industry concept was first proposed by the Japanese MITI, the purpose is to reduce the workload of the site, shorten the construction period, to improve housing production efficiency. Related studies have shown that, in recent years, the precast construction has reached more than 65 % in Singapore (BCA 2005). Jaillon and Poon (2008), says that many developed countries support the extensive use of prefabricated in housing construction, which consists of the slab floors, staircase, toilet unit and internal filling part, etc. Yee (2001) suggests that prefabricated components have a great advantage in the housing construction, such as, the prefabricated components can shorten the construction period, Improve the quality of projects, reduce the waste of energy and water, etc. Chen et al. (2010) provides a objective and transparent tool to test the feasibility that whether prefabricated components put into use in the concrete construction well.

In 1999, the State Council issued several opinions on promoting the modernization of housing industry to improve the quality of housing and articulated the importance of establishing system of housing components. Wu and Ding (2014) probes the prospect of prefabricated housing in the whole baths by analyzing the construction process of the whole baths and present the innovation compared to traditional bathroom renovation. Pan and Zhang (2014) use the method of fixed set of price to analyze the direct cost between the precast external wall panels and the traditional brick facades and put forward relevant recommendations to promote the application of precast concrete wall panels. Pan et al. (2011) analyze the feasibility of the application of the inner precast wall panels in Chongqing. Wei (2012) makes some exploration and reflection on the demand of residential parts for the fully furnished residential from the perspective of promoting the development of housing industry. Zhang and Xu (2013) analyzes the life cycle cost of the assembly of residential apartments and make comparative analysis of the economy between prefabricated houses and the traditional houses by the life-cycle assessment model.

In conclusion, most of the researches at present aim at the whole prefabricated system. The paper select PC stair and PC balcony as the object and makes comparative analysis between the prefabricated components and traditional production in construction process, cost, value etc. We also put forward some suggestions to the application of the industrialization of residential components.

97.3 Construction Process Comparison Between PC Staircase, Balcony and Traditional Staircase, Balcony

97.3.1 Construction Technology

97.3.1.1 The Construction Process of Cast-in-Place Staircase and Balcony

Cast-in-place staircase and balcony use the whole formwork setting and casting in the construction site. The stiffness of cast-in-place staircase and balcony is big and the integrality is good, but it's construction speed is slow and labour demand and environmental pollution are bigger. Their construction process are as follows:

The construction process of cast-in-place staircase: Measuring and unreeling → The stair bottom die → Tie the bottom of the stair board reinforced → The side form of staircase → Tie the negative reinforcement and the upper reinforcement of stair board → The footfall template → Concealment acceptance → concrete.

The construction process of cast-in-place balcony: Measuring and unreeling → The beam, plate template → Concealment acceptance → concrete.

97.3.1.2 The Construction Process of PC Staircase and PC Balcony

PC staircase and PC balcony use the factory production and prefabricated construction, the construction method can not only meet the use function and but also can shorten the construction period effectively. They also can save labor and reduce construction waste dramatically. Their construction process are as follows:

The construction process of PC staircase: Pouring the concrete → Install the rest flat pallet → Install the flight → welding → Crack seal.

The construction process of PC balcony: Sit pulp → lifting → Adjust → Welding anchor reinforcement → concrete.

97.3.2 The Composition of the Project Cost

According to method of the quota pricing, the cost composition of the staircase and balcony contain the direct cost, indirect cost, profit and taxes. The direct cost contains labor cost, material cost and machinery cost and it is the main part of the direct cost. Because of the construction of prefabricated components such as PC staircase, PC balcony is prefabricated in factory or construction site. The direct cost of PC staircase and PC balcony mainly comes from the process which the prefabricated components are produced, transported and installed. From that, we can see that the production, transportation and installation of the PC stair and PC balcony has an powerful influence on the construction cost.

97.3.3 The Comparison of Life Cycle Cost Between Two Construction Methods

The Life Cycle Cost of projects means that costs incurred in the project design, development, construction, use, maintenance and disposal. This paper select a specific project, use GBQ and the method of fixed set of price to analyze the construction cost of staircase and balcony under two construction methods; We use the method of literature collection, construction site survey, professional and technical personnel face to face interviews to estimate the life cycle assessment of staircase and balcony under two construction methods. The paper evaluates PC stair and PC balcony from the construction cost, the life cycle cost and value engineering. Then, we can have a new understanding in prefabricated residential components, and put forward some suggestion for the promotion and application of prefabricated residential parts.

The paper select a residential building as the object of the study. This residential building has six layers; The floor height is 3 m; The horizontal projected area of the staircase is 219.28 m^2; The horizontal projected area of the balcony is 234.2 m^2.

(1) Construction cost
The paper uses budget software and the method of fixed set of price and gets the project cost of the staircase and balcony when they are prefabricated and cast-in-place as shown in Table 97.1:

(2) the cost of use and maintenance period
Because the cost of use and maintenance period is lack at present, we refer to the regulation of the property management fee standard (the property management fee of traditional ordinary is 1.5–3.0 yuan/m^2/month) and the building maintenance expenses in our country (the maintenance cost of traditional house is 60 yuan/m^2) (Wang 2008). We get the property management fee of the cast-in-place staircase and balcony are 2.6 yuan/m^2/month and 2.4 yuan/m^2/month; the maintenance cost of cast-in-place staircase and

Table 97.1 The cost comparison of the staircase and balcony (unit: yuan)

Items	Staircase			Balcony		
	Cast-in-place	PC	Percent increase (%)	Cast-in-place	PC	Percent increase (%)
1 Direct cost	104,398.72	120,859.66	15.76	168,447.9	197,904.98	17.48
2 Indirect cost	9918.88	10,262.89	3.47	16,056.17	16,640.14	3.63
3 Profit	2288.09	2367.45	3.44	3703.85	3838.56	3.60
4 Taxes	4057.88	4645.45	14.47	64,549.64	7599.75	17.55
5 Total cost	120,663.57	138,135.45	14.48	194,757.56	225,983.43	16.03
3 Unilateral price	550.27	629.95	14.48	831.59	964.92	16.03

balcony are 1.2 yuan/m^2 and 1.4 yuan/m^2 when we get the life cycle is 50. So the cost of use and maintenance of the traditional staircase is 2.6 * 12 + 1.2 = 32.40 yuan/m^2; The cost of use and maintenance of the traditional balcony is 2.4 * 12 + 1.4 = 30.20 yuan/m^2. For PC staircase and balcony, We get the property management fee of the PC staircase and balcony are 2.08 yuan/m^2/month and 1.80 yuan/m^2/month; the maintenance cost of cast-in-place staircase and balcony are 0.8 yuan/m^2 and 1.0 yuan/m^2 when we get the life cycle is 50. So the cost of use and maintenance of the traditional staircase is 2.08 * 12 + 0.80 = 25.80 yuan/m^2; The cost of use and maintenance of the traditional balcony is 1.8 * 12 + 1.00 = 22.6 yuan/m^2.

(3) Recycling cost of demolition

By consulting relevant literature, we estimate the total value of the dismantling costs of the residence and the benefits of recycling, the final remaining construction and installation's cost of traditional residence is about 3 %, of the housing industrialization is about 10 % (Liu and Zhou 2012). The main reason of the difference lies in that prefabricated components have the characteristics of sustainable development and can be recycled in the construction mode of housing industrialization. According to Table 97.1, we know that demolition recycling costs of Cast-in-place staircase and balcony is 16.5 yuan/m^2 and 24.9 yuan/m^2; demolition recycling cost of prefabricated stair and prefabricated balcony is 63.0 yuan/m^2 and 96.5 yuan/m^2.

(4) Contrast of Life Cost Cycle

The construction time of this residential building is one year and its full life cycle is 50 years. The discount rate we choose 12 %. We can know the whole life cycle cost of the staircase and balcony under the two construction methods as Table 97.2 shown:

In conclusion, the life cycle cost of the cast-in-place staircase, namely C1 is 731.51 yuan/m^2,the life cycle cost of prefabricated staircase, namely C2 is 753.89 yuan/m^2, so C2/C1 is 1.031. That is to say, the life cycle cost of prefabricated staircase is 3.1 % higher than that of traditional cast-in-place staircase. The life cycle cost of traditional cast-in-place balcony, namely C3 is 966.41 yuan/m^2, the life cycle

Table 97.2 The contrast of the whole life cycle cost of staircase and balcony (unit:yuan)

Items	Staircase		Balcony	
	Cast-in-place	PC	Cast-in-place	PC
Construction cost	550.27	629.95	831.59	964.92
The cost of use and maintenance	32.4	25.8	30.2	22.6
Recycling cost of demolition	16.5	63.0	24.9	96.5
Life Cycle Cost (50 years)	731.51	753.89	966.41	1029.37

cost of Prefabricated balcony, namely C4 is 1029.37 yuan/m^2, so C4/C3 is 1.065, That is to say, the life cycle cost of Prefabricated balconies is 6.5 % higher than that of traditional cast-in-place balcony. But, the cost increase of staircase and balcony make their quality promotion and construction period decrease.

97.4 Value Engineering Research

Value Engineering (VE) refers to analyze the function of the specific product and recognize the cost of achieving the function to get the specific method of product value. The value is the ratio between consumption cost and function gaining. This paper uses VE to research the value variance staircase and balcony under the two construction methods.

97.4.1 Value Research of PC Staircase and Cast-in-Place Staircase Based on VE

97.4.1.1 Functional Comparison Between Cast-in-Place Staircase and PC Staircase

Analyzing the staircase functions, professional visitors think the safety, sustainability, energy saving and emission reduction, integrity, durability, appearance are the most important factors based on VE. Through the market survey questionnaire, 34 % of the property buyers consider the safety is the most important, 18 % consider the sustainability is the most important, 24 % consider energy saving is the most important, 11 % consider integrity is the most important, 9 % consider durability is the most important, and only 4 % consider the appearance is the most important.

The paper uses the 6 indexes and use expert investigation method to judge the indexes of the staircase under two kinds of construction mode. The paper chooses 9 experts to grade and judge it. The experts constitute with 3 construction worker representatives, 3 construction enterprise delegates and 3 design expert representative. The rule of scoring is that the experts grade it on two kinds of mode of production of the staircase, scoring from 1–10 between integers, the higher the score, the better the function is. The expert scoring results as shown in Table 97.3:

According to Table 97.3, we can know the comprehensive functional score of cast-in-place staircase as shown:

$$\begin{aligned} F1 &= 9.1 * 34\,\% + 7.0 * 18\,\% + 6.7 * 24\,\% + 9.2 * 11\,\% + 8.7 * 9\,\% + 8.1 * 4\,\% \\ &= 8.08 \end{aligned}$$

The comprehensive functional score of PC staircase as shown:

$$\begin{aligned} F2 &= 9.0 * 34\,\% + 8.8 * 18\,\% + 9.0 * 24\,\% + 8.1 * 11\,\% + 9.3 * 9\,\% + 9.2 * 4\,\% \\ &= 8.90 \end{aligned}$$

F2/F1 = 8.90/8.08 = 1.101, means the comprehensive function of PC staircase is 10.1 % higher than that of traditional cast-in-place staircase.

97.4.1.2 Value Engineering Analysis of the Staircase

Through the value engineering model: V = F/C, the relationship of the value between PC staircase and cast-in-place staircase can be expressed as V2 = F2/C2 = 1.101F1/1.031C1 = 1.068, that is the value of PC staircase is increased by 6.8 % compared with the cast-in-place staircase.

97.4.2 Research of PC Balcony and Cast-in-Place Balcony Based on VE

The research approach of the balcony is the same as the stair. The only difference is that we select safety, permeability resistance, sustainability, energy saving and emission reduction, integrity, durability and appearance, seven in total, as the indexes, and the weight of index respectively are 30, 14, 12, 22, 10, 9 and 3 %.

According to the research, we get that the comprehensive functional score of cast-in-place balcony as shown:

$$\begin{aligned} F_3 &= 9.0 * 30\,\% + 8.6 * 14\,\% + 7.2 * 12\,\% + 6.7 * 22\,\% + 8.8 * 10\,\% + 8.4 * 9\,\% \\ &\quad + 8.1 * 3\,\% \\ &= 8.12; \end{aligned}$$

Table 97.3 The mark sheet of the staircase

Function items	Construction worker representatives						Construction enterprises representatives						Design expert representatives						Average	
	R1		R2		R3		R1		R2		R3		R1		R2		R3			
	CIP	PC	CIP	PC	CIP	PC	CIP	PC	CIP	PC	CIP	PC	CIP	PC	CIP	PC	CIP	PC	CIP	PC
Safety	9	9	8	9	9	10	9	8	9	9	10	9	10	9	9	8	9	10	9.1	9.0
Sustainability	7	8	7	9	6	8	7	8	7	9	8	10	8	9	6	9	7	9	7.0	8.8
Energy saving	6	8	7	9	7	10	7	9	6	8	6	9	7	9	8	10	6	9	6.7	9.0
Integrity	9	8	9	7	10	9	9	7	9	8	9	8	10	9	9	8	9	9	9.2	8.1
Durability	9	9	8	9	9	10	9	10	9	9	8	9	9	10	8	9	9	9	8.7	9.3
Appearance	8	9	9	10	8	9	9	10	8	9	7	9	8	9	7	9	9	9	8.1	9.2

Annotation: CIP represents cast-in-place

The comprehensive functional score of PC balcony as shown:

$$\begin{aligned} F_4 &= 9.2 * 30\,\% + 9.2 * 14\,\% + 8.9 * 12\,\% + 8.9 * 22\,\% + 8.3 * 10\,\% + 9.0 * 9\,\% \\ &\quad + 8.7 * 3\,\% \\ &= 8.98 \end{aligned}$$

F_4/F_3 = 8.98/8.12 = 1.106, It means that the comprehensive functions of PC balcony is 10.6 % higher than that of cast-in-place balcony.

97.5 Conclusion

The paper selects staircase and balcony as the object of the research, it analyzes the variances in the construction process, construction cost, the life cycle cost and value between the PC staircase, balcony and the cast-in-place staircase, balcony. We gets the main conclusion as follows:

(1) PC staircase and PC balcony can shorten the work period, save labour, reduce construction waste emissions and alleviate the environmental pollution through the factory production and prefabricated construction at the scene. Besides, PC staircase and PC balcony can recycle and it has the characteristics of the sustainable development.
(2) The initial cost of PC staircase and PC balcony is higher than the cast-in-place staircase and balcony. We can know that the machine cost of PC staircase and PC balcony is higher, but the labour cost of them is lower. PC staircase and PC balcony reduce the labour significantly. We can adopt advanced productive technology of the precast components, means of transportation and installation. So, we should build a industry chain of prefabricated housing and form scale effect. We can take the large-scale public rental housing construction as an opportunity to promote the application of housing components.
(3) We can know that the value of PC staircase and PC balcony is higher than the cast-in-place staircase and balcony, so the increased cost brings the significant function increase. It's worth applying the prefabricated components. We can build propaganda system to let more people the high cost-effective of PC staircase and PC balcony to form scale effect and promote the application of precast components.

Appendix: The Questionnaire of the Industrialization of Residential Component's Application Status

Hello! I am a student of management science and engineering in Chongqing Jiaotong University in grade 2013. I am composing a paper named "Application of the Precast Staircase and Balcony in the Residential Building". The paper refers to some subjective issue about the application status of the industrialization of residential components and the function judgments of the staircase and balcony. The purpose of the questionnaire is to know the application status of the industrialization of residential components. Your coordination is important for us to understand relevant information and get the conclusion of the paper. Please answer questions according to your own actual situation. We will keep your answer secret. Thank you for your participation of cooperation!

Part 1. The Survey of Essential Information

1. How old are you?(…)
   A. under the age of 22
   B. 22–27
   C. 26–31
   D. 32–37
   E. 38–45
   F. above 45 years old
2. What's your degree of education?
   A. below the middle school
   B. high school, technical secondary school and college
   C. undergraduate course
   D. above the master degree
3. How much is your family's monthly income?
   A. below 3000 yuan
   B. 3001–6000 yuan
   C. 10,001–12,000 yuan
   D. 12,001–15,000 yuan
   F. above 15,000 yuan

Part 2. The Essential Condition of the PC Staircase and PC Balcony
Housing components is the ingredient which have independent function in the residence construction. They can be designed, manufactured and installed solely and they are in favour of the development of different enterprises.

1. Do you understand residential components?
   A. yes B. know a little C. don't know at all
2. Which the following residential components are used in your house?
   A. structure components (support structure, floorslab, the staircase, the balcony)
   B. outside maintenance structure components (doors and windows, the ground, floor)
   C. in-built components (dividing walls, decorative parts)
   D. kitchen and bath components (bathroom, kitchen)
   E. facility components(HVAC, water supply and drainage equipment system, gas equipment system, electrical and lighting system)

3. Do you want to live in the houses which use the residential components?
   A. yes B. no C. don't care
4. What advantages do you know when the house uses residential components?
   A. It can improve the integrity of the house
   B. It can extend the adaption time
   C. It can reduce the cost of maintenance period
   D. It can reduce the construction period effectively
   E. It can reduce environmental pollution
5. Are you willing to pay more for using the house that constructed by residential component?
   A. yes B. no
6. Do you know PC staircase and PC Balcony?
   A. yes B. a little C. not at all
7. Which function, do you think, are the most important for the staircase?(···) Which function, do you think, are the most important for the balcony?(···) (multiple selection)
   A. safety
   B. permeability resistance
   C. energy saving and emission reduction
   D. durability
   E. appearance
   F. sustainability
   G. integrity

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Chapter 98
Critical Success Factors for Refurbishment Projects

Lyall Jackson, Jian Zuo, Zhenyu Zhao, George Zillante and Yingbin Feng

Abstract Refurbishment of the existing buildings has attracted a growing attention due to its associated benefits such as sustainability and cost. However, the delivery of refurbishment projects is not also successful. This study aims to explore the critical success factors for refurbishment projects. Results showed that the following factors are regarded as most important when undertaking a refurbishment project: effective forward planning, excellent communication, excellent ability to change, detailed due diligence/site investigation/document control, healthy contingencies (client and builder), and excellent project team experience. This study revealed that investment into refurbishment project sector is steady and some individuals have begun to notice a rise in the amount of refurbishment projects in the market. This study concludes with a discussion and recommendations for professionals undertaking refurbishment projects in the future.

Keywords Critical success factors · Refurbishment projects

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98.1 Introduction

The construction industry continues to be extremely competitive with reports that the dangers in tendering at cut-throat levels are only increasing (Smiley et al. 2014). Recent research suggests that building companies are submitting tenders with negative margins in an attempt to successfully procure work (Uher and Davenport 2009). Undertaking projects with little or negative margins presents major risks for the builder as any mistakes or un-expected circumstances could result in catastrophic circumstances such as businesses placed under administration. This has resulted in the requirement for construction companies to deliver successful projects every time they are undertaken. Not only is this way of business risky, it has large economic repercussions for the construction industry as it forces competitors to mimic the low or negative margins, or else they won't continue to win work (Uher and Davenport 2009).

This has already been observed in some sectors, for example, the new residential construction sector is expecting to shrink by 10 % in 2012–2013 from the previous period (ACIF 2012). While the new build market is expecting to shrink, the latest figures from HIA economic group have forecast the refurbishment/renovation sector to increase by 3.5 % during 2013/2014 with a total estimate value of investment at $27 billion Australia wide (HIA Economics Group 2013). This enormous amount of investment indicates refurbishment projects are situated well in the market with solid foundations and is currently in demand which presents excellent opportunities to businesses willing to undertake these types of projects.

Refurbishment projects are somewhat significant in the current Australian market, considering not only the large amount of investments but also investigating the large number of existing buildings and the age profile of the current building stock. In Sydney's CBD, it is currently estimated that 45 % of Sydney's office stock is more than 30 years old. This is similar in Perth's and Brisbane's current building profile with 35–40 % more than 30 years old (Brown 2013). This alone indicates the mass potential for refurbishment projects to take off in some of Australia's main CBD's.

This study aims to investigate what factors are essential for delivering successful refurbishment projects. Many of refurbishment projects are regarded as high risk and are prone to have the potential to fail. The findings and recommendations will lead to construction professionals understanding what does and does not work on this type of projects.

Literature review

To begin investigating refurbishment projects an understanding of the word 'refurbishment' must be defined. In the past, several terms have been used to describe alterations or additions to an existing building or structure. *Renovate*, *retrofit*, *fit out*, *restoration*, *renew*, *revamp* are some examples that are used to describe, more or less, the same thing. For the purpose of this project, the word 'refurbishment' refers to any construction works that are undertaken to give an existing building or structure further useful life. This could range from the small home renovation to a large commercial entire office floor refurbishment.

Egbu (1999) identified 75 different types of management skills applicable to a refurbishment project. The 6 most important management skills for a refurbishment project are “leadership, oral and written communication, motivation of others, health and safety, decision making and forecasting and planning” (Egbu 1999). According to Roberts and Kraynak (2007), the most important traits required by construction professionals undertaking refurbishment projects include: how they perform in a crisis, an enthusiastic approach, an organised approach, have excellent communication skills and finally how well they can deal with failure. Many of these traits can be directly related to fast tempo environments that are subject to continuous and unexpected changes. Roberts and Kraynak (2007) additionally reported that refurbishment projects are prone to higher potential risks that could be encountered through a projects life cycle.

These higher risks relate to refurbishment works are more difficult than a new project due to a number of factors. For example, construction uncertainty, higher number of variations and unknown latent conditions are all risks that are known to be associated with refurbishment projects (Egbu 1999). This is supported by Rahmat and Torrance (1998) which suggested that refurbishment work can be classified as high risk work mainly due to the complexity and uncertainty of existing factors on these projects (Rahmat and Torrance 1998). Refurbishment projects are often being undertaken on old rundown buildings that have reached the end of their building life cycle.

