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Sustainable building development in China – A system thinking study

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Abstract

The demand for sustainable building is increasing rapidly throughout the global construction marketplace. However, the real success of sustainable building development depends on the concerted effort of different stakeholders. Without knowing the drivers and barriers, it is difficult to introduce pragmatic policies and strategies to promote such development. While sustainable building development in China is still at an infancy stage, its experience should help other developing countries to develop a road map for developing sustainable buildings. In this paper, twelve semi-structured interviews with senior managers of listed real estate developers in China were conducted. The results indicated that government regulation, incentives and CEO's vision are the key drivers of sustainable building development. The most significant barriers identified by the interviewees are the additional costs due to sustainable initiatives, lack of customers demand and lack of mature green supply chain. To better understand the system structures causing these management problems, a causal loop diagram was developed to identify the relationships and the causal influences between the elements of the sustainable building development sector. Finally, a suite of effective sustainable strategies is proposed based on the findings.

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Keywords: Sustainable building; system thinking; causal loop diagram; drivers; barriers

1. Introduction

Sustainable buildings are regarded as one of the most effective solutions to address various global issues such as climate change, human health, social impact, renewable energy, etc. Such development requires the most efficient and least disruptive use of energy, land, water and resources [1]. According to McGraw-Hill Construction's latest

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Smart Market Report – "World Green Building Trends" [2], the demand for sustainable buildings is increasing rapidly throughout the global construction marketplace, without being limited to one geographic region or economic state. The report also pointed out that the market of sustainable building has been shifted from "push" to "pull" and sustainability has become a worldwide business imperative.

In China, the strain on energy and natural resource along with environmental degradation during recent years alerts Chinese government and business enterprises to promote a sustainable building practice which seeks to strike a balance between economic, social and environmental performance [3,4]. The Chinese government first released the Three-Star Green Building Evaluation Standard in 2006. Then in 2012, the Ministry of Finance and the Ministry of Housing Urban and Rural Development published "The Implementation Opinion Regarding Accelerating Promotion of National Green Building Development" which sets an aggressive target to have 30% of all new construction meeting the green building standard by 2020. It is expected that the market of new sustainable buildings would worth between US$220-400 billion by then [5]. In view of such an ambitious goal, it is imperative to have the real estate developers actively participated in the sustainability practices to lead the best practice. However, most developers especially those listed companies would put their profit and shareholders' interest at the first place. Therefore, what key barriers they are confronting and how to motivate them to develop more sustainable buildings become the key questions for this paper.

2. Literature Review

2.1. Drivers and Barriers

Various studies have addressed barriers and drivers during the process of delivering sustainable buildings. Williams & Dair [6] identified that the major barriers for sustainable building in England included a lack of consideration of sustainability measures, real and perceived costs and inadequate expertise and powers. Pitt, Tucker, Riley & Longden [7] suggested that fiscal incentives/penalties and regulations were the two most important drivers of sustainable construction, which were consistent with "affordability" as the biggest barrier identified. Häkkinen and Belloni [8] concluded that the major barriers for promoting sustainable buildings in Finland were the steering mechanisms, economics, a lack of client understanding, process, and underpinning knowledge. On the other hand, the major drivers were clients' awareness about the benefits of sustainable building, development and adoption of methods for sustainable building requirement management, sustainable building tools mobilisation, designers' competence and team working, and development of new concepts and services. Bond [9] investigated the barriers and drivers of sustainable building in Australia and New Zealand and suggested that the initial costs of sustainable features, a lack of consumer information, and people's reluctance to change are the main barriers for improving building energy efficiency. Instead, an appropriate mixture of government regulation, greater use of energy saving technologies and behavioural change are the major drivers to reduce CO_2 emissions. Zhang, Platten, & Shen [10] examined the costs and barriers in the process of developing Chinese sustainable property projects. They recognised that 'active' design strategies are more expensive than the passive design strategy, and the major barrier is the higher costs and this has hindered the widely application of sustainable technologies in the construction industry in China. Another research in China [11] identified that additional cost, incremental time and limited availability of green suppliers and information are critical barriers to foster a sustainable construction practice. These factors are similar to previous researches in Hong Kong [12] and in China [4]. Ahn, Pearce, Wang, Y., & Wang, G. [13] also investigated the main drivers and barriers of sustainable design and construction in the US construction industry. Energy conservation, improving indoor environmental quality, environmental/resource conservation, and waste reduction were the most important drivers while the most noteworthy barriers were first cost premium of the project, long pay back periods from sustainable practices, tendency to maintain current practices, and limited knowledge and skills of subcontractors.

Although these researches identified the barriers and drivers encountered during the sustainable building development, most of them failed to capture the underline relationships of these factors as well as the causes and effects among them in a systematic way. Thus, this paper seeks to apply a causal loop diagram to capture the

system structure and highlight the causal relationships between the factors which may impact sustainable building development and performance from a systematic perspective.

