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# Why sustainable construction? Why not? An owner's perspective

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**Abstract:** Rapid urbanization in developing countries such as China has been creating unprecedented opportunities for the adoption of sustainable construction (SC). Owner, as a key driver of urbanization, plays an influential role for other stakeholders to undertake SC practices. However, lacking their demands and requirements of owners were regarded as the main barriers for the adoption of SC. Notwithstanding the diversity of previous studies on the barriers to SC, there is a dearth of research from the owner’s perspective. This paper presents an empirical study identifying the critical factors impeding the adoption of SC from the owners’ point of view. A list of 25 factors was preliminarily identified through extensive literature review and interviews with industry professionals. This was followed by a questionnaire survey to collect owners’ opinions on the relative importance of these factors. Using factor analysis, seven most critical factors are identified, namely, economic feasibility, awareness, support from project stakeholders, legislation and regulation, operability of SC, resource risk, and project management model. The research findings show that economic feasibility, awareness, legislation and regulation are the most important factors impeding owners in adopting SC practices. This implied that the government plays a vital role in removing the barriers impeding the greater adoption of SC by building owners in China. This is helpful for a transition to the low carbon urbanization.

**Keywords:** Sustainable construction; critical factors; owners; China.

## 1 Introduction

It is well acknowledged that developing countries experiencing rapid urbanization have met formidable challenges in producing sufficient housing and infrastructure in a socially and ecologically responsible manner (Plessis, 2007), and adequate and safe housing is still a dream for the majority of the population (Golubchikov and Badyina, 2012). In Southeast Asia, the emphasis

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of sustainability tends to be on the development for eradication of poverty and provision of basic housing instead of environmental issues (Shafii et al. , 2006). Despite the urgent need for SC in developing countries, however, owners still regard it as a “nice-to-have” addition to normal practice without bring integrated into decision making and business practices (CIB and UNEP-IETC, 2002). As Shen, Tam (2010) pointed out, this is also the case in Mainland China, where economic performance is the most important concern in current project feasibility practice, with less attention being paid to environmental and social performance.

Urbanization is closely linked to the construction industry due to its associated developments such as housing and infrastructures (Shi et al., 2014). Urban planning and the construction industry intertwined under the context of urbanization which is significantly affected by climate change policies (Kocabas, 2013). Indeed, the construction industry plays a critical role in sustainable urban development in China (Wang, 2014). The construction industry has a significant impact on the environment and society, and is a major sector involved in achieving sustainability (Shi et al. , 2012). The shift of the construction industry from the traditional paradigm towards sustainable development has received close global attention in the form of "sustainable construction" (SC) (Shi et al. , 2014, Zhang et al. , 2014). Basically, SC outlines the creation and management of a healthy built environment based on resource efficient and ecological principles and aims to strike a trade-off between the economic, social and environmental (triple bottom line) dimensions of sustainability (Shen et al. , 2010).

Adopting sustainable construction involves integrating all of the principles of SC into the construction activities of the project life cycle, with every stakeholder having a responsibility for carrying out sustainability practices (Hill and Bowen, 1997, Matar et al. , 2008). As Shen et al. (2008) point out, every stakeholder makes specific contributions to improving sustainability, while owners play a critical role in requiring other stakeholders to adopt SC practices (Abidin and Pasquire, 2007, Fadeyi et al. , 2012). Normally, owners are the demanders in the building sector, their willingness and their needs shape the products and process from the very beginning of construction projects (Pitt et al. , 2009, Qi et al. , 2010). By incorporating sustainability principles from the start of their projects, the owners’ subsequent decision-making and practices are more likely to promote SC (Abidin, 2010). In other words, the real driving force for SC can come from the owners (Shen, Tam, 2010). Despite owners being regarded as key drivers of SC, lacking their demands and requirements has been considered as the main barriers (Pitt, Tucker, 2009). In Malaysia, for example, although governments have initiated the implementation of SC, owners are not willing to shift from the conventional approach or venture into new realms of technology(Abidin, 2010). Similarly, Häkkinen and Belloni (2011)argue that owners’ lacking understanding of SC hinders the supply of sustainable buildings. There is also generally weak support and contribution from owners in environmental management (Shen et al. , 2006).

