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IDENTIFICATION OF DRIVING FACTORS FOR GREEN BUILDING DEVELOPMENT IN CHINA.

Xia Wang, Hong Ren, Weiguang Cai, Yan Liu, Lizi Luo

Abstract

Green building (GB) has been actively promoted in many countries, but it has not become the mainstream in Chinese construction industry due to various reasons. This paper aims to investigate the major driving factors for the development of GB with reference of the Chinese construction market. Twenty-one factors influencing the development of GB were identified through a literature review, questionnaire survey, and face-to-face interview with professionals in the construction industry. Structural equation model was established to identify the critical driving path and three critical factors hierarchies. The result of model analysis also verifies the theoretical hypotheses that government body is the biggest motivation for the development of GB, and the path coefficient is high. The results demonstrate the necessity for the formulation of incentive policies and power of GB propaganda. We identify distinct government and market effects and then induce a government-led GB development path. These findings provide a valuable reference for government body aiming at promoting GB in the construction industry to put forward relevant policies and incentives and for the market body to understand the major driving factors and path when making decisions.

Keywords: *Green Building, Driving Factors, Driving Path , Structural Equation Modelin.*

1. Introduction

Green building (GB)development is one of the effective strategies to encourage energy conservation, and it is the best practice of the concept of sustainable building development. The Common elements of definitions of GB are: life cycle perspective, environmental sustainability, health issues and impacts on the community (Kibert 2008; Robichaud and Anantatmula, 2010; Zuo and Zhao, 2014; Pacheco-Blanco et al., 2014; Sanz-Calcedo and Pena-Corpa, 2014). The concept of GB in China was developed from "Energy-Saving and Land-Saving Residential Building" required by the central government in 2004(Ye, Cheng et al. 2013). To be specific, the GB should be energy-saving, land-saving, water-saving and material-saving, environment- benign and pollution-reducing, summarized as "Four-saving and One-benign". It is defined in Chinese national standard, Evaluation Standard for Green Building, enacted in 2006 (Jian-ping, 2010).

To create a better environment for developing GB, countries around the world began to formulate relevant standards (Li F. et al., 2014b). However, GB in China started relatively late. In 2004 with the start of Green Building Innovation Award, GB in China stepped into a comprehensive developing stage. In 2006, Evaluation Standard for Green Building was officially promulgated, and in 2008 six buildings obtained the first batch of GB certification(Figure1 is one of the green buildings). At present, at least 50% building energy efficiency is achieved in almost all regions of China. Big cities as Beijing and Shanghai are executing the standards which require at least 65%energy efficiency (Li and Wang, 2012).

Figure 1. Green Building: Shenzhen IBR Office Building.

In recent years, there have been extensive studies on GB. Most research tends to focus on evaluation and system research of GB, cost effectiveness, analysis of relevant policy and institution, full-life-cycle assessment ,and construction management of GB (Ross, López-Alcalá et al., 2007; Si-qin, 2009;Ye 2009;Chau, Tse et al., 2010; Issa, Rankin et al., 2010;Ye, 2012). However, there is little research focusing on how GB development is driven by human behavior and the critical factors driving GB development. Therefore, this article aims to identify the driving factors of GB development by stakeholders, including enterprises, government, customers and other stake-

holders(including third-party certification authority, green technology research institutes, design firms, and material suppliers). The planners and decision-makers should consider the critical path for developing GB in the planning and construction processes. The critical path depends on the driving factors of different stakeholders.

2.Driving factors for green building development

2.1. Enterprise

Schumpeter(1947) defined "entrepreneur" as a driving force of many important phenomena, such as innovation and economic development. Entrepreneurs who promote GB development include developers and contractors. Developers are the originators and investors of GB, and they play the role of primary decision makers in the process of GB development. Contractors are the main executors of GB. Therefore, the main driving factors affecting GB development from the two main bodies see as Table 1.

2.2.Government

The government is a type of system arrangement for resource allocation that serves as a substitute for the market. The problem of market allocation failure can be solved only through government intervention. As a new representative in the field of construction, GB holds a strong driving and strategic significance to the sustainable development of the construction industry. Therefore, measures taken by the government are vital to GB development. The main driving factors of the government show as Table 1.

2.3 Customers

Customers act as users of GB. The needs and desires of customers affect the behavior patterns of policy-makers. In particular, end customer demands during the early stages of GB promotion directly affect the enterprise by imposing the need to develop GB in accordance with customer demands and behaviors. Therefore, the driving factors of customers affecting GB development include three main aspects, namely, customer perceptions of GB benefit, customer demand, and environmental protection consciousness(Hoffman and Henn, 2008). (Table 1).

