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Effects of Project Manager Competency on Green Construction Performance: The Chinese Context

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Abstract: Project manager competency is a key factor determining the success of a project. With the deterioration of the environment, green buildings have come into being. Compared to traditional buildings, green buildings encounter more complex problems during the construction process, and project managers are faced with greater challenges. Existing research on the evaluation of project manager competency based on green building construction (GBC) is scarce. Thus, the aim of this paper is to evaluate project manager competency for green construction. By means of a literature review and a focus group meeting, the key success factors of green buildings and project manager competency were determined. Thereafter, a questionnaire survey was used to investigate people's understanding of the importance of project manager skills. Structural equation modeling was selected to test the hypotheses. The results demonstrate that China is in the infancy of GBC development. Leadership and organization, target management, and emotional intelligence of project managers are considered to be important factors that affect green construction performance. The results of this study provide a theoretical basis for the selection of excellent project managers for GBC.

Keywords: green building construction; project manager; project manager competency

1. Introduction

Traditionally, the construction project management system has been very complete. Significant attention is paid to the management of the planning and the implementation of the established target; that is, the management and control activities surrounding the three major construction objectives, which are time limit, quality, and cost. As the core figure of the temporary organization and the construction project management activities, the contractor project manager (hereinafter referred to as the project manager) management ability and knowledge reserve will have a significant effect on the project efficiency [1]. Moreover, the project manager is responsible for communication and coordination with stakeholders, such as the owner and supervisory agencies, and it needs to lead the project team and promote sincere cooperation among members [2]. Their level of competence therefore has a significant impact on the project performance [3]. Therefore, the determination of the competence of project managers is a prerequisite for selecting qualified project managers, thereby promoting successful project implementation.

With the rapid development of social economy, resource shortages and environmental degradation problems have become primary obstacles to social development, with the construction industry facing increasingly serious resource and environmental problems [4]. The construction industry consumes a high amount of energy and other natural resources, which have a significant effect on the environment,

economy, and society [5]. Research of Ürge-Vorsatz shows that between 2010 and 2050, global heating and cooling needs are expected to increase by 79% in residential buildings, and by 84% in commercial buildings [6].

Under the current background, sustainable development strategies have become a common topic in China and the world. The concept of green building emerged by introducing the meaning of sustainable development into buildings [7]. Furthermore, China is in a period of accelerated urbanization and industrialization, as well as improved living standards, and the per capita increase in energy consumption greatly aggravates the negative impact of the construction industry on energy consumption and environmental pollution. As a result, green building has received extensive attention and has been developing rapidly [8]. From 2010 to 2016, a total of 2720 green buildings were certified in China, of which 370 were certified by Leadership in Energy & Environmental Design (LEED) [9]. Research on green buildings is also emerging, with a great deal of research on green building evaluation criteria, purchase intentions, and development obstacles. However, research on project manager competency remains in the stage of traditional construction projects. In GBC development, project managers can also transform the project to achieve improved productivity by their style and manner of managing the project.

Compared to traditional buildings, green buildings encounter more complex problems during the construction process, and project managers face additional challenges. In terms of project objectives, green buildings must accomplish additional goals in comparison to traditional buildings, namely energy, land, water, and material savings, as well as environmental friendliness [8]. Energy saving and water resource recovery technologies are also important technical indicators for green building [10]. Project managers may be confused by new designs, complex construction methods, and green material shortages [11]. Furthermore, as the number of project members and participants increases, the communication scope between project managers will be expanded further. Faced with the complicated construction process, the professional competency of project managers is particularly important for the realization of project objectives. There will be different requirements for project manager competence based on the green construction. Owing to the delayed start of green buildings in China, research in this area is still lacking. Thus, this article aims to determine the key success factors for green building construction (GBC) by means of the literature research method, followed by the identification of the project manager competency for construction. Thereafter, the research is designed to construct a model for studying project manager competency in GBC in order to answer the following question:

Does the project manager competency affect the achievements in the success of GBC?

2. Literature Review

2.1. Green Building

Sustainable development and environmental protection have become a major focus for the Chinese government. Existing buildings consume a high amount of energy and materials, while the greenhouse gases released are also significant [12]. In order to meet the demands of society and reduce the energy consumption of the construction industry, green building emerged as a solution during the green movement from the 1970s to 1980s [7]. Attempts have been made to determine alternative means of traditional construction, aimed at saving energy and reducing environmental pollution. Accordingly, GBC is an important means of reducing environmental pollution and improving quality of life [13]. Green building is one of measures been put forward to mitigate significant impacts of the building stock on the environment, society, and economy [14]. During design and construction, green buildings use recycled materials, less water, less energy, and resource efficient techniques, thereby reducing the impact on the environment [15]. In this paper, green building refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout

the building life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition [16].