There are a number of issues associated with the rapid urbanization in China, largely due to the significant amount of resources required and a large number of stakeholders involved. This study places focuses on one of these issues, i.e. sustainable construction. Despite the great efforts made in promoting sustainable construction, there is little research concerning the adoption of SC from the owner’s perspective. This is compounded by the crucial role owner plays in promoting sustainable development Therefore, it is important to explore the critical factors impeding SC from this perspective. Addressing this issue can provide useful references for both policymakers and industry practitioners to facilitate the adoption of SC, which in turn promoting sustainable urbanization.

## 2. Policy landscape

Sustainable development has been a major strategy in China's development since 1997. As one of measures to deal with environmental issues associated with rapid urbanization, sustainable construction has continually featured on the government's agenda. The Chinese government has developed relatively systematic measures to promote SC, ranging from strategies and regulations, standards and codes, to economic and financial incentives. For example, after the issue of *China's Agenda 21*, the environmental policy framework has been vigorously developed and renewed, resulting in a generally adequate set of environmental policies and regulations (Zhang and Wen, 2008). Related technical standards have also been revised to meet the requirements of SC, such as *The National Design Standard for the Energy Efficiency* for residential buildings and public buildings (DBJ01-602-2004, GB50189-2005) (Sha et al. , 2000). Furthermore, the Chinese government has established the *Green Building Innovation Award* in 2004 and promulgated *Evaluation Standard of Green Building* (GB/T 50378-2006). The *Green Building Action Plan* was released by NDRC and MOHURD in 2013 with an aim of constructing more than 1 million $m^2$ newly built green buildings in the following 5 years. However, SC is still in its infancy in China (Mao et al. , 2011, Shi et al. , 2013). For instance, only 4% of the building stock meet the green building standard (Liu et al. , 2012). Li et al. (2014) also argue that the green building practices in China lagged behind of that in developed countries significantly.

In 2014, the Chinese government issued the *National New-type Urbanization Plan* (2014-2020), because of which approximately 100 million rural people are expected to be formally relocated to urban areas. This has created a massive demand for building and infrastructure. It is estimated that around 30 billion square meters of building area will be newly constructed by 2020 to meet the requirements of urbanization (Liu, Low, 2012). Without paying attention to sustainability during this development process, there is likely to be a considerable new burden on the environment, with economic wastefulness and social deficiencies, and taking many years to reduce the ensuing environmental footprint (Golubchikov and Badyina, 2012). Also, the large-scale construction of housing and infrastructure provides a convenient opportunity for innovative construction materials and technologies, and re-evaluation of traditional construction methods, management practices and ethical values (CIB and UNEP-IETC, 2002).

In terms of sustainable construction, this is indeed a challenging task for the Chinese construction industry due to the significant environmental impact and the large scale consumption of natural resources involved (Liu, Low, 2012, Shi, Zuo, 2012). Despite measures that have been introduced for promoting SC, their effectiveness is in doubt where action relies on the stakeholders' own initiatives (Qi, Shen, 2010). Other stakeholders are more likely to invest resources in SC following the owner's requirements (Abidin, 2010, Pitt, Tucker, 2009).

## 3 Literature review

The literature related to sustainable construction was critically reviewed in order to develop a list of critical factors for SC adoption from the owners' perspective. This step also serves the basis for the questionnaire design. The papers published in leading academic journals were consulted, from which the critical factors that impede owners' adoption of SC were found to generally fall into five categories - economic, consciousness, resources, process, and policies and regulations. These are summarized in detail in the following sections.

### *Economic*

Economic factors relate to the cost and benefit aspects of construction activities - such as the initial investment, benefit and payback time. Economic factors are normally the highest priority for owners when new norms or technologies are introduced into the construction industry. Compared to traditional construction projects, more initial investment is generally needed for SC (Hwang and Ng, 2013, Zhang et al. , 2011). For instance, as Shen, Yao (2006) point out, the application of ISO 14000 and HK-BEAM often increases the capital costs of equipment, staff training, human resources and technology for protecting the environment (such as water treatment) and the application of noise-barrier materials. The benefits of SC are either long-term or intangible, e.g., reduction of operation cost during the building service life, improving environmental performance, enhancement of corporate image, job creation and causing a longer payback time for owners (Yung and Chan, 2012). Higher initial investment coupled with a long payback period present significant barriers to owners and financial institutions in adopting SC. Lack of support from financial institutions directly results in financial constraints, which prevents related organizations in effectively managing their sustainability responsibilities (Elmualim et al. , 2012).

