Using PLS-SEM to analyze challenges hindering success of green building projects in Vietnam

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Abstract

Purpose – This study focused on investigation of the critical challenges the general contractors are facing in executing green building (GB) projects in Vietnam.

Design/methodology/approach – The study conducted a literature review and three in-depth interviews to define 31 potential challenges hindering success of GB projects. Data was collected from 163 respondents through the questionnaire survey and was analyzed by the mean ranking technique, EFA and PLS-SEM.

Findings – The result found general contractors in Vietnam are facing the four components of challenges, namely "Planning activities-related challenges", "Organizational activities-related challenges", "Onsite management and control activities-related challenges" and "Green supply chain-related challenges"; and all of them have statistically significant effects on success of GB projects in Vietnam. Furthermore, the most dominant component was related to the non-readiness of external GB supply chain.

Practical implications – The findings suggest for practical measures to enhance success of GB projects in Vietnam, including (1) completing the system of legal regulations and technical codes, standards, guidelines on GB, (2) providing incentive policies to promote the R&D activities on GB and (3) providing educational programs to improve the awareness and capacity on GB in domestic construction organizations, especially medium and small subcontractors.

Originality/value – This study seeks to gain a better understanding on critical challenges hindering success of green building projects under the view point of general contractors with reference to the context of Vietnam – a developing economy. This study is the first study to identify potential challenges and evaluate the impact of the key components of challenges on success of GB projects.

Keywords Green building projects, General contractors, Challenges, Vietnam

Paper type Research paper

1. Introduction

According to the literature, the construction industry uses more than 40% of the total global energy and accounted for more than 40% of global greenhouse gases resulting in a series of environmental problems for the sustainable economic development (Wang *et al.*, 2019; Chan *et al.*, 2017). Green building is considered as to be one of the strategic solutions

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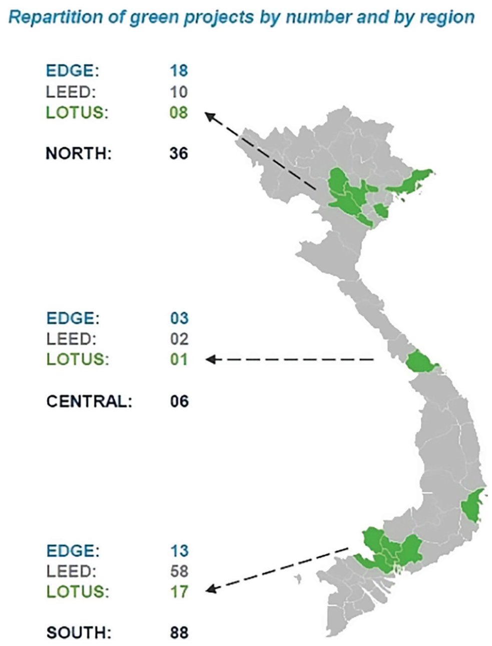
to reduce the negatively environmental and social impact of the industry by maximizing the conservation of resources, energy and water saving and reduced pollution throughout the life cycle of construction (Darko *et al.*, 2017b; Wang *et al.*, 2018). According to statistics, green buildings could potentially help to decrease 35% in GHGs, 70% in waste output and save 70% on water usage (Wang *et al.*, 2019; Chan *et al.*, 2017; Zhang *et al.*, 2011; Balaras *et al.*, 2007). In fact, there is a significant increase in numbers of green buildings constructed over the world (Hwang *et al.*, 2015). Particularly in the building market in Vietnam, up to 09/2019, there are about 108 building projects having green certifications, including 30 LOTUS [1] certified projects, 56 LEED [2] certified projects, 10 EDGE [3] certified projects and about 12 Green Mark [4] certified projects (Duong, 2020; Tran, 2020). This is a notable number; however, the GB market in Vietnam is criticized being very slow as compared to many countries in the region. For example, Singapore has more than 2,100 Green Mark certified projects and Australia has approximately 750 Green Star certified projects (Duong, 2020). Additionally, the green building development is very unbalanced in different regions nationwide. As showed in Figure 1, green buildings are mainly based in the principal cities, such as Hanoi, Ho Chi Minh and Da Nang (Duong, 2020).

With the huge potential of GB in reducing or eliminating the negatively environmental and social impact of the construction industry, it is very important to promote the successful development of the green building market. In orders to this, it is necessary to identify key factors having negatively or positively significant impacts on the development of GB. As acknowledged, the construction market is characterized by involvement of a numerous number of relevant stakeholders with various goals from different backgrounds, such as client/developers, general contractors, subcontractors, consultants, designers, end users/occupants,



Source(s): Duong (2020)

Figure 1.
Overview of Vietnamese green building market

suppliers, property managers, government agencies, etc. Each of them has the various responsibilities for different functions and roles in the whole life cycle of building projects (Darko *et al.*, 2017b). Additionally, GB projects are inherently more complicated and problematic than conventional projects in terms of both technical and managerial issues (Khodadadzadeh, 2016; Li *et al.*, 2011). Such projects often adopt more innovative construction practices and more environmental friendly building technologies/products, which bring out many unique challenges to parties during the delivery process of projects (see Berardi (2013), Chan *et al.* (2016), Chan *et al.* (2018), Nguyen *et al.* (2017), Lam *et al.* (2009), and Darko *et al.* (2017a)). There have been many previous studies investigating determinants of the development of GB market and success of green building projects from various perspectives such as project managers, designers, client/developers (e.g. Wang *et al.* (2019); Chan *et al.* (2016); Bond (2011); Chan *et al.* (2018); Koebel *et al.* (2015); and Nguyen *et al.* (2017)); however, there has been little attention specifically paid on the side of general contractors.

In order to fill the gap mentioned, this study seeks to gain a better understanding on critical challenges hindering success of green building projects under the view point of general contractors with reference to the context of Vietnam – a developing economy. This study first identified potential challenges, then evaluated the impact of the key components of challenges on success of GB projects. Data collected through questionnaire surveys was analyzed by using the partial least square-structural equation modeling (PLS-SEM) technique. The following parts of this paper present a literature review, research methodology, data analysis results, discussions and conclusions. Finally, the limitations of this study as well as future research directions are also presented.

2. Literature review and research hypotheses

2.1 Delivery of green vs traditional building projects

Green buildings are the facilities built for the purpose of promoting occupant health and safety, energy and water efficiency and minimizing the negative impacts on the natural ecology system (Nguyen and Gray, 2016). Such GB projects must adopt more environmental friendly materials and products as well as more innovative construction practices to achieve sustainability in the whole life cycle of projects (Wang *et al.*, 2019; Karakaya *et al.*, 2014). Very often, these such technologies and practices are new, more costly, unfamiliar and more complex in terms of technique (Wang *et al.*, 2019). This can result in GB projects having higher initial cost and requiring higher competency in terms of change management, communications and integrated design than those in traditional ones (Karakaya *et al.*, 2014; García-Granero *et al.*, 2020). In order to gain success of GB projects, general contractors must take on a more direct and active role to enhance interdisciplinary cross-team interaction, collaboration and coordination among relevant stakeholders under the point of view considering a building as an interdependent but holistic system of the separate components (Glavinich, 2008). This approach is to ensure that the components work in harmony rather than conflict with each other. The literature shows successful factors of GB projects as presented in Table 1.