2.2. System Thinking and Casual loop

Richmond [14] defines systems thinking as: "the art and science of linking structure to performance, and performance to structure-often for purposes of changing structure (relationships) so as to improve performance." Sherwood [15] postulated in his book that it is necessary to study the system as a whole so as to understand it, and predict its performance. System thinking can be applied in numerous scientific fields including planning and evaluation, education, business and management, public health, sociology and psychology sustainability, and so on [16]. System dynamics is one of the important approaches of system thinking and is best suited to assist businesses and government organisations in developing strategies; analysing dynamic processes and selecting policies by capturing the information flow and feedback [17]. System Dynamics has also been used to address a number of Construction Project Management issues such as assessing the impacts of client behaviour on project performance [18]; modeling design and build procurement [19]; exploring performance enhancement in a construction organization [20]; assessment of sustainable performance of construction projects [21]; construction risk analysis [22]; and improving building services works in Hong Kong [23]. Moreover, the causal loop diagram as a useful system dynamics tool can be applied to describe a complex system in terms of its cause-and-effect relationships, to restrain the complexity by seeing things as a whole, and to highlight the connectivity of various component parts [15]. It can be used to build system dynamics simulation model to show the impacts of inputs on outputs and vice versa [24, 25]. In a causal loop diagram, loops consist of links where the cause is the tail of the linking arrow and the effect at the head. A positive link (arrow with "+" or "s") represents that there is an increase in the cause giving rise to an increase in the effect while a negative link (arrow with "-"or "o") represents there is an increase in the cause leading to a decrease in the effect [15].

3. Research Method

According to the Annual Report on Climate Change Actions [26], real estate developers especially those listed and well-known developers became the pioneer in the development of sustainable buildings in China. Since the local listed real estate developers have larger market share and more social and market influences than those small ones. Therefore, a total 20 invitation letters were sent by email to invite them to participate in an interview. After the telephone follow up, eight developers consist of both state-owned and private-owned ones responded and accepted the invitation. A total of twelve semi-structured interviews were carried out during October 2013 to December 2013. Among them, ten interviewees were from the eight developers who had diverse backgrounds ranging from top managers who are responsible for setting the sustainability strategies for their business, to design consultants, procurement managers who are carrying out the day-to-day works. The other two interviewees were from the China Academy of Building Research – Shanghai Institute which is the branch of the largest research institution in the Chinese construction industry and have devoted much effort to drive sustainable building innovation and research during recent years.

4. Interview Results Summary

The interviewees were invited to express their opinions related to the current practices, key drivers, and barriers of sustainable building development and they were also encouraged to talk about any other experience and perception on sustainable building development. Each interview lasted for around an hour.

4.1. Current practice of sustainable building

All developers interviewed demonstrated a good understanding of the issues about sustainable building and indicated they have strategic plans to develop sustainable buildings. Their focus was on developing sustainable

buildings for both the private and public residential sector as well as large and complex eco city projects in urban areas. Among them, three developers set ambitious goals for developing and constructing 60-100% of their projects according to the green building standards. Except one developer which has just embarked on sustainable building development, the other developers have s a diverse sustainable building experience, i.e. 10-80% of their total projects. Some developers prefer pursuing LEED certification over China's Three-star Green Building Certificate, while certain interviewees considered that it too costly and timing consuming to apply for green certification and they had developed the sustainable buildings according to the sustainable building standards only. All developers except one have invested in R&D and training to uplift their organizations' competitive advantage in sustainable building development. Four of them even have their own sustainable technology R&D center.

4.2. Key drivers for sustainable building development

The interviewees were asked to identify the key drivers for sustainable building development. As show in Table 1, the top three key drivers identified by the interviewees are government regulation, government incentives and CEO's vision.

Although some developers opined that a good reputation in sustainability, lower operation cost and higher rental value are their motivation, ten interviewees admitted that it is the series of government regulations at all levels in recent years that have effectively stimulated their sustainable building development plan. For example, several interviewees mentioned that the Shenzhen Government stipulated that all new residential projects should meet or surpass the one star green building standard in China from 20 August 2013, and the carbon emissions of all sustainable buildings should be calculated and evaluated. Furthermore, the city government as also grants subsidies, expedited permit, waiver of application fee, etc., to sustainable buildings and these has resulted in a higher application of sustainable technologies and energy performance contracting. Most interviewees agreed that the regulations and incentives of the government would influence CEO's vision by and large and this would in turn change the company's sustainable strategy.

Table 1. Drivers for sustainable building development..

