Critical Success Factors in Thailand's Green Building Industry

Wenxin Shen¹, Wenzhe Tang*,², Atthaset Siripanan³, Zhen Lei¹, Colin F. Duffield⁴, David Wilson⁵, Felix Kin Peng Hui⁶ and Yongping Wei⁷

¹ Ph.D. Candidate, Institute of Project Management and Construction Technology, State Key Laboratory of Hydroscience and Engineering, Tsinghua University, China
² Associate Professor, Institute of Project Management and Construction Technology, State Key Laboratory of Hydroscience and Engineering, Tsinghua University, China
³ Graduate, Institute of Project Management and Construction Technology, State Key Laboratory of Hydroscience and Engineering, Tsinghua University, China
⁴ Professor, Department of Infrastructure Engineering, The University of Melbourne, Australia
⁵ Lecturer, Department of Infrastructure Engineering, The University of Melbourne, Australia
⁶ Senior Research Fellow, Department of Infrastructure Engineering, The University of Melbourne, Australia
⁷ Associate Professor, School of Geography, Planning and Environmental Management, The University of Queensland, Australia

Abstract

The promotion of Green Buildings (GB) has become a global trend that improves resource efficiency and the well-being of societies. The development of GB still encounters different obstacles in developing countries. The critical success factors of GB and their relationships with GB certification levels in Thailand have been investigated. The relationships between the competence of individual project participants and competence of project team at different GB certification levels are also analyzed. The results reveal the underlying patterns of the overall picture of the GB industry in Thailand, and suggest that all project participants should continuously improve their competences via technical and management innovation for delivering affordable and sustainable products, thereby making green buildings more available and appealing to the public. This study provides empirical evidence for all project participants to adopt appropriate team building strategies and optimally allocate their resources to achieve the suitable GB certification levels.

Keywords: Green building; Success factors; Leadership in Energy and Environmental Design (LEED); Thailand's Rating of Energy and Environmental Sustainability (TREES)

1. Introduction

Green Buildings (GB) are being globally recommended for their potential to improve natural resource efficiency, decrease operation costs, and create a healthier built environment for users (USGBC 2015). With the rapid development of worldwide GB markets, various GB rating systems have been created and form the basis for designing, constructing and maintaining and evaluating GB. Leadership in Energy and Environmental Design (LEED) is one of the most well-known and successful GB rating systems, and has been widely adopted in over 140 countries around the world, including Thailand.

The adoption of green building concepts in the rapidly growing Asian markets is especially noteworthy (Chan et al. 2009). Many developing countries in Asia have witnessed major progress in green building development, for example, up until 2015, the Indian Green Building Council LEED-INDIA program saw some 664 Indian buildings achieve LEED certification (USGBC 2016). Malaysia has launched its own green building rating system — Green Building Index in 2009, which was developed based on LEED and was adapted specifically to Malaysia's tropical climate, environmental and developmental context, cultural and social needs (Chua and Oh 2011). The National Green Technology Policy, an important policy for green building development in Malaysia was also launched in 2009 (Samari et al. 2013).

Similar to the above developing Asian countries, Thailand is following the global trend in developing their green building industry on the basis of LEED (Wethyavivorn et al. 2009). After the first green building project in Thailand received certification from LEED in 2007, 165 projects have been registered with LEED until 2015 (USGBC 2016). Modified

*Contact Author: Wenzhe Tang, Associate Professor, Department of Hydraulic Engineering, 212 Room, New Hydraulic Building, Tsinghua University, Beijing 100084, China
Tel: +86-10-62794324 Fax: +86-10-62794324
E-mail: twz@mail.tsinghua.edu.cn

(Received April 6, 2016; accepted March 10, 2017)
DOI http://doi.org/10.3130/jaabe.16.317
from LEED to fit Thailand's environment, Thailand's Rating of Energy and Environmental Sustainability (TREES) has also been launched as Thailand's own green building rating system by Thai Green Building Institute in 2010 (Srimalee 2014). The number of green buildings applying for TREES has risen quickly with 63 projects awarded TREES certifications since 2012. This indicates that TREES is playing a more and more important role in the green building industry of Thailand (TGBI 2015). With great growth potential in the green building market, Thailand, along with other developing countries in Asia will need strategies for delivering green buildings. This research will be useful in understanding the factors responsible for successful GB ratings.