Fawcett and Palmer (2004) investigated good practice guidance for refurbishing occupied buildings as a large majority of refurbishment works happen in or close to existing structures that will contain other occupants. Their study showed that project planning, having an experienced project team and communication were key factors in the delivery of a successful refurbishment project, while being undertaken in an occupied building. These findings are similar to the 6 important management skills that were highlighted by Egbu (1999). Refurbishment projects go hand in hand with occupied spaces as many of these projects are undertaken in and around operational facilities. This brings up many issues for example, noise restrictions, site access, public and occupant safety, delivery access, initial site investigation limitations, etc. This compares with new build projects where these are often undertaken on a vacant block or away from operational facilities.

One of the main issues with refurbishment projects is trying to piece together what existing structure and services are currently installed and their locations. Gorse and Emmitt (2003) reported that one of the most important aspects when undertaking a refurbishment project is completing a detailed and thorough initial site investigation to map out what is currently in place. The more detailed the initial site investigation is in the early stages of the project, the less complications that will be encountered during the later stage. These complications can result in large variations to the client and subsequently will not be priced competitively in comparison to if it was priced at tender stage (Gorse and Emmitt 2003).

Sanvido and Riggs (1993) pointed out that due to nature of refurbishment projects being undertaken in existing facilities, it imposes constraints on all parties involved such as the owners, operators, designers and builders. The four main constraints that were discovered from the investigation were constraint in information, time, space and working environment. Similar to the findings of Gorse and Emmitt (2003), information was often constrained as the existing data is often limited. Additionally, the project scope can be unclear and the condition of existing information such as 'As Built Drawings'. Time is another constraint due to the common tight time construction programs set out on these types of projects. For example, narrow time frames such as school holidays, or short factory shut down periods are both often common time for refurbishment projects to occur. The third major constraint Sanvido and Riggs (1993) highlighted was the limited amount of space often associated with refurbishment projects. This can often be accounted to the locations of these types of projects being undertaken in existing spaces that are more than often occupied. Site access, site congestion, safety concerns, material setdown areas and staged construction processes are all common constraints on refurbishment projects.

98.2 Research Methodology

Semi-structured interviews were undertaken with selected industry practitioners that have worked directly on fit out and refurbishment projects. Interviewees were chosen based on construction industry job positions, previous work experience and availability. The interviewees are all currently employed in the construction industry and positions range from project managers, client representative project managers, engineers, owner/builders and subcontractors (see Table 98.1).

Table 98.1 Interviewee profiles

Interviewee	Company	Position
A	Contractor	Senior Construction Manager
B	Design consultant	Director
C	Subcontractor	Procurement Manager
D	Contractor	Project Manager
E	Design consultant	Director
F	Design consultant	Civil Engineer
G	Subcontractor	Director
H	Owner	Director

The main interview questions are:

(1) In your professional opinion, have you observed a rise or fall in the amount of refurbishment projects undertaken within the last 5 years?
(2) From a management point of view, what factors were/are crucial to successfully completing a refurbishment project?

The interview responses have been detailed in a discussion format to help explain the interviewee ideas more clearly and effectively. All interview sessions were recorded. Content analysis was employed to identify the emerging patterns.

98.3 Findings

To identify the rise or fall of refurbishment projects in Australia 6 out of the 8 interviewees have noticed a rise in refurbishment projects in the Australian market over the past 5 years. It is noticeable there is a rise in the amount of enquiries into refurbishment which provides a good indication that refurbishment projects are in demand. Interviewee A explained the importance his company puts on them and how they are encouraging a business focus on these types of projects: "If completed successfully they provide large benefits for the business. Generally, refurbishment projects can make excellent profits in a relatively short amount of time".

Interviewee B discussed the demand they were receiving from the industry was due to more and more businesses looking to reposition themselves. Similar to the findings from Sanvido and Riggs (1993), interviewee B noted that these businesses are starting to view refurbishment options favourable as the nature of these projects are undertaken with tight programs, occupied spaces and tight budgets. One of the examples Interviewee B provided was in relation to a client's initial attitude. The attitude was that to undertake any construction works, the business was going to have to cease trading and vacate the premise for the construction period. Where in fact, the builder was able to work with and around the client who continued trading throughout that period. The client noted if they had previously understood the capabilities of refurbishment projects, they would have undertaken the project earlier. Other interviewees agreed that due to the way construction professionals can now manage construction works, clients and businesses have increased looking to undertake refurbishment. Both subcontractors interviewed agreed how they view refurbishment projects as unfavourable and often attempt to engage new build projects only. Therefore they were unsure of certain patterns emerging of these types of projects rising or falling.

98.3.1 Factors Contributed to the Successful Completion of a Refurbishment Project

The following factors were commonly nominated by interviewees as critical success factors for refurbishment projects: forward planning, communication, ability to change, initial site investigation, document control, contingencies and project team experience.

In preparation for refurbishment projects, the construction individuals should dedicate time and effort to attempt to satisfy these discovered characteristics. All interviewees agreed that project team experience and communication were required, the two aspects that could be seen as most desirable. Project team experience related to effective forward planning, excellent programming skills and good trade co-ordination. Communication was linked to consultant involvement and prompt responses, clear client communication and project team communication.

The subcontractor interviewees also had similar responses highlighting the importance they place on the project team they assign to refurbishment jobs. Interviewee G discussed how apprentices will often be placed on new build projects so they can undertake and learn the new methods in an appropriate environment.

According to consultant interviewees, successful factors were past projects they had been involved in as well as appropriately allocated budgets and time taken through the design phase. Interviewee F spoke about projects that were rushed through the design phase which resulted in unhappy clients as design finishes were changed at late stages which subsequently raised the project cost and length.

98.3.2 How Different Parties Treat Refurbishment Projects Differently

Many of the interviewees viewed refurbishment projects differently. Interviewees A, C, D and H all are viewed as builders or head contractors. Interestingly, they all regard the issue of safety as an acute level of priority for refurbishment projects. This was due to the continuous occupied nature of refurbishment projects where there is often construction activities located in very close proximity to client activities. Recently, changes to the national WHS Act and Regulations have shifted the safety responsibilities to the PCBU (person conducting business or undertaking) meaning the head contractor is now entirely responsible for the safety of their projects. If a safety accident is found to be at fault of a PCBU fines in excess of $100,000 and/or jail time can be sentenced. Interviewee A noted: 'The first and foremost factor in treating these types of projects differently is to act as a facilitator first and a builder second'.

Selecting the right subcontractors for the job was also discussed and regarded very important as mentioned by multiple builders during the interviews. Interviewee D discussed the importance of knowing subcontractor capabilities before they are engaged to undertake refurbishment projects. Some contractors may best be suited to new build projects so it is important to understand the full extent of the scope of works involved. Sometimes this means engaging a subcontractor based on experience not price. Other interviewees agreed that the attitude from the subcontractors is also important to how effectively a refurbishment project will progress. The attitude must be flexible and willing to work with and around other trades as also discussed in the builder interviews.

Interviewee E discussed the one of the key factor when undertaking refurbishment projects is the team he assigns to undertake the work. Interviewee E explained the importance that experience plays in the team selected. The team has to be able to problem solve and additionally have the ability to work around continuous changes. Interviewee A explained the view that new employees to the construction industry should start in refurbishment projects:

'Many of the new starters that come to this business start in refurbishment projects. This is for a few reasons. Firstly, the type of construction is generally simpler, such as internal fit out works, compared to intricate structural engineered design details. Secondly, short project lengths give new beginners excellent exposure to the full project experience, start to finish. This will help them understand the different stages of a construction project. Finally, the fast tempo of refurbishment projects keeps the new beginners on their toes. There is no way better to develop a career by hitting the ground running whilst under pressure.'

Clear ongoing communication was also another important aspect that was viewed different when comparing refurbishment projects. Both interviewees A and D indicated that without continuous communication with the client during the construction period, projects could easily turn into negative working environments.

The subcontractor interviewees also discussed the benefits of clear communications between the builders, other subcontractors and themselves. Continuous subcontractor co-ordination meetings to discuss the program, job progress and involvement of other subcontractors will often solve many issues and questions and help organise the project on a short term basis.

Interviewee E had experienced unrealistic time durations that were handed down from the builder and assumed to be accepted by the subcontractor. These time durations are incorrectly estimated to attempt to make head contact deadlines that are not possible to begin with. The head contractor may review the 'refurbishment project' work involved and determine that it's of easy construction so should take less time without taking into consideration other typical refurbishment project constraints. This is one of the main reason the subcontractors interviewed highly regarded the 'project team experience' as one of the most important factors when undertaking refurbishment projects. Another issue often encountered by interviewee E on refurbishment projects was the tight space allocated to complete the works. Head contractors often overlay trades over trades which complicates the tasks that are to be undertaken: 'One [worker] trying to hang plasterboard sheet in a hallway while other trades are constantly walking in and out heavily increases the total time taken to complete the job. This time increase results in additional costs paid by me as it takes longer to complete the same amount of work'.

Interviewee B had extensive experience in client project management which meant his views differed slightly. For example, safety was not his primary objective and was regarded relatively low in comparison to the builders. What was more important to the client project manager was an emphasis on due diligence and initial site investigations. This could be due to the early involvement of client project managers during the design phase. He noted increased and detailed investigations undertaken early in the project life will result in minimal challenges as projects proceed later on.

Interviewee F explained some of the circumstances that are undertaken when completing an initial engineering site investigation: 'Many initial site investigations have major limitations when researching the existing conditions of a building/ structure. In some circumstances, guessing and assuming has to be undertaken as full investigations would include the deconstructing of a building.'

Without a good quality initial site investigation, unexpected discoveries can result in hefty unexpected variations to the client which has been known to terminate some construction projects mid construction. Another issue that can arise from poor site investigation is the lengthy amount of time it takes to solve unexpected circumstances/issues. Interview D went on to explain: 'Often this [unexpected condition] can hold up the progress of works while a solution is found. For example the process as follows: Consultant Inspection → Consultant Proposal → Issue Remedial Solution and Drawings → Price Remedial Solution → Gain Variation Approval → Schedule Works.'

Interviewee C indicated that initial high level quality of documents was most important at the tender stage. Often many of the unknowns and latent conditions will not be documented on the drawings so it can prove very difficult to pick up prior to construction commencement. Interviewee C indicated the use of a rating tool system that helps determine if projects are worth undertaking by scoring them on factors. One of these factors is clear documentation. At tender stage it can prove difficult to determine if the drawings replicate what is actually on site so a site visit must be undertaken. If the tendering builder deems there is too much risk associated with the drawings in comparison to what is actually on site then the builder must withdraw from the tender or price the job accordingly with contingencies. Contingencies are allocated funds that are often kept aside for the safe guard of unexpected occurrences that may unfold. Interviewees suggested that contingencies are important to have on refurbishment projects but caution is required to be taken. This is due to the possibilities the tender contingencies included could cause the total tender figure to be higher than the competitors, which therefore would result in the tender being awarded elsewhere. In contrast, if the contingency priced into the job is too low, then what is allocated may not be enough in some circumstances.

Overall, all interviews understood and discussed the higher possibilities of running into latent conditions on refurbishment projects. It is not unusual that contractor price jobs with what is shown on the drawings only. This will result in variations to the client for any further discovery of unknown or additional work not shown on the drawings. Interviewee B discussed how latent conditions are mostly limited to underground issues in comparison to refurbishment projects where the latent conditions can be found in ceiling spaces, walls, existing structures, existing services and also underground. Both the builders and the subcontractors discussed, to deal with these higher risks on refurbishment projects, tender/quote qualifications are paramount to ensure project success.

The interviewees also explained the importance of contractual agreements, specifically the contract inclusions and exclusions. The builders will often have a clear set of exclusions that remediates the risk from them and puts it back onto the client. Interviewee E additionally agreed with the importance of contact agreements when undertaking refurbishment projects. Interviewee E responded with the view from a subcontractor's perspective and expressed the importance of clauses around latent conditions.

98.4 Conclusions

With the total value of investment into the refurbishment/renovate sector being $27 billion per annum (HIA Economics Group 2013), it is clear that the sector is strong and has momentum to continue doing so for the future. Refurbishment projects should be regarded as important projects that can be very beneficial if undertaken in the correct way. The refurbishment sector is showing economic strength as continuous investment indicates that it is not slowing in the future. The ageing building stock and rising demand for sustainable buildings are drivers for the refurbishment sector.

To assess the successfulness of a refurbishment projects time, cost, quality, safety and environmental impact should be the key indicators used. These factors determined are not only specific to refurbishment projects but can be used to judge the success of any project.

Delays, missing deadlines, longer programs, un-accounted costs, dissatisfied clients, not delivering on what is promised and the possibility of liquidated damages are all factors that will impact a project negatively and cause it to be unsuccessful.

Safety should be considered the most important factor on all types of projects, ahead of time, cost and quality as the work involved with construction is always associated with high risk work. This high risk can be undertaken safely where any major catastrophes should be avoidable.

Fundamental skills that are significant to construction professionals on refurbishment projects are: effective forward planning, excellent communication, excellent ability to change, detailed due diligence/site investigation/document control, healthy contingencies (client and builder), and excellent project team experience

Project team experience with refurbishment projects is additionally essential to these types of projects as the construction personal have an understanding of the noise restrictions, site access, public and occupant safety, delivery access, initial site investigation limitations, client specific requirements etc. The 4 main constrains Sanvido and Riggs (1993) highlighted in relation to refurbishment projects was information, time, space and working environment. This can be accounted to refurbishment projects often being undertaken in tight occupied buildings on short timelines and higher associated risks.

Refurbishment projects have higher risks than other types of projects due to the large numbers of unknowns and potential latent conditions. To adequately deal with these risks, contingencies need to be considered and put into place to ensure a 'plan B' when unknowns are encountered. Contingencies need to be appropriately estimated by an experience construction professional. Additionally, detailed site investigation which creates accurate drawings and documents will also help lower this associated risk.

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Chapter 99
Service Apartment Business Model Research—Take Ziroomapartment as an Example

Mingxuan Yu, Xiaobei Zhang and Naiyue Zhang

Abstract In Chinese first-tier and second-tier cities' housing rental market, houses are in short supply, market is in disorder, housing quality and service level are low, which are major factors contributing to the situation that rent living can't be the main living style. Against this background, there emerges chain type service apartments, aiming at the mass consumers at the mid-end market. In China, service apartment represented by Ziroomapartment will embrace a full development in future. This article starts with Ziroomapartment's business model research, hoping to provide guide experience for companies interested in this line of business and providing government with empirical case study results for regulating the real estate market.

Keywords Ziroomapartment · Business model · Case study

99.1 Introduction

Service apartment refers to a real estate operation model, companies possess a whole building or other large scale real estate projects through development, renting, purchase or other ways. These buildings or real estate projects are not for sale, but for long-term revenue management via renting or other modes. The feature of service apartment is "service like hotel + management like apartment", targeting at self-occupation people who have high requirement for renting quality and businessmen with long-term business trip. Service apartments provide perfect, quality, independent and private living environment, furnished with living room, chamber, washing room, kitchen, and other self-service facilities. There are also professional apartment service staff, gym, shopping mall, cafe bar, library, recreational facilities.

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This article will make analysis and research on service apartment business model, researching into case entity and finding out development problems of service apartments. We focus on business model research, analyzing its business essence, finding out best practical and research outcome for reference, providing development suggestion for business development.

99.2 Literature Review

Domestic focus on service apartment starts from 1980s, domestic service apartments are represented by first commercial and residential building International Building in Beijing, LongHu Apartment and Jingu Apartment in Shantou, those apartments are only renting to foreign businessmen and diplomatic personnel. Huiyuan International Apartment was built in Beijing Asian Sports Village in 1990, this is the first service apartment facing to general tourists and provides hotel service. The market has been divided into three parts: specific tour, family tour and joint tour with random combination, and for those three parts we offer differently designed apartment hosting and service model (Tourism Tribune 1991). During 1990–1997, policy restricted that service apartment can only receive integrated management with hotel, leading to relative research confined to hotel management field.

1998 policy opened up, the supply of hotel type service apartment increased dramatically, and relative research also increased. MaoDaqing published a series of articles on service apartment model and concept introduction, thinking "Service apartment is the extension of Real Estate", when he was a chief representative of Shenjie (Mao 2008). Since 2005, research on service apartment has increased gradually, and reached peak in 2012. In 2005, ZhuHaiping's research on single case —East Lake Villas Apartment (Zhu 2005), Shibo's research on Zhongguancun regional case (Shi 2005). These researches all adopt market survey method, analyzing economic and policy macro environment, comparing same kind and side-line range of products, arguing the product feasibility. It also presents problems and suggestions on product customer orientation, operation and moneymaking way features. These research results provide practical cases and reference experience, and make development prediction for future 5–7 years, all these research results are meaningful for early-stage industry.

After entering the boom period of real estate industry, service apartment comes up with new type: a type of real estate product for sale, its attached hotel service aiming to provide owners and habitants with better property management and value-added service, its aim is to help developer to achieve higher price and volume. Therefore, most service apartment researches focus on real estate development, investment value, business real estate design and management, marketing scheming, construction design. Most of those research results are published on journals, there is barely subject study.

With the service apartment products becoming diverse, corresponding research becoming more specific and academic. Zhang (2009) put forward a concept —“economic short-term hotel style apartment”. It is significant for concept extension of service hotel to let hotel style apartment target at mid-level general consumers. In 2012, YuKe analyzed service apartment from business model research angel, concluding three types of business real estate modes, including only for renting, whole or part renting, whole or part renting those sold property. “Investment development + possessing development” service apartment model is best option for company long term operation (Yu 2012).

Up to now, service apartment research basically involves two forms to develop, one is defined as business real estate service apartment, another is renting hotel service hotel targeting at high-level market. However, mass chain service apartment research results discussed in this article is rare, not to mention academic subject research achievement. Therefore, this article has the value of filling such academic gap.

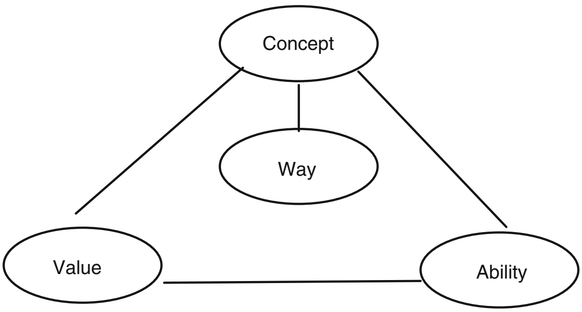
99.3 Present Business Model and Existing Problems

99.3.1 Business Model Concept

Business Model research start from the research of the boom and bust of IT companies. In new times, business model research and innovation have become an important way for companies to succeed and break operation bottleneck. Start from the business model research, it helps companies to think about and plan its market positioning, customers value, business service chain, management system, moneymaking model and financial models.

The four-factor model bases on Joan Magretta’s three-factor model, as Fig. 99.1 (Huang 2003). It adds realization way on the three-factor model. Concept doesn’t create value directly, but the realization way makes concept-ability-value to recycle, which creates value and achieves sustainable value cycle.

Fig. 99.1 Business model four elements



99.3.2 The Existing Typical Model of Service Apartment

99.3.2.1 "Capital-Driven Style" Service Apartment Business Model

Model Introduction

Capital-driven business model represented by Ascott, Ascott has Singapore real estate trust REITS fund as its capital backing. Ascott's parent company is CapitaLand, which is an excellent real estate listed company in Asia, Ascott does not take its parent company fund support as their primary source of funding, but use the real estate investment income and real estate REITs as its investment and operation driving force. In the past two years, the domestic SAIF also followed Ascott model, investing in the construction of the Beijing Bullock door apartment and New Breed Apartments, among them New Breed Apartments are located near the Forbidden City.

Shortcomings

Profit principle of such apartment business model lies in appreciation on investment and realization, the provision of products and services are based on how to improve brand value and asset value, different from Ziroomapartment's model to meet the needs of a large number of tenants for its revenue. In this kind of model, the enterprise does not pursue large scale, multi-quantity, but rather quality and high value. However, due to the high value of such assets, the size of such chain service apartments is generally not very large.

99.3.2.2 "Light Asset + Plat Formication" Service Apartment Business Model

Model Introduction

Light asset driven business model represented by passers-house, based on American HomeAway, founded profitable website for vacant houses to make profit, not only take advantage of the electric supplier's channel advantages, but also achieving a strong position to reach and development strategic partners, and with the individual owners of tightly bound listings acquisition mode, and realizing profit sharing and risk-sharing with owners. Passers-home mode are known as most successful tourism business model.

Shortcomings

If you want to expand business in Guangzhou-Shenzhen-tier cities, these service apartments mode must face fierce competition from housing end and tremendous challenge. How to ensure dominance in the listing status of cooperation, how to maintain the asset-light model, are all the problems needs to be solved in the country layout.

99.3.2.3 "Developers + Platform Integrated Service Provider" Service Apartment Business Model

Model Introduction

Japan Leopalace21 Corporation was founded in 1973, listed companies, it was forced to make transition from developer to apartment building subcontracting business and real estate leasing business during the Japanese real estate bubble in the 90s of the last century, now it has become Japan's largest service-oriented apartment rental agency. Enterprise development is divided into three phases, the first phase from 1973 to 1993: develop and operate apartment sales; second stage from 1994 to 1996: the transition from real estate developers to building subcontractors; third stage from 1997 to now, focus on building business and leasing business synergy. The corporate restructuring and business models are of reference significance for the development of China's current real estate industry.

Shortcomings

Leopalace21 not only has outlets, as well as channel partners to join the brand, to achieve lower costs and higher revenues in this way, but the platform for integrated services requires a larger investment, for small developers, it is impossible to copy this mode, but it provides a reference for the future direction and development model.