2.2 Challenges hindering success of green building projects

The present study conducted a literature review to identify potential challenges hindering success of GB projects. Many previous studies have investigated such barriers/challenges from the different perspectives, such as project managers (Hwang and Ng, 2013; Robichaud and Anantatmula, 2010), the owners (Zhang *et al.*, 2019), designers (Lam *et al.*, 2010) and different stakeholders (Chan *et al.*, 2018; Quangdung *et al.*, 2019; Nguyen *et al.*, 2017).

Hwang and Ng (2013) found that project managers face many critical challenges to complete GB projects, such as higher initial costs, more technical difficulty during the

Relevant project activities	Successful factors	Sources
Planning activities	Interdisciplinary interaction of project participants to gain an earlier and more comprehensive perception of project requirements for planning purpose	Isa *et al.* (2014), Hwang *et al.* (2015)
Organization activities	The owners' strong motivation and commitments on green building	Isa *et al.* (2014), Hwang *et al.* (2015)
Organization activities	Integrating the construction team into the project team is extremely critical	Hwang *et al.* (2015), Swarup *et al.* (2011)
Organization activities	Capacity of change management to effectively solve emerging issues related to schedule, cost, quality and environment during the process of GB project delivery	Isa *et al.* (2014), Horman *et al.* (2006)
Organization activities	GB project participants need to continuously improve their knowledge of, expertise and readiness on green building	Isa *et al.* (2014), Li *et al.* (2011), Horman *et al.* (2006)
Onsite management and control activities	More communications and information sharing to limit conflicts among project participants	Swarup *et al.* (2011), Hwang *et al.* (2015)
Onsite management and control activities	Active and full collaboration and cooperation among all the relevant stakeholders to successfully incorporate innovative and advanced building technologies into the building systems	Li *et al.* (2011), Horman *et al.* (2006)
Onsite management and control activities	Provision of explicit and comprehensive green building codes and regulations	Isa *et al.* (2014), Li *et al.* (2011)
Green supply chain activities	Readiness of reliable green building technologies, products, materials	Isa *et al.* (2014), Hwang *et al.* (2015)

Table 1.
Successful factors to delivery GB projects

construction process, more risk in contract management, lengthy planning and approval process, unfamiliarity with GBTs, increased communication and more time to execute green construction practices onsite. Another study by Li *et al.* (2011) revealed that in order to successfully deliver GB projects, it is necessary to meet the following critical requirements: top management's strong support, skilled project-team members, strong collaboration and cooperation of all project parties, more effort to establish a detailed plan in design and construction, appropriate channels to communicate and share, change management capacity and readiness in financial budget. Besides that, it is also cited that lack of appropriate tools, equipment and unavailability of third-party service providers to validate green construction products or materials were the considerable challenges in delivering GB projects (Robichaud and Anantatmula, 2010). Additionally, emerging technical changes during the onsite construction process are also empirically found as one of the primary challenges hindering success of GB projects (Hwang and Ng, 2013).

The literature consistently showed that GB projects face many challenges in management in terms of contract, schedule and budget (Hwang *et al.*, 2015). Selecting and establishing appropriate contracts for the delivery of GB projects is one difficult task because the contracts used must integrate the details of a fully integrated green design. GBTs, the green design service and management practices are more expensive; therefore it is more difficult to manage GB projects within the defined budget (Zhang *et al.*, 2019). Besides that, meeting the planned schedule of GB projects will be also a tough challenge due to many factors, such as more communications, more meetings, much more required time to approve GBTs as well as conduct green construction practices onsite (Hwang *et al.*, 2015; Lam *et al.*, 2010). Furthermore, architects, engineers, consultants, etc. arguably tend to deliver technical services in isolation; and it also empirically found that improved communication among such project players was one of the key but difficult requirements to manage changes, mitigate risks and unexpected costs in the delivery of GB projects (Robichaud and Anantatmula, 2010).

In Vietnam, legislative and institutional barriers and social and cognitive barriers are widely perceived as the most significant challenges (Nguyen *et al.*, 2017). Accordingly, "slow and unwieldy administration process in policy making", "lack of a comprehensive code/policy package to guide action on sustainability", "lack of an explicit financing mechanism", "inadequate fiscal incentives" and "price sensitivity" were found out as the most significant barriers to the GB development. Quangdung *et al.* (2019) conducted a SWOT analysis of the GBTs market development and found that the unique characteristics of the context including "the system of technical codes, standards, guidelines is insufficient"; "green R&D activities are not paid appropriately attention by the industry", and "it is lacking of competent contractors to execute green building projects". The study of Pham *et al.* (2019) identified challenges for general contractors in implementing green building projects in Vietnam, including general contractors lack experience in implementing almost LEED credits; lack experience in selecting and documenting the purchasing of LEED materials, regulations and standards do not have such strict requirements compare to LEED requirements. Besides that, Pham *et al.* (2020) also found incompetence of project managers, limited green construction materials and technologies, reluctance to change toward sustainability, lack of government incentives and low implementation level of sustainable practices were the five most significant barriers to sustainable construction. Generally, the literature suggested a wide range of potential challenges hindering success of GB projects in Vietnam that are related to planning, organizing, onsite controlling activities and green supply chain activities (see Tran (2020) and Table 2).

2.3 Research hypotheses

In the light of the related literature review, the following research hypotheses are proposed:

H1. Planning activities-related challenges (PA) have a significant impact on success of green building projects under the general contractors' perspective.

H2. Organization activities-related challenges (OA) have a significant impact on success of green building projects under the general contractors' perspective.

H3. Onsite management and control activities-related challenges (OMA) have a significant impact on success of green building projects under the general contractors' perspective.

H4. Green supply chain-related challenges (GSC) have a significant impact on success of green building projects under the general contractors' perspective.

3. Research methodology

3.1 Questionnaire design

First, a literature review was carried out and found a list of 31 potential challenges likely facing the contractors in executing green building projects (see Table 2). Next, based on the discussions of academia and consultants issued at the Website http://congtrinhxanhvietnam.vn/goc-nhin-chuyen-gia-c4, six challenges specific for the context of Vietnam were added to the list. Then, the interviews with two construction managers and a senior lecture that had much experience in the local construction industry and possessed relevant experience in green building activities were conducted to validate and refine the list of identified 36 potential challenges. They were asked to assess the questionnaire with regard to question construction, use of technical language/terms, whether the questionnaire covered all possible challenges as well as whether any factors could be added to, or deleted from the questionnaire.