2.4 Other stakeholders

Other subjects include GB designers and GB technology research and development institutions. The behaviors of third-party certification authority and material suppliers also exert significant effects on the industrial chain of GB development. The behaviors of stakeholders in the industry chains determine the success or failure of the promotion of new things. Therefore, the driving factors of other stakeholders affecting GB development present as Table 1.

3. Methodology

3.1.Theory of Planed Behavior

Behavioral science, which emerged in the 1930s, is a new branch of science that studies human behavior(Fishbein and Ajzen, 1977). The main subjects of behavioral science are individual behavior, group behavior, and organizational behavior. Organizational behavior is the most important among the three because it is based on individual and group behaviors(Ajzen, 1991).

This study mainly analyzed the driving factors affecting behavior. GB development was considered a form of behavior. All bodies involved were assumed to affect the development of this behavior. We studied the driving factors of GB development and classified the main factors into four items, namely, enterprise, government, customer, and other stakeholders. According to Lewin's equation(1946), in this work, B represents the willingness and behavior related to green building development(WBRGBD); P represents the driving body involved GB development, including enterprise (P1), government (P2), customer (P3), and other stakeholders (P4); the interaction between the main body(P) and environment (E) is the driving factor of behavior.

According to the theory of planned behavior, the WBRGBD are driven by the forces of the enterprise, government, customers and other stakeholders.

Latent variables	No.	Driving factors	Main sources
enterprise	A1	Corporate social responsibility	(Li Y. et al 2014,Isa et al 2013)
	A2	sustainable development strategy and value orientation of the GB of the enterprise	(Li Y. et al 2014, Kasai and Jabbour 2014)
	A3	incremental cost	(Hoffman and Henn 2008,Ying Liu et al 2012)
	A4	financing channels	(Lam et al 2010)
	A5	economic benefits	(Lam et al 2010)
	A6	green construction technology	(Li Y. et al 2014)
	A7	management mode	(Kasai and Jabbour 2014, Hwang and Ng 2013)
	A8	talent training for green building	Li Y. et al 2014,Kasai and Jabbour 2014
	A9	correct market forecast of enterprise	Chan and Chow 2013
government	B1	formulation of incentive policies	Ying Liu et al 2012
	B2	perfection level of mandatory policies	Ying Liu et al 2012
	B3	power of GB propaganda	Moon 2007
	B4	evaluation of the standard GB criteria system	Li F. et al 2014
	B5	capacity of policy implementation	Chan et al 2009
consumer	C1	customer perceptions of GB benefit	Chan and Chow 2013, Chan et al 2009
	C2	customer demand	Li F. et al 2014
	C3	Environmental protection consciousness	Chan and Chow 2013
other stakeholder	D1	the professional knowledge and skill level of designers	Ying Liu et al 2012, Chan et al 2009
	D2	sense of achievement of green technology research and development institutions	Chan et al 2009
	D3	social responsibilities and value orientation of third-party institutions	Li F. et al 2014
	D4	social responsibilities and value orientation of material suppliers	Haffman and Henn 2008

Table 1. Overview.

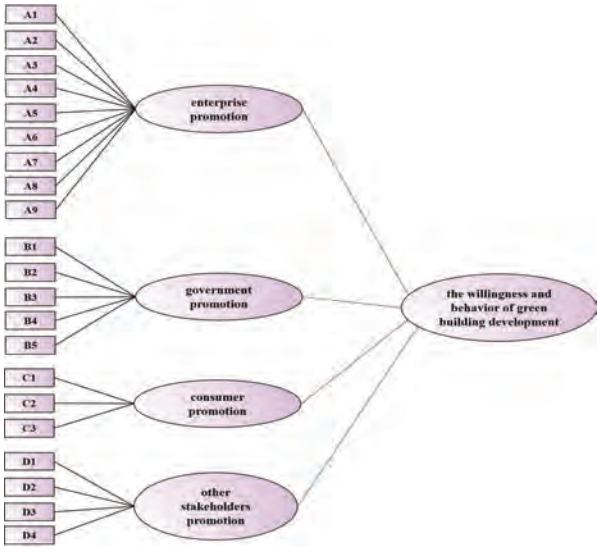

Figure 2. Theoretical model of Green building development and willingness of behavioral drivers.