The key success indicators of green building projects have a wide range of definitions and various systems, because of the differences in cultural and climatic conditions in every country or region. However, through the literature analysis, it was found that various definitions of the key success indicators of green building projects have the same values; that is, minimal destruction of the environmental system. As the first environmental certification system, Building Research Establishment Environmental Assessment Method (BREEAM) was established in the United Kingdom in 1990. It mainly includes the following nine aspects: management, health, and comfort, energy, transportation, water, materials, land use and ecology, garbage, and pollution [17]. The Leadership in Energy & Environmental Design (LEED) rating system, which is the most widely used in the world, consists of seven systems and numerous indicators, namely sustainable building sites, water efficiency, energy and atmosphere, resources and materials, indoor air quality, innovations in design, and regional priority [18]. Several other evaluation systems exist, such as the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, the German Sustainable Building Council (DGNB) in Germany, and the Building Environmental Assessment Method (BEAM) in Hong Kong, which are based on similar key indicators. Various scholars have studied the green building key success indicators based on the above evaluation systems. The majority of the research has been aimed at identifying the key success factors of green building from the perspective of the entire life cycle. However, the object of this study is the contractor project manager, and in identifying key success indicators for green buildings, the author focuses on analyzing and studying the relevant aspects of green construction. Kibert introduced seven principles for implementing sustainable construction practices: conserving to minimize resource consumption, reusing to maximize the reuse of resources, recycling to use renewable or recyclable resources, protecting nature, using nontoxic materials to create a healthy, nontoxic environment, economic benefits (to apply life cycle cost analysis), and providing quality products [19]. High-performance green buildings provide improved indoor environmental quality and reduced energy consumption, resulting in lower operational costs, easier learning and healthier environments in schools, higher productivity for office employees, and reduced sick time for occupants in all building types [10]. The development of sustainable buildings should also consider the site conditions, vegetation, pollution, and other building characteristics [20]. When Tabassi studied the problem of project manager leadership in sustainable building projects, he summarized the success indicators of green buildings in six parts: energy efficiency, indoor environmental quality, sustainable site planning and management, materials and resources, water efficiency, and innovation [3]. Mattoni made a comparative study of various evaluation systems and defined six new macro-aggregation areas (site, water, energy, comfort and safety, materials and outdoor quality) [21]. Ye studied the development of green building standards in China, where 17 national and trade standards as well as more than 50 local standards exist [22]. Among all of these evaluation standards, the Evaluation Standard for Green Building (GB/T50378-2014) is the most popular, and includes construction management, land use, outdoor environment utilization, energy saving, material saving, water saving, indoor environmental quality, and operation management.

The above green building evaluation criteria and key success indicators have encouraged developers to reduce the degree of environmental damage and save energy. Accordingly, when determining the key success indicators, the author considers the relevant aspects of the contractor project manager. Compared to traditional architecture, the key success factors for green construction include cost, duration, and quality, among others. The reasons for the selection are as follows. (1) The following four key success indicators can reflect the objectives of the construction project objectives; (2) These factors all appear in the green building evaluation system. In order to obtain LEED or BREEAM authentication, the building must meet these standards following the completion of construction; (3) These indicators respond to the requirements of the Chinese government in terms of saving materials and reducing energy consumption; (4) The "land saving" index was not included

because it was determined by the architect at the design stage. The final four green building key success indicators are displayed in Table 1.

Table 1. Key success factors for evaluating green buildings used in this study.

Key Success Indicators
Energy efficiency (EE)
Saving water (SW)
Resources and materials (RM)
Indoor environmental quality (IEQ)

2.2. Competencies of the Project Manager in Construction

In order to meet the new demands for saving energy and environmental friendliness in the construction industry, there has been increasing attention within research and development on the need to improve the performance of construction project managers. This attention stems from the influence of the project manager competency and authority on the project performance [23]. Despite the rapid developments in science and technology, construction remains a human-intensive industry, with the majority of the project manager focus still being on the organization and the management of staff [24]. Project managers possess different working backgrounds and cultural knowledge, and their competencies should be standardized. The manner in which to select an effective project manager has always been a hot topic in the engineering management field. The review of project manager competencies indicates that this has been broadly studied in numerous fields, such as human resource management and organization management.

Several versions of the definition for the project manager competencies exist: the project manager competency development (PMCD) defines three project manager competency areas, namely knowledge, performance, and personal competencies [25]. The American Society of Civil Engineers (ASCE) has created 24 basic competencies for an engineer, such as problem recognition and solving, risk and uncertainty, project management, communication, public policy, business and public administration, globalization, leadership, teamwork, attitudes, lifelong learning, and professional and ethical responsibility [26]. Dainty developed a competency-based framework for performance in projects, which includes information seeking, team leadership, and impact and influence [1]. In an interview with Perini, who is the commissioner of the Division of Capital Asset Management (DCAM), he mentioned the top 10 qualities of project managers, such as possessing superior technical skills, building and maintaining effective team dynamics, communicating effectively, working hard, focusing on client needs, making safety a top priority, remaining calm under pressure, always asking the right questions, and taking responsibility and appropriate risks in order to achieve excellence and leadership [27]. According to the context of western scholars' research, the author proposed two dimensions of project manager competencies, which are basic literacy (BL) and target management (TM). In PMBOK, the definition of "project manager" is described first, and the basic literacy of the project manager are further proposed. The competencies of these two dimensions mainly measure the work ability and knowledge level of project managers. Now there are regulations (People's Republic of China Certified Constructor) in China, only registered constructor can be a project manager. But the conditions for registering a constructor are very broad, anyone with an engineering or economic degree can apply. Based on the current situation in China, Zhang proposed a popular competency system for project managers in China, including four dimensions and 18 indicators [28]. ZHANG emphasized that Chinese companies valued leadership and organization skills (LO) and emotional intelligence (EI) in selecting project managers [28]. Therefore:

This article proposes four dimensions for the competency index of project managers: leadership and organization, basic literacy, target management, and emotional intelligence. The proposed competencies of the project manager as shown in Table 2.