2. Literature Review
The delivery of green building projects is a multi-organization process involving players such as designers, contractors, and GB consultants. Designers, defined here as building designers and structural engineers, need to consider the impact of the building elements on the green building system as a whole and choose among alternatives to arrive at the optimal solution (Chan et al. 2004). GB consultants play an important role in understanding the owners' expectations, carrying out feasibility studies, determining green building objectives, and analyzing energy use in order to select appropriate materials and offering guidance on the application of green building standards (Bayraktar and Owens 2010). Contractors execute and complete the works by efficiently transforming various resources into green deliverables (Inayat et al. 2015). It is essential that these project participants are competent to complete their green building tasks (Isik et al. 2009). As the complexity of green buildings increase, interdisciplinary interactions during project implementation and close cooperation among participants is necessary to form an integrated project team. Effective communication enables fast problem solution (Hwang and Ng 2013). Enhancing the competence of a project team can also help to achieve green building project goals.

Many studies have investigated the critical success factors (CSFs) for delivering construction projects (Inayat et al., 2015; Hwang and Ng, 2013; Li et al. 2011, 2014; Kog and Loh, 2012; Vallance et al., 2011; Korkmaz et al., 2010; Chan et al., 2009; Beheiry et al., 2006; Riley et al., 2004; Ling et al., 2004; Chan et al., 2004; Smith, 2003; Thomas et al., 2002; Chua et al., 1999; Konchar and Sanvido, 1998). Specifically, Chua et al. (1999) identified that socio-political environment, relationships among stakeholders, and competences of project manager, designer, and contractor are critical to construction projects. Korkmaz et al. (2010) explored the important factors for sustainable high-performance construction projects and found that the key stakeholders' early involvement in projects is one of the important indicators influencing project performance. Li et al. (2011) indicated that support from senior decision makers, innovative technological approaches, external environment, and project team motivation are the critical project management factors for Green Mark certified projects in Singapore. Kog and Loh (2012) distinguished the importance of factors from different perspectives of stakeholders, and pointed out that competence of stakeholders, project team motivation, socio-political environment, and project size are influential in project delivery. Chan et al. (2009) suggested that innovative technological approaches and project team motivation are necessary to reduce possible cost in green building projects.

By reviewing the literature, it is evident that the most relevant CSFs differ from various perspectives. From a holistic view, this study extracts 16 critical success factors for developing green buildings on the basis of the above literature review, which are summarized in Table 1.

Table 1. Critical Success Factors of Green Buildings Identified from Relevant Literature

<table>
<thead>
<tr>
<th>Success factors</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competence of project manager</td>
<td>Hwang and Ng, 2013; Chua et al. 1999</td>
</tr>
<tr>
<td>Competence of GB consultant</td>
<td>Inayat et al., 2015</td>
</tr>
<tr>
<td>Competence of contractor</td>
<td>Kog and Loh, 2012; Inayat et al., 2015; Chua et al., 1999</td>
</tr>
<tr>
<td>Competence of designer</td>
<td>Chua et al. 1999; Riley et al., 2004</td>
</tr>
<tr>
<td>Support from senior decision makers</td>
<td>Li et al., 2011</td>
</tr>
<tr>
<td>Relationships among stakeholders</td>
<td>Chua et al., 1999</td>
</tr>
<tr>
<td>Innovative technological approaches</td>
<td>Li et al., 2011; Chan et al., 2009</td>
</tr>
<tr>
<td>Early involvement of stakeholders</td>
<td>Korkmaz et al., 2010</td>
</tr>
<tr>
<td>Competence of project team</td>
<td>Beheiry et al., 2006</td>
</tr>
<tr>
<td>Project team motivation</td>
<td>Kog and Loh, 2012; Li et al., 2011; Chan et al., 2009</td>
</tr>
<tr>
<td>Communication among participants</td>
<td>Hwang and Ng, 2013</td>
</tr>
<tr>
<td>Advanced machinery and equipment</td>
<td>Li et al. 2014</td>
</tr>
<tr>
<td>External environment</td>
<td>Li et al., 2011</td>
</tr>
<tr>
<td>Socio-political environment</td>
<td>Kog and Loh, 2012; Vallance et al., 2011; Chua et al., 1999</td>
</tr>
<tr>
<td>Type of the project</td>
<td>Konchar and Sanvido, 1998; Thomas et al., 2002; Ling et al., 2004</td>
</tr>
<tr>
<td>Project size</td>
<td>Kog and Loh, 2012; Smith, 2003</td>
</tr>
</tbody>
</table>