Relevant activities	Code	Challenges	References
Planning activities-related challenges	C1	Difficult in establishing a quality management system	Hwang and Ng (2013), Hwang and Tan (2012), Pham *et al.* (2019), Nguyen *et al.* (2017)
	C2	Difficult in comprehending the green specifications	Robichaud and Anantatmula (2010), Zhang *et al.* (2019), Hwang and Ng (2013)
	C3	Difficult in assessing quality, monitoring and surveying technical parameter onsite	Nguyen *et al.* (2017), Hwang and Ng (2013)
	C4	Difficult in controlling and inspecting quality of materials, equipment, structural components	Nguyen *et al.* (2017), Hwang and Ng (2013), Pham *et al.* (2019)
	C5	Difficult in designing construction technique methods	Nguyen *et al.* (2017), Hwang and Ng (2013)
	C6	Difficult in designing a plan of inspection and acceptance for building tasks, works	Li *et al.* (2011), Isa *et al.* (2013), Pham *et al.* (2019)
Organization activities-related challenges	C7	Difficult in establishing a competent, multidisciplinary project team	Hwang and Ng (2013), Robichaud and Anantatmula (2010), Mohammadi and Birgonul (2016)
	C8	Lack of competent project managers, superintendents and engineers on GB	Pham *et al.* (2019), Quangdung *et al.* (2019)
	C9	Lack of skilled employees on GB	Li *et al.* (2011), Quangdung *et al.* (2019), Isa *et al.* (2013), Hwang and Ng (2013)
	C10	Lack of appropriate tools/laboratories specific for testing, assessing, measuring and inspecting the green performance of construction products	Thomas and Glavinich (2008)
	C11	Lack of appropriate tools/equipment to conduct green construction practices onsite	Li *et al.* (2011), Thomas and Glavinich (2008)
	C12	Lack of appropriate guidelines specific for conducting green construction practices onsite	Nguyen *et al.* (2017), Hwang and Ng (2013), Zhang *et al.* (2019)
	C13	Require a larger financial resource for GB projects	Li *et al.* (2011), Lam *et al.* (2010)
Onsite management and control activities-related challenges	C14	Lack of legal regulations and technical codes on GB	Zhang *et al.* (2019), Mohammadi and Birgonul (2016)
	C15	Lack of GB cost estimated norms	Pham *et al.* (2019), Quangdung *et al.* (2019)
	C16	Cost sensitive of GB activities	Hwang and Ng (2013), Nguyen *et al.* (2017), Lam *et al.* (2010)
	C17	Conflict of interest among project stakeholders	Hwang and Ng (2013), Nguyen *et al.* (2017), Lam *et al.* (2010)
	C18	Unforeseen circumstances in GB projects	Nguyen *et al.* (2017), Thomas and Glavinich (2008)
	C19	Time to implement green construction practices onsite	Li *et al.* (2011), Thomas and Glavinich (2008)
	C20	Alteration and variation during green construction process	Hwang and Ng (2013), Pham *et al.* (2019), Lam *et al.* (2010)
	C21	More communications and collaboration are required among project team members	Thomas and Glavinich (2008), Hwang and Ng (2013), Pham *et al.* (2019)
	C22	Difficult in preparing construction documents	Robichaud and Anantatmula (2010), Hwang and Ng (2013), Pham *et al.* (2019)

(*continued*)

Table 2.
Potential challenges hindering success of GB projects under the view of general contractors

Relevant activities	Code	Challenges	References
Green supply chain-related challenges	C23	Government incentive policies are not clear, ineffective	Hwang and Ng (2013), Nguyen *et al.* (2017), Lam *et al.* (2010), Pham *et al.* (2019)
	C24	Client's budget plan	Nguyen *et al.* (2017), Thomas and Glavinich (2008)
	C25	Shortage of reliable GB materials/ equipment in the market	Pham *et al.* (2019), Quangdung *et al.* (2019)
	C26	Lack of reliable green suppliers	Hwang and Ng (2013), Pham *et al.* (2019), Quangdung *et al.* (2019)
	C27	Difficulty in selecting and managing subcontractors	Pham *et al.* (2019), Nguyen *et al.* (2017), Lam *et al.* (2010)
	C28	Low level of officials' GB awareness	Pham *et al.* (2019), Quangdung *et al.* (2019)
	C29	Low level of users and public's GB awareness	Pham *et al.* (2019), Nguyen *et al.* (2017), Lam *et al.* (2010)
	C30	Lack of financing schemes (e.g. bank loans, surety bonds)	Pham *et al.* (2019), Quangdung *et al.* (2019)
	C31	Lack of insurance for GB projects	Isa *et al.* (2013), Li *et al.* (2011)

Table 2.

A few challenges were removed or merged; eventually the list of potential challenges was adopted for a full survey questionnaire.

The first section of the instrument captured the respondent's profile. The second listed the potential challenges that contractors may face during the construction phase of green buildings. The respondents were asked to rate the extent to which one factor was a critical challenge to managing green building projects using a five-point Likert scale (1 = Not critical, 2 = Less critical, 3 = Neutral, 4 = Critical and 5 = Very critical). The five-point Likert scale was selected because it is easier for the respondents to express their opinions. Before sending out the survey, a couple of pilot tests were carried out to determine the required time for its completion, to ensure that the questions and instructions were clear.

3.2. Data collection

This study adopted the non-probability sampling technique using the snowball sampling method. This method is arguably appropriate to acquire a representative sample when the respondents can be selected on the basis of their willingness to participate in the research. Detail of the data collection was presented in Tran (2020) – another publication belonging to the same research project. The study collected 164 completed responses to analyze, yielding a rate of 76% responses. According to the literature, this sample size is acceptable for EFA, CFA. Additionally, the sample size was adequate compared with previous studies on green building management (see Hwang and Ng (2013); Zhang *et al.* (2019); Tran *et al.* (2014)).

3.2 Data analysis

First, descriptive and inferential analyses including mean ranking analysis, a one-way analysis of variance (ANOVA) test and exploratory factor analysis (EFA), were conducted using the Statistical Package for Social Science (SPSS) 19.0. Then, the component-based structural equation modeling (PLS-SEM) – a multivariate statistical analysis technique was conducted to test the hypotheses about the impacts of the challenge groupings on success of GB projects. A typical SEM consists of a set of measurement models and a structural model. SEM not only has the ability to test the relationships between constructs (i.e. latent variables) and their respective measurement items (i.e. observable variables) within the measurement models, but it also tests hypotheses among constructs (both independent and dependent latent variables) within the structural model (Haenlein and Kaplan, 2004; Aibinu and Al-Lawati, 2010). PLS-SEM was adopted because of the key reasons: (1) PLS-SEM can work well with small sample sizes and nonnormal data (Aibinu and Al-Lawati, 2010) and (2) PLS-SEM is more appropriate for assessing the models that are more complex with a large number of latent and observable variables and include both reflective and formative constructs (Chin, 1998). Additionally, PLS-SEM is more adequate if the studied phenomenon is relatively new and measurement models are newly developed and not yet validated before (Urbach and Ahlemann, 2010). Literature shows PLS-SEM was adopted by many previous studies (with small sample sizes) in the field of construction engineering and management; for example, Tran *et al.* (2014), Aibinu and Al-Lawati (2010), and Leung *et al.* (2005).