99.4 Ziroomapartment Business Model

99.4.1 Ziroomapartment Business Model Elements

Using Osterwalder's business model design nine elements of the business model to analyze Ziroomapartment. Ziroomapartment nine elements of the business model and its relationship are shown in Fig. 99.2. This paper will take value proposition, customer segmentation, customer relationships and revenue sources for core

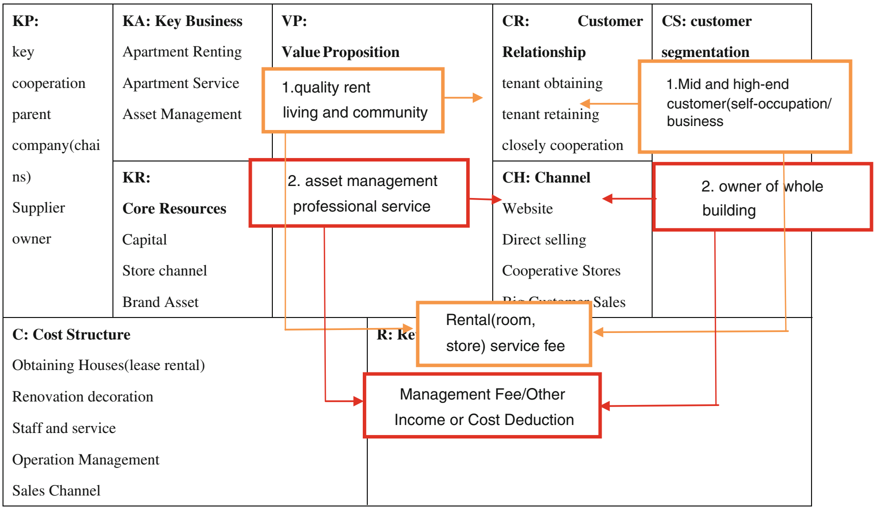


Fig. 99.2 Ziroomapartment business model design

research bilateral business model of Ziroomapartment; it starts from revenue sources and cost models to find the key factors determining the profit model of Ziroomapartment; made research on core resources and channel's impact on core competencies and key business of Ziroomapartment.

99.4.2 Ziroomapartment Bilateral Business Model

Ziroomapartment creates a bilateral business model, its customer segmentation, value proposition and source of income have characteristics of bilateral relations. One side is renting apartments consumers, businesses get the rent and service fee income through the provision of housing and services, by acquiring a large number of consumers to expand the operation scale and brand influence. On the other side of business model is the owner, a professional enterprise output management, co-operation and common development or benefit-sharing approach to obtain management revenues or costs deductible. When Ziroomapartment brand is strong enough, a sufficient number of tenants and projects for a long time, business houses and consumers participating in Ziroomapartment, to increase mutual promotion, business listings acquisition costs and tenant acquisition costs greatly reduced. With the help of channels, companies get the ability of radiation of business to the country's other regions.

Under this business model cycle design, customer relations also need to be bilateral. On the one hand, to obtain and retain customer service through service. Establishment of Ziroomapartment membership system and creating personalized fashion community culture to achieve a high level of referral rate. Increase customer stickiness, so that the formation of the tenant in apartment living habits freely extend the lease the tenant lease. On the other hand, the owners' cooperation with Ziroomapartment mainly through accepting leases, after the brand influence becomes strong, the owners will form a close cooperation partnership with Ziroomapartment.

99.4.3 Ziroomapartment Revenue-Cost Model

99.4.3.1 Revenue Resources

Ziroomapartment rental agency fee is not paid in the traditional sense, but "service fee." Service charges connotation and denotation are a new definition, business-to-business concepts have greater autonomy. Ziroomapartment differs from the traditional value-added services visualization, packaged into computable value of services sold to the tenants to collect 10 % a year service charge.

Affected by intense competition and market regulation, space of rent pricing premium is limited. To take Jang-Fu Park Ziroomapartment for an example, since it opened in mid-December 2012, the occupancy rate rose from 0 to 98 % during 4 months' time, although in the Spring Festival Lease slack season, but due to a large promotional efforts, this cycle is still of a reference value.[1]

99.4.3.2 Ziroomapartment Cost Structure

Classified according to the time period, there are six different cost comprising structure: housing obtaining stage, project preparation and construction stage, sales stage, operation stage, renovation stage and exit stage.

In housing obtaining stage, main housing production development team to design the project and the first payments of rent expenses; costs during the preparatory phase of the project, including project design, engineering and decoration plan and budget, vendor bidding, compliance review, product design, customers approaching of target group, project construction, project acceptance, appliances furniture approach, stay ready, personnel and services and other aspects of the approach; Into the sales phase, mainly comprising promotional fees, channel expenses and personnel costs, the latter two constitute a major expense; costs operation stage involving two parts, one part is similar to hotel management, including water, electricity, gas heating costs, staff costs, equipment maintenance and other expenses, the other part is for continued room sales; service apartments

[1]occupancy rate = (total room number * this month effective days − accumulated vacant days for all the rooms)/total rooms * total days for this month.

generally need renovation work after 7–10 years, if it is a 20-year lease, you need 2–3 times renovation, including engineering, decoration and configuration overhaul and reset, which is expected to be as much as the initial cost; Ziroomapartment mostly takes a long-term lease of the apartment to get availability, the presence of the lease expiration or release the lease. Therefore, exit way of Ziroomapartment has a significant impact on its profitability.

To sum up, how to provide so much value-added services in the same market rent level, and manage multiple uneven costs to get enough profit margins, which is the key test for Ziroomapartment profitability.

99.5 Business Models Analysis of Ziroomapartment

99.5.1 Issues and Challenges of Business Models

In contrast to a service-oriented business model in apartments, each typical enterprise are offering similar services and products, but has a different business model behind the support. It can be strengthen their own strengths and opportunities, find more weaknesses and risks, and get help by more possibilities for improvement. Through elaborating analysis of the business model, you can get the following conclusions.

From the point of view of their own conditions, (1) In the early stages of development, product quality and quality of service delivery management and consumer expectations and brand image are disparity, it can lead consumer's displeasure. Customers during the transfer operations has not yet formed a barrier and internal cross-selling mechanisms, potential customer churn rate. (2) Development from initial evaluation of a single project point of view, it does not have a high rate of return. (3) Single source of income, there is a question that the business model of the other bilateral owner of the profit model is able to run up, but without the latter income, existing revenue model will not optimistic. (4) When it has not reached economies of scale before, it will be a long-term low-yield investment process. (5) As the project management chain is long, from the project until the final sale lease rental, the ability of the initial team could be challenged. (6) Occupied by a large amount of funds, low asset turnover, long payback period, the larger risk. (7) Costs are controlled at a low level, and there is a gap between design and branding requirements. (8) Newly built over 300 suites source will be listed at the same point in time, which is a big challenge. (9) Continuing operations of maintenance, cleaning and several years after the overhaul of the service management and cost management is a challenge. (10) Get houses acquisition mode is single, and in a weak position in cooperation.

Judging from threats, (1) It faces competition from backgrounds different companies in service apartments because the market is not yet mature, there are some irregular service apartments against the order and the image of the industry.

(2) Monomer need to face direct competition with neighboring traditional rental market in terms of quality and price. (3) There is a fierce battle between economy hotels and other industries in getting houses. It has been in a fully competitive market, the price of Get houses has been transparent, the owners expect irrational expansion, price competition often beyond the rational profit estimates could afford, after as entrants Get houses stirred into the battle, the situation is very bad. (4) It is a question that it can be realized in the future an unknown market environment. (5) There is no government control policies for long-term lease-type service apartment, enterprise access, business qualifications, approval, withdraw, manage and taxes are no clear regulations and we don't know whether it is positive in the future.

99.5.2 The Key Success Factor

99.5.2.1 A Multilateral Platform Business Model

After studying various types of apartment, we found that its core of business model is multilateralism. Because business object is real estate which is fixed, high value, hard cash, regional, livelihood, subject to policy control and other characteristics, the amount of real estate transactions is often huge. There is a time-gap between service apartment investment and income, that acquisition costs are often the first expenditure listing on rental income, making the enterprise to generate cash flow gap. Meanwhile, the slow rise in rental income subject to price increases, the cost of capital to offset the effect of the impact, long payback periods which lead to the rental income become unprofitable business types.

Therefore, companies need to create more diversified sources of revenue to get profit. As a operators, the greatest asset in the hands of companies, is a property and the right to use the value of the property, and the other is a potential consumer value tenant groups. How to make these two assets contact, interaction, driving the value of the loop, entry point for enterprise is a question that the business model.

99.5.2.2 Business Model Innovation Concepts and Implementations

According to the theory of the four elements, there is a question that the business model, the concept of specific implementations, prompting the formation of core competence, the concepts and the ability of the initial team could translate into value. Therefore, for these four elements of successful innovation can bring new business model. Many start-ups are beginning from a new business concept, or following the best practices of a successful, but the concept does not directly generate value, therefore, it tends to drive innovative business concepts and innovative implementations. With the development of service apartments, there are more new business opportunities to be found, there are more ways available to maximize value.

99.5.2.3 Guaranteed Funds and Efficiently Turnover

The Application of Real Estate Lease REITs in Service Apartments

REITs means real estate investment trusts (Real Estate Investment Trusts) which through the issuance of Fund Shares to raise funds, and get help in investment management institutions entrusted with funds dedicated to real estate investment and profits are allocated to investors in accordance with the corresponding proportion. In China, although there are no REITs policies and regulations, the market already has some of the trust fund for commercial real estate investment management. A new breed of apartment financing mode, using the SAIF, is using private placement financing for investments and returns. This model is very close to REITs, and in the operation and the technical level there is no difficulty.

99.5.2.4 Core Resources and Capabilities Matched with the Business Models

Enterprises are able to engage in some kind of business model, it must be based on its own capacity or resources required for this mode, these capabilities and resources are unique and valuable market. It lacks of experience in real estate investment and development, construction, renovation and hotel services, therefore, it would appear budget and project cycle are not under-control, low-quality product delivery and unstable quality of service, higher room service rate, higher customer complaints and so on. Link- home has a high ability of obtaining the customers, but it does not well in the agency owners, owners of resources.

Therefore, how to effectively use existing enterprise is an important question that determines the business model capabilities and resources. With the development of enterprises, changes in market conditions and consumer's requirement and policy environment, the models, capabilities and resources the companies relying on also need to make a new plan and change accordingly.

99.6 Conclusions and Prospects

In this paper, we study the implementation of the business model theory and application of service apartments, and we develop and verify the theory, and provide a new perspective and approach in studying research.

There are four factors which are important for Service apartments. First, Service apartments profit model is generally not a one-way, you need more sources of income to supplement profit margins yields insufficient rental business, and with forming a virtuous circle of mutual promotion. Second, Second, service apartments in China has just started, offers tremendous opportunities for innovation and new business concepts. Third, service apartments must ensure adequate funding and quick turnaround capabilities. Funding sources have their own funds, investment liquidity, financing, and real estate REITs and other listed. Fourth, service apartments business enterprises usually have the capacity or resources to diversify across industries, in order to pry large asset management business, including channels, capital, value chain.

Start-up phase of freely apartment need to solve the mismatch competitive market pressures and future ability to design stage, facing the lack of a large source of income, the higher cost, the irrational structure, and the risk of cash flow, the ability and resources to solve business and demand are mismatched, a single project payback period is longer predicament and need to pay the cost of a lot of consumer education, the initial investment and brand accumulation.

So, we should design the business model with focusing on the existing investment direction and the future income. And we should improve the existing operating conditions, innovate, and expand the access to get houses and we should integrate and increase sales channels, optimize costs and ways to expand diversified sources of income, with the balance of financial products to optimize cash flow, and get help for policy support, which can help us get break through the bottleneck, get rapid scale development and achieve business model design.

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Chapter 100
Corporate Social Responsibility in Construction: A Critical Review on Research

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Abstract Corporate social responsibility (CSR) has drawn closer attention than before from both practitioners and academics in the past decades. This has given rise to a plethora of CSR studies published in academic journals. The richness in CSR publications in return makes it possible to rethink CSR research from a general sense to a specific angle. Through a thorough literature review, the themes of CSR studies in general were first identified. The subject of "CSR in construction" (C-CSR) was then examined by placing the general themes in the construction research area. To this end, research methods including content analysis and documentary analysis were adopted. The results indicate that C-CSR research has a couple of gaps concerning how to make it effective in practices. The agenda of C-CSR research is also discussed. Findings of the research identify a road towards a more systematic and specific C-CSR research in the future.

Keywords Corporate social responsibility · CSR implementation · Construction industry · Research gap

100.1 Introduction

The publication by Howard Bowen entitled Social Responsibility of Businessman opened a new era of literature on CSR (Carroll 1999). Since that, the concept of CSR has sustained evolving, as driven by social concern over environmental stewardship and ecological crises in the globe, closer ontological debates on what business runs for, and the proliferation of CSR research (Berger et al. 2007; Carroll

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and Shabana 2010). The ongoing studies on CSR in general show that academicians' interest in CSR has centred not only on 'whether CSR is an imperative', but also on 'how to make it effective' (Smith 2003).

The construction industry plays a vitally important role in the attainment of sustainable development (Huang and Lien 2012). The significant impacts of construction activities on the physical environment and wider communities necessitate including CSR in the domain of sustainable construction (Myers 2004). While CSR engagement in construction has gained closer attention over the past years, contractors are often criticised for poor performance in the fulfillment of CSR (Murray and Dainty 2009; Barthorpe 2010). One of the main reasons is that contractors have not sufficient knowledge about how to implement CSR effectively, while it does not seem that the academicians have provided much support to the industry.

The bulk of general CSR studies facilitates the examination on the same topics and enables to identify some potential research gaps in the construction industry. This study first reviewed general CSR research with intention of identifying the scope of CSR themes in previous studies. A couple of leading journals in the area of construction management and economics were determined and reviewed critically provided that they address CSR issues. Thereafter, CSR implementation in construction was discussed. Some research gaps were outlined towards the end of the research and insights for future agenda were offered.

100.2 CSR Theories

Previous studies have attempted to give a scientific CSR definition and thus to derive a better understanding on how business can be engaged in social responsibility.

CSR *attributes*

The notion of CSR means differently to different people. Basing on 37 definitions, Dahlsrud (2008) identified five dimensions of CSR, namely environmental, social, economic, stakeholder, and voluntariness. Fundamentally, business as a part of the society ought to accord their behaviours and practices with the guidelines set by society (Bowen 1953), and thereby has the predominant social accountability to maximize business profitability. This gives the hint that business may embrace those actions that are not stipulated by law, extend beyond explicit transactional interests of the firm, but aligns with social welfare (McWilliams and Siegel 2000). As such, stakeholders involved in CSR should distribute wider across sectors than expected. Friedman (1962) offered a narrow economic perspective of business entity that is responsible to its stockholders. However, some other researchers claim that stakeholders of a firm are not limited to its stockholders. In the construction industry, for instance, stakeholders exist both within and outside a firm, which probably include customers, employees, communities, owners/investors, government, suppliers, competitors, and the local community (Hopkins 2003). Firms act in a socially responsible manner when they embark on two main activities—not hurt the main stakeholders within which they are engaged and they must rectify it whenever they bring harms to stakeholders (Campbell 2007).

CSR means taking responsibilities towards the environment and acknowledging the social dimension of sustainability which is often overlooked (Hutchins and Sutherland 2008). Most of CSR behaviours are voluntary. A voluntary behaviour view on CSR highlights that firms integrate social and environmental concerns with business strategies and the interaction with stakeholders should be placed on a voluntary basis (Steurer et al. 2005). While CSR is expected to conceptualize from both management philosophy and business operation perspectives, the crux of CSR controversies probably stems from the meanings of ‘social’ and how it links to daily construction activities. Therefore, by comparing the aforementioned views, the attributes of CSR are summarized below:

1. CSR has an important element of philanthropic community investment and environmental impact mitigation.
2. CSR accounts for the effects of a firm’s action on community and environment, and
3. CSR should be considered as core activities and decision-making of a company.

Categories of CSR

Maslow’s hierarchy of needs is useful to construct the layers of CSR. Steiner (1975) opined a continuum of social responsibilities, which range from conventional economic production, dictation to a voluntary area, and to those expectations beyond reality. Carroll (1991) developed a pyramid of CSR and pointed out that a firm should strive to make a profit, obey the law, be ethical, and be a good corporate citizen.

The usefulness of the needs hierarchy has been appreciated in previous studies. As stated by Tuzzolino and Armandi (1981), the role of business in satisfying physiological and safety needs is to sustain accountability to stockholders, in satisfying its affiliative need to its peers, and in self-actualizing to react to its claimants. In light of the hierarchical needs theory, firms ought to upgrade from social responsibility to social responsiveness by adapting corporate behaviours to social needs. Along this trajectory, the spectrum of CSR has two dimensions—internal and external. The internal dimension is concerned with human resources management, health and safety at work, adaptation to change, and the management of environmental impacts and natural resources. The external dimension addresses the interests of investors, local communities, business partners, suppliers and consumers, human rights and global environmental concerns.

Furthermore, the needs hierarchy lays a useful foundation for scholars to propose three levels of analysis on CSR—institutional, organizational, and individual level (Wood 1991a). According to Thompson and Ke (2012), the institutional level spells out those issues related to regulations, standards, certification demands, stakeholders; the organizational level elaborates firms’ instrumental and normative motives, firms’ mission and values and governance structure; and the individual level is concerned with supervisory commitment to CSR, values, needs, and awareness regarding CSR. In addition, there are three circles of CSR. The inner circle is for economic function (e.g., products, jobs, and economic growth), the intermediate circle—for a sensitive awareness of changing social values and priorities (e.g., environmental conservation, hiring, and relations with employees); and the outer circle for more involvement in actively improving the social environment (e.g., poverty and community welfare).

100.3 Research Methods

Literature was surveyed in the current study with the intention of identifying those themes of both "CSR in general" and "CSR in construction" (C-CSR) that were presented in previous studies. The results are shown in Table 100.1. As shown in this table, 24 themes were identified. In parallel, the world leading journals in the discipline of construction management and economics such as Journal of Construction management and economics, Journal of Construction Management

Table 100.1 Key themes of CSR studies in the literature

No.	Key themes	References
1	Audit	Kemp et al. (2012)
2	Attitudes	Brammer et al. (2007)
3	Consumers' interest	Ramsey and Yeung (2009)
4	CSP[a]	Carroll (1979), Gond and Crane (2010)
5	Definition and attribute	Carroll (1979), Dahlsrud (2008)
6	Drivers and obstacles	Carroll and Shabana (2010)
7	Education	Matten and Moon (2004)
8	Ethics	Bond (2009)
9	CP[b] and profitability	Cochran and Wood (1984), Tang et al. (2012)
10	Marketing	Vaaland et al. (2008)
11	Measurement and benchmarking	Tuzzolino and Armandi (1981), Wood (2010)
12	Governance	Jamali et al. (2008)
13	Implementation methods	Nijhof et al. (2008)
14	Organizational culture	Maon et al. (2010)
15	Public policies	Albareda et al. (2007)
16	Reporting	Du et al. (2010)
17	Risk management	Husted (2005)
18	Social issues	Wood (1991b)
19	Industrial background	Sobhani et al. (2012)
20	National background	and Bell (Yu 2007)
21	Stakeholders	Jamali (2008)
22	Strategic management	Asif et al. (2011)
23	Supply chain	Andersen and Skjoett-Larsen (2009)
24	Sustainability	Montiel (2008)

Note [a]Corporate social performance; [b]Corporate performance

Table 100.2 Key research themes of C-CSR

References	Key research themes in general																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Myers (2005)		✓											✓		✓				✓	✓				✓
Petrovic-Lazarevic (2008)												✓	✓			✓			✓	✓				
Peter et al. (2006)																		✓	✓	✓	✓			
Barthorpe (2010)					✓								✓			✓			✓	✓				
Willetts et al. (2011)													✓			✓		✓	✓	✓				
Griffith (2011)													✓						✓					
Patricia et al. (2011)							✓												✓	✓				
Oo and Lim (2011)		✓	✓												✓				✓	✓				✓
Huang and Lien (2012)									✓		✓								✓	✓				
Kornfeldová and Myšková (2012)		✓									✓		✓						✓	✓				
Zhao et al. (2012)											✓		✓						✓		✓			
Barnes and Croker (2013)		✓											✓						✓	✓				
Lichtenstein et al. (2013)		✓							✓		✓								✓	✓				✓
Liu et al. (2011a)				✓															✓		✓			
Wottrich and Sastararuji (2008)						✓							✓						✓	✓	✓			
Croker (2013)		✓				✓							✓						✓	✓				
Total number	0	6	1	1	1	2	1	0	2	0	4	1	10	0	2	3	0	2	16	13	4	0	0	3

and Engineering, Journal of Management in Engineering, Journal of cleaner Production, International Journal of Construction Management, and International Journal of Project Management were scanned carefully to identify whatever papers that present the subject of CSR. As a consequence, there are totally 16 papers identified, and each one was further examined in detail to examine the keywords they represented. The results are listed in Table 100.2.

100.4 Results of Literature Analysis

As shown in Table 100.1, CSR research in general distributes over a wide range of themes, such as stakeholders, measurement, reporting, and financial performance. By comparison, the relevant studies in construction are centred on three themes, namely “industrial background, national background, implementation methods”. It seems therefore that academicians’ concerns in general have been over ‘how to make CSR effective’, while the studies in construction highlights ‘whether CSR is an imperative’.

The three themes identified above indicate that C-CSR research has just kicked off its development step. The three themes indicated in Table 100.2 suggest that the difference of CSR attributes in construction from that in other sectors has been recognized in previous studies, which might lead to the establishment of C-CSR theories. Thus, the nature of construction business deserves much attention when C-CSR is compared with the counterparts in other sectors. Meanwhile, China implemented a socialist market economic system. The characteristics of national backgrounds such as the dominating market position of state-owned enterprises and the Chinese traditional culture can enable CSR to be different. It seems therefore that C-CSR research specifies more the application of generic theory to the construction arena, while little attention has been paid to enriching the body of CSR knowledge.