Previous studies demonstrate that the successful development of green buildings requires consideration of multiple factors: markets, technology, environment, society, and management at project, organizational and national levels (Zuo and Zhao 2014; Love and Edwards 2012; York and Horman 2009; Riley and Horman 2004). However, these studies mainly focused on developed countries and regions, and did not address the issues detailed above for developing countries.
Thus, the aim of this research is to systematically investigate the critical success factors of green building projects in Thailand via an industry survey, thereby helping project participants to adopt optimal strategies in successful delivery of green buildings in emerging markets in developing countries. Specifically, the survey tries to answer the following research questions:

• What are the importance of the critical success factors of green buildings in Thailand?

• What is the relationship between the critical success factors and GB certification outcomes?

3. Research Methodology
3.1 Questionnaire Survey
A questionnaire was used as the data collection method. The questionnaire was divided into three parts. The first part related to the respondents’ general information such as the role of work, professions, and experience involved in green buildings. The second part required the respondent to give a specific green building project's characteristics, including location, type of rating systems, project classification, type of owners, and delivery method. The third part asked respondents to evaluate 16 success factors on 5-point Likert scale. These success factors were drawn from the literature.

Up until 2015, there were 165 and 63 GB projects in Thailand had registered with LEED and TREES, respectively (USGBC 2016; TGBI 2016). The questionnaires were sent to professional consultants and designers (architects and engineers) with experience in LEED or TREES projects in Thailand. There were a total of 70 questionnaires sent out, by email and personal delivery. 38 questionnaires were received, with an acceptable response rate of 54.3%. 52.6% of respondents have more than five years work experience in green building industry. More than 40% of the respondents are architects, while engineers and GB consultants account for 28.9% respectively. Considering the total number of green building projects in Thailand, the distribution and green building experience of the respondents could, to a large extent, be taken to be representative of the whole green building industry in Thailand.

3.2 Performance Measurement of Green Building Projects
GB certification levels are used to measure green building performance in Thailand. The required scores of each certification level and their classification criteria are shown in Table 2.

<table>
<thead>
<tr>
<th>Certification Level</th>
<th>TREES score</th>
<th>LEED score</th>
<th>%</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified Level</td>
<td>30-37</td>
<td>35-44</td>
<td>40-49</td>
<td>36-44</td>
</tr>
<tr>
<td>Silver Level</td>
<td>38-45</td>
<td>45-53</td>
<td>50-59</td>
<td>45-54</td>
</tr>
<tr>
<td>Gold Level</td>
<td>46-60</td>
<td>54-71</td>
<td>60-79</td>
<td>55-72</td>
</tr>
<tr>
<td>Platinum Level</td>
<td>61+</td>
<td>72</td>
<td>80+</td>
<td>73</td>
</tr>
<tr>
<td>Total score</td>
<td>85</td>
<td>100</td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>

4. Survey Results
4.1 Descriptive Statistics of Sampled GB Projects
Characteristics of the 38 sample projects are summarized, which serves as the background for interpreting the following survey outcomes. The proportions of the investigated cases choosing LEED and TREES as their rating systems are 55.3% and 44.7%, respectively. As for GB certification level, certified level and gold level account for 36.8%, respectively, followed by platinum level (21.1%) and silver level (5.3%). When it comes to building type, the majority of projects are office buildings (52.6%), followed by commercial buildings, (21.1%) educational buildings (13.2%), and residential buildings (10.5%). Most of the cases used DBB project delivery approach (81.6%), while 18.4% of the investigated projects adopted design and build (DB) approach.