In this study, leadership and organization refers to a competency that integrates the members of the project department and let them work efficiently under the correct leadership. Leadership is considered a major factor in promoting project success. Leadership and organizational competency are regarded as essential skills for project managers, and also applicable in green building projects. In a construction project, as a temporary organization, the ability to work within a team is the most basic and necessary competency for project managers [29]. Engaging in communication is also a skill that the project manager must have. Communication or social skills means that individuals possess the ability to interact with customers and other stakeholders effectively [30]. In the construction process, communication has always been the driving factor of the project, where both making goals and solving conflict need to be communicated with employees. Coordinating work among departments is also an important task for the project manager. Zhang's research demonstrated that the project manager needs to communicate and coordinate the internal needs of the project team with other stakeholders, such as real estate developers, supervision units, subcontractors, and other stakeholders. Therefore:

Hypothesis 1 (H1). *The leadership and organization of the project manager has a positive effect on the success of GBC.*

Basic literacy is defined as the professional learning background for project managers, including the ability to continue learning. In China, project managers should be familiar with two aspects of knowledge in civil engineering and management [31]. Construction is a project-oriented industry that benefits from both the technical and interpersonal skills that a project manager has to offer [32]. Project managers must have the opportunity to receive education and attend training courses so that they can update their skills. Therefore, the technical skills and learning abilities of project managers have been identified as factors contributing to project success [33]. The professional knowledge that a project manager needs to master includes primary civil engineering technology, project evaluation review technology (PERT), knowledge regarding engineering costs, and contract management, among others. Benjaoran proposed the use of a 4D CAD model to achieve comprehensive safety management in construction projects [34]. The competency statement above is mainly concerned with the project internal environment. Understanding the project external environment also forms part of the inevitable work of a project manager during the construction process. With the rapid development of information technology and the emergence of affordable, high-performance computers, a great deal of information is obtained, and it is necessary for project managers to identify useful information rapidly and respond in a timely manner [35]. The above skills are regarded as the basic literacy of project managers. Thus, the following hypothesis is suggested. Therefore:

Hypothesis 2 (H2). *The basic literacy of a project manager has a positive effect on the success of GBC.*

In addition to the coordination and management of project participants, the project manager must control the important project nodes, in order to deliver in accordance with the expected target. In PMBOK, target management is divided into three chapters, which are time, quality, and cost. Resource management (including construction equipment and materials) and financial management are key points in project management, and should be included in the project manager competencies [36]. However, conflicts, and risks in the construction industry are important factors leading to high construction costs [8,37]. Thus, in order to prevent the increase in construction costs and delays of the time limit, the project manager should focus on avoiding conflict and risk. Health and safety management can also save lives and money [38]. Therefore:

Hypothesis 3 (H3). *The target management competency of a project manager has a positive effect on the success of GBC.*

In addition to the above common competencies, project managers should also possess emotional intelligence, which may also affect the project manager performance. Boyatzis demonstrated that

competencies are behavioral manifestations of emotional intelligence [39]. Certain factors relating to the emotional intelligence of a project manager are analyzed in the following paragraphs.

Table 2. Proposed competencies of the project manager.

Components	Attributes	References
Leadership & organization	Co-operation	[47–51]
	Engaging in communication	[30,49,51,52]
	Teamwork	[26,29,49,53]
	Conflict management	[36,37,49]
Basic literacy	Professional knowledge	[49,54–56]
	Information seeking and management	[49]
	Learning	[32,33,49]
Target management	Resource management	[36,49]
	Financial management	[36,49]
	Risk management	[8,49,51,57]
	Health and safety management	[34,38,49]
Emotional intelligence	Interpersonal skills	[40,41]
	Emotional control ability	[42–45]
	Guanxi management	[46,58]

Interpersonal skills: Traditionally, research in the project management field has tended to focus on the application of construction technology, but has neglected to pay attention to the management of people and interpersonal relationships. The social interaction of project relations in the development of construction projects is essentially emotional, and the ensuing emotion plays an important role in the project process [40]. Employees from the same construction project have different educational backgrounds and cultural knowledge. In order to achieve a project goal within a short period, the project manager needs to establish strong relationships with the key members quickly. Effective interpersonal relationships have a positive impact on the leadership of project managers [41]. The interpersonal relationship skills of project managers are mainly reflected in their ability to perceive employees' feelings and thoughts, and being able to listen to other people's suggestions for making appropriate decisions in a timely manner so that they can maintain strong relationships for a lengthy period.