It can also be found that CSR research in construction has not followed the other seven themes that the general CSR studies have outlined. The seven themes are audit, ethics, marketing, organizational culture, risk management, strategic management, and supply chain. The lack of these themes means that the merits of integrating CSR into daily business management have not in the construction research area. Meanwhile, a few CSR themes (e.g., sustainability) have been offered by construction researchers.

100.5 Discussion

Since CSR research in construction has just been at infant, it is very important to discuss the attributes of C-CSR and the potential directions of C-CSR studies in the future.

100.5.1 Attributes of C-CSR

C-CSR is a management tool.

CSR is basically concerned with stakeholders. Although business in general is accountable toward society at large, an individual business can be deemed responsible only toward stakeholders, or the definable agents with whom it interacts. A construction firm is knitted by a wide array of stakeholders who have dissimilar interest and demand interlinked in the construction process. They may claim for either economic or social interests, or both. Ineffective stakeholder management for CSR can result in serious problems. For instance, poor response to financiers' social expectations would undermine the mutual trust and results in insufficient financial supports to construction organizations. Thus, C-CSR should be deemed as a management tool in the construction process.

C-CSR contains a wide span of activities.

CSR activities are characterised by policies or actions that recognize a company as being concerned with society-related issues. CSR in many areas includes the following categories: (1) the environment, (2) affirmative action programs, (3) equal employment opportunity policies, (4) community involvement, (5) product safety, (6) policies toward South Africa, (7) energy policies, and (8) social responsibility disclosure (Roberts 1992). The works by Griffith (2011) identified five core features of CSR, namely social accountability, associations of stakeholders, compliance with law and regulation, ethically sound operational practices and business sustainability. It is therefore arguable that C-CSR is not limited to a certain type of social or environmental activity.

C-CSR as a subject comprises two levels of analysis.

C-CSR has two levels of analysis in light of a stakeholder view on CSR. One refers to stakeholders at a project level, which contain four types, namely client, project leader's organization, outside services, and invisible team members (Briner et al. 1996). The other refers to stakeholders at a firm level, which can be classified in several ways (Cleland 1995). A typical approach is to classify them as policy-makers, building officials, investors, financiers, developers, owners, architects and designers, engineering professionals, specialist consultants, product manufacturers, project managers, builders/contractors, sub-contractors, facilities managers, users, tenants, and teachers/educators (Bakens et al. 2005).

100.5.2 Fulfillment of CSR in Construction

CSR addresses in nature the interdependence between business and society (Carroll and Shabana 2010), but not all construction businesses are highly engaged in CSR practices. What inspires some construction firms to embrace CSR activities, and why do a vast majority of medium-and-small construction firms keep away from CSR duties? In effect, the practice of CSR is subject to a number of obstacles and drivers. A well understanding of the obstacles and drivers of CSR engagement underscores the erection of CSR behaviours in the construction industry.

Drivers of CSR fulfillment

According to the study by Aguilera et al. (2007), there are three key drivers for business to fulfill CSR—instrumental, relational and moral. The instrumental drivers refer to self-interest that CSR is beneficial for business to enhance competitiveness (Bansal and Roth 2000) and legitimacy (Aguinis and Glavas 2012; Bansal and Roth 2000). CSR will be integrated into business plans if resources input into CSR can give rise to the improvement of financial performance, brand image and reputation, sales and customer loyalty, productivity and quality, stability of workforces, capital access, benefits to community, and product durability and functionality, while decrease operating costs at the same time.

The rational driver lies in the relationships of business with society. Firms are more likely to engage in CSR when governance structures are placed on external relationships with larger communities. Corporate governance structures such as the inclusion of outside directors broadened the focus of the firm to go beyond the exclusive interest of shareholders. Furthermore, the moral driver is based on a concern with ethical standards and moral principles. Firms are motivated by normative reasons such as a sense of responsibility and duty (Bansal and Roth 2000), following a higher order or morals (Aguilera et al. 2007).

Obstacles of CSR fulfillment

Obstacles refer to something able to prevent action or slow progress. As described above, numerous firms in construction industry do not fully comprehend the demands from stakeholders and do not fully realize how much they value CSR. This suggests some obstacles of CSR fulfillment in the industry. In fact, there are a range of obstacles inhibiting business to invest more in CSR programs. Subject to the abstractness of CSR, the obstacles can contain the lack of awareness, the lack of organizational buy-in and commitment to CSR, the difficulty in integrating CSR with organizational values and practices, and the lack of sufficient time and financial resources. In addition, it is arguable that the incompleteness of CSR strategy may constitute another obstacle of CSR fulfillment.

Human resource is another major obstacle that business needs to deal with. To derive good CSR policies and practices, recruiting/training staff prioritizes the elements of CSR initiatives. A major concern for many business owners and managers is connected to competing codes of conduct from different customers. The nature of business can in part stop managers to take more CSR actions. For instance, construction firms have to move from one project to another and thereby using external resources to construct a project has brought much difficulty to contractors in the implementation of CSR strategies. When an organization finds it difficult to make a business case for CSR or link it to core organizational operations, it will be reluctant to commit and allocate resources or time to such practices.

Furthermore, many firms may constantly encounter tighter budgets brought about by CSR implementation, which cannot return profits in the short run. Therefore, most are unable to spend much money on CSR initiatives.

Liu et al. (2011b) pointed out that building projects overly focus upon the client, creating a barrier to the company exerting their own CSR policies upon the project. They also argue that the nature of project work as having 'power-based opportunism towards self-orientated profitability…among participants' means that CSR is seldom realized. Similarly, Green (2009, p.49) blames the industry's 'obsession with narrowly defined efficiency' as being a hindrance to developing concerns outside of profitability. Petrovic-Lazarevic (2008) highlights that the construction companies' approach to CSR is predominately a one-sided communication with the company communicating its values and policy with little or no community input. She also notes that none of the companies interviewed had a representative of suppliers or community on its board of directors.

100.6 Concluding Remarks

Construction activities can generate considerable negative impacts on the environment and the society. The growing importance of striking the trade-off between social equity, environmental degradation and ecological crisis has driven researchers to understand that CSR is an ingredient of sustainable construction that deserves much attention in the recent years. This study identifies three key themes (i.e., implementation, industrial background, and country background) of CSR that construction researchers have outlined their importance in parallel to those studies in general. In addition, there are up to twenty themes that previous studies in construction have not much taken into consideration. This implies that CSR research in construction has just been at an infant stage that researchers are expected to put unfailing efforts to synthesize CSR into the routine construction business management. It is recommended that future research continues contributing to the body of knowledge by placing emphasis on the attributes, drivers and obstacles of CSR in the construction industry.

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Chapter 101
Analysis of the Relationship Between Optimal Incentive Plan and Supervision Cost

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Abstract There are principal-agent relationships between owners and engineers in the practices of construction supervision. Because of the inconsistency of their goals and the asymmetry of information, fixed supervision cost can not effectively produce incentives for the engineers' effort. Firstly we assumed that the information is symmetrical and analyzed the fixed supervision cost mechanism based on the principal-agent theory. Furthermore, the incentive mechanism under the condition of information asymmetry was analyzed, and the finding was that an optimal incentive plan should adopt floating supervision cost mechanism.

Keywords Construction supervision · Principal-agent · Incentive mechanism

101.1 Introduction

Construction supervision has been treated as a scientific management system in the construction context for over 100 years. With reference to the standard practices worldwide, China's reform of construction management system keeps continuously developing. The Ministry of Construction issued the "notice on carrying out construction supervision work" in 1988, which marks the start of the construction supervision system taking into account China's specific characteristics of construction business.

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The main market players in the Chinese construction industry includes owners, supervision engineers (hereinafter referred to engineer) and contractors in the engineering construction supervision system. Behind these three entities are principal-agent relationship. On one hand, contractors usually find it easier to learn more about the environment and the actual situation than owners. This would unavoidable give rise to the information asymmetry between the two sides, and owners cannot observe contractors' construction actions directly. If this happens, the interests of owners will be effected, if the contractors pursue their own economic profits with unethical behavior, such as cutting corners, quality deception, etc. Owners entrust a specialized engineer to supervise the behavior of the contractor in order to protect his own profits, which formed the second principal-agent relationship–the principal-agent relationship between the owners and engineers. The clients' (the owners') profits are closely related to the trustees' (engineers') behavior in this relationship. The engineers can improve the engineering quality, shorten the project construction period, save construction costs for the owners by their own works (such as putting forward reasonable suggestions, using the new design, using new technology, new materials, etc.), supervising the contractors powerful and getting the maximization of the profits of the owners. But there also exists information asymmetry between the owners and engineers so that the true effort level of the engineers cannot be directly observed by owners, and only the engineers' supervision performance can be observed. But it is not totally depending on the engineers' effort level, it also been affected by a variety of other factors. In this way, the engineers will use own information superiority to hide their true effort level to maximize their own utility.

Therefore, in order to ensure the realization of engineering project target better, the relationship between the owners, engineers and contractors deserves close attention. We also need to understand the relationship between the principal profit goals and behavior characteristics, designing the strategy to meet the specification of main body behavior. And the game theory of information economics is to investigate the countermeasures when the direct interaction of countermeasure body occurs and the equilibrium problems of those countermeasures in the condition of asymmetric information (Zhang 1996; Xie 2002). There are limited literatures concerned with the game of actors in the field of construction from different angles. Zhang and Guan (2000) are the earlier domestic scholars studying on the scenario of asymmetric information of construction industry, their papers expound the influence of the degree of scenario of symmetric information on construction cost. Chen (2001a) made some relevant qualitative analysis in the Scenario of Asymmetric Information of construction industry. Cheng (2001b) studied the game model of rent-seeking supervision in architecture subjects. Wang and Huang (2003) studied the game model of quality control between engineers and the contractors by the method of game theory. Besfamile (2003) mainly studied how to realize the maximization of profits under the condition when the owners cannot distinguish the "hard" or "not hard" in contractors. Zhu and Li (2005) extracted the contractor's moral hazard model during engineering construction period using the principal-agent theory, and drew a conclusion which was good for the constraint of the contractor's immoral behavior and improvement of the management level of the project contract through quantitative analysis. Cao and Yang (2005) and Qing (2007) researched principal-agent relationship between owners and engineers in construction supervision, but the research was only limited to the specific functions of prior assumption, analyzing the influence of each parameter in a hypothesis function on the incentive coefficient.

This paper analyzed the relationship between the optimal incentive plan and supervision cost based on the principal-agent theory starting from the general situation of the more common meaning, which in order to designing effective incentive mechanism. In that case, the enthusiasm of engineers can be aroused and the level of supervision can be raised, which ensuring projects smoothly and achieve the project goals.

101.2 The Principal-Agent Theory

101.2.1 Introduction of the Principal-Agent Theory

According to M. Jensen and W. Meckling's definition, the principal-agent relationship is one or more of the behavior subject specifying and hiring other agents to provide service. The service side has the right of decision and how much reward they get according to the quality and quantity of the service they provide (Zhou 2013). The franchisor is the principal and the grantee is the agent. The principal has the right to decide the payment rules or the payment scheme of the agent's compensation. Some economists, such as J. Pratt and R. Zeckhauser, they think the principal-agent relationship is here as long as a person depending on another person's action. The agent take the action and the affected party is the principal. In the real economic life, principal-agent relationship is almost everywhere. Principal-agent relationship is based on universality of asymmetric information between the principal and the agent. Due to the universality of asymmetric information and the inconsistency of both sides, the one party with the advantage of information may use the information advantages to damage the interests of another party with the information disadvantage. The key principle of solving principal-agent problem is how to establish a kind of incentive mechanism to make the agent's behavior be propitious to the interests of the agent (Zhang and Liu 2003).

As the development of Kos's property rights theory and Williamson's transaction cost theory, as well as the information economics and contract theory's breakthroughs in the field of microeconomics Since the 1970s. A rapid development of modern enterprise principal-agent theory in nearly 20 years was also obtained by Coase, Berle and Means (Li and Huang 2003).

Later, the scenario of asymmetric information existing in principal-agent relationship was solved in principal-agent theory and analysis of the application model created by Wilson and Ross. Based on the study of the theory of the scenario of asymmetric information, they proposed incentive measures which were related to the residual distribution with performance according to the contractual property of certain distribution of the residual claim right. This method is used to motivate managers by most companies of two rights separation. The only difference from these companies is proportion of the residual claim right (Liu 2003).

101.2.2 The Principal-Agent Model

101.2.2.1 Assumptions of the Model

The three basic hypothesis of principal-agent modes (Li and Li 2003):

1. Risk attitudes on both sides. The client is risk neutral. The agent is risk avoidable. Based on the strong financial resources, clients have more positive attitude to risk compared with the agents because of their strong financial ability.
2. We assume that the agents' action e decides the results (for example, profit), namely the $\pi = \pi(e)$ and only the π can be observed by the agents. This reflects the information asymmetry between principals and agents. The agents have the advantage over clients for the agents' activity information e.
3. The agent's utility function $u(\omega, e)$. ω: what agent be paid. e: the behavior of the agent. We assumed that $u(\omega, e) = v(\omega) - g(e)$, the $g(e)$ here: the negative utility of the behavior(labor) of the agents. Clients hope that agents work hard. That is to say, the bigger is the better to ω. And for agents, the greater the ω is what they want. And they try to bring the negative effects of $g(e)$ as small as possible.

101.2.2.2 General Principal-Agent Model

Clients want to maximize their benefits, namely:

$$Max \int (\pi - \omega) f(\pi, e) d\pi \tag{101.1}$$

$f(\pi, e)$ is the density function.

Due to information asymmetry between the two parties, the clients cannot observe agent's action and hold the first hand information so that it been unable to limit the action of agent. Therefore, maximizing principal's goals is bound to the restraint of information, it also need to consider the constraints modeling problem of the principal, which requires principal must also consider the interests of the agent itself to make contract carried out smoothly (Shenzong 2009). That is to say, to let agent agree to implement action according to their expected, the principal need to make the agent's expected utility in this operation not less than the execution of other actions provided by the utility, which is the participation constraint. In addition, another constraint for principal to achieve expected goal is impel Compatible constraint conditions, namely the client's desire action must conform to the agent's own interests. Respectively as follows:

$$\int u(\omega, e) f(\pi, e) d\pi \geq \overline{u} \tag{101.2}$$

$$\int u(\omega, e) f(\pi, e) d\pi \geq \int u(\omega, \tilde{e}) f(\pi, \tilde{e}) d\pi, \forall \tilde{e} \in E \tag{101.3}$$

To form a general principal-agent model by Eqs. 101.1, 101.2, and 101.3 the principal-agent problem is the maximization problem of the Eq. 101.1 under the constraint conditions that have solved in the Eqs. 101.2 and 101.3.

101.3 Owner and Engineer's Incentive Mechanism Model

101.3.1 Owner and Engineer's Characteristics

101.3.1.1 The Inconsistency of the Target

Owners entrust engineers to conduct supervision on the process contractors of buildings so that the project can meet the requirements of the contracts and make the owners satisfied. Engineers employed by owners resort to the virtue of their technical experience, enjoying the pay for their supervision from owners, control and conduct supervision on contractors, paying the appropriate labor, their target is to seek for the interest maximization. There are inconsistencies between the desired target of owners and engineers. The inconsistency of the target may lead engineers to harm the interest of owners in order to seek for their interest maximization in the process of supervision.

101.3.1.2 Information Asymmetry

Owners entrust engineers to conduct supervision on the contractors and engineers stand for the owners during the process of project construction. Compared with owners, engineers have more professional knowledge and technology. There is information asymmetry between owners and engineers in the following two aspects:

1. Hiding the action

Owners entrust engineers to conduct supervision on the whole or part process of the project construction to achieve the goal of the project's quality, cost and schedule, and achieve the requirements of the contract. So achieving goals are affected by the engineers' action more or less. If engineers' action can be observed, then the contract between the owners and engineers is relatively simple. Contracts can appoint the effort level that engineers must pay and the return which owners should provide (payment of engineers' wages). But the fact is that engineers' action is unobservable, so the contract can not effectively stipulate the effort level and wage payment. Because there is no way to confirm whether engineers to fulfill his obligations. In this case, owners must design a compensation plan so that they can indirectly take corrective action to motivate engineers.

2. Hiding the information

Hiding the information means that after signing the contract, engineers' effort level and hard work bring negative effect which is unobservable, then engineers may find themselves very suitable for this supervision mission, so high level of effort will bring quite low disutility. Or the real situation is just the opposite. But only engineers know which situation they are. Engineers have more information on the potential profitability of the commissioner's action than owners, so owners should give appropriate incentives to engineers.

101.3.2 Assumption and Explanation of Parameters

As mentioned earlier, agency relationship exists between owners and engineers. Owners are principals and engineers are agents. Owners pursue projects of high quality, short duration and low costs while engineers pursuing their own maximum interest. Their interest objectives are inconsistent and the supervision of the asymmetry of information exists between owners and engineers. Engineers master more and more accurate information about project than owners. So they are in the information advantage of a party and owners are in the information disadvantage of a party. Engineers monitor and control the process of building the project so that projects meeting the requirements specified in the contract and making the owners satisfied. Engineers' work is to provide services for owners. Owners and engineers' related property and assumed conditions are as follows (Zhou 2003; Hou and Wang 1999): (1) π: Observable profits from the supervision conducted by engineers which entrusted by owners on contractors, in the interval $[\underline{\pi}, \overline{\pi}]$

1. e: The engineer's choice of action, engineer effort level measure; Possible action set down as E, $e \in E$
2. ω: The cost owners pay for the engineers' supervision

3. $f(\pi|e)$: conditional density function about project's observable profit π and the engineer's effort level e; for all $e \in E$ and all $\pi \in [\underline{\pi}, \bar{\pi}]$, there is $f(\pi|e) > 0$. Therefore given engineers' any kind of effort level or any potential profits are possible realized.
4. In order to simplify the model to facilitate analysis, assuming the engineer has only two kinds of effort choice: e_H and $e_{L,}$ and assuming that the engineer who has high effort level brings higher profit by choosing e_H than $e_{L,}$ but also to bring more negative effect to engineers. Because there is a conflict between the interests of the owners and the interests of the engineers.
5. Further specific, assuming that the conditional distribution of first-order stochastic of π relying on e_H is better than which relying on $e_{L.}$ That is to say, the owner's profit level will be higher when the engineer selects e_H than $e_{L,}$ $\int \pi f(\pi|e_H)d\pi > \int \pi f(\pi|e_L)d\pi$.
6. *U(ω, e)*:Engineers' Bernoulli utility function and expecting utility maximization. Engineers are risk avoid investor, for all *(ω, e)*, the utility function satisfy $\partial u(\omega, e)/\partial\omega > 0$ and $\partial^2 u(\omega, e)/\partial\omega^2 \leq 0$; for all ω, there is $u(\omega, e_H) < u(\omega, e_L)$, which means engineers preferring high-income. Assuming $u(\omega, e) = v(\omega) - g(e)$, than $v'(\omega) > 0$, $v''(\omega) \leq 0$, and $g(e_H) > g(e_L)$.

101.3.3 Scenario of Symmetric Information

Symmetric information means the engineer's level of effort e can be observed for owners and it can be the starting point for analysis of unobservable effort level. Due to the engineer's observable effort level, owners can set the engineer's effort level $e \in \{e_L, e_H\}$ and that the engineer's cost of supervision payment is observable profit function $\omega(\pi)$. Assuming supervision market is completely competitive, only on the premise that the utility owners provide to engineers is not lower than the engineer's expected utility $\bar{u}$($\bar{u}$ is the engineer's reservation utility level), the engineer may accept the project management work. So the optimal equipment supervision contract should meet the following model.

$$\underset{e \in \{e_L, e_H\}, \omega(\pi)}{\text{Max}} \int (\pi - \omega(\pi))f(\pi|e)d\pi \tag{101.4}$$

$$s.t. \int v(\omega(\pi))f(\pi|e)d\pi - g(e) \geq \bar{u} \tag{101.5}$$

We can discuss this model from two stages. Firstly, for all possible effort choice e in the contract, how is the optimal compensation scheme for engineers. Secondly, what is the optimal selection of e.

Given the contract specified effort level, we choose owners' maximum profit:

$$\int (\pi - \omega(\pi))f(\pi|e)d\pi = \int \pi f(\pi|e)d\pi - \int \omega(\pi)f(\pi|e)d\pi \tag{101.6}$$

Equaling minimizing the owner's expected value compensation cost $\int \omega(\pi)f(\pi|e)d\pi$, so according to Eq. 101.4, the optimal compensation scheme in this case must solve the following problems:

$$\underset{e\in\{e_L,e_H\},\,\omega(\pi)}{\text{Min}} \int \omega(\pi)f(\pi|e)d\pi \tag{101.7}$$

$$s.t. \int v(\omega(\pi))f(\pi|e)d\pi - g(e) \geq \bar{u} \tag{101.8}$$

γ represents the Constraint Lagrange multiplier, for each level of $\pi \in [\underline{\pi}, \bar{\pi}]$, the wage owners paid in the solution of Eq. 101.7 must meet the first-order condition: $-f(\pi|e) + \gamma v'(\omega(\pi))f(\pi|e) = 0$, that is:

$$\frac{1}{v'(\omega(\pi))} = \gamma \tag{101.9}$$

Due to the contract clearly stipulates the engineer's effort choice. On the premise of that the incentive problem does not exist, owners must ensure that engineers avoid income instability risks so that the optimal compensation plan $\omega(\pi)$ should be a constant, which means The owners have to pay fixed supervision costs to the engineer. Under the case that giving the e of contract, owners must provide the fixed supervision cost to pay for the ω_e^* to make the engineer just get reservation utility level:

$$v(\omega_e^*) - g(e^*) = \bar{u} \tag{101.10}$$

So in the principal agent model of engineer's effort level, the optimal contract set engineer's effort level to be e^*, the cost of supervision that owners paid for engineers is $\omega^* = v^{-1}(\bar{u} + g(e^*))$.