### *Consciousness*

SC would be impossible without a change of attitude and behavior of stakeholders where consciousness is the starting point (Pitt, Tucker, 2009, Plessis, 2007). Nevertheless, the stakeholders' consciousness towards SC is influenced by their understanding and acceptance of SC, and the industry culture. As Abidin (2010) points out, the consciousness of owners towards SC cannot be motivated without sufficient market demand. The acceptance of consumers is not strong enough to ensure the adoption of SC due to its affordability (Tseng et al. , 2013). In addition, a low-level consciousness of SC is caused by a lack of related information and knowledge (Sakr et al. , 2010). Education and training in SC is rare due to heavy work commitments and lack of sponsorship from employers (Wong and Yip, 2004). This impedes the understanding and acceptance of SC, and consequently its adoption. Moreover, the consciousness of SC is affected by industry culture. The profit-driven and survival-focused culture of the construction industry may be conflict with the principle of SC (Mukherjee and Muga, 2010). Without taking the issues of environmental and society into consideration, The predominant intense focus on cost reductions in developing countries such as China inhibits owners in adopting SC (Shi, Zuo, 2013).

### *Resources*

The practice of sustainable construction is concerned with the application of advanced technologies, which demands related resources such as humans and materials (Hill and Bowen, 1997). A lack of skilled and qualified workers is one of most significant barriers to the adoption of related technologies and methods (Sakr, Sherif, 2010, Zhang, Platten, 2011, Zhang et al. , 2012). At the same time, the adoption of related technologies and methods also increases construction time (Elmualim, Valle, 2012, Lam et al. , 2011). In addition, Mao et al. (2013) pinpoint the lack of R&D institutes and services in Mainland China in comparison with developed countries. As a result, there are not only great uncertainties concerning products entering into the market but also an absence of related standards, codes and certification for technologies and materials (Zhang, Skitmore, 2014). In addition, Wong and Yip (2004) claim there is a very limited choice of green materials available. Uncertainty in performance coupled with a limited choice of green technologies and materials may discourage industry practitioners in adopting SC.

### *Process*

This group of factors relates to the process management activities involved in SC, which is a major factor contributing to the failure to meet sustainability requirements (Fadeyi, Jallow, 2012). The adoption of SC emphasizes a holistic integration of various methods and technologies and depends on the cooperation of project stakeholders (Hill and Bowen, 1997). However, the lack of cooperation between project stakeholders is recognized as one of most significant challenges in the successful delivery of green projects (Hwang and Ng, 2013). Similarly, the traditional procurement model and inappropriate project organization structure are regarded as the main reasons for the incapacity of project management to deal with sustainable parameters (Rwelamila et al. , 2000). In addition, the definition of sustainable construction is still vague, diverse and sometimes contradictory (Plessis, 2007, Tseng, Chiu, 2013). As a result, there are lack of quantitative standards to determine whether or not an action can be considered to be sustainable (Hill and Bowen, 1997).

### *Policies and Regulations*

Government policies and regulations provide the main approach to mitigating the negative impact of construction activities on the environment and society. However, the effectiveness of policies and regulations has a close relationship with not only their content but also their enforcement. Related to this, there is a perception that governments, especially in China, fail to sufficiently enforce their policies and regulations (Zhang, Platten, 2011, Zhang, Wu, 2012). This could result in the conservative attitudes of industry practitioners toward SC. Also, lacking an efficient monitoring system lessens the enforcement of related policies and regulations (Tseng, Chiu, 2013). According to Häkkinen and Belloni (2011), one of major weaknesses of current regulations is that they mainly focus on new buildings rather than the existing building stock. In addition, fiscal incentive polices, such as tax incentive measures, award subsides and financial discounts are the main instruments for governments in driving the adoption of SC (Zhang and Dong, 2011). However, the effective enforcement of fiscal incentive policies is very complicated. As Yung and Chan (2012) state, government funding often impedes project schedules due to excessive regulations and bureaucracy.

## 3 Methodology

A preliminary list of critical factors was formulated with inputs from the literature review and preliminary interviews with practitioners involved. A questionnaire survey was then conducted to collect owners' opinions on the relative importance of these critical factors in terms of the impediments to the adoption of SC in Mainland China.