Emotional control ability: Studies have shown that the most important factor affecting project progress is management skills, rather than construction technology issues [42]. In recent research, the emotion of project managers has been emphasized as the core factor influencing the manner in which leaders manage daily work [43]. The Mayer–Salovey–Caruso emotional intelligence test (MSCEIT) measures the managing emotions in two branches: emotional and social management [44]. The author believes that emotional management can be divided into two aspects: emotional self-management and regulating employee emotions so that they have a positive attitude towards work. The ability of project managers to understand and control their own and employee emotions affects the quality of their relationships with internal and external stakeholders [45], thereby affecting the management efficiency of the project manager.

Guanxi management ability: Understanding and adapting to local culture is also a necessity for project managers. The environment of China is a human society, in which "Guanxi" represents the basic connections among Chinese people, which are trained into their interactions every day, including their relationships with family, friends, and business partners [46]. The social relationships of project managers are extensive and complicated, such as maintaining long-term cooperation with suppliers. Therefore:

Hypothesis 4 (H4). *The emotional intelligence of a project manager has a positive effect on the success of GBC.*

2.3. Index Revision and Establishment of Structural Equation Modeling

In addition to conventional construction procedures, green building projects must implement sustainable construction practices, which are typically listed in the green building evaluation system, such as LEED. By reviewing the relationships between the project manager competencies and key success criteria for green building, it was found that research in this field is very scarce. The success of a green building project is strong linked to the leadership of project managers. A case showed that a well-designed construction project failed due to improper management by the project manager. On 15 November 2011, a high-rise fire broke out in the Jing'an District of Shanghai, because of the confusion of construction site management and the appointment of unlicensed technicians by project managers. Zhao identified the leadership characteristics and styles of project managers in Singaporean green building projects, such as striving for work performance and productivity, exhibiting strong concern for work tasks, and directing subordinates with clear roles and goals [59]. Tabassi noted that transformational leadership, managerial competency, and intellectual competency are all essential for sustainable building success [3]. Hwang placed emphasis on the management of green buildings, including high cost premium, unequal distribution of benefits, lack of green product information, complex legislation, and lack of awareness [60]. Owing to the lack of relevant research literature, the author invited five experts in GBC for an interview. The purpose of this interview was the correction and evaluation of the project manager competencies proposed above, in order to achieve scientific results in data analysis, and to improve the reliability and validity of the measurement scales. According to the expert discussions, the final index system was deleted based on the original and added systems. The experts provided a basic affirmation of the initial recognition index. They believed that the above abilities could summarize the capability requirements of the construction project manager. "Health and safety management" was removed, as all experts held the view that the project manager had done a good job for the health and safety management of workers in the traditional construction process, and the construction technology of the green building was complex but not highly dangerous. Three experts pointed out that, during the GBC process, the manager should pay attention to national policies and regulations. For project managers, another very important ability is to understand the relevant policies and regulations accurately and to have knowledge of the industry development trends. Brill suggested that project managers need to "know the politics and future" in a study on efficient project managers [61]. The author made another investigation to verify the saturation of factor list attained from the previous expert interview. The survey was conducted among the other 10 experts in project management research areas. The background information of the 10 experts was displayed in Table 3 After investigation, the 10 experts did not propose any additional factors. Therefore, the final project manager competency factors were reasonable. The final project manager competencies included 14 items, as indicated in Table 3.

Table 3. Final project manager competency factors.

Components	Number	Attributes
Leadership & Organization	No. 1	Co-operation
	No. 2	Engaging in communication
	No. 3	Teamwork
	No. 4	Conflict management
Target management	No. 5	Resource management
	No. 6	Financial management
	No. 7	Risk management
Basic literacy	No. 8	Information seeking and management
	No. 9	Learning
	No. 10	Know the politics and future
	No. 11	Professional knowledge
Emotional intelligence	No. 12	Interpersonal skills
	No. 13	Emotional control ability
	No. 14	Guanxi management

Moreover, the structural equation model (SEM) corresponding to the hypothesis was established, as illustrated in Figure 1. In the constructed structural equation, four dimensions for the project manager competency and success factors of GBC were regarded as latent variables, with each factor considered as an observation variable.

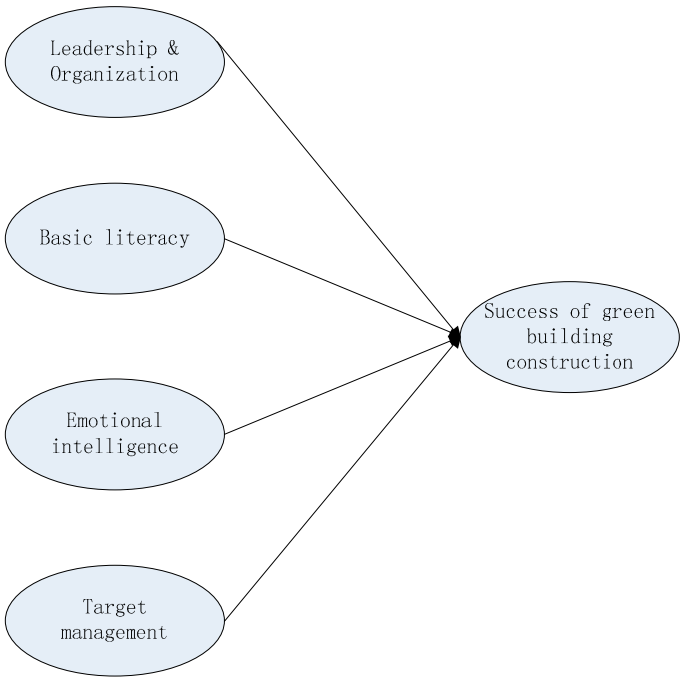

Figure 1. Proposed research model.