101.3.4 Scenario of Asymmetric Information

Because in reality, the information between the owner and the engineer is asymmetric, the owner cannot observe the engineer's effort level. The owner and engineer do not match the target and conflict. The only way can let the engineer work hard is relate his compensation and realize profits. The owner's incentive for the high level of efforts can only at the expense of the engineers in the face of risk.

The optimal incentive plan to implement a certain level of effort is the supervision cost payment which the minimize owners except that meet two constraint conditions. First of all, if the engineers want to accept the task of supervision, it must obtain the expected utility of at least $\bar{u}$, that is, the participation constraint; at the same time, it also must meet the incentive compatibility constraint, that is, engineers face the incentive plan $\omega(\pi)$, must really want to choose effort of the level e. So the optimal equipment supervision contract should meet the following model.

$$\operatorname*{Min}_{e \in \{e_L, e_H\}, \omega(\pi)} \int \omega(\pi) f(\pi|e) d\pi \tag{101.11}$$

$$s.t. \int v(\omega(\pi)) f(\pi|e) d\pi - g(e) \geq \bar{u} \tag{101.12}$$

$$\int v(\omega(\pi)) f(\pi|e) d\pi - g(e) \geq \int v(\omega(\pi)) f(\pi|\tilde{e}) d\pi - g(\tilde{e}),\ \forall \tilde{e} \in E \tag{101.13}$$

Due to when the profit level which the general owners expected in engineer choosing e_H is higher than choosing $e_{L,}$ so engineers usually hope the owners choose effort level e_H through incentive plan, so the incentive compatibility constraint Eq. 101.13 can be written as:

$$\int v(\omega(\pi)) f(\pi|e_H) d\pi - g(e_H) \geq \int v(\omega(\pi)) f(\pi|e_L) d\pi - g(e_L) \tag{101.14}$$

To represent $\gamma \geq 0$, $\mu \geq 0$ as the Eqs. 101.12 and 101.14s Lagrange multipliers respectively, so in each $\pi \in [\underline{\pi}, \bar{\pi}]$, $\omega(\pi)$ must meet the following Kuhn-Tucker first-order conditions:

$$-f(\pi|e_H) + \gamma v'(\omega(\pi)) f(\pi|e_H) + \mu[f(\pi|e_H) - f(\pi|e_L)] v'(\omega(\pi)) = 0 \tag{101.15}$$

or:

$$\frac{1}{v'(\omega(\pi))} = \gamma + \mu[1 - \frac{f(\pi|e_L)}{f(\pi|e_H)}] \tag{101.16}$$

Due to the engineer as an agent is in risk avoidance, so $v'(\omega)$ is strictly decreasing in ω. The Eq. 101.9 shows that if the fixed supervision cost $\hat{\omega}$ let $1/v'(\hat{\omega}) = \gamma$, then there is:

When $\frac{f(\pi|e_L)}{f(\pi|e_H)} < 1$, $\omega(\pi) > \hat{\omega}$; when $\frac{f(\pi|e_L)}{f(\pi|e_H)} > 1$, $\omega(\pi) < \hat{\omega}$.

$\frac{f(\pi|e_L)}{f(\pi|e_H)}$ is called likelihood ratio, It reflects a ratio of probability of occurrence of engineer effort level e_L with probability to occur in eH in a given profit π which the engineers bringing to the owners.

101.4 Concluding Remarks

1. In the optimal incentive plan, the compensation in profit which the owner give to the engineer is not must monotonically increasing, dependence and engineer action profit conditional distribution function of first-order are randomly dominant, but there is no guarantee that likelihood ratio $\frac{f(\pi|e_L)}{f(\pi|e_H)}$ is must monotonically decreasing in π, so the Eq. 101.16 shows that the compensation which the owner give to the engineer is not must monotonically increasing.
2. When likelihood ratio $\frac{f(\pi|e_L)}{f(\pi|e_H)} < 1$, when the profit's appearance probability under e_H is higher than $e_{L,}$ the optimal incentive plan will pay more supervision cost than $\hat{\omega}$. Similarly, the results which is more likely to appear in the selection of e_L, it will pay less compensation than $\hat{\omega}$. The owners of a given incentive plan know what level of effort will be selected, so owners use this way to construct the compensation, which can offer a selection of e_H instead of e_L incentive to engineer.
3. Due to the engineers for the wage payment of variability is introduced, engineers can get the wage payment must be strictly greater than observed cases of permanent job. In order to ensure that the engineer get expected utility $\bar{u}$, for any risk which engineers bear, the owners have to pay a higher evaluation of wage., The owners cannot observe engineers' effort level because of the information asymmetry, leading to the increasing expected value of owner's compensation cost when engineers implement effort level e_H.
4. According to the above analysis, owners should incent engineers choosing what kind of effort level. They should compare the added value of the expected profit under two kinds of effort level $\int \pi f(\pi|e_H)d\pi - \int \pi f(\pi|e_L)d\pi$ and the difference which expected salary to pay when implementing two effort levels. The expected wage payment needed in implementing $e_{H.}$ When the effort level being unobservable is strictly greater than the observed situation, so under this model, the unobservability can raise the cost of implementing e_H.

In order to make the engineers offer better service for the owners in engineering construction supervision. It's necessary to design effective incentive mechanism. Link the payment of engineering supervision cost and the profits which engineering supervision bringing to owners arousing the enthusiasm of engineers, impelling them to raise the level of supervision and reducing the cost of supervision, raising reputation of supervision. Ensure to achieve the project goals fundamentally and guarantee the project participates' profits maximally.

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Chapter 102
Cost of Prequalification: A Pilot Study

M. Motiar Rahman

Abstract Selecting appropriate consultant and contractor is important for successful delivery of construction projects, where prequalification plays a critical role. Such prequalification process is claimed to be creating excessive costs in Scotland, due to higher number of return of prequalification questionnaires (PQQs), as it is required for every project, irrespective of the contract size. However, the claim is not supported by any estimation. This paper aims to fill this gap of information by providing a preliminary estimate of the cost of prequalification process. A pilot study revealed that the cost of prequalification is about one-fifth of the annual turnover of construction industry in Scotland. These figures are believed to be of the right order of magnitude, but accuracy of this figure is somewhat uncertain, because of smaller sample size, diverse nature and scope of construction projects and subjectivity in assessing PQQs. More accurate quantification with larger groups of clients, consultants and contractors is therefore recommended, along with investigating the nature of PQQ assessment with the target to reduce any subjectivity element, identifying suitable factors/criteria and sub-factors/criteria, and developing an appropriate framework for PQQ process to reduce the cost. It is envisaged that a nationwide registration scheme or database of consultants and contractors with information of different type and weight will potentially reduce the cost of prequalification.

Keywords Clients · Consultants · Contractors · Prequalification · Procurement · Scotland

102.1 Introduction

Prequalification in construction is a pre-tender process of investigating and assessing the capabilities of a group of parties, e.g. contractors and consultants (Hatush and Skitmore 1997), aiming at identifying a pool of competitive, competent

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and capable parties (Lam et al. 2010, Huang et al. 2014), in order for carrying out a contract satisfactorily if it is awarded to them (Oladapo 2011), and under any incentive mechanism as modern delivery methods allow (Hosseinian and Carmichael 2012). A good design by the consultant allows pleasant view, structural stability and usability of the facilities, as well as contributes to the social, cultural and economic quality of the built environment (Cheung et al. 2002, Xia et al. 2014). A capable consultant should observe client's interest, ensure accuracy and relevance of the structural design and bring genuine and lasting value, which will increase the chance of delivering a project on time and within budget (Ng and Chow 2004). On the other hand, contractor is the party who is responsible for carrying out the works, ensuring the required quality, and delivering the project on time and within budget. Moreover, construction is a multi-party endeavour, with inter-related activities, which require frequent interactions among the parties (Cristobal 2012). Therefore, a harmonious working relationship between the consultant, the client, and the contractor is invaluable to the successful project delivery (Kumaraswamy and Rahman 2006) and ensuring sustainability (Kumaraswamy et al. 2005; Xia et al. 2014). Therefore, selecting a competent consultant and a capable and compatible contractor is important; using a suitable selection framework with a range of criteria and their relative weight, where prequalification plays a critical role (Cheung et al. 2002; Ng and Chow 2004).

Prequalification provides a client with a list of parties to be invited to tender for a specific project, or a standing list of potential parties to invite to tender for similar types of project on a regular basis (Hatush and Skitmore 1997). Such an essential decision-making process involves the development and consideration of a wide range of necessary and sufficient decision criteria (Russell and Skibniewski 1988; Cristobal 2012). It can aid public and private clients in achieving successful and efficient use of their funds by ensuring that a qualified contractor or consultant is selected to execute the work (Lam et al. 2005). In order to meet individual cliental needs and project specific requirements, many clients develop their own prequalification process, with their own set of criteria and their emphasis (Ng and Chow 2004). Client-specific prequalification process is expected to maintain consistency across its own organisation, e.g. for large public sector clients. However, such a prequalification process in Scotland is claimed to be creating extra costs to the clients, due to the very high number of return of prequalification questionnaires (PQQs) and their consequent assessment.

The aim of this paper is to provide a preliminary estimate of prequalification cost in Scotland, through identifying costs in preparing, issuing and assessing the PQQs, targeting overall cost reduction in PQQ process. The paper first discusses the regulatory requirements for prequalification in Scotland (i.e. brief literature review), the industry concerns on the PQQ issue (i.e. meta-data from workshops organized in Scotland), and then presents the outcomes from a pilot survey. A carefully designed and tested questionnaire was used to collect information about the cost of current PPQ process to clients. The outcome of the overall research project is expected to allow the policy makers and industry practitioners to appreciate the apparently hidden cost in PQQ process and help them focus on the means of minimising them.

102.2 Construction Prequalification in Scotland

Following the recent industry review reports and developments (e.g. those by Latham 1994; Egan 1998; McClelland 2006) and subsequent publication of diverse and somewhat scattered guidance, the Scottish Procurement Directorate (SPD) has compiled "Construction Procurement Manual" (henceforth "Manual"), to draw together key policy principles and procedures relating to construction procurement from many sources. The Manual was first published in 2010, and is regularly reviewed and updated to take account of feedback from users and guidance available from other sources. The 'screen' version (available at the website) is regarded as the current version (SG 2011). The Manual is mandatory throughout the Scottish Government, its Associated Agencies and all other public bodies which are subject to the Scottish Public Finance Manual. The Manual stipulates a three stage procurement procedure for the public construction procurement, involving a screening mechanism for reducing 'long list' of potential consultants and contractors to a 'short list' through PQQ, irrespective of the cost of construction project.

The Manual is voluntary to other public bodies, in particular, the Local Authorities (LAs). However, public sector procurement in Scotland adheres to EU (European Union) rules in general. This means every project undertaken by the LAs needs to go through a prequalification process for appointing contractors and consultants, irrespective of the cost and size of the construction project. Therefore, LAs too need to exercise PQQ for every project, in the process of selecting consultants and contractors, even though they are not covered by the Manual (SG 2014). However, LAs can develop their own individual procedures and implement them through their own standing orders (McClelland 2006).

102.3 Industry Concerns on Prequalification

The Scottish Construction Centre (SCC) organised a series of half-day-long workshops throughout Scotland, in order to develop a general awareness of the SPD's Manual in the Scottish construction industry, and in particular to disseminate and discuss the 'current' and proposed procurement and PQQ arrangements for public works in Scotland (SCC 2010). Table 102.1 summarizes the information of attendees in the five workshops. Their further details have been deliberately withheld due to confidentiality purposes. Nevertheless, only the experienced professionals and managerial level personnel attended the workshops, due to the nature of its content. Almost all the participants were key 'decision makers' in their respective organisations. A wide range of issues was raised and feedback received from the workshops. However, prequalification was surfaced out to be the greatest

Table 102.1 Number of attendees in workshops

Date	Location	No of attendees	Consultant	Contractor	Public bodies	Others
12.05.2010	Dundee	39	6	13	17	3
13.05.2010	Aberdeen	14	2	11	0	1
26.05.2010	Glasgow	37	7	13	13	4
09.06.2010	Edinburgh	15	5	5	3	2
10.06.2010	Stirling	13	1	7	5	0
Total for five workshops		118	21	49	38	10

Source SCC (2010)

concern in the industry, placing a huge burden in terms of resources, time and cost. This happens to be true whether an organisation is issuing and assessing PQQs (i.e. clients) or responding to them (i.e. consultants and contractors). The following subsections summarize the issues/feedback relevant to PQQs.

102.3.1 Volume of PQQs

Both under the EU directives, and the Manual of the Scottish Government (SG 2014), prequalification is necessary for each project in the public sector, for selecting its consultant and contractor. As a result, the public clients (both government and LAs) need to prepare and issue a project specific PQQ document, and in some cases for projects with estimated cost as low as £10,000. On the other hand, each interested party (i.e. contractor and consultant) wishing to be prequalified needs to fill-in and submit those documents for individual projects (SCC 2010). The clients then need to assess those submitted PQQs. Through this process, both the issuing (i.e. clients) and the responding (i.e. consultants and contractors) organisations are spending excessive amount of time and resources. Thus, the prequalification process is incurring considerable unrecoverable costs, which is not achieving appropriate outcome. The situation becomes more acute when the economy is in recession or affected by credit crunch. There are fewer contracts to be awarded, and contractors and/or consultants are starved for work. This creates excessive number of responses, whenever there is any invitation for prequalification. One of the attendees shared his experience that there were more than 70 submissions in response to one invitation for consultant prequalification. However, there is no official estimation on the extent of cost incurred in such prequalification process, especially in the Scottish Construction Industry.

102.3.2 Scope of PQQs

Although LAs (Local Authorities) and other public clients follow EU and Scottish Government (SG) legislation, their procurement requirements are diverse, e.g. due to specific needs (e.g. hospitals by National Health Service versus a museum by a LA), types of projects (e.g. residential buildings versus roads) and location or topographical features (e.g. plain versus hilly area, and city centre versus rural area). They manage such diverse requirements by developing their own individual procedures and implementing them through their own standing orders. This is creating a wide variation in the procurement requirements and procedures between the LAs leading to duplication of effort, inefficient use of resources and considerable additional cost for organisational bidding for LA works (SCC 2010). Moreover, many clients require both past experience and specific project proposals, with the latter often in considerable detail, although PQQs under EU regulations should be based only on current company standing and past relevant experience, not on proposal on a specific project in hand. As a result, there exists considerable inconsistency in both the requirements of the issuing organisations and also in the quality of information being returned, particularly relating to specific project proposals, much of which may change by the tender/contract stage.

102.3.3 Prequalification Scheme

The benefits of the principle of online prequalification schemes, such as ConstructionLine, are widely accepted (ConstuctionLine 2014). They can avoid the laborious task of repeatedly providing generic standard information on the company. However they have not been accepted wide enough and adopted to become universal practice across the industry and therefore be effective. Such schemes are also fee based, so the SG cannot make them mandatory although often the option is offered to provide evidence of registration instead of answering some questions. There is also a view that the ConstructionLine tries to go too far in that it tried to effectively select the shortlist for you with some less than appropriate outcomes further discrediting the system. Therefore, many PQQs require standard generic information in varying and inconsistent forms, which consequently effects time and resources for both responder and assessor (SCC 2010). Furthermore, the attempt of establishing a general registration database for all industry sectors is not appropriate. Construction projects spend considerable amount of money in a shorter period of time, and also costlier than some other industry sector. Construction specific registration scheme is therefore necessary, which will preferably be mandatory, if to reduce cost involvement in repeat works in the PQQ process, and minimise the wastage of efforts.

102.3.4 Cost of PQQ

A pilot study was carried out to estimate the cost of PQQs. Data was collected through a carefully designed and tested questionnaire. The questionnaire was distributed to 135 public clients by email, which produced nine responsive responses, with a response rate of 6.67 %. Table 102.2 summarizes the salient features from the nine responses. It is seen that all the nine clients have dedicated units in their organizations, which manage their construction procurement activities. Only three clients do not 'strictly' adhere to the SPD procurement Manual, implying that all the nine clients follow them in general. It is also seen that the clients mainly prepare and assess the PQQs of their own, and take external assistance of professional services, when necessary, e.g. in case of any special project. About half of the clients use their organization specific standard PQQs, and the other half use project-specific PQQs that have got commonalities to a great extent. Total annual volume of procurement of the surveyed nine clients was approximately £650 million, which is about 11 % of the average value of works procured by Scottish public sector clients (SG 2014). Six clients use database for prequalifying contractors or consultants, namely the ConstructionLine (2014), but for reference purposes only, as parties registered with this database still need to go through the submission and assessment procedure. The questionnaire collected information about the cost to clients of the current PQQ process, which is presented in the subsequent

Table 102.2 Salient features of the questionnaire survey

Factor	Description
Number of responses	Total responses 9: 6 local authorities, 1 university, 1 housing association, 1 NHS Scotland
How constructions are procured	Dedicated procurement unit—7, combined (both external and internal)—1, external—1 (local authority manages for a college, so considered as dedicated)
Adherence to SPD procurement manual:	6—Yes, 3—No
Who prepares and assesses the PQQs	Contractors: dedicated unit—3, external unit—2, both internal and external experts (if required)—3, dedicated and general unit —1 Consultant: dedicated unit—3, both internal and external experts (if required)—1, external unit—1, did not mention—4
Use of a standard PQQ:	Contractor: 8 responded, 4—Yes, 4—No (but commonalities) Consultant: 5 responded: 2—Yes, 3—No (but commonalities)
Use of any database or scheme	6—yes, 1—for notice only, 2—No
Advertising place for PQQs	Both for contractors and consultants: EU journal (if applicable), national advertising portal, and 'company' websites
Annual volume of procurement	Total: £650 m, Average: £80.76 m

Table 102.3 Cost of preparing and assessing PQQs for contractors

Contract size	Preparation (%)	Assessment (%)	Total (%)	Average number of bids received[b]
Small (up to £50,000)	1.50	1.50	3.00	9
Medium (£50,001 to £500,000)	1.13	1.59	2.72	25
Large (£500,001 to EU threshold)[a]	0.65	0.62	1.27	17
Major (over EU threshold)[a]	0.65	0.65	1.30	20
Average	0.98	1.09	2.07	18

[a]EU (European Union) threshold for construction works from 01/01/2012 is £4,348,350
[b]Figures are rounded off to the next higher integer

paragraphs. The respondents also provided their comments on prequalification practices in general, which have been incorporated in a later section.

Tables 102.3 and 102.4 summarize the cost incurred by clients in preparing and assessing PQQs for contractors and professional service providers, respectively. It is seen for the contractors that small contracts cost the highest percentage of the construction value (3.0 %), while large contracts incur the lowest (1.27 %). Cost of preparing and assessing the PQQs are seen to somewhat similar, except medium sized contracts, in which case the former is less than the latter. On the whole, the average total cost of preparing and assessing PQQs for selecting contractors are 2.07 %. The number of submissions varies from 9 to 25, with an average of 18 per invitation.

For the professional service providers, the cost is higher in small contracts (6.33 %), compared to those in major contracts (0.90 %), with total average of 3.47 %. The average number of submissions is 18, with 12 in small contracts, 26 in medium contracts, 27 in large contracts and 31 in major contracts.

Table 102.4 Cost of preparing and assessing PQQs for consultants

Contract size (fees)	Preparation (%)	Assessment (%)	Total (%)	Average number of bids received[b]
Small (up to £10,000)	2.50	3.83	6.33	12
Medium (£10,001 to £50,000)	1.87	2.20	4.07	26
Large (£50,001 to EU threshold)[a]	0.78	1.78	2.56	27
Major (over EU threshold)[a]	0.44	0.46	0.90	31
Average	1.40	2.07	3.47	24

[a]EU (European Union) threshold for professional services from 01/01/2012 is £173,934
[b]Figures are rounded off to the next higher integer

Table 102.5 Total cost of PQQs

Description of cost items	Cost (m)
Cost of preparing and assessing PQQs for construction works	£124.2
Cost of preparing and assessing PQQs for professional services	£20.8
Cost to contractors for submitting PQQs	£680.4
Cost to consultants for submitting PQQs	£492.4
Total cost of PQQs	£1317.8

This is merely a pilot study, with the sample size of only nine. Moreover, the cost of PQQs varies considerably from project to project, and also in terms of the rigour of the questions set in PQQs, their subjectivity and consequent judgements, complexities in assessment and many more (Hughes et al. 2006). Furthermore, the cost of PQQs also includes the costs incurred by the contractors and consultants for their submissions. Although only one bidder finally becomes successful, the expenses by unsuccessful bidders are included in their ‘business operation’ costs, which they recover from their winning bids. Therefore, the expenses of these unsuccessful bids also form part of the costs of the PQQs.

Table 102.5 summarizes the total cost of PQQs, with the following assumptions:

Relative proportion of contracts of different size is unknown, so the calculations are based simply on the average figures from Tables 102.3 and 102.4.

The turnover of the Scottish construction industry is about £15bn (SG 2014) and the public sector accounts for about 40 % of this figures, or approximately £6 bn.

The average cost of preparing a PQQ response is 0.63 % of the contract value for contractors and 3.42 % of the contract value for consultants or professional service providers (Hughes et al. 2006).

The fee for professional services (i.e. for architectural and engineering services, or consultants) is quotes as between 8 and 12 % (RIBA 2008). As such an average of 10 % of construction cost has been considered.

Thus the cost of preparing, submitting and assessing PQQs to the Scottish public sector is £1317.8 m, or about 22 % of the value of construction works procured.