3.3 Respondent profiles

Of the 164 responses collected, one was removed from the sample due to missing more than 30% critical data. Thus, it remains 163 responses available for further analysis. This study uses the means to substitute missing values in the responses which have less than 10% missing data. Figure 2 shows the respondents' profiles. It can be seen that most of the respondents held senior positions with the professional background in construction engineering and the majority of them had engaged in delivering more than three GB projects. This profile signifies the validity and reliability of the responses.

4. Analysis results

4.1 Results of ranking analysis

The results of Cronbach's alpha coefficient and ranking analysis for the 31 challenges were presented in detail in the previous publication of the same research project (see Tran (2020)). It is worth noting that the Top Five of the statistically significant challenges faced the general contractors are associated with different issues in terms of legislation, labor resources and onsite technical operations. Expectedly, "lack of legal regulations and technical codes, standards, guidelines on green building" (C14) was ranked first with the highest mean score (4.34), indicating that legal and technical issues are the most critical challenges hindering success of GB projects in Vietnam. Next, "more difficult to early establish a competent, integrated, multidisciplinary project team" (C7) was found as the second challenge (4.25), followed by "more difficult for comprehending the owner's green goals as well as the green specifications" (C2, 4.22) and "difficulty in the selection of competent subcontractors in providing green building services" (C27, 4.18). The fifth most significant challenge was "shortage of reliable green building methods, materials, technologies, and equipment in the market" (C25, 4.05). It is worth noting that these top five challenges were spread across the different project activities including planning, organizing, onsite controlling and green supply chain management activities (see Table 3).

4.2 Results of exploratory factor analysis (EFA)

In order to better understand the challenges facing the general contractors in executing GB projects in Vietnam, the 29 significant challenges (variables) were subjected to EFA. The result is presented in Table 4.

Accordingly, four key components of challenges with eigenvalues greater than 1 are extracted, explaining 67.614% of the variance, including: *Component 1: Planning activities-related challenges (PA).* This underlying component is represented by five critical challenges, including C1, C2, C3, C4 and C5. This component covers issues that fall within the complex nature of planning green building projects. It accounts for 17.13% of the total variance and is

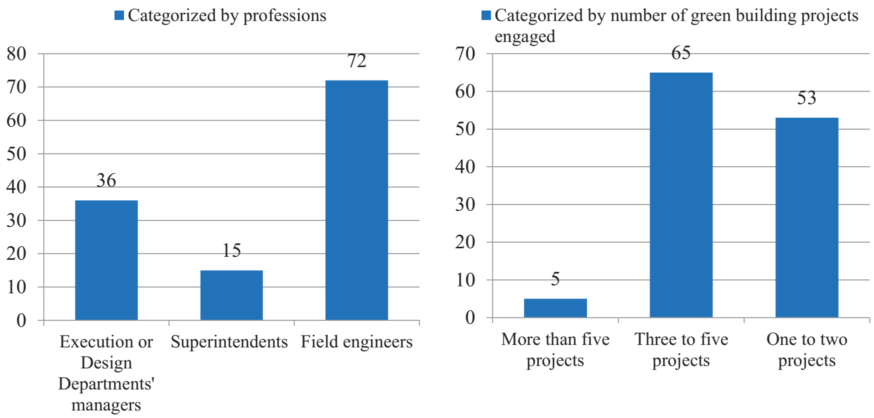


Figure 2.
Respondent profiles

considered the third critical of the four components from a statistical point of view. *Component 2: Organization activities-related challenges (OA)*. This component consists of six critical challenges: C7, C8, C9, C10, C12 and C13. These six challenges reflect more about issues related to the internal capacity of the general contractors in terms of human, equipment and capital resources. This is the second dominant among all the four components, explaining 21.465% of the total variance. *Component 3: Onsite management and control activities-related challenges (OMA)*. This component explains the lowest variance (6.117%) and contains eight critical challenges related to management and control activities onsite, including C17, C18, C19, C20, C21 and C22. *Component 4: Green supply chain-related challenges (GSC)*. This component accounts for 22.902% of the total variance and is considered the most dominant of the four components. It consists of eleven critical challenges that focus on green construction supply chain, including C14, C15, C16, C23, C25, C26, C27, C28, C29, C30 and C31. The green construction supply chain is an important issue because any shortage or unavailability among other parties may result in difficulties or challenges that can affect the delivery process of green building projects by the contractors. This implies the important roles of external parties; specifically government and green building technology suppliers on success of GB projects in Vietnam.

Further analysis in this study, the assessment of relative significance among the identified components was carried out. Based on all samples, when the mean rankings of the challenges comprising each component are added up and divided by its number of challenges, the average ranking of that component can be obtained, indicating its relative significance. As shown in Figure 3, Component 4 is the most significant, followed by Component 1 and Component 2. Meanwhile Component 3 "Onsite management and control activities-related challenges" is the least significant with its lowest average ranking value.

4.3 Partial least square structural equation model

In order to analyze the impact of the different components on success of GB projects (GBPS), a partial least squares structural equation model (PLS-SEM) was evaluated by SmartPLS 3.2.2 software. The initial PLS-SEM is shown in Figure 4.

4.3.1 Assessment of outer measurement model. 4.3.1.1 Individual item reliability and convergent validity. First of all, confirmative factor analysis (CFA) was carried out to test if all measuring items were appropriate for each respective construct. According to the literature, the factor loading of each item should exceed the threshold of 0.700. The analysis result shows that most factor loadings were greater than the threshold; exception of OA5, GSC3, GSC4, GSC5, GSC8, OMA5 and PA3 (see Figure 3). These five items were deleted from

Code	Mean	Total sample Ranking	Normalized value	ANOVA[b]
C14	4.34	1	1.00	0.41
C7	4.25	2	0.93	0.21
C2	4.22	3	0.91	0.31
C27	4.18	4	0.88	0.44
C25	4.05	5	0.79	0.12
C12	3.89	6	0.59	0.09
C15	3.87	7	0.68	0.23
C22	3.87	7	0.68	0.13
C20	3.87	7	0.68	0.28
C3	3.85	10	0.65	0.32
C4	3.84	11	0.65	0.19
C26	3.82	12	0.63	0.45
C28	3.82	12	0.63	0.60
C29	3.80	14	0.61	0.22
C30	3.80	14	0.61	0.19
C10	3.78	16	0.60	0.17
C9	3.78	16	0.60	0.37
C19	3.76	18	0.59	0.22
C1	3.76	18	0.59	0.22
C21	3.76	18	0.57	0.13
C8	3.76	18	0.59	0.22
C17	3.73	22	0.57	0.29
C18	3.71	22	0.55	0.31
C16	3.68	24	0.53	0.20
C31	3.68	24	0.53	0.16
C23	3.66	26	0.51	0.26
C5	3.66	26	0.51	0.22
C24	3.66	26	0.51	0.32
C13	3.64	29	0.50	0.17
C6	3.29*	30	0.25[(a)]	0.15
C11	2.94	31	0.00[(a)]	0.41
Kendall's W**	0.303			
Chi-Square	313.12			
df	31			
Level of significance	0000			