### 3.1 Preliminary lists

**Table 1.** List of preliminary CFs influencing the adoption of SC

| Number | Critical factors (CFs) | Key references |
|---|---|---|
| CF1 | Consumer acceptance of SC | (Abidin, 2010) |
| CF 2 | Information/knowledge of SC | (Elmualim, Valle, 2012, Sakr, Sherif, 2010) |
| CF 3 | Education and training of SC | (Wong and Yip, 2004) |
| CF 4 | Industrial culture | (Shi, Zuo, 2013) |
| CF 5 | Initial investment | (Hwang and Ng, 2013, Zhang, Platten, 2011) |
| CF 6 | Payback period | (Yung and Chan, 2012) |
| CF 7 | Support from financial institution | (Elmualim, Valle, 2012) |
| CF 8 | Affordable | (Pitt, Tucker, 2009, Tseng, Chiu, 2013) |
| CF 9 | Intangible benefits | (Yung and Chan, 2012) |
| CF 10 | Qualified workers and expertise | (Sakr, Sherif, 2010, Zhang, Wu, 2012) |
| CF 11 | Time for SC practices | (Elmualim, Valle, 2012, Lam, Chan, 2011) |
| CF 12 | Risk of related technology and material | (Zhang, Skitmore, 2014) |
| CF 13 | Related standard, code and certification | (Zhang, Skitmore, 2014) |
| CF 14 | Available of related technology, material | (Wong and Yip, 2004) |
| CF 15 | Support from professional institution | (Mao, Shen, 2013) |
| CF 16 | Cooperation of project stakeholder | (Hwang and Ng, 2013, Shen, Yao, 2006) |
| CF 17 | Guidance of SC | (Plessis, 2007, Tseng, Chiu, 2013) |
| CF 18 | Performance measurement of SC | (Hill and Bowen, 1997) |
| CF 19 | Commit for changing behavior | (Elmualim, Valle, 2012, Lam et al. , 2010) |
| CF 20 | Project organization structure | (Rwelamila, Talukhaba, 2000) |
| CF 21 | Project procurement system | (Zhang, Wu, 2012) |
| CF 22 | Policy implementation effort | (Tseng, Chiu, 2013, Zhang, Platten, 2011) |
| CF 23 | Legal/regulatory framework | (Zhang and Wen, 2008) |
| CF 24 | Realization of incentive policy | (Yung and Chan, 2012, Zhang and Dong, 2011) |
| CF 25 | Policy monitoring system | (Tseng, Chiu, 2013) |

The critical factors (CFs) are those key areas that significantly affect the owners' decision to adopt SC in their projects. Based on a content analysis of the relevant literature, an initial list of 25 CFs were identified and synthesized (see Table 1). Interviews were conducted in order to explore the rationality of the 25 CFs. As shown in Table 2, the interviewees have an average of around 9 years of experience in SC and are from owner and research institutions. The initial list of CFs was supplied to each interviewee prior to the interviews. The interviews were then conducted individually face-to-face in the interviewees' offices and lasted at least 30 minutes. Interviewees were asked to express their professional views on the rationality of the CFs in the context of Chinese construction industry.

The interviewees experienced no difficultiy in understanding the factors and essentially agreed with the initial list provided. Additional valuable comments were also received. For instance, almost all interviewees advised that the first CIF *Consumer acceptance of SC* should be changed to *Market demand for SC*. This is consistent with findings of Pitt, Tucker (2009) who consider that both the lack of affordability and interest in sustainability seriously affect the market demand for SC. These comments were incorporated into the final version of the questionnaire.

**Table 2.** Expert profiles

| Expert | Role | Position | Experience(years) |
|---|---|---|---|
| 1 | Owner | Senior manager | 14 |
| 2 | Owner | Senior manager | 11 |
| 3 | Owner | Project manager | 16 |
| 4 | Owner | Project manager | 12 |
| 5 | Academic | Professor | 8 |
| 6 | Academic | Professor | 6 |

### 3.2 Questionnaire design

A three-part questionnaire was designed to collect owners’ opinions on these critical factors. A clear definition of SC was provided at the beginning of the questionnaire. This was followed by Part I, which was designed to collect the demographic information of respondents, e.g. company type, position and years of experience. In Part II, respondents were asked to evaluate the relative importance of the 25 CFs on a 5-point Likert scale from 1 (“strongly disagree”) to 5 ("strongly agree”), with 3 being neutral. In Part III, respondents were asked to comment on the status of SC practices in their projects in terms of six aspects of SC (Qi, Shen, 2010). A 5-point Likert scale was used, ranging from 1 (none of the practices are implemented) to 5 (all practices are implemented)

### 3.3 Data collection

The target population of the questionnaire survey was building owners from Chongqing City, Mainland China. Chongqing is one of Municipal cities and has witnessed a rapid urbanization with associated large scale of construction activities. This presents an opportunity to minimize the negative impacts of the building industry via the implementation of sustainable construction during the rapid urbanization. Invitation letters were sent to the directors and senior executives of various owner organizations, followed by distribution of the questionnaire by e-mail or post. The survey was conducted from March to Jun 2013 using the snowball sampling method. A total of 500 questionnaires were dispatched and 148 valid responses were returned with a response rate of 29.6 %.