Drivers	Frequency
Current government regulation	10
Government incentives	9
CEO vision	8
Anticipated sustainable marketing expansion and government regulation	7
Social Responsibility	7
Company's sustainable development strategy	6
To lead the best practice	5
Increasing profits	3
Market Reputation	3
Customer demand	2

4.3. Key barriers for sustainable building development

The key barriers as identified by developers are additional cost due to the sustainable initiatives, lack of customers demand and lack of mature sustainable supply chain as showed in Table 2. 11 of 12 interviewees believed that sustainable buildings would cost more than conventional buildings, but yet the profits brought by sustainable buildings are still unclear. This is partly because sustainable building is just at an infancy stage in China. Many sustainable buildings are still yet to recover their initial costs partly because the high material and equipment prices originated from the immature sustainable supply chain, and also due to the fact that developers have little

benefits accrued from the saving in operation costs. According to majority of the interviewees, most local customers choose a building to buy or rent according to its location, house type, floor area, price, reputation of developer instead of sustainability, which shows they still lack the demand and understanding of sustainable buildings. Besides, a number of developers indicated that they did not practice sustainable supply chain management in their projects. Although they have been trying to establish long-term strategic relationships with green suppliers, there are not sufficient qualified green suppliers in the market. Sometimes there may only have a single supplier available for a specific green product and the delivery of such product could take time. Only two developers interviewed had developed their own green supplier database in order to keep track on their performance.

Table 2. Barriers for sustainable building development..

Barriers	Frequency
Additional cost due to sustainable initiatives	11
Lack of customer understanding and demand	9
Lack of mature sustainable supply chain	9
Low level of facility management and operational management	8
Insufficient Regulatory demand and incentives	6
Difficult to meet profit goal	6
Lack of integrated process management for the life cycle of sustainable building	6
Sustainable design elements may be wasteful and cannot be fully implemented during operation stage	5
Costly and time-consuming to apply for the green building certification	4
Incomplete and insufficient sustainable building standards and green material label	4

4.4. Casual loop diagram analysis and discussion

By referring to the interview findings, a causal loop diagram was developed (Fig. 1). The causal loop diagram demonstrates the influences of key barriers and drivers for sustainable building development from the developer's perspective and the inter-relationships between these factors can also be identified through the diagram.

As shown in Fig. 1, "government regulation" and "government incentive" affect "CEO vision" which in turn influences "sustainable strategy". "Customer understanding and demand" and "profit" as well as "sustainable strategy" lead to "willingness for developing sustainable building and related products" which determines "sustainable building market size". The links between these variables are all positively linked (arrow with "+") representing that the stronger these variables are the more willing the developers are in developing sustainable buildings and hence a bigger sustainable building market size. Government regulation has always been found to be the most important determinant of sustainable practices [27, 7]. Walton, Handfield & Melnyk [28] argued that the tightening of government regulations for environmental practice could influence executive's perception and strategic planning, which echoed with the perception of the interviewees. For example, several interviewees mentioned that Shenzhen government stipulated that all the new residential projects should meet or surpass the one star green building standard from August 20, 2013, and carbon emission should be calculated and evaluated for all the green buildings. This regulation changed the perception of developers' CEOs and stimulated them to make strategic plans to build sustainable buildings. Furthermore, government incentives such as density bonuses, tax incentives, zoning requirements for private buildings [28] can stimulate sustainable innovation and lead to cost-effective sustainable technologies [7]. At current stage, Chinese government offers policy incentives to the higher level green buildings with a 45 RMB per square meter subsidy for two Star sustainable buildings, and an 80 RMB per square meter

subsidy for three Star sustainable buildings. In summary, it is recommended that the Chinese government should devote greater effort to regulate and to provide more incentive to stimulate the sustainable building market and to influence the vision of developers and their sustainable strategies. Meanwhile, it is also very important for government, news media, and developers to promulgate sustainable building concept and to increase customer understanding and demand for sustainable practices promotion [7].