Note(s): Normalized value = (mean − minimum mean)/(maximum mean − minimum mean); "*" Data with insignificant results of one-sample *t*-test ($p > 0.05$) (2-tailed); "**"Kendall's Coefficient of Concordance test on the challenges amongst the three respondent groups; (a) The normalized values indicate that the barriers are not a critical barrier (normalized value < 0.50); (b) The ANOVA result is insignificant at the 0.05 significance level (sig. > 0.05)

Table 3.
The result of mean ranking analysis

the model. Next, convergent validity was assessed using the Cronbach's α coefficient, composite reliability (CR) and average variance extracted (AVE). The literature suggests that these indicators should be greater than the thresholds of 0.6, 0.7 and 0.5, respectively. As can be seen from Table 5, the Cronbach's α values were between 0.8035 and 0.9238, the CR values were between 0.8642 and 0.9427, and the AVE values were between 0.5610 and 0.7674. Thus, it can be said that the measurement scales have good convergent validity and internal consistency.

4.3.1.2 Discriminant validity analysis. At measurement scale level, the discriminant validity is good if items have a higher correlation with their respective construct than with any others. At construct level, discriminant validity is adequate if the square root of AVE of each variable is greater than the correlations among the other constructs. The new model

Code	Components 1	2	3	4	New codes
Component 1: planning activities-related challenges					
C1	0.857	–	–	–	PA1
C2	0.677	–	–	–	PA2
C3	0.889	–	–	–	PA3
C4	0.781	–	–	–	PA4
C5	0.779	–	–	–	PA5
Component 2: organization activities-related challenges					
C7	–	0.676	–	–	OA1
C8	–	0.879	–	–	OA2
C9	–	0.680	–	–	OA3
C10	–	0.611	–	–	OA4
C12	–	0.608	–	–	OA5
C13	–	0.667	–	–	OA6
Component 3: onsite management and control activities-related challenges					
C17	–	–	0.680	–	OMA1
C18	–	–	0.770		OMA2
C19	–	–	0.644		OMA3
C20	–	–	0.743		OMA4
C21	–	–	0.650		OMA5
C22	–	–	0.775	–	OMA6
Component 4: green supply chain-related challenges					
C14	–	–	–	0.879	GSC1
C15	–	–	–	0.875	GSC2
C16	–	–	–	0.892	GSC3
C23	–	–	–	0.770	GSC4
C25	–	–	–	0.815	GSC5
C26	–	–	–	0.715	GSC6
C27	–	–	–	0.850	GSC7
C28	–	–	–	0.780	GSC8
C29	–	–	–	0.607	GSC9
C30	–	–	–	0.612	GSC10
C31	–	–	–	0.703	GSC11
Eigenvalue	5.406	2.313	2.085	1.466	
Variance (%)	17.130	21.465	6.117	22. 902	
Cumulative variance (%)	17.130	38.595	54.712	67.914	

Note(s): Extraction method = principal component analysis; rotation method = Varimax with Kaiser Normalization

Table 4. Results of EFA on challenges in executing green building projects under the view of contractors (rotated component matrix with factor loadings)

(with 29 remaining items) was run again. The cross loadings and the square root of AVE of each variable were presented in Tables 5 and 6. The result implies that the measurement model holds discriminant validity.

4.4 Evaluation of Inner Structure Model

The explanatory power of the structural model was evaluated by examining the amount of variance (R^2) in the dependent variable of GBPS. The R^2 of GBPS was 0.854 meaning that about 85.3% of the changes to the success of green building projects are due to the four latent variables PA, OA, OMA and GSC (see Figure 5). F-test was performed to assess the significance of the R^2 value. The result of value $F = 112$ with $p = 0.000$ for $R^2 = 0.853$. Thus, the explanatory power of the structural model is statistically significant. Table 7 shows the bootstrapping results for the structural model. As can be seen, all four path coefficients were statistically significant.

5. Discussions

The study makes two notable points: (1) the significant challenges the general contractors face during executing GB projects in Vietnam exist in all various project phases from planning phase, organizational phase to onsite management and control; (2) the non-readiness of green building supply chain in Vietnam is the most significant challenges to gain success of GB projects. These findings are now discussed in detail.

First of all, the non-readiness of green building supply chain was found as the most significant challenges hindering success of GB projects in Vietnam (the coefficient of "GSC → GBPS" reached 0.342, and the *t*-value reached 2.9051). Green supply chain-related challenges include lack of legal regulations and technical codes on GB, lack of green construction cost estimated norms, lack of green construction materials/equipment as well as lack of reliable suppliers of such products, lack of competent subcontractors on GB, low level of public awareness of GB, lack of incentive financing schemes and lack of insurance for GB projects. This finding is consistent with the previous studies conducted within the context of developing economies, such as Nguyen *et al.* (2017) and Hwang and Tan (2012). This finding is not sudden because the Vietnam green building market is arguably new and still at its initial development (Nguyen *et al.*, 2017). In fact, almost green construction products/materials must be transported to foreign markets such as Singapore or the United States to