3. Research Methodology

3.1. Data Collection

A questionnaire survey was implemented for data collection, and the questions were divided into three parts. The first part investigated the basic information of the respondents, such as the working category, number of working years, education level, and their experience of participating in GBC. The second part was for measuring the indicators selected by the means of the literature review. The manner of asking questions was as follows: Compared to traditional buildings, do you think this factor is more important for a project manager? In the designed questionnaire, the proposed project manager competency indices were measured by items evaluated on five-point Likert scales, where "1" = very unimportant, "2" = unimportant, "3" = commonly, "4" = important, and "5" = very important. The success indicators of the GBC were measured using the same method. The third part investigated the respondent understanding of the questionnaire and provided the opportunity for several suggestions.

The target population of the questionnaire survey were professors and all practitioners in the industry. The collection of questionnaires was divided into two channels. The first channel was through publishing the questionnaire on the Internet and sending the link to construction industry practitioners, from which 173 responses were collected. The second channel was through distributing the questionnaire to professionals and graduating college students through e-mails. A "snowball sampling" strategy was adopted by inviting respondents to distribute questionnaires to their classmates at the same time. From these two channels, a total of 296 responses were collected. Thereafter, the questionnaire was filtered to ensure the data quality. Questionnaires that were blank or contained incomplete information were deleted, so the final effective questionnaires totaled 262, and the effective response rate was approximately 88.5%.

3.2. Data Analysis Process

The collected data were analyzed using SEM with the AMOS 20 software. Prior to testing the structural equation, the data reliability and validity had to be tested, for which SPSS software was used. As the Cronbach's α value was 0.887, which is higher than 0.7, it was considered that the data reliability was satisfactory. After testing the data reliability and validity, the next step was to conduct confirmatory factor analysis (CFA). In factor analysis, CFA is used to test whether measures of a construct are consistent with researcher understanding of the nature of that construct [62]. The final step was to construct the SEM, test the model goodness of fit, and determine the regression weight of the factors.

4. Results and Discussion

4.1. Respondent Profiles

The background information of the 262 respondents is displayed in Table 4. The number of female respondents was slightly higher than that of male respondents, accounting for 51.91%. Among the respondents, construction engineers, professors, and students were the main components, accounting for 67% of the total number. Over 60% (66.41%) of the respondents had less than five years of work experience. Moreover, 32.06% of the respondents were grass-roots managers of enterprises, accounting for a larger proportion of the total. A total of 35.11% of the respondents had been involved in GBC, with working experience.

Table 4. Background information of respondents.

Variable	Category	Frequency	Percentage (%)	Cumulative Percentage (%)
Gender	Male	126	48.09	48.09
	Female	136	51.91	100
Working category	Real estate enterprise	32	12.21	12.21
	Construction engineering	72	27.48	39.69
	Engineering consulting	40	15.27	54.96
	Engineering supervision	8	3.05	58.01
	Supplier	6	2.29	60.3
	Professors and students	104	39.7	100
Working experience	0–5	174	66.41	66.41
	6–10	20	7.63	74.04
	11–15	18	6.87	80.91
	16–20	12	4.58	85.49
	>20	38	14.51	100
Position	Senior manager	18	6.87	6.87
	Middle managers	56	21.37	28.24
	Grass-roots managers	84	32.06	60.30
	Others (professors and students)	104	39.70	100
Experience participating in green building	Yes	92	35.11	35.11
	No	170	64.89	100

4.2. Confirmatory Factor Analysis

Factor analysis can reduce the numbers and recombination of factors according to the scores of each factor. However, prior to carrying out factor analysis, the Kaiser-Meyer-Olkin (KMO) test is required to determine whether the data is suitable for factor analysis. In this research, the value of the KMO index was 0.919 (greater than 0.7), indicating that the data were suitable for factor analysis. The SPSS22.0 software was used to conduct the factor analysis. Principal component factor analysis with Varimax rotation conducted on the 14 project manager competency factors produced four underlying components, and the results are displayed in Table 5. During the CFA, the observed variables with factor loadings of less than 0.5 were considered as insignificant contributors

to the components. From Table 6, the results of the factor analysis conformed to the settings of the structural equation.

Table 5. Factor loadings of competency factors.