102.4 Discussions and Way Forwards

The above results are indicative estimation of the cost of PQQ in the Scottish public sector, although from a pilot study with a limited number of clients, and amidst the widespread variations of PQQ practices for a wide range of projects and their relevant requirements. Nevertheless, the figure is alarming, and such expenses contain duplication of efforts and/or wastage of resources. However, these may not be addressed by ‘one size fits all’ solution for different kinds of construction projects with diverse needs. Secondly, even within construction, services provided by the contractors and consultants vary considerably. In general, contractors employ significantly more people and have significantly larger turnovers than consultants of professional practices, who do not expend large sums on plant and materials. Thus, for example, a contract for £100 k is of much more significance to the average designer (i.e. consultant) than it is to the average contractor. This implies that any solution has to be different for contractors and consultants.

Minimizing expenses of excessive time/resource should be both from the perspectives of client and responding organizations. However, the existing system allows responding parties an environment like a "free market". One respondent commented that many companies "simply fill in a PQQ for virtually anything, without reading the project information properly, or taking the time to understand" the project specific requirement. Irrespective of the quality of the content, clients need to spend time/resources in assessing such PQQs. Another respondent had "experience of contractors/consultants being invited to tender, following a rigorous PQQ process, then not bothering to submit a tender …" This is certainly a commercial decision for contractors/consultants, but there is no recourse for the public sector client to claim for time/resources wasted in evaluating a PQQ.

One respondent appropriately mentioned: "what is required in one part of the country, or on one particular project, is not necessarily the same in/on another." Complex and/or large projects or those are in remote/hilly areas, will need special criteria, requiring more skilled people for preparation and assessment. Only large contractors can submit such bids, who have a very well organised process for dealing with PQQs and with dedicated staffs. Existing PQQ system is appropriate for such projects. However, as one respondent mentioned, "…[even] wider advertising has not netted any more interest from national [i.e. from other part of the UK]/international [i.e. countries other than UK] contractors … due to the obvious factor that only a very large (>£10 m) contract is going to be worth any construction contractor's time given our geographic location and the associated logistics." It is quite obvious that, for much smaller works, the interest is not there beyond locally-based small and medium contractors (SMCs) because it is not commercially viable. Yet there are inefficient "hoops" to be gone through in public sector procurement. SMCs hardly can afford the skills and resources required to bid for such projects.

One respondent approved that the principles in the Construction Procurement Manual (SG 2014) are clearly sound, in terms of the vast majority of projects they manage/procure, but "adhering to it would be like using a sledge hammer to crack a nut". This may be one of the reasons that many companies "simply fill in a PQQ for virtually anything, without reading the project information properly …" Therefore, a "baseline" approach, i.e. company registration scheme or generic database system, seems to be a potential solution, with key questions asked for specific projects/clients. This will allow SMCs/locally based contractors to effectively use their scarce resources, and also reduce overall cost of PQQ. In such a scheme, all generic information about contractors and consultants may be stored, and then updated periodically. A summary sheet of information on each participating party can be generated from the database at any given time, which will considerably reduce the time and efforts by the clients. Moreover, contractors and consultants will not be required to fill in their generic information to participate in PPQs of their interest. Potentially, only the project specific information on financial stability and construction specific technical ability will be required in prequalification exercise. Such postulation is expected to reduce the cost of PQQ process considerably. However, this will first require more accurate quantification of the cost of PQQ with population comprising larger groups of clients, consultants and contractors; investigating the nature of PQQ assessment with the target to reduce any subjectivity element, identifying the exact factors/criteria and sub-factors/criteria, and developing an appropriate structure of the registration scheme or database, as seem suitable. It is envisaged that a similar approach is deemed to be suitable for consultants and contractors, albeit with information of different type and weight.

102.5 Concluding Remarks

Prequalification plays an important role in selecting appropriate consultants and contractors for delivering successful construction projects. This is done mainly by a carefully designed prequalification questionnaire (PQQ). However, lion share of both the client- specific and project-specific PQQs collect the same information, and contractors and consultants respond them for every bid for prequalification they submit. Also, the number of responses for prequalification becomes high when there are fewer contracts to be offered. Clients also need to assess them for individual projects. All these lead to expending excessive time and resources in Scotland. A pilot study was undertaken to estimate the cost of prequalification. Data from nine public clients were collected through a questionnaire survey. Results show that the cost of PQQ process in Scotland is alarmingly high, with over one-fifth of the annual turnover. It was recommended to more accurately quantify the cost of PQQ with study population comprising larger groups of clients, consultants and contractors; and to investigate the nature of PQQ assessment with the target to reduce the subjectivity element. A company registration scheme or generic database system was envisaged to reduce the higher cost of PPQ process. All generic information of contractors and consultants may be stored and periodically updated. Contractors and consultants will not require filling in their generic information to participate in PPQs of their interest. A summary sheet of information on each participating party can be generated from the database at any given time, which will considerably reduce the time and efforts by the clients.

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Chapter 103
Study on the Inherent Mechanism of Construction Safety Supervision in China

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Abstract In order to analyze the inherent mechanism of safety supervision and seek for more effective ways for safety monitoring, the present paper, with the help of interpretive structural modeling, not only analyzes the factors influencing the safety supervision and their relationship with each other, but also computes reachability matrix and establishes an interpretative structural model for the validity of construction safety supervision. On the previous basis, a new path which can enhance the effectiveness of construction safety supervision system in China is put forward.

Keywords Construction safety supervision · Inherent mechanism · Interpretative structural modeling method

103.1 Introduction

In recent years, with the rapid growth of the national economy, China has stepped into the phase of rapid development in the construction industry. Although a large amount of projects can perfect Chinese infrastructure, they also impose more arduous work on the safety supervision task, therefore construction safety situation is still grim. Take the statistics of the first half year in 2014 as an example, China had witnessed a total of 225 municipal housing engineering accidents in 30 regions with 267 deaths, among which the number of accidents in 10 regions showed a year-on-year rising tendency. The casualty rate is second only to the mining industry (Ministry of Housing and Urban-Rural Development of the People's Republic of China 2014). Construction safety supervision is the key safeguard of construction production. Given that construction safety supervision in our country has been dominated by administration for a long time, the legislative system is incomplete, and a monitoring mechanism between and inside construction enterprises is lacked (Xiaomin and Qiang 2009), the development of safety supervision has been restricted.

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There are many studies on construction safety supervision system home and abroad. Blair's study suggests that all participants in the construction market take corresponding responsibilities for construction safety problems, including property owners, designers, (sub) contractors, government and insurance companies, etc. (Blair 1996); Michael 2005 analyzes the obstacles faced by designers at the design stage considering the safety issues, including lack of professional knowledge of building security, poor understanding of the construction process, conflict with the contract terms, extra design costs (Michael 2005); Huang and Hinze (2006a, b) demonstrates that the house owners' direct involvement in project safety management plays an important role in raising the safety performance via empirical analysis method, and pointed out how property owners directly affect the level of safety performance. Fang et al. (2005) drawing on the advanced security management in developed countries and regions, discuss Chinese government's management mode for construction safety supervision. In order to improve safety supervision effects, Zhang et al. (2005) first propose an assumption, that is to bring government institutions, construction companies, industry units, social units and individuals together into the scale of safety supervision system.

In General, safety management at the enterprise level has been paid more emphasis and study on whole staff security management is gaining importance in foreign countries, but there is very few research on safety supervision at the government level. By contrast, domestic study on security supervision at the government level has always been a hot spot, but studies have been focused only at the macro and theoretical level, and the methods employed are borrowed from foreign experience, relevant theoretical support is lacked, all lead to the failure of systemic solutions. The present paper first studies the internal mechanism of construction safety supervision system from the perspective of whole staff participation with the help of interpretive structural modeling and then puts forward concrete measures to refine construction safety supervision system based on previous study.

103.2 Interpretive Structural Modeling

Interpretive structural modeling (ISM) is systematic analysis method raised by an American Professor Warfield (1974) in 1973 to analyze complex problems in socio-economic system. The main basis of this model are the directed graph model and the Boolean matrix. ISM is an effective method for analyzing and revealing the complex relationship structure. Because it can sort out complex, messy relationships between the factors of the system into clear hierarchical structures, it is especially suitable for system analysis with many variables, complicated relationship and unclear structures.

As a complex system influenced by multiple factors, in general, construction safety supervision system can be divided into five levels: materials technology subsystem, production subsystem, project safety management system, project safety monitoring system and governmental supervision subsystem. Each system has a complex internal structure, and the interrelationships among subsystems are complex too, so it is difficult for the general analysis methods to explain the mechanism of construction safety supervision and the affecting scale of influential factors. Interpretative structural model can integrate all influential factors, quantifying the complex relationships between factors and form layered structure model after complex calculations, which can have a graphical display of the operating mechanism inside the system. This is helpful for people to have a full understanding of the operation rules of construction safety supervision system and to optimize the supervision performance.

To establish a systematic structure model, at first we should survey and analyze the system, determine the constituent elements of the system and their relationships, and establish an adjacency matrix and reachability matrix. And then divide the logical relationship after a certain amount of processing to clarify the hierarchy and structure of the system. ISM establishes a model for the system according to its hierarchy structures, which is composed of the following 6 steps (Farris and Sage 1975).

1. Form an ISM Group which has no less than 10 people, identify key issues; the key issue in the analysis is to determine the mechanism of production safety supervision effectiveness.
2. Systematically construct influencing factors on key issues and determine the relationship between factors. The relationship needs to be clarified and consistent among factors;
3. Generate adjacency matrix. The assigned value of two relative factors in the adjacency matrix A is 1, otherwise is 0, there is no relationship between the general factors S and itself;
4. Create reachability matrix. The reachability matrix is obtained by performing algebraic operations on power of A + I matrix (I is the unit matrix);
5. Build the system structure model. In the first mathematical operation circle, get the reachability set and the antecedent set respectively. If the intersection of two sets is a reachability set, all factors that meet that criterion belong to the first layer factors (the highest layer). And then obtain a new matrix by deleting rows and columns corresponding to the first layer's factors, repeat the same operation, and eventually assign each key factor to its corresponding level to generate a hierarchy structure diagram;
6. Analyze the model, identify critical factors and responsive solutions. The purpose of this analysis is to clarify the internal mechanism of construction safety supervision system in China and seek specific measures to improve the effectiveness of construction safety supervision in our country.

103.3 Internal Mechanism Analysis on Safety Construction Supervision

103.3.1 Influencing Factors on Effectiveness of Construction Safety Supervision

Construction safety supervision system contains four parts: security supervision subject, supervision object, supervision behavior and monitoring environment. From the main differences among its subjects, construction safety supervision includes three levels—governmental supervision, project supervision and safety management by the construction companies. Factors associated with supervision body are: supervisory system, the internal management of safety supervision agencies, quantity and quality of supervision staff, and the basis to define each supervision subject's responsibility. Supervision behavior consists of law enforcement, supervision content and supervision technology corresponding to its objects; supervision environment is made up of social monitoring environment (macro-environment) and project supervision environment (micro-environment). Each factor is divided into one or more critical sub-factors, as shown in Table 103.1.

(The key influencing factors of construction safety supervision were decided by a working group with 15 experts from the project research group and the Nanjing municipal safety supervision station staff).

Table 103.1 Table of the key influencing factors of construction safety monitoring effectiveness

Influencing factors		Influencing factors	
Social environment	S1: professional safety awareness	Supervision content	S8: supervision coverage
Supervision basis	S2: completion of law and regulation		S9: targeted supervision
Structural system	S3: supervision system		S10: ratio of service in supervision
	S4: inner management of supervision institution	Project environment	S11: attention degree of each construction unit to safety supervision
	S5: quantity and quality of supervision staff		S12: cooperation desire of each unit
Law enforcement in supervision	S6: rigidity of law enforcement	Supervision technology	S13: information system
	S7: supervision flow setting		S14: safety supervision equipment

103.3.2 Analysis on Interpretative Structural Model for Construction Safety Supervision Mechanism

1. Relationship analysis about influencing factors of construction safety supervision
   The purpose of this analysis of interpretive structural modeling is to find out the influencing factors and mechanism of construction safety supervision. Relationship analysis results among the various factors are shown in Table 103.2.
2. Reachability matrix calculations. Generate an adjacency matrix in accordance with the factors' relationship, reachability matrix is computed as follows:

$$A + I \neq (A + I)^2 \neq \ldots \neq (A + I)^6 = (A + I)^7 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

Table 103.2 Table of the influencing factors' relationship

Factors	Influencing factors
S1	S2
S2	S1
S3	S2, S4
S4	S1, S2, S3, S5
S5	S1, S2, S4, S13, S14
S6	S1, S2, S3, S5, S7
S7	S2, S3
S8	S4, S7, S11, S13, S14
S9	S4, S5, S13, S14
S10	S4, S5, S9, S12
S11	S1, S2, S3, S4, S5, S6
S12	S1, S2, S3, S5, S6, S7
S13	S2, S5, S7
S14	S11

Table 103.3 Table of the analysis on influencing factors extracted from the first layer

Number	Influencing factors	Reachability set $R(S_i)$	Antecedent set $A(S_i)$	Intersection $R(S_i) \cap A(S_i)$	Factors extracted
1	S0	–	–	–	–
2	S1	S1, S2	S0–S14	S1, S2	S1
3	S2	S1, S2	S0–S14	S1, S2	S2
4	S3	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–
5	S4	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–
6	S5	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–
7	S6	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–
8	S7	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–
9	S8	S1–S8, S11, S13, S14	S0, S8	S8	–
10	S9	S1–S7, S9, S11, S13, S14	S0, S9, S10	S9	–
11	S10	S1–S7, S9–S14	S0, S10	S10	–
12	S11	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–
13	S12	S1–S7, S11–S14	S0, S10, S12	S12	–
14	S13	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–
15	S14	S1–S7, S11, S13, S14	S0, S3–S14	S3–S7, S11, S13, S14	–

It can be clearly seen that the final reachability matrix we get is $(A + I)^6$.

3. Decomposition of the reachability matrix. The analyzing results of the first layer decomposition are shown in Table 103.3. S0 is the target for analysis which can be drawn directly. Finally, since S1 and S2 meet the requirement, they become the factors taken from the first layer.
   Delete the rows and columns corresponding to S0, S1and S2 respectively in the reachability matrix, repeat the previous practice, do the same analysis on the newly formed matrix, we get factors in the second layer which includes S3, S4, S5, S6, S7, S11, S13, S14), factors in the third layer are S8 and S12, S9 in the fourth layer and S10 in the fifth layer.
4. Build the system structure model. Based on the result of reachability matrix decomposition, interpretative structural model of construction safety supervision validity is shown in Fig. 103.1.

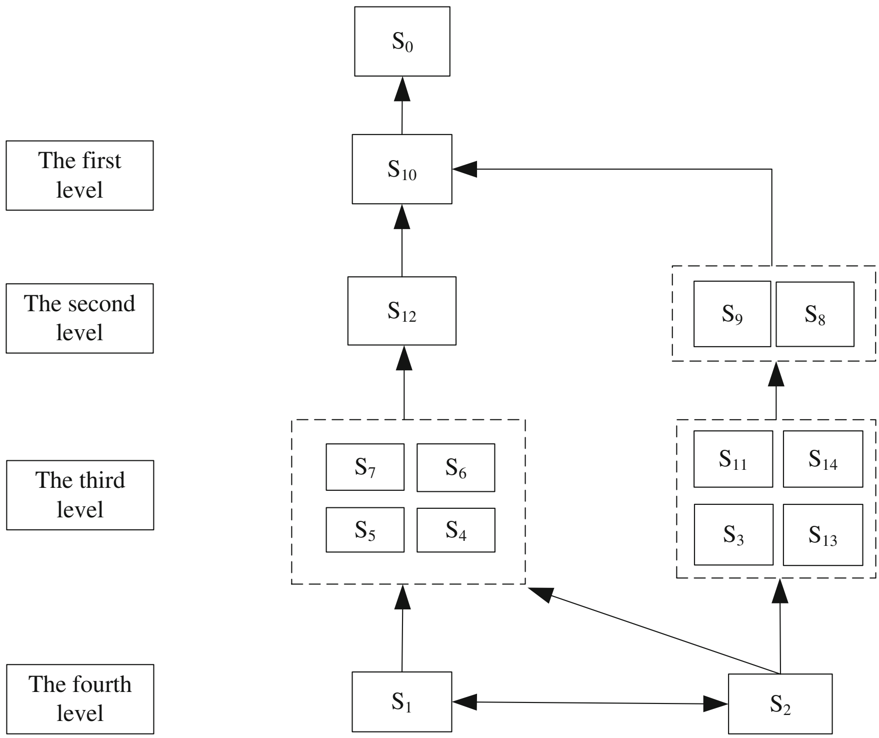

Fig. 103.1 Interpretive structural model for construction safety supervision effectiveness

5. Internal mechanism analysis of construction safety supervision system. It is demonstrated by the results of interpretive structure model that the internal mechanism of construction safety supervision system is formed by the step by step operation of factors in four levels, specific analysis is as follows:
   (a) In the fourth level factors, law and regulation as well as industry's security consciousness are basic factors which affect construction safety supervision, among which, law and regulations, as supervision basis, can clarify subjects' responsibility, obligation and security standard of construction site entity that possess compulsory binding force. Industry safety awareness constitutes a soft supervision environment which have a decisive impact on the effect of supervision;
   (b) In the third level, factors such as supervision personnel's quality, internal management of supervision institutions and scientific supervision process design are the basis to enhance supervision institutions' cooperation desire while rigid law enforcement in supervision is a driving force to stimulate such desire; factors like perfection degree of supervision system, information technology level, equipment level and subject's attention degree on

security have a direct impact on the improvement of supervision purpose and coverage;

(c) In the second-level factors, improving supervision coverage can enhance the systematicness and comprehension of supervision, yet bring more supervision tasks; to increase supervision purposefulness is to strengthen the targeted supervision considering the supervision coverage, which requires to build a consistency between decision-making and implementation among supervision bodies. The relationship between improving supervision coverage and strengthening supervision purposefulness are like the relationship between "surface" and "point" in the process of construction safety supervision which can improve the safety supervision effect significantly. These two factors raise high demands to increase co-ordination among the various supervision units, in other words, it is an essential way to realize increased supervision coverage and enhanced supervision purposefulness through better cooperation within supervision units;

(d) An important display of the cooperation among construction safety supervision units is the ratio of service in the supervision. Increasing the service ratio in the supervision can intensively apply decentralised safety knowledge in different supervisory bodies to the supervision process, therefore, uncertainty will be avoided from insufficient safety knowledge or lack of willingness. Meanwhile, higher proportion service in supervision is also helpful to enhance cooperation between the different subjects, reduce human resistance, and thereby increase the effectiveness of supervision.

(e) In the interpretative structural model, there is a positive interactive effect from the fourth layer to the first layer. The previous factors are the prerequisite for the latter ones while the latter ones are regarded as the measurement or heading direction of the previous ones. Interaction at all levels generates the inner mechanism of construction safety supervision system.

103.4 The Upgrading Paths of Construction Safety Supervision Effectiveness

Through the interpretative structure model, the path to upgrade the effectiveness of construction safety supervision in our country can be obtained as follows:

1. As a mandatory constraint, laws and regulations are the most powerful factors to ensure effective supervision. Through scientific legislation, to regulate safety supervision and production can increase the attention degree in supervision units and their willingness to cooperate.
2. Refine safety supervision system, introduce the grid management concepts and strengthen the project monitoring role. Grid management has been fully applied in city management and achieved good social effects. Initial ideas of grid

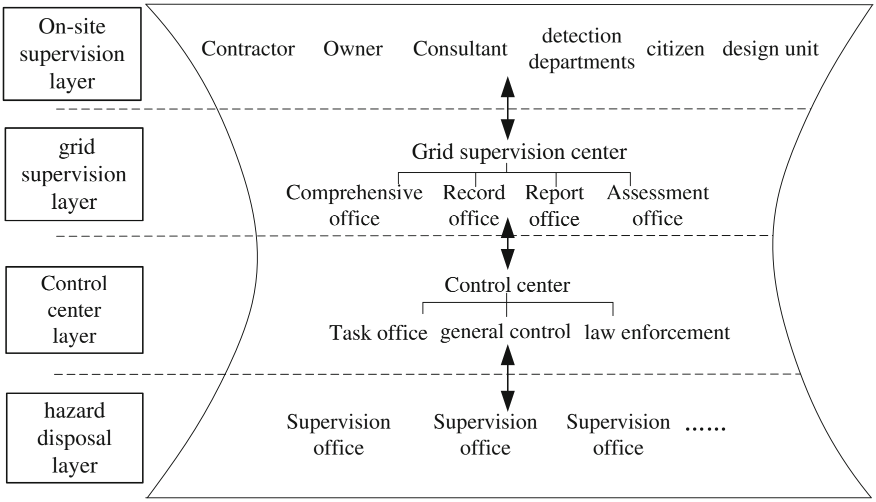

Fig. 103.2 Model of the grid construction safety supervision system

security supervision system is shown in Fig. 103.2, former Municipal and County safety supervision stations have transferred into the grid supervision center and safety supervision control center, which respectively direct on-site supervision layer and risk and hazard disposal layer to carry out routine on-site supervision and hazard disposal supervision. Inviting grid management philosophy into construction safety supervision can change the situation of over-dependence on government administrative supervision in safety monitoring, promote participation of projects and social supervision power, realize close cooperation among supervision subjects, and guarantee the effectiveness of safety supervision.