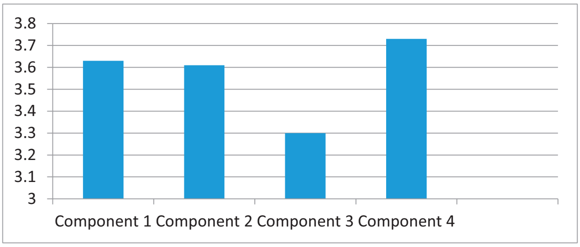


Figure 3.
Average rankings of significance of the identified components

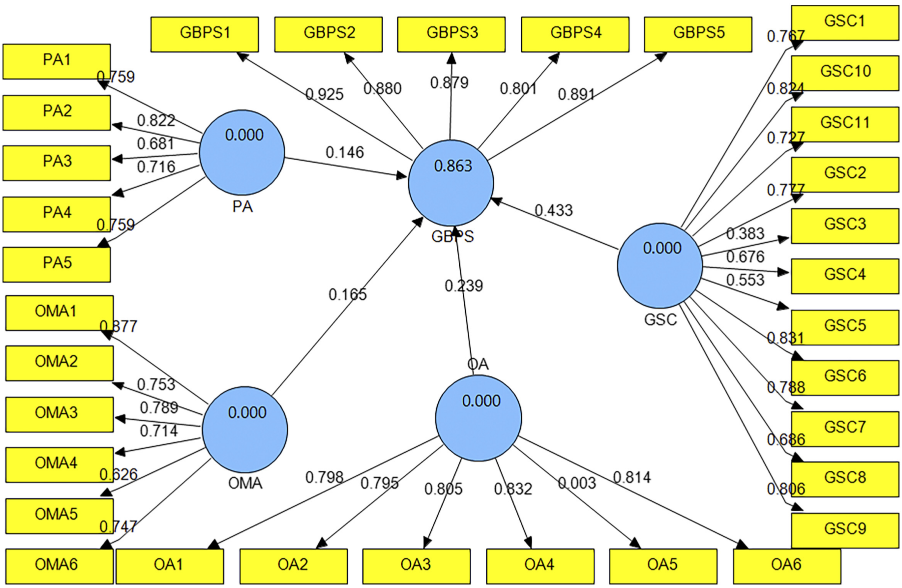


Figure 4.
The initial PLS-SEM

	GBPS	GSC	OA	OMA	PA	α	AVE	CR
GBPS1	*0.9246*	0.7747	0.7429	0.7646	0.7082	0.9238	0.767	0.943
GBPS2	*0.8800*	0.8212	0.8025	0.8506	0.7546			
GBPS3	*0.8793*	0.8226	0.7945	0.8786	0.7226			
GBPS4	*0.8012*	0.7174	0.7073	0.6627	0.6603			
GBPS5	*0.8905*	0.6629	0.6696	0.6978	0.6279			
GSC1	0.7013	*0.7781*	0.6344	0.7368	0.5428	0.9060	0.529	0.923
GSC2	0.7121	*0.7958*	0.6383	0.7268	0.5315			
GSC6	0.5401	*0.8395*	0.5525	0.5984	0.5924			
GSC7	0.7090	*0.8006*	0.7177	0.7419	0.6139			
GSC9	0.7298	*0.8373*	0.7710	0.6813	0.7095			
GSC10	0.7417	*0.8149*	0.7419	0.7368	0.6974			
GSC11	0.6706	*0.7547*	0.6063	0.6661	0.5457			
OA1	0.7317	0.7542	*0.7979*	0.7171	0.7005	0.8463	0.570	0.887
OA2	0.6136	0.6496	*0.7951*	0.6305	0.6097			
OA3	0.6379	0.6620	*0.8051*	0.6713	0.5988			
OA4	0.6233	0.6192	*0.8319*	0.6048	0.5912			
OA6	0.7310	0.6627	*0.8138*	0.6641	0.5112			
OMA1	0.7179	0.6709	0.6962	*0.8649*	0.6268	0.8864	0.639	0.914
OMA2	0.7122	0.7416	0.6754	*0.7714*	0.5756			
OMA3	0.7505	0.7594	0.7131	*0.8014*	0.6561			
OMA4	0.7089	0.7059	0.6894	*0.7374*	0.5954			
OMA6	0.7110	0.7031	0.6697	*0.7543*	0.5945			
PA1	0.5399	0.6157	0.5913	0.5520	*0.7899*	0.8035	0.561	0.864
PA2	0.6134	0.6103	0.5764	0.5907	*0.8055*			
PA4	0.6003	0.5191	0.5566	0.4901	*0.7403*			
PA5	0.6933	0.6605	0.6448	0.6331	*0.7810*			

Note(s): Hint: Italic values show that measuring items had the highest loadings on their respective construct

Table 5. The results of cross loadings, Cronbach's α, composite reliability (CR) and average variance extracted (AVE)

Component	PA	OA	OMA	GSC	GBPS
PA	*0.7490*				
OA	0.7001	*0.7550*			
OMA	0.6934	0.7003	*0.7995*		
GSC	0.7130	0.6853	0.6856	*0.7273*	
GBPS	0.7268	0.7257	0.7274	0.6717	*0.8760*

Table 6. The square root of AVE of each variable (i.e. Italic values) and the correlations among the other constructs

measure and inspect their green performance due to lacking appropriate technical tools and labs in the domestic market (Quangdung *et al.*, 2019). Additionally, presently, many new green construction products/materials are imported from the international market. This situation makes consequent concerns associated to cost, legislation, inspection and track record on green performance for such products. This finding indicates that the green construction supply chain plays an extremely important role for success of the delivery process of GB projects by general contractors.

The second significant challenges concerns organizational activities. The path coefficient of "OA → GBPS" reached 0.296, and the *t*-value reached 2.4576. Accordingly, lack of appropriate organizational resources in terms of human, equipment/tools, and finance to perform green construction practices were empirically found to be critical challenges hindering success of GB projects. This finding is supported by the previous studies, such as Li *et al.* (2014), and Isa *et al.* (2013). As acknowledged, green building projects are more

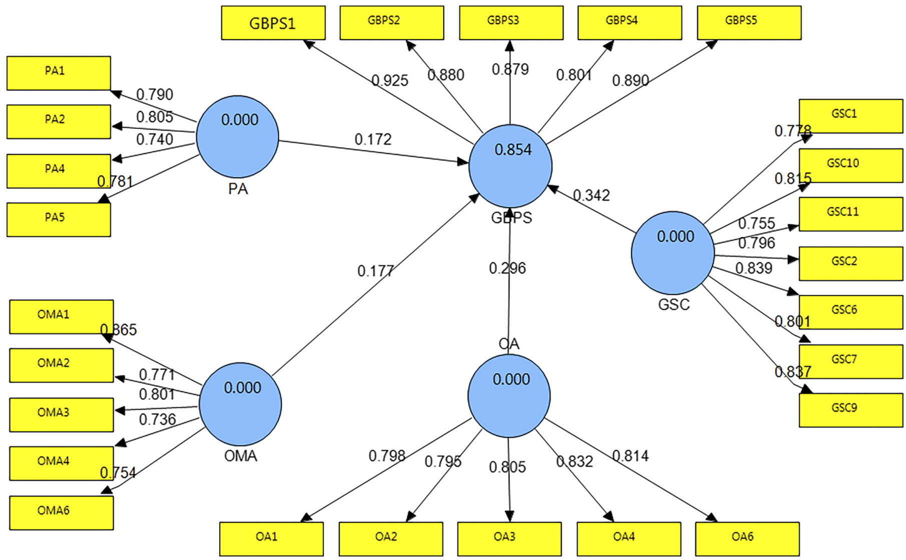


Figure 5.
Path coefficients and R^2 of the structural model

Table 7.
Bootstrapping results of the structured model

Hypotheses	Paths	Path coefficients	*t*-value *	SD	Inferences
H1	PA → GBPS	0.172	2.5831	0.0666	Supported
H2	OA → GBPS	0.296	2.4576	0.1203	Supported
H3	OMA → GBPS	0.177	2.2018	0.0806	Supported
H4	GSC → GBPS	0.342	2.9051	0.1177	Supported