4.2 Critical Success Factors of Green Building
The respondents were asked to rate the importance of the identified CSFs in green building projects on a five-point scale, ranging from "1 = not important" to "5 = very important". The results are presented in Table 3.

As seen in Table 3, overall, competence of GB consultant, competence of designer, competence of project teams, and competence of contractor are the top four factors. These show that not only the competence of individual participant but also the integration of the project team are critical in fulfilling planning, design, and construction tasks of green building at different stages. It is notable that economic
environment is ranked as the fifth important factor, which shows that external economic conditions can greatly impact the green building industry. Good global and local economic climates can create new demand and supply in a green building market. This will stimulate developers’ investment in green building projects and relevant technical innovation, as the increased purchasing power can facilitate the investors in obtaining satisfactory paybacks.

5. Data Analysis and Discussion

5.1 Factor Analysis on CSFs of Green Building

To discover the underlying patterns of CSFs of green buildings, factorizing the CSFs above into a smaller number of groupings is necessary (Wong and Cheung, 2004). The results of factor analysis are presented in Table 4. The KMO value of the CSFs is 0.592 and the significance level of Bartlett's test of sphericity is 0.000 (p < 0.01), indicating that the data were suitable for factor analysis.

Based on eigenvalues-greater-than-one (Evelyn et al., 2005), after Varimax rotation, five underlying components were extracted, and these components cumulatively explain 72% of the total variance. These five components are discussed below.

(1) Competence of Project Participants

Competence of project participants consists of competences of project manager, GB consultant, contractor, designer, and project team, accounting for 16.78% of the total variance. GB consultants play a critical role in understanding owners’ expectations, and transforming them to specific requirements and objectives. Designers (including architects and engineers) need to conduct integrated building system design by considering sustainable site development, energy and water efficiency, use of green material, and indoor environmental quality. Accordingly, contractors execute and complete the works for the purposes of the green building. Each participant's competence is significant to fulfill the specific tasks in delivering green building projects. Compared to conventional projects, implementation of green building projects will encounter problems arising from use of new technologies and materials (Li et al., 2014). This requires project participants to cooperate with each other in facilitating project team's capability, which significantly depends on the competence of the project manager. The project manager may face various...
challenges in a green building project, such as longer time, higher cost, and construction conflicts (Hwang and Lim, 2013). In dealing with these challenges, the project manager should be skilled in planning, organizing, leading, and controlling the processes of green building project, thereby enhancing the overall capability of project team in problem resolution.

(2) Integration of Project Team

Integration of a project team includes relationships among participants, communication among participants, early involvement of key participants, and support from senior decision makers. Green strategies increase complexity of project delivery, requiring increased interdisciplinary interactions among participants to find optimum solutions (Korkmaz et al., 2013). Good relationships form the foundation to integrate diverse GB project activities by facilitating the resource inputs of participants. In integrating various resources, efficiently sharing project information in the team is critical, which is largely decided by the effectiveness of the communication among the participants. Open communication can not only help team members understand an owner's expectations and participants' specific requirements but also assist in implementation of the generally interdependent processes of design, procurement, and construction.

Early involvement of the key participants is an important attribute of green team integration, which can greatly facilitate designers to seek cost effective solutions by a value engineering approach with added information from the key players. Support from senior decision makers is also critical to integrate the project team. The team leader plays the role in facilitating inter-organizational cooperation, communication, and coordination by chairing a design charrette, value engineering, and seeking ways of resolving key project problems. Moreover, with the support from senior decision makers, necessary resources such as money, manpower, and equipment can be efficiently allocated and integrated in the implementation processes of green building projects. This is in line with the finding that continuous support by senior management of the owner is a critical success factor in green buildings (Aktas and Ozrhon, 2015).