3. Improving the level of information technology is the key to improve monitoring effectiveness. Employing information technology is the need to realize grid safety supervision which can enhance the safety supervision purpose, achieve transparency in safety supervision, ensure rigid law enforcement in supervision and formal supervision process and improve the efficiency of safety supervision. The structure of information platform for construction safety supervision is shown in Fig. 103.3.
4. Implement unified safety supervision in every city and county. Construction safety monitoring framework includes: hazard identification, hazard assessment, monitoring plan's setting, implementation and revision. The basic idea of unified supervision is to unify the hazard identification and evaluation, unify the formulation and implementation of plans with a powerful information system. The unified mechanism serves as a major security problem's discovery and disposal mechanism. On the basis of internal supervision, directed by the unified

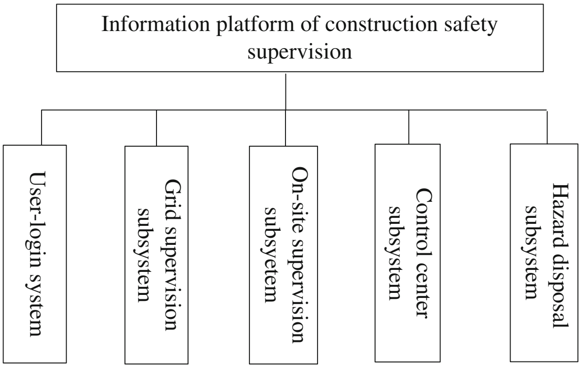

Fig. 103.3 The functioning structure chart of supervision platform

leadership from the city and county safety supervision stations, it works out the supervision plans, collects information on safety and security assessment, screens safety hazards timely from a mass of information and corrects them until checked and accepted.

103.5 Conclusion

The launch of a large amount of engineering projects in China has raised higher demand to construction safety supervision. The present paper, through interpretative structure model, analyzes the affecting factors in construction safety supervision, establishes an expert group to study the relationship between factors, by quantitative analysis, obtains internal mechanism of Chinese construction safety supervision and eventually comes to the suggestion to strengthen security supervision legislation and regulation, improve information technology of security supervision, take grid security supervision model and implement unified supervision. How to build a grid management system in construction safety supervision and how to establish its corresponding information system still need further study.

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Chapter 104
Some Suggestions for Chinese Construction Contractor's Overseas Operations Related to Performance Bond

Yan Li and Zhenyu Zhang

Abstract For Chinese contractors, performance bonds are required by the majority of projects in overseas market, it is sensible for the companies to address the related issues properly. Based on both conceptual study and empirical study, this paper makes some suggestions for Chinese contractors to improve their ability to deal with performance bonds in overseas market, especially concerns the contractual issues such as drafting bond documentaries, incorporate main contract with bond documentaries and so on.

Keywords Performance bonds · Chinese contractors · Overseas market

104.1 Introduction

As an insurance instrument, performance bonds are now been heavily used in construction industry. However, there are different cases in different regions, some regions applied more intensively than others, in some parts of west Europe and US, the construction projects are almost all insured by performance bonds. On the other hand, this type of bond is just on the beginning phase in China and it is still relatively new to the industry. Moreover, for those Chinese contractors doing projects in overseas market, they are dealing with performance bonds in a substantial amount. Indeed, performance bonds are designed in order to protect the projects from the contractors' default, under the bond documentary (Crewdson 2006). Therefore, the performance bonds are more client friendly instrument. And

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Hinchey (1986) opined that on-demand performance bonds are open to beneficiary abuse. It is never an easy task to tangle with performance bonds. Therefore, in a humble perspective, this paper is trying to make some suggestions for Chinese contractors, concern the hot issues of performance bonds.

Performance bonds are commonly used as an insurance instrument in construction industry, in order to guarantee the performance of contractors (sub contractors) on site and keep the main contract implemented by the contractors in the way it is agreed. In the case of US, the contractors have to have insured performance bond to get jobs. However, for the performance bonds itself, there are fundamental differences for the different types of performance bonds.

From a Technical point of view, Hinchey (1986) suggests that the major difference between on-demand performance bond and default performance bond is whether the conditions "materially interfere" the payment obligation, if the conditions do not interfere the primary payment obligation, the bond is considered impose a primary payment obligation on the insurers. The primary payment obligation refers to that the bond itself is "autonomous" under the contract. That means the insurer is automatically obliged to pay upon a request without any demonstration of that bond is been entitled to pay. Moreover, according to Joseph there is another sensible issue for the on demand performance bond. In the drafting documentaries, it is possible to require the occurrences of some particular events as the pre condition to call the bond, but the parties should be very careful about to avoid any possible demonstration obligation, once there are any clues of liability of demonstration or proceeding for demonstration, it will be taken by the courts as default performance bond. The existence of event or the circumstances that are required in the bond documentaries as pre condition should not need the confirmation from beneficiary or surety.

To shortly concluded the two points made before, the technical distinctions of on-demand performance bond and default performance bond give a more detailed perception about this instrument, it focus on the actual implementation and the contractual process. The drafting issues for the pre occurrence as a pre condition to call the bond are more focus on the practical aspect for the bond documentary, to combine these two points. One could just focus on how to make the on demand performance bond works better, on the contractual basis. In order to protect contractor against unfair calls and make the beneficiary satisfied. The point is respect the essence of on demand performance bond which is pay upon request without demonstration, but try to optimize the way of how the beneficiary make request. From this point of view, this technique is more empirical and operational.

104.2 Literature Review

According to researches, there are several aspects worth to notice which could help drafting the bond documentaries more appropriately, in the terms of making pre condition on demand performance bond, which in many believes, could work better for different parties. Firstly, according to Hinchey (1986), in the bond documentary, as pre condition, require beneficiary simply producing a documentary that states contractor has default in the contract, if possible, giving reasons why they think the contractor has breached the contract. The idea behind this is to create evidences for future reference; compare to a simple phone calling, the statement could makes beneficiary think carefully if they make any unfaithful claim, because the existence of an untrue statement could bring civil liability and could be easily to take into proceeding in further legal actions. Once the documentary is been made, they are exposed to Fraud Act 2006. (Elizabeth II). Interestingly, Joseph also suggest that the demand could be made through prior request in paper form, and in practices, it is more and more often to see the request has been made in paper form now. Secondly, require beneficiary to provide a notice to the bank or insurers, this could be another layer of protection to the banks or insurers. On one hand, it is another procedure before they get the money. On another hand, as Hinchey (1986) suggests that the demand could even be mitigated through the investigation carried out by an independent third party. But one could strongly argue that once the third party gets involved to investigate the bond or even the bond's paper work, the primary payment obligation is been disrupted as soon as the investigation is carrying out. Therefore, this third party involvement suggestion will change the nature of on demand performance bond. The purely procedure requirement from the banks however could still be an option but the argument would be the notice itself is the evidence that beneficiary provided to get the bond. Van Der in practice, the possible method to operate it could be to settle this condition as the normal business procedure of how the banks dealing with on demand performance bond. On another hand, Joseph suggests that the bank could expect some terms that contain the notice provision as pre conditions been accepted by the courts. Thirdly, giving notice to contractor, such as certain conditions in Australia contract. Standards Australia (1992) this could give the contractor valuable time to prepare for the possible consequences, if possible, to optimise the potential losses both for the client and themselves. One could argue that this suggestion is logic and sensible, from one perspective, contractor is the direct responsible party who caused the calling of bond, a notice to them could bring the whole thing onto the table, to an extent, this would create a good foundation for future communication and cooperation. And of course, reduce the risk of bond.

If we focus on the content of performance bond in more legal perspective, there is another relatively strong concept about the bond in the jurisdictional perception. As lord Denning emphasis in the case of Edward Owen Engineering Ltd versus Barclays Bank International Ltd, a performance bond should be a "promissory note", the promissory note, according to Dalby (2010), is like a letter of credit or documentary of credit, it shall be independent and autonomous. The critical feature is the economy purpose; it stands for certain sum of money will be paid upon the delivery of documentary, "not by proof of the facts asserted". At this point, some might suggest that the kind of performance bond which Dalby (2010) describes is on demand performance bond, cause he agrees with pay upon delivery, without a proof. And indeed, in his perception, if a performance bond could only be paid when the beneficiary demonstrate the default of contractor, it is so called a guarantee. First of all, in general meaning, the performance bond is a form of guarantee. Secondly, to avoid to make things more complicate, the guarantee that been described by Joseph has nothing to do with parent company guarantee.

Briglia and Etcheverry (2010) suggest that a surety should seeking claims if the surety is carrying out some remedy works on site, and this process is been interfered by the default that have been left out by the other contractors who left before. It is been widely accepted that, as a mitigation method to prevent the bond been called, the surety would step into the project as the beneficiary notified them or demonstrate contractor's failure of fulfill their obligations. Another case for the coverage issues would be Hartford Fire Insurance Company versus Paul H. Schwendener, Inc. according to Rossetti and McKeeman (2007); the major contractor entered the contracts for two projects with sub contractor that named Solai & Cameron, Inc (S&C), indicated that the major contractor could replace S&C if the sub contractor consecutively failed its obligation, by giving a three days notice in prior.

The paper is based on both conceptual theoretical study and empirical study; conceptual study was mainly carried out by the method of secondary research, empirical study was mainly carried out by the method of primary research. In order to achieve the aim and objective, the paper firstly carried out certain amount of secondary research, established some understandings about what happened in the industry from an academic point of view. This paper is trying to make suggestions for Chinese contractors on the aspects of performance bonds. In order to achieve the objective, this paper will find the issues in the secondary data which are raised by other authors trying to understand some popular theories for this topic. Then, trying to understand what is happening in the field, this paper will collect information from the practice for example, how do they drafting the bond,, how is the bond documentary cooperate with main contract, and so on. Thirdly, apply the theories to the reality, trying to get sensible conclusion for the situation and make hypotheses if necessary.

104.3 Research Methodologies

Both conceptual study and empirical study were implemented in this paper in order to find some solutions for Chinese contractors to improve their abilities to deal with performance bonds in overseas market.

The study populations consisted with all large Chinese contractors. Because only lager players could undertake the job overseas, the Chinese contractors only doing significant amount of performance bonds in overseas market. However, setting research with these companies is never an easy task. The paper known from very beginning, these big players will be very difficult to hold, partly because of the hierarchy business culture, partly might due to they are really too busy to be get hold of, especially the interview request is come from a unknown personnel. In order to get access, the paper almost tried all the social relationship which might have the possibility to bring the process forward. Eventually a friend from a consultancy firm introduced a senior manager to arrange the appointments with the big players, the interview are settled. The are reasons why it pursued interview as the primary research method, firstly, the questionnaire which are all open questions, it going to take a lots of time to answer the question if one would like to do it properly. Secondly, the information this paper needed to make analysis have to be asked in a form of open question, there is no alternative question style. Thirdly, the research purpose was to understand what is happening in the practices, for this particular question which is performance bond, to a maximum extent, this purpose does require the paper to squeeze the information from the respondent as much as possible.

The interview was taking in the form of asking and answering, this paper prepared a proposal for the questions that are going to be asked, but organised in a relatively flexible way, during the interview process, some unexpected but important information might come out as the talking carrying on, and it is essential to chase the information further more by time to time, and the paper expect some flexibility for free talking, at same time, keep the talking stick to the designed routine.

However, there is one sample which is got through e-mail, out of 10 plus sending. The e-mail contacted companies are also big players but could not get appointment for the interviews, for the paper sent them surveys and got one respond. Some of them did reply by refused to answer the questions, some of them did not reply at all. And the sample which is obtained by e-mail contains quite simple and general information; this is due to the company choosing to respond in a simplest way, it might be caused by the opening question style, and partly demonstrated the interview is the best way of carrying out the primary research for this particular research purpose.

104.4 Research Results

There are three intensive interviews would be presented in this chapter, as well as one questionnaire results. As the confidential reasons, all the names of those companies would not be mentioned, neither for other information that might make them been precisely identified as a company. The interviewed two contractors will be called “company A” and “company B”; the contractor responded questionnaire will be called “company C”; and “the insurance organization” will be refer to the interviewed insurance organization.

104.4.1 The First Company (Company A)

This company is mainly doing bridges and road; it has overseas market spread through different continents, such as South Asian, Africa, Middle East, South America, East Europe. Their annual income for their overseas market in last year was some things over $10 billion. This is a mega state owned enterprise, as they doing projects intensively in Africa.

Found out with surprise, for their overseas projects in Africa, all the performance bonds they are doing are on demand performance bond; there is no one single exception at all. As one could imagine, this is quite tough condition for any contractors. First, they doing a lot of projects at same time, secondly, on demand performance bond are relatively tight commitment and it is relatively easy to be called. Then we find that there are none bone that have been called for last two year. Furthermore, company A does not specify certain circumstances have to happen prior the calling, but it did have pre conditions as the procedures to call the bond, firstly, making statement and delivery to contractor, secondly, obtain the receipt. These two pre conditions however, does not interfere the primary payment obligation.

This company sent the term in their actual bond's documentaries by e-mail, which is originally quoted the English version as below "Payment will be made without objection or legal proceedings of any kind, upon receipt of your first written claim (sent by registered letter with confirmation of receipt) stating that the Contractor has failed to perform its contractual obligations fully and properly or that the Contract has been terminated." One could suggest that the wording in this documentary is not perfectly an "unconditional" on demand performance bond, but it consist a primary payment obligation which clearly indicate the beneficiary will be paid upon the receipt of demand. Furthermore, in the documentary, it does not specify certain circumstances have to happen prior the calling, but it did have pre conditions as the procedures to call the bond, firstly, making statement and delivery to contractor, secondly, obtain the receipt. These two pre conditions however, does not interfere the primary payment obligation. Therefore, except to doubt the content that provided by the respondent, the company is doing on demand performance bonds all the time and has not been called for once, for at least 2 years, in their Africa market. It is by all means an incredible achievement, the interview went further with what contract did they use for main project contract, and the drafting process, how did they actually engage the bond, in addition, how did they do to avoid callings.

The interview found out that for the main project contract, they use FIDIC in majority of cases, client draft it, send it to them, they have relatively short period time to go through it, normally, from one or two weeks up to one month before signing it. In this company, there is another layer called "middle man" between the contractor and client, who have very close access to client, One could suggest that this is very Chinese way of doing things, operate something under the table, in order to handle the whole situation well on the table. They do all sorts of contracts as well, such as PPP, EPC, BOT and design and build. In this point, one could suggest that this Chinese contractor does have strong market rates in Africa, and dealing the "GUANXI" very well with the client.

The typical way is to bond 10 % of the project price, but it is possible to negotiate to a lower portion in lots of cases. The insurers or so called sureties are the Chinese banks in mainland China; sometimes clients did require the bond has to be issued by a local bank, then the Chinese banks will dealing with the local bank whichever it is the case. The typical way of doing it is the Chinese banks undertake all the risks African banks would have to engage the bond. The Chinese banks will issue a credit of letter to African banks; indicate that they would undertake all the liability that the local banks paid to the beneficiary, whichever is generated under the bond that they issued to Chinese contractor. On one hand, it is understandable that "company A" has very good credit that it's on demand performance bonds have never been called for at least last 2 years. On another hand, one might think there must be something deep behind the lower rate agreement that makes the banks perceives the projects have very low risks.

Another featured way of how they doing bond is that they insist the writing notice from client and the receipt from them as the pre-condition to call the bond, but this condition was rejected time by time, the approximate portion is about half of the client accept this, half of client demand something more direct or so called "tight" conditions. The employees indicated they would negotiate with client, but if not worked out, they would accept the condition offered by client.

For why they could get rid of callings, the reasons are simpler than expected; one of the reasons is that they work very closely with the banks. According to them, the banks would always be noticed as prior before the client call the bond, (the paper did not want more details of what are the conditions in each cases, cause it is almost impossible to retrieve the details under the circumstance.) and the banks will notify them at very first place. Hence, the contractor will work with banks to remedy the situation; it always worked out with banks that they avoided the bonds being called by the client. Other reasons are firstly, good management, Secondly, good communication with client. These two reasons are simpler than general, the paper strongly perceives there are other factors exist in the practices, but the interviewed employees did not give any more clues. However, the answer of this question in the second company brought some interesting points.

104.4.2 The Second Company (Company B)

The company B mainly doing their overseas projects in Africa countries, such as Ethiopia, Uganda, Cameroon, and so on, they are one of the subsidiaries belonging to a large corporation, and their annual income for last year was some $100 million, they did not give what the amount of their employment. As mentioned before, the second contractor is a state owned enterprises as well, their business dimension is smaller than company A, they only doing overseas projects in Africa, such as, but the major business sector is similar to company A, they mainly do bridges and roads.

For the performance bonds, with less surprising, company B doing only on demand performance bonds. And they're on demand performance bonds have never been called, according to the interviewed employee.

Company B admitted they had several bad projects, and they admitted the breach of contracts in those projects, but the client has not called for the performance bond in those projects. There are two reasons. Firstly, when those situations happened, company B as a contractor undertake all the losses that the client claimed in the projects, the details of how exactly they did these are not given, but one could suggest that this will not be a small sum of money, to some extent, it might exceed the bond sum which is 10 % of the project price.

For the procurement method, they mainly doing design and build contract, as well as traditional construction contract, the portion is about 50 % of D&B, 50 % of traditional contract. The adjusted version of FIDIC contract has been intensively used, the content of adjustment, however, is mainly for the convenience of client and the contractor, the parties would normally come to a contract version that is appropriate for the specific project and accepted by both parties. Furthermore, if the FIDIC contract could not fit the needs of the project on some aspects, company B indicate that they would negotiate with clients, in order to address the contracts under other jurisdictions, the principle for this practice again is the convenience for both parties and leave some room for future negotiation.

104.4.3 The Third Company (Company C)

The third company is the only one that responded the survey out of 20 samples. Their annual income for last year was $3.2 billion, and the profit was $15,000,000, which indicates some 4.6 % profit rate, this is an extremely good profit rate for a contractor by all the measurements. The officially registered employment of the company is approximately 600 hundreds personnel. But the names on their actual payroll is 6500 people, as this research was done by e-mail exchange, the paper do not have a chance to ask more details, and company C did not make any further explanations for this phenomenon. They mainly build harbours as contractor; their major overseas business market spread several different continents such as East Asian, South America, Middle East, Africa, and South Asia.

For the questions about contracts and performance bonds, company C indicates that they mainly deal with FIDIC contract, one exception is for South Africa, they doing NEC contract in the country. The clients in Middle East promote adjusted version of FIDIC, and company C follows the client's version of contract in the region. With no suspiring, for those "client bond" projects, the company will prepare Chinese contract called EPC, incorporate with intensively consideration of FIDIC terms. Similar to previous two companies, for company C, all the performance bonds they are doing are on demand performance bonds, but issued by local banks in the overseas market, the Chinese banks will negotiate with local banks for the conditions and so on. The premium they paid for the bonds is approximately 0.8 %, which is relatively higher than company A. And finally, as one could predict, with no exception, company C indicate that they have never been called on demand performance bonds.

104.5 Discussion

Interestingly, all the three Chinese contractors indicated as long as the projects require bonds, they only do on demand performance bonds for all the projects overseas, and their bonds have never been called for even once. There are two possibilities. If this is true, then they are doing very good business, one might suggest that from certain point of views, they have their own ways to avoid the callings for on demand performance bonds. And this issue will be concluded more intensively in the final conclusion. On another hand, the statements are not true, they did got calls from time by time, but for some reasons they could not reveal that. This is understandable because they could either do it for protect reputation of the companies, or do it for other confidential reasons. To understand this "business philosophy", one should keep in mind they are state owned enterprises. The whole business organisation and running strategies for state owned enterprises are very different to the private firms in China. The companies have relatively strong bureaucracy and hierarchy culture in their business gene. Furthermore, the top man in the enterprises will be responsible for the higher level of authorities. For the top man in enterprises, it is more likely to work for the government, they might run the business, but they do not really own the companies, and if the business running into trouble, it will directly affect their positions. Therefore, it is understandable to these companies to cover some losses such as deny any calling have happened for the on demand performance bond.

Hence, as revealed in the literature review, drafting on demand performance bonds could be problematic; if the parties do not draft it carefully, the bonds will turn on to be a different instrument that disobeys the original purpose for making it. This point should be well addressed to Chinese contractors as they drafting the bonds documentaries, the sensible boundaries of on demand performance bond and default performance bond should always in their mind. Indeed, one could find out from the findings, Chinese contractors do not have significant problems of producing right bond documentaries, as least they did not raise any of this. Partly it might because they working in quite different jurisdiction systems; compare to those journal authors' working environments, and under these jurisdiction, there courts might not be so keen on the distinctions of on demand performance bonds and default performance bonds. Moreover, even if they did turn the on demand performance bonds into other instrument, the actual impacts of the protection purpose of on demand performance bond as an instrument have not been diminished. Chinese contractors undertake all the losses that triggered by their defaults any way. Again, this point will be discussed further in the final chapter.

104.6 Conclusion and Suggestions

Based on both conceptual study and empirical study, this paper finds that Chinese contractors are mainly doing on demand performance bond. They listed pre procedures as pre condition for the pre conditional on demand performance bond to protect them to against unfair calls. According to the results, the Chinese banks have relatively strong connections with contractors; there is no doubt to them to bind with Chinese contractors for same scope of liabilities. In contrast, there is a possibility that the banks will give up their right to discharge themselves from the liabilities, once they do so, the on demand performance bond will turn into default performance bond. We also find that none of the Chinese company mentioned any information related to the reduction mechanism and adjudication performance bond either in the interviews, or in the survey respond. Therefore, three suggestions are offered as follows.

1. Drafting the pre conditional on demand performance bond with pre event occurrence and pre procedures occurrence. The pre event occurrence conditions have to avoid potential demonstrating obligations. One possible way to achieve this is by listing the events that are not directly indicate in the event of breach but related to the main contract obligation.
2. Do not let banks give up their rights to discharge in the bond documentaries to avoid the on demand performance bond turning into default performance bond.
3. Reduction mechanism and adjudication performance bond should be practiced by Chinese contractors. The reduction mechanism will be a burden releasing for the contractors to reduce the bond sum gradually, this might please the banks as well. For the adjudication performance bond, it is not saying that Chinese contractors should have exactly the same performance bond as this, but they develop a type of bond which is appropriate to the practice.