79.8% of respondents have more than 5 years of experience in the construction industry and 30.4% are managers. As shown in Table 3, only 11.5% of the respondents' organizations have mostly adopted SC while none reported complete adoption. This indicates a huge room for improvement in SC.

**Table 3.** Respondents' judgment of the status of SC practices in their projects

| **The status of SC practices** | **Frequency** | **Percentage** | **Cumulative percentage** |
|---|---|---|---|
| 1-- Never implemented | 2 | 1 | 1 |
| 2-- Rarely implemented | 53 | 36 | 37 |
| 3-- Partly implemented | 76 | 51 | 88 |
| 4-- Mostly implemented | 17 | 12 | 100 |
| 5-- Completely implemented | 0 | 0 | 100 |
| Total | 148 | 100 | 100 |

## 3.4 Data analysis

### *Factor analysis*

Principle component analysis (PCA) is an effective method of identifying clusters or related variables and compressing a large number of variables into a more easily understood framework (Mao, Shen, 2013). The Bartlett test of sphericity and Kaiser-Meyer-Olkin test (KMO) are widely used to test the appropriateness of proceeding with PCA. With these data, the Bartlett test of sphericity is significant at $p<0.05$ ($p<0.001$) and the KMO value is 0.749, which means that the PCA should provide valid results (Li et al. , 2011).

### *Multiple regression analysis*

Factor analysis can group the CFs into a smaller number of dimensions but provides no information concerning the most critical CFs. To achieve this, stepwise multiple regression analysis was used as in previous studies (Chan et al. , 2010, Li, Chen, 2011). In doing this, the extracted principal components are used as independent variables, and the status of SC practice is the dependent variable. The most critical CFs can be identified according to the relative significance of the extracted components and the perception of status of SC practice.

# 4. Results

## 4.1 Factor analysis

**Table 4.** Principle factor extraction and varimax rotation of SC influencing factors

| Number | Factor loading | Percentage of variance explained | Cumulative percentage of variance explained |
|---|---|---|---|
| Component 1: *Economic feasibility* | | 12% | 12% |
| CIF 5: Initial investment | 0.718 | | |
| CIF 6: Payback period | 0.71 | | |
| CIF 8: Competition | 0.674 | | |
| CIF 9: Intangible benefits | 0.669 | | |
| CIF 11: Time for SC practices | 0.668 | | |
| CIF 24: Realization of incentive policy | 0.667 | | |
| Component 2: *Awareness* | | 10% | 22% |
| CIF 1: Market demand of SC | 0.784 | | |
| CIF 2: Information/knowledge of SC | 0.758 | | |
| CIF 3: Education and training of SC | 0.75 | | |
| CIF 4: Industrial culture | 0.733 | | |
| *Component 3: Support from project stakeholder* | | 8% | 30 % |
| CIF 7: Support from financial institution | 0.79 | | |
| CIF 15: Support from professional institution | 0.77 | | |
| CIF 16: Cooperation between project stakeholder | 0.695 | | |
| CIF 19: Commit for changing behavior | 0.619 | | |
| Component 4: *Policy and regulations* | | 8% | 38 % |
| CIF 22 : Policy implementation effort | 0.856 | | |
| CIF 23: A legal/regulatory framework | 0.885 | | |
| CIF 25: Efficient monitoring system | 0.528 | | |
| Component 5: *Operability of SC* | | 7% | 45% |
| CIF 13: Standard, code and certification | 0.75 | | |
| CIF 17: Guidance of SC | 0.727 | | |
| CIF 18: Performance measurement of SC | 0.704 | | |
| Component 6: *Resource risk* | | 7% | 52% |
| CIF 12: Maturity of related technology, material | 0.739 | | |
| CIF10: Qualified workers and expertise | 0.683 | | |
| CIF14: Available of technology and material | 0.614 | | |
| Component 7: *Project management model* | | 5% | 57% |
| CIF 20: Project procurement system | 0.733 | | |
| CIF 21: Project organization structure | 0.729 | | |

Principle component analysis with Varimax rotation was carried out on the 25 CFs. As a result, 7 principle components were extracted based on the conventional rule of eigenvalues greater than 1.0 as shown in Table 4. Almost all CF loadings are greater than 0.6, except CF 25 with a factor loading of 0.528. The seven components can be termed economic feasibility, awareness, support from project stakeholders, policy and regulation, operability of SC, related resource risk, and project management model.