Code	Factors	Components			
		1	2	3	4
No. 2	Engaging in communication	0.81	0.26	0.34	0.17
No. 3	Teamwork	0.69	0.48	0.22	0.25
No. 4	Conflict management	0.68	0.43	0.28	0.30
No. 1	Co-operation	0.60	0.26	0.49	0.32
No. 9	Learning	0.18	0.76	0.33	0.24
No. 7	Professional knowledge	0.32	0.76	0.17	0.25
No. 8	Information seeking and management	0.46	0.65	0.15	0.33
No. 10	Know the politics and future	0.24	0.61	0.37	0.27
No. 14	Guanxi management	0.20	0.31	0.83	0.15
No. 13	Emotional control ability	0.26	0.33	0.79	0.24
No. 12	Interpersonal skills	0.53		0.70	0.24
No. 11	Risk management	0.17	0.18	0.21	0.87
No. 6	Financial management	0.14	0.28	0.19	0.76
No. 5	Resource management	0.36	0.29	0.16	0.75

Table 6. Background information of experts.

Variable	Category	Frequency
Gender	Male	2
	Female	8
Working Category	Real estate enterprise	2
	Construction Engineering	3
	Engineering consulting	2
	Professors	3
Working Experience	0–5	3
	6–10	2
	11–15	4
	16–20	1

The four extracted components represent several dimensions of project manager capability, namely leadership and organization, basic literacy, emotional intelligence, and target management. Although these components do not contain all project manager capability factors, they covered almost all of the important factors.

4.3. Structural Equation Modeling

By means of the CFA, this study aimed to reduce and regroup the factors. This was a necessary analysis for the next step, to determine which areas of the project manager competencies are more important. In order to solve the research problem "does the competency of the project manager affect the achievement in the GBC success," four hypotheses were proposed. The structural model was implemented using AMOS 22.0 to test for the goodness of fit statistics. The goodness of fit results for the initial model are displayed in Table 7.

Table 7. Goodness of fit of initial model.

Goodness of Fit Measure	Level of Acceptance Fit	Fit Statistics
Chi-square/(degree of freedom)	<5 acceptable; <3 good	3.642
Goodness of fit index (GFI)	>0.8 acceptable; >0.9 good	0.848
Adjusted goodness of fit index (AGFI)	>0.8 acceptable; >0.9 good	0.792
Relative fit index (RFI)	>0.9	0.876
Normed fit index (NFI)	>0.9	0.898
Comparative fit index (CFI)	>0.9	0.924
Root mean square error of approximation (RMSEA)	<0.1 acceptable; >0.08 good	0.100

Based on the test for the goodness of fit statistics, the test results of the initial model were not ideal. Four indicators reached acceptable levels, while three indicators not meeting the standard. The values of AGFI, RFI, and NFI were close to the standard, with only a small difference. The regression weights in the initial model are displayed in Table 8, where only the path BL→GBC was insignificant. The modification indices of the regression weights are presented in Table 9. After applying the modification indices, two covariance links were added, which were the paths e1↔e4, and e1↔e2. Subsequently, the value expressed an improved model fit, as presented in Table 10. Among the seven fit indices, five indicators reached an acceptable level, while one indicator reached an effective degree, only RFI has not reached the acceptable level. The author believes that the model can continue to be used, as per the following discussion.

Table 8. Regression weights in the initial model.

			Estimate	S.E.	C.R.	P
GBC	←	LO	0.49	0.074	5.99	***
GBC	←	TM	0.302	0.038	6.739	***
GBC	←	BL	0.108	0.079	1.49	0.136
GBC	←	EI	0.203	0.05	4.13	***
X3	←	LO	0.867			
X2	←	LO	0.852	0.058	18.539	***
X1	←	LO	0.847	0.054	18.328	***
X4	←	LO	0.871	0.056	19.352	***
X11	←	TM	0.838			
X6	←	TM	0.75	0.07	13.576	***
X5	←	TM	0.864	0.061	16.445	***
X10	←	BL	0.743			
X9	←	BL	0.784	0.078	12.757	***
X8	←	BL	0.841	0.076	13.766	***
X7	←	BL	0.818	0.086	13.355	***
X14	←	EI	0.839			
X13	←	EI	0.898	0.064	18.233	***
X12	←	EI	0.843	0.066	16.598	***
EE	←	GBC	0.87			
SW	←	GBC	0.818	0.052	17.747	***
RM	←	GBC	0.881	0.053	20.484	***
IEQ	←	GBC	0.786	0.055	16.512	***

Note: *** Significance level of 0.05.

Table 9. Modification indices of the regression weights for the initial model.