In this section, the relationships of these four forces with the WBRGBD were verified. Figure 2 illustrates the established analysis model.

We proposed the following hypotheses related to the interaction among the five latent variables:
H1: Enterprise promotion exerts a significant influence on the WBRGBD
H2: Government promotion exerts a significant influence on the WBRGBD
H3: Consumer promotion exerts a significant influence on the WBRGBD
H4: Other stakeholder promotion exerts a significant influence on the WBRGBD

3.2. Structural Equation Modeling

Structural Equation Modeling (SEM) is widely used to explore and test the relationships among different constructs in the social sciences(Hair et al., 2012). SEM can create variable that cannot be observed directly but must be studied and discussed as a latent variable, which can be reflected by a variable that can be observed directly. SEM combines the advantage of factor analysis and path analysis, and it compensates for their disadvantage. The assumption limitation of path analysis has no effect on SEM. Thus, it provides the direct effect, indirect effect, and total effect of independent variables on dependent variables (Ozorhon et al., 2008, Leung et al., 2011)

SEM is used in a wide range of applications in construction research (Xiong et al., 2015). Aibinu and Al-Lawati(2010)developed a theoretical structural model representing the effect of six latent variables on the willingness of construction organizations to participate in e-bidding. (Mohamed, 2002) used SEM to test the research model on the causal relationship between safety climate and safe work behavior. (Wong and Cheung, 2005) determined the priorities of all parties in a partnering model by establishing SEM, which affects the success of partnering model; they also conducted a factor analysis of factor indexes and path analysis.

3.3 Data Collection

A formal questionnaire survey was conducted to solicit opinions from the target respondents.Out of 400 questionnaires sent out,192 were returned with valid responses, accounting for a response rate of 48%. Of these, only 29% of the respondents had experience on GB projects, which demonstrates the slow development speed of GB. The respondents were asked to evaluate the degree to which each item was a promotion to GB development using a five-point Likert scale in which 5 represented "strongly promotion,"1 represented "low promotion", and the middle position (3) was neutral.

The SEM established in this study consisted of a measurement model and structural model. According to the SEM requirement for sample data, the feasibility of sample data must be verified before running the model. Reliability test, validity test, factorial analysis were used to verify the data in this study. 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 varied from 0.727 to 0.892, which was higher than the 0.5 threshold, indicating that the five-point scale measurement was reliable at the 5% significance level (Pallant, 2001). KMO and Bartlett were used to decide whether sample data are suitable for factorial analysis. The test result of this paper was 0.892, which means factorial analysis is suitable (Kaiser, 1974).Therefore, the collected sample can be treated as a whole, and is thus suitable for SEM analysis.

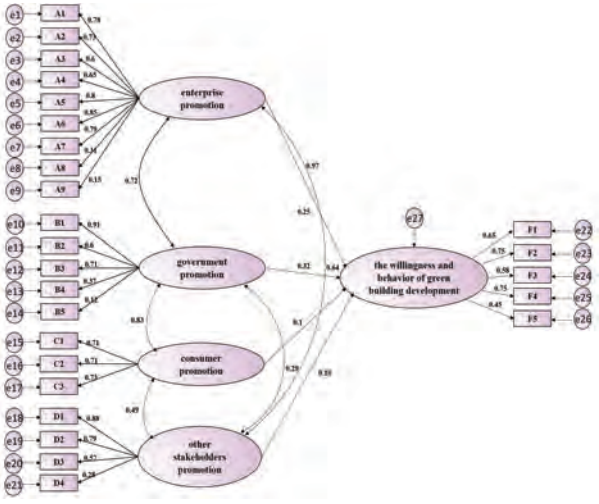

Figure 3. Initial structural equation model.

4. Survey result

The standardized structural diagram of the path coefficient of the initial model was created by importing the data from the questionnaire to AMOS19.0. The initial model (Figure 3) was evaluated on the basis of the output of the software.

This study used maximum likelihood estimation to conduct the SEM model test.Using AMOS19.0, the indexes P of enterprise promotion and customer promotion were 0.072 and 0.094, respectively. This observation indicated that both factors exerted zero influence on the target variable. However, in theory, government promotion and customer promotion can absolutely affect the target variable. Such reality reveals the existence of a certain flaw in the initial model and the need for further improvement.