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Chapter 105
Study on Green Ecological Property Management Model at Residential Area in China

Peng Wang, Chen Liang, Xiangang Shi and Dandan Li

Abstract With domestic new urbanization pushed forward gradually, the green ecological Residential construction spring up like the mushrooms. Meanwhile, due to the imperfect evaluation system, domestic green residential area is lack of reasonable, normative and effective management methods and models. In this paper, by using comparative study with qualitative and quantitative methods, we will summarize the management theory at current green ecological residential area to explore an effective green ecological property management model.

Keywords Residential area · Green construction · Property management · Model

105.1 Current Situation and Problems on Green Ecological Property Management

105.1.1 Current Situation on Green Ecological Property Management

According to the requirements of the 12th 5-year plan in China, from 2010 to 2015 the green construction area will cover over 1 billion square meters, accounted for

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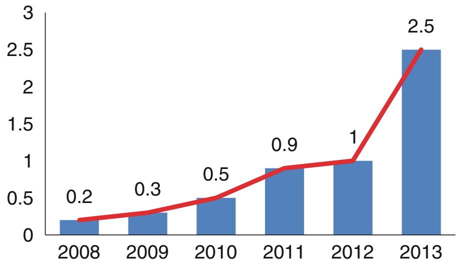

Fig. 105.1 2008–2013 green construction area growth trend

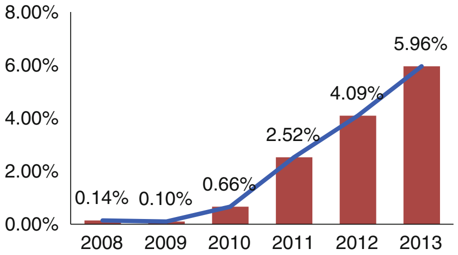

Fig. 105.2 2008–2013 growth trend of green construction area accounted for proportion of new construction area

20 % of the new construction area (Figs. 105.1, 105.2). But with the rapid rise of green residential construction, the aim of construction area growth has gradually turned to the requirements of a more comprehensive and systematic sustainable development on green residential construction. Therefore, the green ecological property management, as a double deepening of green construction and property management will become a development trend of extending the life cycle of the green residential construction (Fig. 105.3).

Internationally, there are lots of development directions, such as green construction evaluation system, energy contract management and so on (Hachem et al. 2014). Green construction evaluation system not only plays the role of evaluating the green eco property management, but also stimulates the promotion of green construction life cycle management (Sheng et al. 2011). For example, BREEAM proposed in 1990 in Britain is the first set of green evaluation method used in marketing and management. The American LEED system has entered the construction market in China since 2003, and has played an important evaluating role in Asian region (Thilakaratne and Lew 2011).

In China, the current assessment and development on green eco property management is mainly based on "green construction evaluation criteria" promulgated in 2006. But the property operation marks only accounts for 17 % of green construction evaluation criteria, it is only a branch of green residential construction, and

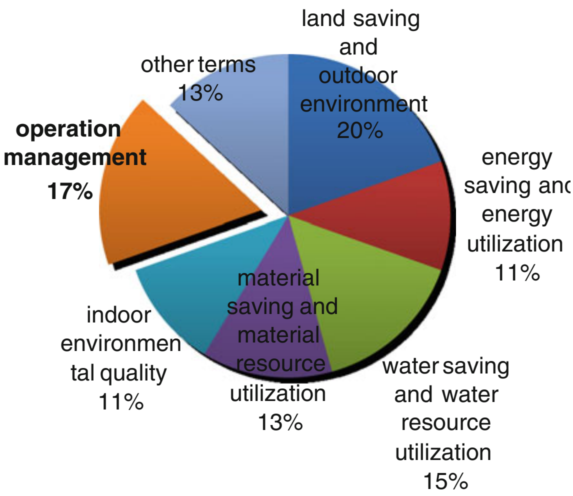

Fig. 105.3 Green construction evaluation criteria. *Data source* National Energy Bureau of Statistics

can not fully regulate the green eco property management. The existing stagnant technology and management on property industry gradually can not match the high-quality service green residential area demands, thus forming a relative contradiction between rapid development of green construction area quantity and high-energy consumption at operation stage. In a word, the disconnection between green eco property management and green residential construction, and the lack of standardization of green eco property management have become the main reason to block its development.

105.1.2 Problems on Green Ecological Property Management

From 2005 when the Ministry of environmental protection issued "guidelines to create national green community" to now, green eco property at residential area is still at the starting stage. This is far from our target of green eco property consciousness, sustainable development, and maintenance and appreciation of values. In this paper, through the research and analysis on property management industry at Chongqing area, the aim is to find out and study the existing problem on green eco property management. Chongqing, as the center of the southwest region, not only has local enterprises that committed to green property development like Longfor, Dazheng, and Jinke, but also has excellent comprehensive professional property companies like Vanke, Zhonghai, and Merchants property. Hence, to make research on green eco property management at Chongqing has a certain reference value.

In this paper, we choose residential areas managed by Longfor, Dazheng, Jinke, Huayu, Haitao and other large property companies to make the research, visiting a

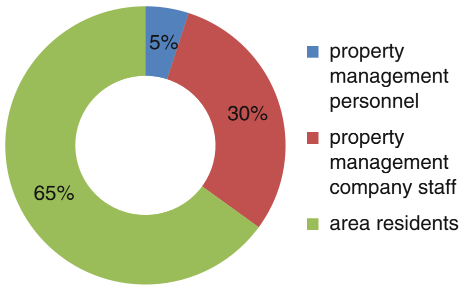

Fig. 105.4 The respondents structure diagram

total of 15 high-grade residential areas covering nine of the urban area of Chongqing City, and handing-out 800 questionnaires. And the research subjects are the property management personnel (5 %), the property management company staff (30 %), and area residents (65 %) (Fig. 105.4). Research contents are three aspects of green construction maintenance, property technical management measures, property service satisfaction, and a total of 17 items. With the method of Richter test scale (Liker-Type Scale) and model of establishing gap analysis and service quality measure, we analyze Chongqing green eco property management and finally summarize the five main problems as follows.

105.1.2.1 Green Ecological Property Evaluation System Needs to Be Perfected

At present domestic measure standard of green eco property follows the operation management criterion in green construction evaluation criteria, in which evaluation is not comprehensive enough and norms is insufficient. At the same time, because green construction evaluation criteria emphasis on the use proportion of renewable energy and the efficiency of energy use and the requirements of maintenance and warranty at operation stage are not systematic, the design of energy saving and environment protection on green residential construction does not achieve the expected effort (Fig. 105.5).

105.1.2.2 Lack of Green Ecological Property Consciousness

From the standpoint of the owners, accustomed to traditional property, lack of green ecological awareness, the owners has difficulty to accept the new green eco property management model in a short time; from the standpoint of property company, in premise of imperfect economic incentive system, the property company will only take basic operation and maintenance work, and will not initiatively promote management and technical ability.

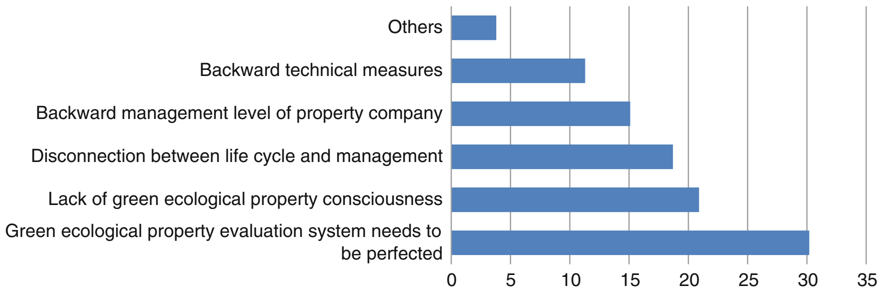

Fig. 105.5 The results of the analysis diagram

105.1.2.3 Disconnection Between Life Cycle and Management

The disconnection between preliminary architectural design and property management, make most green construction ignore the high energy consumption caused by the design itself. Meanwhile, the disconnection between green ecological property company and development unit result that the construction and use of residential area exit a certain gap and the green residential construction can not fully play its advantages.

105.1.2.4 Backward Management Level of Property Company

Some problems exists in our current green eco property management, like low execution efficiency, imperfect management structure and so on. From the human resource structure, the present property management is labor intensive, and most property staff has low professional quality; from the management structure, green eco property company lack of perfect management system, responsibility is not clear, and management measure does not match our target requirements.

105.1.2.5 Backward Technical Measures

The limitations of the technical measure of present eco property management are mainly embodied in the following three aspects: (a) The designed technical equipment of green residential construction and technical measures of ecological property company exist a certain gap. (b) Lack of high-tech measures, the green ecological property company has difficulty to transfer the labor intensive model to technology intelligent model. (c) The backwardness of municipal planning, make the electric power, water and other facilities can not meet the requirements of green eco construction.

105.2 Connotation and Characteristics of Green Ecological Property Management

105.2.1 Concept of Green Ecological Property Management

Green ecological property management is a new concept, it has three characteristics of management, specialization and socialization, and it is the upgrade of traditional property management method and idea (Sanchao et al. 2010). Lianggang (2003) proposed that green ecological property is a combination of a number of indicators, by using the modern technology and advanced culture concept to provide a health living environment. Sun Jun and Chen Wenjun (2014) also put forward the definition of green ecological sustainable property: commissioned by the owners, from the perspective of sustainable development, taking the community environment and community property as the management subject, taking the environmental protection, energy-saving, and intelligent as high-tech means, using advanced management experience, the property company will create a safe, environmental protection, comfort, health, and harmony living environment to meet the owners' multi-level needs and assets value (Shensheng et al. 2010).

Based on previous studies, the author further expanded and explained the concept of green ecological property management. This concept develops from sustainable buildings and property management. Green eco property management is a holistic and well-targeted management mode that fully utilizes the existing advantages in design and facilities of sustainable buildings. Advanced technology and intelligent management tools are also employed. Green eco property management advocates "green consciousness", stresses sustainable development and full life-cycle energy conservation and concerns about the increase of property net worth. The ultimate goal is to build harmonious relations between human and nature, human and buildings, buildings and nature.

105.2.2 Features of Green Eco Property Management

Green eco property management combines several indicators. The management focuses on the relations among sustainable buildings, ecological environment and human. This mode has 4 key features: (a) Green and eco conscious and progress-prone; (b) Efficient, intelligent and well-structured; (c) Specialized and holistic, covering areas of ecology, human and economy; (d) Technology intensive, using advanced facilities and technology.

105.3 Comparative Analysis of Traditional Residential Property Management and Green Eco Property Management

105.3.1 Traditional Residential Property Management

Affected by different environment, natural resources and economic development conditions, traditional residential property management varies in different regions in China. At present, there are basically 4 kinds of traditional property management agencies: (a) Housing Management Bureau period managing one certain district as a result of China's planned economy; (b) Logistics departments in large SOEs managing social residential property gradually during the reform; (c) Property management departments set up by real estate developers to provide after-sales service; (d) Companies specialized in property management.

As the social economy and people's consumption capacity improves, traditional management can no longer provide satisfactory maintenance to ordinary residential communities, not to mention reaching operating standards of green residential buildings. Researches show that the existing traditional property management.

Firstly, provides only basic services of maintenance, cleaning, security.

Secondly, lacks sound system to ensure efficiency.

Thirdly, lacks adequate facilities and high standard building, leading to poor living environment.

Fourthly, lacks competition and awareness of self-improvement (Zhongtao 2009).

105.3.2 Green Ecological Property Management

The huge gap between the emergence of sustainable buildings and traditional property management paved the way for the development of green eco property management industry. In November, 2007, Sino-Singapore Tianjin Eco city was set up. The Eco-city marks an important change from traditional communities to green and eco communities in China. With the help of advanced technologies, SSTEC has established a full life-cycle operation management mode for green residential buildings.

Green eco property management differs from traditional management in many ways. Green management takes full advantage of sustainable buildings and applies multiple professional knowledge to the holistic management covering social, economic and environmental aspects. Management and technology enables green property management to operate throughout the entire life-cycle of green buildings.

105.3.2.1 Management

Green eco property management takes "human and nature, human and building" as the management core. It is designed to make green buildings comfortable and practical with management tools.

(a) Broad participation. Property companies remain the most important, while property owners, municipal departments, developing and designing institutions are encouraged to join.
(b) Specialized sections. Establish an efficient and professional management level. Clearly plan each section's tasks, improve efficiency, and hire professionals.
(c) More services. Provide customized services to property owners with different requirements, and improve service quality.

105.3.2.2 Technology

Green eco property management takes "building and nature" as the technological core. Green eco property management is at the operation phase of sustainable buildings. Its goal is to ensure the buildings are sustainable and harmless to the environment. Advanced technologies will be employed to improve service quality.

(a) Introduce high technology to improve the management system. For instance, electronic information management system can provide complete audit and control.
(b) Fully utilize the existing facilities and design. For instance, green biodegradable materials and economical planning can save energy and extend life of the buildings.

105.3.3 Comparative Analysis

The table compares traditional property management and green eco property management in goals, awareness, structure, technology and standards (Table 105.1).

105.4 Explore Green Eco Property Management Mode in Residential Areas

As sustainable buildings and property management industry develop, in order to provide more specialized service, green eco property management should ensure the sustainable development of the buildings, meanwhile fully utilize the advantages of green residential buildings and management and technological tools.

Table 105.1 The form of comparative analysis between traditional residential property management and green eco property management

	Traditional residential property management	Green eco property management
Management goals	Retain the value	Retain and increase the value. Provide holistic property management with high quality to ensure the sustainable development of buildings
Management awareness	Provide basic service of maintenance and security. Slow in self-improvement	Develop green awareness and incentive mechanism. Cooperate with property owners, municipal departments and other participants and strive for innovation and progress
Management structure	Simple management structure. Labor intensive with inadequate technology	Comprehensive management. Green eco property management company as a service platform will provide more services though professional managers with higher quality and technology
Management services	Basic management such as maintenance, security, gardening and withholding energies payments	Specialized and comprehensive, providing basic property management services, energy and ecological environment related services
Management technology	Use traditional facilities and devices	Make full use of the existing facilities and devices, and introduce advanced technologies

Many property companies have made great efforts in exploring the development mode of green property management. Jinmao (Shanghai) Property Agency is an example. In December 2012, general administration of quality and technical supervision issued energy management system certification to Jinmao, making it the first of its kind. Jinmao set up a green technology group to explore scientific eco development approach, gradually mastered new technology and material and applies these to the property management. These competitive edges enable Jinmao to provide professional and leading service.

Based on China's traditional property management model and researches and analysis on green property management cases, the paper has proposed a new and multi-dimensioned green eco property management mode. To manage effectively and systematically, property agencies should be the core manager and cooperate with property owners, municipal departments, developers and other participants. Green eco property companies opens up and masters a comprehensive service platform with advanced technology and management tools. Property owners will get feedback through evaluation system. A virtuous cycle is thus formed to improve green eco property management.

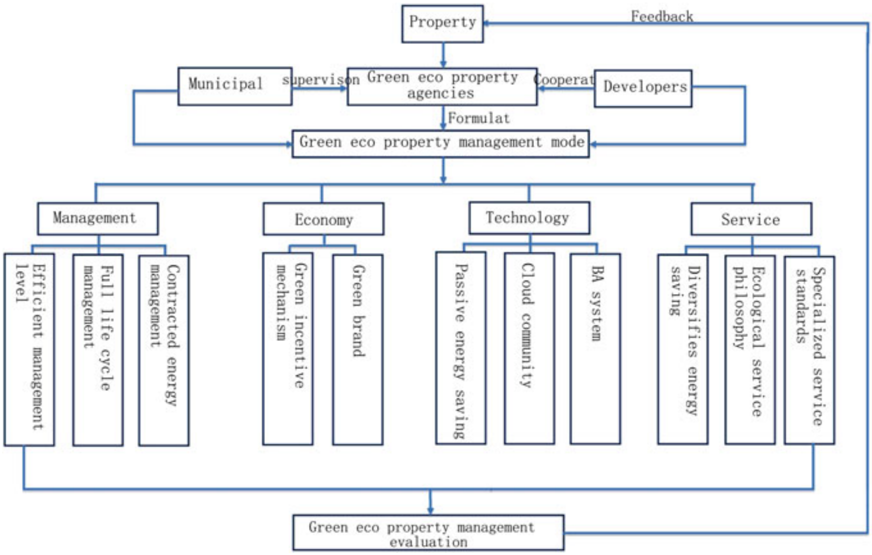

Fig. 105.6 The framework of green property management mode

In summary, green eco property management companies should improve management, economy, technology and service, and form a goal of serving the entire life-cycle of the sustainable building (Fig. 105.6).

105.4.1 Management

Property agencies are at the core of green eco property management. Management structure and capabilities are an important foundation of the other three dimensions.

(a) Efficient management structure. Green eco management mode is integrated and specialized. Property agencies therefore should set up a proactive and all-round management level and divide specialized sectors internally at the same time. Keep a holistic and streamlined structure and manage the entire sustainable building with advanced technology.
(b) Full life cycle management. Instead of focusing on a separate operating block, green property management should run through the entire life cycle of green residential buildings. Develop a comprehensive and systematic property management plan when designing and constructing the building. In this way, the gap between the utilization of the buildings in construction and operation will be narrowed and green residential building and green property management can truly play their roles.

(c) Contracted energy management. Providing energy project management services helps property companies save energy and make profits. Contracted energy management makes full use of the central role of the property company in green eco-property management and provides customized service for property owners with energy saving control system.

105.4.2 Economy

Economic benefit motivates technological advancement and promotes the progress of green eco property management mode. Establishing a "green consciousness" with economic incentive is particularly important:

(a) Develop green consciousness and green incentive mechanism. As new property management develops, property agencies, property owners and other participants should also gradually develop "green consciousness". Incentive mechanism should be established to increase the initiatives in promoting green eco management. Internally, property agencies and owners have contracted cooperation. Externally, the government supervises and evaluates the property agencies, and grant awards for innovation and progress.
(b) Build a green brand. Green eco property agencies combine the existing experience with related sustainable building cases, master new technologies and ideas and develop effective maintenance plans, operating procedures and other technical documents. Industrial model established in this way can benefit the company in management capacity and image building.

105.4.3 Technology

Technology is increasingly becoming an indispensable part of intelligent property management. Only with a complete technological system can the goals of green eco property management be reached.

(a) Passive energy-saving technologies. Passive energy-saving technology fully considers features of buildings in the early stage of designing and reduces the use of machinery and electrical equipment, so as to optimize energy-saving effect at operational phase (Whang and Kim 2014). Passive energy-saving costs less than other energy-saving technologies, making it the first choice of its kind (Qing and Zengwen 2006).
(b) BA system (building automation system). Computer networking is designed to monitor and control mechanical and electronic devices and upgrade the control, energy-saving measures and devices. Recording energy consumption at a regular basis, analyzing energy difference of devices and improving BA

system will ensure that devices in the buildings operate in an energy-saving and efficient condition (Yuping 2005).

(c) Cloud community. Cloud community sets up an information platform that links up property owners, municipal departments, and professional service companies. Property management APPs brings convenience in security, remote monitoring, fees collection and other services. Integrated management enabled the property agencies to provide property owners with comprehensive and easy services.

105.4.4 Service

Providing services to property owners remains the most important for green eco property companies in residential communities. Property management develops from traditional services, and becomes more streamlined and considerate.

(a) Diversified service. Systematic services will be offered with the help of electronic platform. Meanwhile, property companies also should cooperate with departments of gardening, public security, fire, water supply and other municipal departments to launch a complete and diversified management system.
(b) Ecological service philosophy. Green eco property companies can encourage property owners to develop "green thinking" according to geographical and environmental features and personal habits. Cultural services can be offered by organizing activities and creating unique community culture (Tonghua 2011).
(c) Specialized service standards. Property agencies should provide services of different levels in accordance with consumption capacity and demand of property owners. Residents will choose the service accordingly. Questionnaires, data analysis, and opinions from property owners' committee can be employed to make the management "people-oriented" and "property owners first" (DTZ 2008).

105.5 Suggestions to Promote Green Eco Property Management in China

At present, green residential buildings are developing rapidly in China, while green ecological property management is still at the exploratory stage. China's green eco property management cannot meet the standards of sustainable maintenance and green property management industry. Moreover, its development lacks motivation and momentum. Green ecological property management requires more practical experiences and incentives. The author has the following proposals:

(a) Establish indicator evaluation system. Evaluation system will help guide, supervise and correct the green eco property standards throughout the entire life cycle to ensure green property management to be practical, adequate and effective.
(b) Strengthen supervision from municipal departments and strictly regulate the qualification of green eco companies.
(c) Stress full life-cycle energy conservation. Encourage the real estate business developers, design institutions, builders and property companies to cooperate to achieve a full life-cycle management in development, design, construction, operation.
(d) Attach importance to technological innovation. Introduce international advanced energy-saving technology and equipment, and protect domestic patents at the same time. Set up awards and bonuses to motivate property agencies to use high technology.
(e) Promote contracted energy management. Allocate municipal funds to establish a credit system for energy-saving service providers. Green communities should fully implement "Energy Management Plan" to get effective energy-saving services.

Green ecological property management has developed for a decade in China. Many projects are successful, delivering good results. As China's property management industry and the real estate market matures, and the public "green consciousness" improves, green eco property management will be a promising industry with long-term development potential. Meanwhile, promoting green eco property management will accelerate the building of energy-saving society, improve resource efficiency, inject a strong impetus to the development of sustainable buildings and finally achieve sustainable development the sustainable buildings in the entire life cycle.

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