			M.I.	Par Change				M.I.	Par Change
e2	↔	e12	31.816	0.102	e13	↔	BL	6.887	0.03
e12	↔	LO	30.413	0.075	e14	↔	e13	6.807	0.036
e8	↔	e12	28.134	−0.099	e4	↔	e5	6.744	0.047
e2	↔	e1	20.571	0.079	e4	↔	e19	6.723	−0.043
e12	↔	BL	19.395	−0.056	e2	↔	TM	6.546	−0.054
e1	↔	EI	17.016	0.061	e2	↔	e13	6.385	−0.041
e1	↔	e4	16.638	−0.067	e8	↔	e13	6.348	0.042
e3	↔	e7	15.841	−0.073	e12	↔	EI	6.294	−0.037
e6	↔	e15	13.904	0.04	e11	↔	EI	6.271	0.044
e11	↔	e9	13.798	−0.067	e14	↔	e12	6.27	−0.039
e13	↔	LO	12.07	−0.042	e2	↔	LO	6.069	0.034
e3	↔	e4	12.02	0.054	e2	↔	e14	5.557	−0.039
e3	↔	e1	11.734	−0.052	e10	↔	e14	5.465	0.039
e2	↔	e10	11.385	−0.062	e7	↔	e5	5.389	0.047
e6	↔	e5	11.238	−0.083	e10	↔	e18	5.352	−0.033
e7	↔	e19	10.609	−0.062	e5	↔	LO	5.19	0.033
e1	↔	e14	9.971	0.05	e7	↔	TM	4.898	0.049
e6	↔	e19	9.354	0.07	e3	↔	e12	4.894	−0.035
e7	↔	LO	9.009	−0.047	e9	↔	e16	4.884	−0.027
e19	↔	BL	8.909	0.036	e4	↔	e16	4.718	0.028
e9	↔	e8	8.729	0.049	e5	↔	e16	4.623	−0.03
e3	↔	EI	8.379	−0.04	e10	↔	e19	4.582	0.037
e13	↔	e16	8.308	−0.034	e4	↔	e9	4.515	0.033
e2	↔	e6	8.247	−0.071	e11	↔	e10	4.507	0.043
e11	↔	e16	8.171	0.044	e11	↔	e13	4.449	0.038
e9	↔	e19	7.584	0.042	e1	↔	LO	4.372	−0.027
e3	↔	e5	6.929	0.045	e9	↔	EI	4.295	−0.029
e6	↔	e10	4.12	0.05	e1	↔	e18	4.28	0.027
e17	↔	EI	4.185	0.027					

Table 10. Goodness of fit of final model.

Goodness of Fit Measure	Level of Acceptance Fit	Fit Statistics
Chi-square/(degree of freedom)	<5 acceptable; <3 good	3.038
Goodness of fit index (GFI)	>0.8 acceptable; >0.9 good	0.859
Adjusted goodness of fit index (AGFI)	>0.8 acceptable; >0.9 good	0.804
Relative fit index (RFI)	>0.9	0.884
Normed fit index (NFI)	>0.9	0.907
Comparative fit index (CFI)	>0.9	0.932
Root mean square error of approximation (RMSEA)	<0.1 acceptable; >0.08 good	0.086

The final SEM is illustrated in Figure 2, and the hypothesis test results are presented in Table 11. The paths GBC←LO, GBC←EI, and GBC←TM were significant, while only the path GBC←BL was not significant (P = 0.497). This also demonstrates that H1, H3, and H4 were supported by the data, while H2 was not supported by the sample data in this model. The following conclusions can be drawn from this study. The leadership and organization of the project manager has the greatest impact among the factors affecting the success of GBC. Emotional intelligence and target management competencies of project managers have a positive effect on the success of GBC. The basic literacy of a project manager was negated in this test, and has no positive impact on the success of GBC.

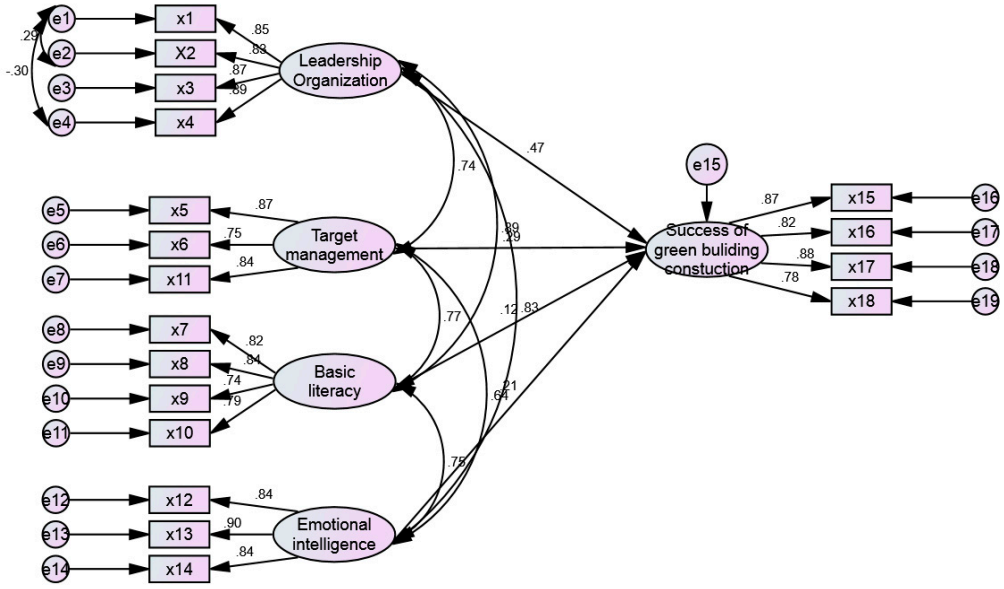

Figure 2. Results of final model.