(3) Technical and Management Innovation

Technical and management innovation contains project team motivation, innovative technological approaches, use of advanced equipment and materials. After the contracts have been awarded, the project team can be assembled to achieve the goals of green building. However, the priorities of participants are different, which is attributed to the fact that each party tends to focus on its specific task (Tang et al., 2006). Even if an alternative is suitable to one participant from an isolated perspective, it may not be an optimum option from a holistic viewpoint (Bayraktar and Owens, 2010). Therefore, owners need to motivate the project team to closely cooperate with each other through using incentives. Financial incentives may not only encourage participants to establish links across organizational boundaries, for efficiently sharing project information, but they can also ensure the participants have the necessary resources to continually seek better ways to achieve project goals with high performance (Tang et al., 2008). The owner's willingness to allocate a higher budget in green building than in a conventional building can greatly encourage the project participants to use innovative green technologies, and apply advanced equipment and materials. In the long term, good performance and technological advancement can help participants to win an owner's trust and to improve their industry image, thereby obtaining more business opportunities in the future. Most of the cases were based on selective bidding/​prequalification or negotiation in awarding contracts (see Table 4.), showing that good reputation can assist designers and contractors to expand their share of the green building market in Thailand.

(4) External Environment

External environment includes the socio-political environment, and economic environment. These factors are closely related to society's attitude towards green products, government's involvement, and status of the economy. Higher upfront cost can significantly affect a society's keenness for green building, as the public lack real knowledge on the improved performance of green building such as energy saving, increased water efficiency, and better indoor air quality. A society's preference largely decides the market demand which is the key driver for an owners' investment in green buildings. The economic environment can also have significant impact on development of green building. Good economic conditions can not only improve an owners' financial capacity in project development, but also enhance the purchasing power of the green building market. Notably, 73.7% of the surveyed cases were invested by private sectors (see Table 4.), indicating that the green building market in Thailand can provide satisfactory products to consumers and create feasible financial return to investors.

Government can play an interface role in many aspects for promoting green building, such as public education, regulatory support for project development permission, tax deductions, and financial incentives for green technological advancement. For instance, the new City Planning Act in Thailand is an effective stimulus for green building, which provides the developers with incentives such as giving them more space for construction. In addition, government can directly invest in green building projects. For example, 26.3% of the investigated cases were developed by public sector, which boost the green building industry in Thailand.

(5) Project Characteristics

Project characteristics contain type of the project, and project size. Different types and sizes of the project require different design and construction skills
and different management strategies. As shown in Table 4, 52.6% of the investigated cases are office buildings, which have the largest share in the green building market in Thailand. 86.8% of the investigated cases were new construction which is attributed to the fact that the green strategies can be cost effectively executed from early stages. Nevertheless, renovation buildings account for 13.2% of total share, indicating that there is a considerable market need to change conventional buildings to green buildings in Thailand. The surveyed cases are medium to large in size, with many standardized units such as office, commercial, educational, and residential buildings. This enables green equipment and materials to be used on a large scale, which facilitates reducing the cost of green buildings.

5.2 Competence of Individual Project Participants and Project Team

As competence of project participants and integration of project team account for large shares (16.78% and 15.68%) of the total variance of the CSFs, the relationships between the competence of individual project participants and competence of project team have been further analyzed. The data is dissected by examining the same relationships at the different certification levels. Results of stepwise regression analysis of different green certification levels are presented in Table 5. The data for Silver certification level could not be used as there were only two data points (N=2) and thus this group was excluded from the analysis. The analysis using for Gold level certification showed no statistical significance between project participant and team competence.

Finding 1: At all certification levels (Certified, Silver, Gold and Platinum), the project manager’s and GB consultant’s competence are positively correlated with the project team’s competence (significant at p < 0.05 and p < 0.01, respectively), as shown in Table 5. The results confirm the critical role of the project manager in integrating various project participants’ resources to jointly resolve the GB project problems as a team (Hwang and Lim 2013). The results also demonstrate that GB consultant’s competence is important to the project team competence. As GB industry is emerging in Thailand, knowledge of GB may not be a mandatory requirement to the designer, engineer, and contractor.