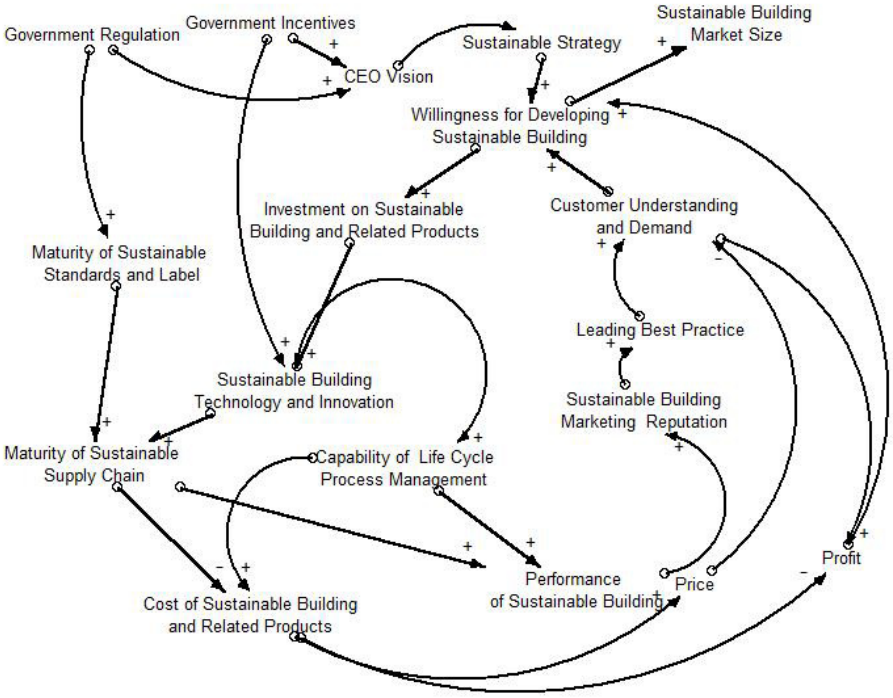

Fig. 1. Influences for Sustainable Building Development

The “willingness for developing sustainable building and related products” would not only lead to an increase in “sustainable building market size”, it could also increase developers’ “investment on sustainable building and related sustainable products”. This together with the “government incentive” can stimulate “sustainable technology and innovation”. Eventually, this would help improve the “maturity of sustainable supply chain” and the “capability of life cycle process management” in China. As mentioned before, lack of mature sustainable supply chain is a key barrier for sustainable building development, in order to implement a sustainable supply chain, more investment and incentive on sustainable technology and innovation should be considered. Moreover, some interviewees mentioned the lack of integrated process management from the life cycle perspective of sustainable building plan, design, construction, and operation hampered to achieve high performance sustainable buildings, the capability of life cycle process management should be fostered by more mature sustainable technology and qualified managers.

“Government regulation” and “sustainable building technology and innovation” can help to enhance the “maturity of sustainable building standards and label”. Although Chinese government at all levels declared central governmental and a diversity of local sustainable buildings standards, these standards all use qualitative analysis method which are considered by the interviewees as incomplete and insufficient and the sustainable material label systems are not complete as well. It is recommended that by adding more quantitative measurements, integrating assessment during the building life cycle, the “maturity of sustainable supply chain” can be increased [30].

Moreover, the sustainable building standards and labelling scheme should take into account economic and social concerns along with the environmental aspects so as to practice the true spirit of sustainability [31, 32, and 33].

The greater the "maturity of sustainable supply chain" and "capability of life cycle process management", the lower the cost and the better the "performance of sustainable building" will be leading to a lower sale or rent "price", a higher "marketing reputation", "customer understanding and demand", and capability of "leading the best practice". All these would result in a higher "profit". In China, among over five hundred projects which achieved the green building certification in 2013, only 50 projects got the green operational certificates. Some interviewees mentioned the facility managers and end users failed to fully realize the sustainable design elements, and some designers only designed for green design certificate since they had only limited control of the construction processes and almost no control of building operations. Lalonde [34] proposed the five basic building blocks for strengthening the supply chain relationship are sharing of information, sharing of benefits and burdens, multiple contacts between economic entities, cross-functional management processes, and future-oriented collaborative processes. This idea can also be applied to help improve developer's sustainable building supply chain. In order to boost the efficiency and effectiveness of the sustainable practices, developers should focus on the efficiency of process management, collaboration and information sharing between project stakeholders during the whole life cycle of a building project rather than merely aiming to pursue a green certificate for a building [35].

5. Conclusion

The demand for sustainable building is increasing rapidly throughout the global construction marketplace, and China is no exception. Based on the findings of twelve semi-structure interviews, the key drivers of sustainable building development viz. government regulation, incentives and CEO's vision are identified. The top barriers as identified by developers include the additional cost brought by sustainable initiatives, lack of customers demand and lack of mature green supply chain. By the use of causal loop diagram, it is possible to capture the key variables and provide a dynamic and holistic view to better understand the causal effect of these key variables so as to develop a set of suitable strategies for sustainable building development.

The results of this research point to a greater effort from the government in China to regulate and provide incentive to promote sustainable technologies, innovation and sustainable building market expansion. On the other hand, developers should expand their emphasis from design process to the entire project life cycle in order to enhance the maturity and performance of the sustainable building supply chain and cultivate a more collaborative and information sharing culture between project stakeholders.

In the next stage of research, a system dynamics model based on findings of this research as well as the next round of interviews and case studies will be conducted to simulate the real world practice and to analyse the sustainable building development problems under different scenarios in a dynamic manner. The results of subsequent research stages will be discussed once they become available.

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