Table2 and Figure 4 show the final results of this model after modification. The chi-square value was 730.638, which was considerably smaller than the χ^2 value of the initial model. Except for AGFI and PGFI, all fitting indices were qualified according to the reference standard. The structural equation was established on different theoretical bases; thus, the priorities of the selected fitting indices were also different. Therefore, according to the analysis of the structural equation, not all the indices must be qualified by the

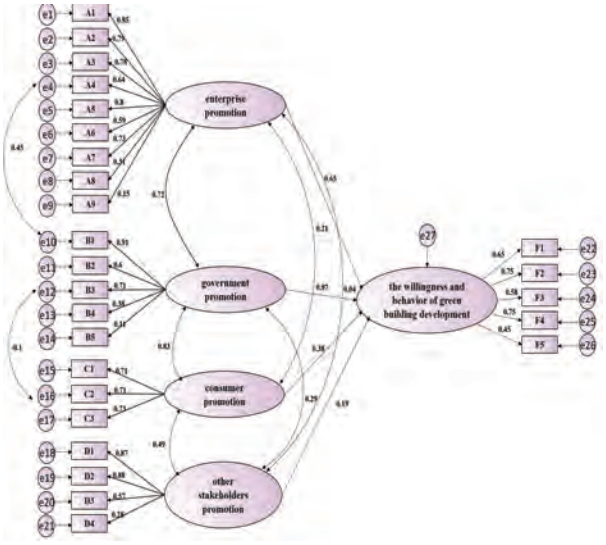

Figure 4. Modified Structural Equation Modeling.

reference standard. Few unqualified indices are acceptable. According to the above analysis, the fitting effect of the modified model in this study is preferable. The sample data and the hypothesized model fit well.

Table 3 shows the direct effect, indirect effect and total effect among latent variables. For example, "Enterprise promotion → WBRGBD" shows that enterprise promotion influences the WBRGBD. The result is shown in the form of a direct effect of 0.651 and a total effect of 0.651. This finding indicated that if other conditions remain unchanged, then a 1 unit increase in enterprise promotion can cause a 0.651 unit increase in the WBRGBD.

As shown in Table 3, the four latent variables indicated total path influences of 0.651, 0.972, 0.382, and 0.293 on WBRGBD. If other conditions remain unchanged, then the four major promotions of the different driving forces could influence WBRGBD. For the index of driving factors of the WBRGBD, the third level of driving factors is not significant according to Cohen's criteria (Cohen, 1988); thus, these factors are not key driving factors.

5.Conclusion

This paper provides a comprehensive explanation of the public perception of GB in China and the driving factors to its development. The factors driven GB development are further analyzed by employing SEM method, thus providing a clear understanding of the interrelationship between these bodies and factors. The SEM offers a choice priority of improving GB development. GB development is affected differently by the 21 driving factors. Formulation of incentive policies and power of GB propaganda provide a most effective measure for improving GB development and. This paper contributes to the existing literature by focusing on the perspective of different bodies, who are the key decision-makers regarding the development of GB. In particular, the results support the view that government behavior is the biggest promotion for

Fit index	χ^2/df	AGFI	PGFI	NFI	RFI	IFI	TLI	CFI	PNFI	PCFI	RMESA
result	2.546	0.728	0.636	0.910	0.958	0.990	0.948	0.986	0.603	0.667	0.076

note1:χ2- value=730.638，df=2

Table 2. Goodness of Fit.

Relationship among variable	Directly effect	Indirectly effect	Total effect
Enterprise promotion →WBRGBD	0.651		0.651
Government promotion →WBRGBD	0.972		0.972
Consumer promotion →WBRGBD	0.382		0.382
Other stakeholder promotion →WBRGBD	0.293		0.293

Table 3. Direct, indirect, total effect.

Factors hierarchy	Driving Factors	Value	Sequence
First level	B1	0.67785	1
	B3	0.69355	2
	B2	0.582	3
	A1	0.55055	4
	A5	0.5187	5
	A2	0.5135	6
	A3	0.50765	7
	A7	0.4719	8
	A4	0.4147	9
	A6	0.3848	10
	B4	0.35308	11
Second level	C2	0.285	12
	C3	0.26904	13
	C1	0.26866	14
	D1	0.25346	15
	D2	0.23142	16
	A8	0.20475	17
Third level	D3	0.16501	18
	B5	0.1067	19
	A9	0.09685	20
	D4	0.08062	21

Table 4. Final SEM Results.

the development of GB. Therefore, promoting GB in China highlighted from the viewpoint of government is significantly important.

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