Table 5. Results of Stepwise Regression Analysis of Different Green Certification Levels

<table>
<thead>
<tr>
<th>Certification Level</th>
<th>Variable</th>
<th>B</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>All levels</td>
<td>Competence of project manager *</td>
<td>0.343</td>
<td>0.350</td>
</tr>
<tr>
<td></td>
<td>Competence of GB consultant **</td>
<td>0.392</td>
<td></td>
</tr>
<tr>
<td>Certified Level</td>
<td>Competence of designer *</td>
<td>0.746</td>
<td>0.519</td>
</tr>
<tr>
<td>Platinum Level</td>
<td>Competence of contractor **</td>
<td>0.866</td>
<td>0.708</td>
</tr>
</tbody>
</table>

Note: *** = Correlation is significant at 0.01 (two-tailed); ** = Correlation is significant at 0.05 (two-tailed).

Finding 2: At the basic certification level (Certified), the designer’s competence is positively correlated with the project team’s competence (significant at p < 0.01), as shown in Table 5. This could be attributed to that it is strongly influenced by the specific strategy chosen by the owner, who considers that acquiring the basic certification level is adequate. To achieve the basic certification level, the project team only need to reach 36%-44% of the total scores of the rating system. This can be reached by emphasizing the role of the designer and focusing on the design-related considerations.

Finding 3: At the highest certification level (Platinum), the contractor’s competence is positively correlated with the project team’s competence (significant at p < 0.01). This could indicate that the GB project teams rely more on a contractor at the highest level where the certification involves meeting a wider range of requirements. All of the eight aspects of certification such as water efficiency, energy and atmosphere, materials and resources, and indoor air quality, must be well performed to achieve more than 72%-73% of the total scores of the rating system. In these circumstances, the competence of the contractor related to executing the intentions of the designer become more prominent in the project team to meet high standards of GB.

5.3 The CSFs and the GB Certification Levels

The critical success factors are further investigated to see if there are significant relationships with the GB certification outcomes. Multiple linear regression was used to test the relationships between them, with the results shown in Table 6.

The results of the stepwise regression analyses on green building project performance are displayed in Table 6. Only three components, competence of project manager, project team motivation, and competence of designer were found to be statistically significant (p < 0.01). Project team motivation has the highest β of 0.544. The β for competence of project manager and competence of designer are 0.464 and -0.446, respectively. The adjusted R² of these three factors is

Table 6. Results of Stepwise Regression Analysis of Green Certification Levels

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>B</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Competence of project manager **</td>
<td>0.426</td>
<td>0.159</td>
</tr>
<tr>
<td>2</td>
<td>Competence of project manager *</td>
<td>0.372</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>Project team motivation*</td>
<td>0.348</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Competence of project manager **</td>
<td>0.464</td>
<td>0.398</td>
</tr>
<tr>
<td></td>
<td>Project team motivation**</td>
<td>0.544</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Competence of designer**</td>
<td>-0.446</td>
<td></td>
</tr>
</tbody>
</table>

Note: ** = Correlation is significant at 0.01 (two-tailed); * = Correlation is significant at 0.05 (two-tailed).
The success of a GB project largely depends on a project team's motivation. Such motivation requires structured initiatives such as use of incentives to align the organizations and individuals' objectives. Appropriate incentives can not only motivate the project team to work together but also ensure project participants to have necessary resources to fulfill the tasks in delivering GB projects. Thus, it is not surprising that the team motivation is closely related to certification outcome.

Finding 5: The competence of the project manager is positively correlated with the certification level (significant at p < 0.01). This means that higher competence of the project manager can lead to higher certification level. This is not a surprising observation given that the project manager often has the task of integrating the project team, pushing for solutions to problems that arise. At higher certification levels where requirements are greater and more stringent, this job becomes increasingly important.