Table 11. Hypothesis results for structural model.

Hypothesis	Path Correlation	Estimate	P	Result
H1	GBC←LO	0.471	***	Supported
H2	GBC←BL	0.124	0.089	Not supported
H3	GBC←TM	0.290	***	Supported
H4	GBC←EI	0.214	***	Supported

Note: *** Significance level of 0.05.

4.4. Discussion

The leadership and organization of project managers is positively related to the success of GBC. Hypothesis 1 mentioned that leadership and organizational competency are regarded as essential skills for project managers, and also applicable in green building projects. At present, the development of green buildings in China is not mature. Investors are not fully aware of green construction technology, and there is a lack of green builders who have been professionally trained. This requires project managers to pay more attention on their leadership and organization skills, to achieve the goal that all kinds of employees can together efficient work. Leadership is also part of the project manager's work, as evidenced by the human resource management and team communication management of the projects mentioned in PMBOK. In addition, the emergence of green construction creates new job opportunities [5]. For example, the use of solar energy on construction sites, as well as the reduction and reuse of construction waste, require professional technical personnel for operation. This in turn requires the project manager to deal with queries from developers and solve personnel assignment problems of the construction project. In order to solve disputed problems efficiently, the project manager must establish a strong communication mechanism with the supplier and supervisor, all of whom depend on the project manager's leadership and organization. Therefore, the test results of H1 conform to reality.

The target management of project managers is positively related to the success of GBC. The cost premium of green building projects is mostly reflected during the construction process, such as the need for expensive construction machinery and new green materials. The test results of the data are supported by the financial management and material management competency of the project managers, as mentioned in Hypothesis 2. Moreover, risk factors, including currency exchange rate fluctuations arising from the purchase of imported materials, may also result in a financial crisis [8]. During the construction preparation stage, the project manager should create a perfect plan for

funds in order to avoid the occurrence of fracture of the capital chain, leading to a project shutdown. Furthermore, the project manager should formulate strict rules for the use and storage of materials and equipment. During the process of GBC, increased attention should be paid to the use and storage of green materials [63], a conclusion that is supported by the survey data in this study.

The emotional intelligence of the project manager is positively related to the key success factors of GBC. This is consistent with Dulewicz's research findings, which shows that good interpersonal relationships with employees help project managers handle their tasks more efficiently [36]. During the GBC process, the project manager is at the core of the social network. In China, current green building projects are dominated by the government, and the project manager's communication will therefore be extended further to include communication with the government. PMBOK also involves the management and interpersonal skills of project stakeholders. Compared to traditional construction projects, the project manager will be responsible for more complex social interactions. In addition, the environment of Chinese architecture is a human society [58], and strong interpersonal relationships aid project managers to work efficiently. In China, Guanxi management has always been a hot topic in the academic field of project management. Experts believed that Guanxi management is an art that project managers should master [64]. Therefore, for Hypothesis 3, the data test results are in line with the actual situation.

There is no positive correlation between the basic literacy of the project manager and the success of GBC. For this test result, a small scope of the expert demonstrations was carried out, among which there were two professors in colleges and universities, three from company. The expert group pointed out the following. Firstly, as green building has only recently begun in the Chinese market, the majority of project managers do not have experience of green construction and do not possess basic knowledge of green building. Secondly, in the actual management process, the main responsibility of the project manager is to organize and coordinate the employees involved in the GBC and control the five major management objectives of the project (cost, time, quality, safety, and information). The specific green construction technology and operating regulations are controlled by the general workers and professional technical team leaders. Thirdly, most project managers lack the initiative to learn. Without the government's mandatory requirement of learning green construction technology, the project manager may overlook the concept of self-improvement. Among the respondents, more than half were employees, who held negative attitudes towards lifelong learning and self-improvement. The results are in accordance with the data test results.

5. Conclusions

Excellent project managers are a prerequisite for the successful implementation of projects, and an important guarantee for successful construction projects. However, with the continual emergence of environmental problems, the advocacy of green building projects is rapidly increasing. Existing research on the evaluation of project manager competencies based on GBC was scarce. Thus, the aim of this paper was to evaluate the competency of the project manager for green construction.

By means of the literature review and the focus group meeting, the key success factors for GBC were determined, including energy efficiency, saving water, resources and materials, and indoor air quality. Thereafter, the practical skills of contractor project managers were determined, consisting of four aspects: leadership and organization, basic literacy, target management, and emotional intelligence. Based on the above factors, the author constructed four hypotheses. An SEM was constructed and the corresponding hypothesis was proposed. Finally, the test results were analyzed and discussed. Leadership and organization, target management, and the emotional intelligence of project managers were considered to be important factors affecting the green construction performance.

At the beginning of green building development in China, the selection of the project manager should prioritize a manager who is effective in leadership and organization, target management, and emotional intelligence. During the later period, the continued training and education of project managers should be considered as a key factor.

Finally, owing to the limitation of the numbers and areas of the questionnaire, the research results may not fully summarize the development trends of all regions in China. With the further development of green buildings and the popularization of green construction, future research can further discuss the effect of project managers' basic literacy in GBC projects.

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