Note(s): (* Coefficients are statistically significant at the 5% level of confidence)

complicated than conventional projects in terms of technology, techniques and management; therefore it requires project team members having a high level of multidisciplinary knowledge, skills and experience on green building (Robichaud and Anantatmula, 2010). Furthermore, in order to ensure the successful delivery of sustainable targets, it requires more communication, coordination, and closed collaboration among project stakeholders during the project's different stages to get a clear and holistic understanding of the defined green goals as well as to plan, manage and conduct the project activities in the most effective manner. In Vietnam, the labor resource is similar with traditional construction practices but not much experienced and knowledge on green building. The finding implies that the construction industry needs to provide appropriate incentive programs or schemes to improving the individual companies' organizational resources in GB. For example, the Government should consider to establish financial incentive policies to help individual companies overcoming their lack of financial capacity, especially medium and small enterprises. It is very likely that education and training efforts are needed to respond to the challenge of limited GB experts or skillful personnel within the companies.

The issues related to project planning activities are found as the third significant challenge hindering success of GB projects. This means that establishing an appropriate quality management system, comprehending green specifications, planning to test, assess and control quality of works and designing appropriate construction methods are critical challenges in delivering GB projects in Vietnam. This finding is consistent strongly with the results of Pham *et al.* (2019), Hwang *et al.* (2015), Li *et al.* (2011), and Robichaud and Anantatmula (2010). Pham *et al.* (2019) showed that Vietnamese general contractors lack experience in selecting and documenting the purchasing of LEED materials.

Finally, the analysis result showed that the general contractors generally believed that the issues related to onsite management and control activities make many significant challenges hindering success of GB projects. This means that more conflict of interest among stakeholders, more unforeseen circumstances, longer green construction practices, more alteration and variation during the construction process, more communications and collaboration among project team members and more complex construction documents and reports are significant challenges to general contractors in executing GB projects in Vietnam. This result is consistent with the previous studies' findings, such as Pham *et al.* (2019), Hwang and Ng (2013), Li *et al.* (2011). As mentioned, the Vietnam GBTs market lacks green construction materials/equipment; and such green products also often lack of necessary green performance certificates. This creates very much difficulty in construction purchasing by the general contractors. Additionally, Vietnamese general contractors is also argued to be lacking experience in preventing onsite construction activity pollution prevention, fundamental commissioning, managing construction and demolition waste and collecting green performance records of construction materials/products/equipment (Pham *et al.*, 2019).

6. Conclusions

Vietnam is a social-oriented emerging market economy, which is experiencing rapid urbanization. As an essential component of general planning for sustainable development of the economy, the Vietnam's government has made strongly commitments on green building in the both private and public sectors. However, the GB market in Vietnam is now still in the initial stages of its development; and in fact the number of green buildings is growing quite slowly (Nguyen *et al.*, 2017). The role of general contractors is considered as being extremely important to the development of GB industry in any economies including Vietnam. In order to look for more appropriate and useful solutions to improve the slow development status of the market, this study aimed to gain a better understanding of the critical challenges hindering success of GB projects under the Vietnamese general contractors' perspective. Based on an extensive literature review and in-depth interviews, such 31 potential challenges were identified. After the mean ranking analysis and the EFA, a total of 28 main challenges with a total interpretation variance of 67.614% were grouped into four components: "Planning activities-related challenges", "Organization activities-related challenges"; "Onsite management and control activities-related challenges", and "Green supply chain-related challenges". The analysis result of PLS-SEM found that all these components have statistically significant effects on success of green building projects in Vietnam. Furthermore, the result also showed that the most dominant component was related to the non-readiness of external green building supply chain.

Besides a substantial contribution to the body of knowledge on GB, the finding is crucial to help policy makers and practitioners to establish and enforce more appropriate measures to enhance the success of GB projects in Vietnam. Accordingly, the Government should play a key role to speed up the process of the holistic development of the system of legal regulations and technical codes, standards, guidelines in which the goal of green construction is covered in a systematic manner. Additionally, policy makers also need to provide appropriate policies to more effectively promote the R&D activities on GB within both the public and private sectors. Especially, such policies should highlight to improve the effectiveness of the transition process of scientific research results into the practical green solutions or marketable green products so that it can accelerate the development of the green supply chain. Besides these, it is also suggested that individual general contractors should further implement effective strategies to enhance the GB capacity of the whole employees, from top managers to workers onsite.

This present study has several notable limitations that may be addressed by future research. First, the data was collected from the quite small sample; and sampling is not randomly conducted. The findings may be tested by a larger dataset from a nationwide population. Also, the generalization of the findings may be limited because the data was only collected under the viewpoint of general contractors within the specific context of Vietnam; future studies should extend to developers and/or project managers, etc.

Notes

1. LOTUS is a market-based green building rating tool developed by the Vietnam Green Building Council specifically for the Vietnamese built environment.
2. LEED is the most widely used green building rating system in the world developed by U.S. Green Building Council.
3. ADGE is a green building certificate system developed by IFC, a member of the World Bank Group.
4. Green Star is a sustainable building certificate tool launched by Green Building Council of Australia (GBCA) in 2003.

References

Aibinu, A.A. and Al-Lawati, A.M. (2010), "Using PLS-SEM technique to model construction organizations' willingness to participate in e-bidding", *Automation in Construction*, Vol. 19, pp. 714-724.

Balaras, C.A., Gaglia, A.G., Georgopoulou, E., Mirasgedis, S., Sarafidis, Y. and Lalas, D.P. (2007), "European residential buildings and empirical assessment of the Hellenic building stock, energy consumption, emissions and potential energy savings", *Building and Environment*, Vol. 42, pp. 1298-1314.

Berardi, U. (2013), "Stakeholders' influence on the adoption of energy-saving technologies in Italian homes", *Energy Policy*, Vol. 60, pp. 520-530.

Bond, S. (2011), "Barriers and drivers to green buildings in Australia and New Zealand", *Journal of Property Investment and Finance*, Vol. 29, pp. 494-509.

Chan, A.P., Darko, A., Ameyaw, E.E. and Owusu-Manu, D.G. (2016), "Barriers affecting the adoption of green building technologies", *Journal of Management in Engineering*, Vol. 33 No. 3, p. 04016057.

Chan, A.P.C., Darko, A. and Ameyaw, E.E. (2017), "Strategies for promoting green building technologies adoption in the construction industry—an international study", *Sustainability*, Vol. 9, p. 969.

Chan, A.P.C., Darko, A., Olanipekun, A.O. and Ameyaw, E.E. (2018), "Critical barriers to green building technologies adoption in developing countries: the case of Ghana", *Journal of Cleaner Production*, Vol. 172, pp. 1067-1079.