Finding 6: The competence of the designer is negatively correlated with the certification level (significant at p < 0.01). This could be due to that acquiring the basic certification level is adequate for developer's need. The project team tends to input the limited resource in order to obtain 36%-44% of the total scores, in which the designer plays a critical part. To get a higher certification level, however, other project participants' competence become more prominent. For example, since GB industry is emerging in Thailand, contractors may be unable to implement the designer's intentions on use of innovative materials such as green roof and wall due to lack of green technical skills, which may restrict the project team to obtaining the higher scores of the GB rating systems.

5.4 Project Characteristics and Certification Levels

Analysis of project characteristics required the use of multinominal logistic regression where the dependent variable is categorical in nature (Greene 2012). Firstly, building type was tested for correlation with certification level. No statistical significance can be observed. Secondly, project size was also tested for correlation with certification level. Again no statistical significance can be observed. Thirdly, two categories of delivery method (Design-Build and Design-Bid-Build) against the certification output are tested. It is also observed that the relationships are statistically not significant. These results could be interpreted that there are no patterns in the project characteristics as to specific certification levels being dominated by a certain type of building, specific project sizes, or project delivery methods.

6. Conclusions and Managerial Implications

Based on the perceptions of GB consultants, architects and engineers, the survey conducted in this study has systematically revealed the importance of 16 CSFs of green building industry in Thailand. Using factor analysis, these CSFs of green building can be grouped into five categories, namely competence of project participants, integration of GB project team, technical and management innovation, external environment, and project characteristics. The results indicate that: 1) enhancing both competence of individual participants and integration of a project team are critical in fulfilling tasks of green building; 2) favorable global and local economic conditions can create new demand and supply of green buildings, and economic environment can greatly impact on the green building industry.

The relationships between the competence of individual project participants and competence of project team have been further analyzed. The results show that, at all certification levels, the project manager's and GB consultant's competence can have significant impacts on the project team's competence. At the basic certification level (Certified), the designer's competence is significantly correlated with the project team's competence, whereas the competence of the contractor is more prominent at the highest certification level (Platinum).

The relationships between critical success factors and the GB certification outcomes have been also investigated. The results indicated that: 1) project team motivation can significantly affect the GB certification outcome; 2) at higher certification levels where requirements are greater and more stringent, the role of project manager becomes increasingly important; 3) the competence of the designer plays a critical part in applying basic certification level, whereas other project participants' competence may become more prominent when the project team aims at obtaining a higher certification level.

The above insights obtained from this study can contribute to the body of knowledge in both theory and practice. Firstly, this study reveals the importance of CSFs in delivering GB projects and the underlying patterns of the overall picture of the GB industry in Thailand. Secondly, the practical implications of this study suggest the need for all project participants to continuously improve their competences via technical and management innovation for delivering affordable and sustainable products to the customers. With such improvements construction costs should be reduced thus improving the appeal of green buildings. Thirdly, this study provides empirical evidence that all project participants should adopt appropriate team building strategies and optimally allocate their resources to achieve the suitable GB certification levels.
7. Limitations and Future Research Directions

This study only examined the key issues of green building from the perspectives of GB consultants, architects, and engineers in Thailand. The findings of this research have drawn on experiences from other geographic regions via the literature. The insights appear transferable to different regions, especially developing countries, and could be extended to the views of other project stakeholders, e.g. owners, contractors, governments, and consumers. Further studies need to be conducted to test these extensions.

The findings of this study imply that future research directions should focus on: 1) systematically exploring the in-depth cause-effect relationships among the CSFs of GB projects; 2) knowledge sharing among project participants to assist organizational learning and innovation, thereby enhancing each participant's capability and project team's competence; 3) government's measures to promote green building by considering the changing external environment; and 4) how to transform green building business to a mainstream market in developing countries.

Acknowledgements

Many thanks are offered to the National Natural Science Foundation of China (Grant Nos. 51379104, 51579135, 51079070, 50539130 and 70671058), and State Key Laboratory of Hydrosience and Engineering (Grant Nos. 2013-KY-5, 2015-KY-5, 2009-ZY-7). Major Science and Technology Research Project of Power China (Grant Nos. 2013-KY-5, 2015-KY-5, 2009-ZY-7). Special thanks are also given to the respondents for their generous contributions during the survey.

References