### 4.2 Stepwise regression

Table 5 shows the standardized regression coefficient (*β*), coefficient of determination ($R^2$), adjusted $R^2$, change in $R^2$ value ($\triangle R^2$) and significance level (*p*) upon completion of the stepwise regression analysis. *Support from project stakeholders*, *SC issues*, *Resource risks* and *Project management model* were excluded from the regression model as they failed to satisfy the entrance criterion of p<0.01, while *Economic feasibility*, *Awareness* and *Policy and regulation* were found most critical for SC adoption from the owner's perspective. Altogether, 81.2% of the variance is explained by the three factors, with *Economic feasibility* being the most important ($R^2$=0.601, $p \leqslant 0.001$), while *Awareness* and *Policy and regulation* account for 16.3% and 4.8% respectively of the variance.

**Table 5.** Stepwise multiple regression results

| Independent variable | Standardized coefficient (β) | $R^2$ | Adjust $R^2$ | $\triangle R^2$ | *p* Value |
|---|---|---|---|---|---|
| Component 1: economic feasibility | 0.844 | 0.601 | 0.601 | 0.601 | 0.000 |
| Component 2: awareness | 0.413 | 0.765 | 0.764 | 0.163 | 0.000 |
| Component 4: policy and regulation | 0.219 | 0.813 | 0.812 | 0.048 | 0.000 |

Note: dependent variable is "the situation of SC"

## 5 Discussion and implications

### 5.1 Economic feasibility

As shown in Table 4, *Economic feasibility* is the most critical CF and positively correlated with the adoption of SC from the owner's perspective (*β*=0.844). This indicates that Chinese owners pay more attention to the economics of SC. This is consistent with previous studies (Liu, Low, 2012, Shi, Zuo, 2013) that regard additional cost as the most significant barrier to green construction from the owner's perspective. It is worth noting that a Finnish study found owners perception of the risk due to lack of related experience and information to be the most crucial barrier to SC (Häkkinen and Belloni, 2011). This is probably due to the more economically developed status of Finland with a greater experience of sustainable development and a better understanding of the costs and benefits associated with SC within the industry. However, in Mainland China, SC is still in its infancy and its benefits are not well understood by owners. As a result, the higher investment involved in SC presents the biggest challenge for owners in China.

Additional cost has been recognized as one of the major barriers to SC. As pointed out by Zhang, Platten (2011), the average green premium percentage of overall project investment in China is 10.9%, which is much higher than the U.S.A's 1.84%. This indeed places extreme pressure on owner profits. The additional costs are mainly incurred by related technologies and materials that have not yet formed a matured market in China. At the moment, some owners have to be both manufacturers and purchasers in order to use related technologies and materials. For China Vanke, for example, pioneer of industrialized buildings in China, housing production costs incorporated sustainable features are 350-500 RMB per $m^2$ more than traditional houses (Zhang, Skitmore, 2014). This presents a major challenge for the use of related technologies and materials during the rapid urbanization.

It is well known that financial incentive policies provided by governments can alleviate the issues of higher initial investment, and the Chinese government has enacted a series of fiscal incentive policies since 1994. However, the effectiveness of these policies in terms of motivating owners to implement sustainable development is questionable. For example, the subsidies for two-star and three-star certified green building projects are RMB 45/m2 and RMB 80/m2 respectively based on The Opinions on Accelerating Development of Green Building in China issued by MOHURD and MOF in 2012. However, the average technological incremental costs of two-star and three-star green building are as high as RMB 207/m2 and RMB 360/m2 respectively (Sun et al. , 2008). The subsidies account for only around 20% of technological incremental costs, and one-star certified green building project costs are not covered by this scheme. Moreover, according to the *Action Plan of Green Building* issued by NDRC and MOHURD (2012), the most economic instruments (such as tariff cuts, soft loans for purchasers and award for volume ratio) for green buildings are still in the planning stage, As a result, there is only one economic instrument available, namely fiscal subsides funding. As Zhu et al. (2011) point out, there is insufficient governmental funding support accompanying the high-speed development of urbanization. In addition, the access process to fiscal subsides funding provided by government impedes the willingness of owners to adopt sustainable features in their developments. Usually, subsidy funding is not provided until about two years after the completion of projects, and then only to local governments to pass on to owners. Cash flow issues occur for owners with such a lengthy process.

To overcome this barrier, more effort is needed in R&D. Effective R&D both reduces the high cost of SC and provides more related products and technical services (Zhu, Zhang, 2011) – helping to speed up SC adoption. In China, R&D funds spent on the building sector account for as little as 0.4% to 0.6% of China's construction industry total GDP contribution (Mao, Shen, 2013). Similarly, R&D should focus more on the codes and standards of related technologies and materials. For example, the combination of space and load-bearing system through to small components within rooms lacks universal technical standards(Zhang, Skitmore, 2014), seriously impeding the development of industrialized buildings. To date, China has not even established certification criteria and systems of related materials for SC. This calls for more collaboration between R&D institutions, universities and other stakeholders for SC adoption.

### 5.2 Awareness

As shown in Table 4, awareness is positively correlated with the status of adopting sustainable features in developments ($\beta$=0.413). While the emergence of SC is essentially a result of an increasing level of awareness of the global environmental crisis, there is a general lack of awareness of SC within the construction sector, especially in developing countries. The small market demand does little to motivate owners to consider SC. Also, China has one of the highest home ownership rates in the world. Thus, migrants prefer to purchase their housing instead of renting. During the current intense process of urbanization, this results in a high demand for basic housing which, in turn, pushes property prices even higher. As a result, rather than bearing the extra capital costs associated with SC, owners prefer to gain sizable profits by buying and selling conventional buildings.

To counter this, the Chinese government has introduced several instruments to drive the development of green building. In order to enhance the awareness of SC, one approach has involved Chinese government paying more attention to market cultivation. According to the *Action Plan of Green Building* issued by NDRC and MOHURD (2012), government funded projects and public projects are compelled to meet the requirements of green building while the private-developed residential projects are encouraged by means of subsidy awards instruments. Another initiative has been the *Green Building Evaluation Results* (2008-2012), However, despite the number of projects achieving green building labeling having grown rapidly since, SC is still as low as 1% of the total construction area nationwide. One problem is that, at present, the additional cost of SC cannot be fully subsidized by fiscal incentive policies. In order to gain maximum profit, owners normally pass the extra cost to consumers. However, consumers pay more attention to the price than the quality, function and location of housing (Mao, Shen, 2013, Zhang and Dong, 2011).

There are regional differences, though. As (Shi, Zuo, 2013) reveal, more than three quarters of green buildings are located in the eastern coast provinces where the level of economic development is comparatively higher than that in western regions, such as Jiangsu, Shanghai, Guangdong (Li, Yang, 2014). One reason is that the income level of western China is much lower than that of eastern coast. As a result, the pricing capacity of western China towards green building is lower - impeding development of the SC market in this region. To date, fiscal incentive policies have not considered this unbalanced regional social-economic development. More fiscal subsides are needed for undeveloped regions such as western China, especially for privately developed residential projects. This could help to effectively narrow the gap of market development between developed and undeveloped regions.

An addition issue is that SC education and training is still lacking in China (Mao, Lu, 2011). For example, China’s university students have a relatively low level of awareness of sustainability issues(Yuan and Zuo, 2013). In general, the public perceives the responsibility for environmental protection belongs with local governments, companies and authorities. The absence of education and training for construction practitioners, students and the public does little to help transform their inherent value system. As a result, the awareness of SC is comparative low and the passive culture of profit and survival dominates the construction industry. A solution is to strengthen sustainable development related education and training by providing more training programs covering new SC methods, technology and materials for all related stakeholders as part of continued professional education. In addition, higher educational institutions could contribute by amending their curricula to incorporate principles of sustainable development to enhance the SC awareness and capabilities of students. Similarity, more SC themed seminars and conferences would provide knowledge and information sharing across the entire construction industry sector. At the same time, more demonstration projects introduced by media and professional organizations would help convince stakeholders to adopt sustainability practices.

**5.3 Legislation and regulation**

The results in Table 4 indicate that legislation and regulation are also positively correlated ($\beta$=0.219) with the status of adopting sustainable features from the owner's perspective. This is supported by previous studies which show that, although, current related legislation and regulation provide insufficient motivation (Liu, Low, 2012, Shi, Zuo, 2013), clients will be more likely to adopt SC once related legislation and regulations are in place (Elmualim, Valle, 2012, Pitt, Tucker, 2009, Shi, Zuo, 2013). These legislation and regulations target sustainability issues at both urban and project level.

In Mainland China, environmental protection has been regarded as fundamental national policy since 1983. Since then, the legal system of environmental protection has been vigorously developed and renewed, resulting in adequate set of legislation and regulation on the issue of environmental sustainability, such as *Law on Environmental Protection* (1989), *Law on the Environment Impact Assessment* (2003), *Law on the promotion of renewable energy* (2005), *Law on energy saving* (2008) and so on. However, the social and economic aspects of sustainability are comparatively undervalued in the current legal framework.

The contents of environmental sustainability are also scattered in those legislations. For instance, the *Law on the prevention and control of air pollution* (2000) focuses on the noise pollution of construction activities; the *Law on the promotion of cleaner production* (2003) emphasizes energy saving of design and construction activities; and the *law on the prevention and control of environmental pollution by solid waste* (2005) deals with the solid waste generated by construction activities. None of this legislation or regulation comprehensively contains all principles of SC. Thus, it is ineffective not only in compelling project organizations to comply entirely with SC requirements, but also for the local governments' effective enforcement. As a result, different legislation and regulations are imposed by different authorities, which creates some confusion and enforcement issues (Zhang and Wen, 2008). There is also a lack of consideration of life cycle issues, especially for the demolition phase of developments. In particular, the urban renewal projects have presented significant sustainability related challenges such as migration issues, demolition of old buildings, protection of heritage buildings as well as local culture.

In addition, some related regulatory obligations are outdated. For example, the baseline of *design standard for energy efficiency of public buildings* (GB50189, 2005) is the energy consumption of public buildings in 1980s. Reaching the energy efficiency standard does not necessarily mean the actual energy consumption is reduced by the 60% desired. At the same time, the claimed 70% compliance with the mandatory standards for new buildings in China is said to be only 30% in reality, mainly due to a weak monitoring mechanism and insufficient legal enforcement (Zhou et al. , 2013).

One approach is for the Chinese government to strengthen collaboration with industry bodies and professional organizations to review related regulatory imperatives aimed at bringing about the adoption of SC. The central government could also play a more active role in coordinating all related authorities such as MOHURD, MEP (environmental protection), NDRC and local governments. Local government, in particular, plays a crucial role in the adoption of SC, and more closely aligning their functions to SC adoption should help provide greater support and increase the effectiveness of legal enforcement.

## 6 Conclusions

Rapid urbanization provides an important opportunity for the adoption of sustainable construction in Mainland China. The adoption of SC will help to accommodate the rapid urbanization without on the cost of environment and society. However, although relatively systematic measures have been adopted by Chinese governments, the adoption of sustainability related practices by owners is generally poor. This study identifies the critical factors that impede owners in adopting sustainable practices during their developments. These include economic feasibility, awareness, legislation and regulation, support from project stakeholders, SC issues, resource risk and project management models. Of these factors, economic feasibility, awareness, legislation and regulation are the most critical. In relation to these three factors, this study implies that there is difference in the economic feasibility of SC between developed countries and developing countries. In addition, there are regional differences in Mainland China in terms of the awareness of sustainable construction. Moreover, compared with developed countries, regulatory enforcement in Mainland China produces a comparatively weaker driving force promoting sustainable construction. All of these recommended that measures should be in place with a consideration of local context to break down these key aspects of barriers.

The government plays a critical role in prompting Chinese owners to adopt SC, as they will not comprehensively implement SC without government support. Related legislation and regulations need to be amended periodically to meet the requirements of SC and more stringently enforced in order to achieve sustainable urbanization. The government could help by having a greater focus on fiscal incentive instruments, such as providing more fiscal incentive instruments, improving subsides funding, streamlining the process of funding allocation. Similarly, it would be beneficial for the financial incentive instruments to include measures for all kinds of projects and take into account China's unbalanced regional development. This should be taken into consideration during the urban and regional planning related decision making process. In addition, more R&D related to SC is needed especially in the development of codes and standards of technologies and materials. This should help in both reducing their current high cost and contribute to the sustainable development of SC market. Similarly beneficial would be the strengthening and improvement of SC education and training through professional training programs, higher education institutions and greater provision of technical information. Finally, an increased engagement and collaboration between stakeholders is needed to improve the current situation, with support from industry bodies, professional organizations, related authorities and especially local governments.

These findings provide useful inputs for the policy making process to drive owners to implement SC to facilitate a transition to low carbon urbanization. Future research opportunities exist to explore the effectiveness of measures to break down key barriers to SC implementation in consideration of the various contextual factors involved.

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