Chin, W.W. (1998), "The partial least squares approach to structural equation modeling", *Modern Methods For Business Research*, Vol. 295, pp. 295-336.

Darko, A., Chan, A.P.C., Ameyaw, E.E., He, B.J. and Olanipekun, A.O. (2017a), "Examining issues influencing green building technologies adoption: the United States green building experts' perspectives", *Energy and Buildings*, Vol. 144, pp. 320-332.

Darko, A., Zhang, C. and Chan, A.P. (2017b), "Drivers for green building: a review of empirical studies", *Habitat International*, Vol. 60, pp. 34-49.

Duong, T. (2020), "Overview of Vietnamese green building market", in *Vietnam Investment Review*, The Ministry of Planning and Investment Publisher, Hanoi.

García-Granero, E.M., Piedra-Muñoz, L. and Galdeano-Gómez, E. (2020), "Measuring eco-innovation dimensions: the role of environmental corporate culture and commercial orientation", *Research Policy*, Vol. 49, p. 104028.

Glavinich, T.E. (2008), *Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction*, John Wiley & Sons.

Haenlein, M. and Kaplan, A.M. (2004), "A beginner's guide to partial least squares analysis", *Understanding Statistics*, Vol. 3, pp. 283-297.

Horman, M.J., Riley, D.R., Lapinski, A.R., Korkmaz, S., Pulaski, M.H., Magent, C.S., Luo, Y., Harding, N. and Dahl, P.K. (2006), "Delivering green buildings: process improvements for sustainable construction", *Journal of Green Building*, Vol. 1, pp. 123-140.

Hwang, B.G. and Ng, W.J. (2013), "Project management knowledge and skills for green construction: overcoming challenges", *International Journal of Project Management*, Vol. 31, pp. 272-284.

Hwang, B.G. and Tan, J.S. (2012), "Green building project management: obstacles and solutions for sustainable development", *Sustainable Development*, Vol. 20, pp. 335-349.

Hwang, B.G., Zhao, X. and Tan, L.L.G. (2015), "Green building projects: schedule performance, influential factors and solutions", *Engineering Construction and Architectural Management*, Vol. 22, pp. 327-346.

Isa, M., Rahman, M.M.G.M.A., Sipan, I. and Hwa, T.K. (2013), "Factors affecting green office building investment in Malaysia", *Procedia-Social and Behavioral Sciences*, Vol. 105, pp. 138-148.

Isa, N., Alias, A. and Samad, Z. (2014), "Towards developing a sustainability integration framework for building project", *Journal of Building Performance*, Vol. 5, pp. 22-33.

Karakaya, E., Hidalgo, A. and Nuur, C. (2014), "Diffusion of eco-innovations: a review", *Renewable and Sustainable Energy Reviews*, Vol. 33, pp. 392-399.

Khodadadzadeh, T. (2016), "Green building project management: obstacles and solutions for sustainable development", *Journal of Project Management*, Vol. 1, pp. 21-26.

Koebel, C.T., McCoy, A.P., Sanderford, A.R., Franck, C.T. and Keefe, M.J. (2015), "Diffusion of green building technologies in new housing construction", *Energy and Buildings*, Vol. 97, pp. 175-185.

Lam, P.T., Chan, E.H., Chau, C., Poon, C. and Chun, K. (2009), "Integrating green specifications in construction and overcoming barriers in their use", *Journal of Professional Issues in Engineering Education and Practice*, Vol. 135, pp. 142-152.

Lam, P.T., Chan, E.H., Poon, C., Chau, C. and Chun, K. (2010), "Factors affecting the implementation of green specifications in construction", *Journal of Environmental Management*, Vol. 91, pp. 654-661.

Leung, M.Y., Ng, S.T., Skitmore, M. and Cheung, S.O. (2005), "Critical stressors influencing construction estimators in Hong Kong", *Construction Management and Economics*, Vol. 23, pp. 33-44.

Li, Y.Y., Chen, P.H., Chew, D.A.S., Teo, C.C. and Ding, R.G. (2011), "Critical project management factors of AEC firms for delivering green building projects in Singapore", *Journal of Construction Engineering and Management*, Vol. 137, pp. 1153-1163.

Li, Y.Y., Chen, P.H., Chew, D.A.S. and Teo, C.C. (2014), "Exploration of critical resources and capabilities of design firms for delivering green building projects: empirical studies in Singapore", *Habitat International*, Vol. 41, pp. 229-235.

Mohammadi, S. and Birgonul, M.T. (2016), "Preventing claims in green construction projects through investigating the components of contractual and legal risks", *Journal of Cleaner Production*, Vol. 139, pp. 1078-1084.

Nguyen, H.T. and Gray, M. (2016), "A review on green building in Vietnam", *Procedia Engineering*, Vol. 142, pp. 313-320.

Nguyen, H.T., Skitmore, M., Gray, M., Zhang, X. and Olanipekun, A.O. (2017), "Will green building development take off? An exploratory study of barriers to green building in Vietnam", *Resources, Conservation and Recycling*, Vol. 127, pp. 8-20.

Pham, D.H., Lee, J. and Ahn, Y. (2019), "Implementing LEED v4 BD+ C projects in Vietnam: contributions and challenges for general contractor", *Sustainability*, Vol. 11, p. 5449.

Pham, H., Kim, S.Y. and Luu, T.V. (2020), "Managerial perceptions on barriers to sustainable construction in developing countries: Vietnam case", *Environment, Development and Sustainability*, Vol. 22, pp. 2979-3003.

Quangdung, T., Tien Toi, P., The Chinh, K., Phuong Nam, T. and Ngoc Thoan, N. (2019), "A SWOT analysis of the market of green building technologies in Vietnam", *Journal of Science and Technology*, Vol. 13, pp. 76-85.

Robichaud, L.B. and Anantatmula, V.S. (2010), "Greening project management practices for sustainable construction", *Journal of Management in Engineering*, Vol. 27, pp. 48-57.

Swarup, L., Korkmaz, S. and Riley, D. (2011), "Project delivery metrics for sustainable, high-performance buildings", *Journal of Construction Engineering and Management*, Vol. 137, pp. 1043-1051.

Thomas, E.G. (2008), *Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction*, John Wiley & Sons, Hoboken, NJ.

Tran, Q. (2020), "Challenges in managing green building projects from the view of the contractors: an exploratory study in Vietnam", *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, p. 062030.

Tran, Q., Zhang, C., Sun, H. and Huang, D. (2014), "Initial adoption versus institutionalization of E-procurement in construction firms: an empirical investigation in Vietnam", *Journal of Global Information Technology Management*, Vol. 17, pp. 91-116.

Urbach, N. and Ahlemann, F. (2010), "Structural equation modeling in information systems research using partial least squares", *Journal of Information Technology Theory and Application*, Vol. 11, pp. 5-40.

Wang, W., Zhang, S., Su, Y. and Deng, X. (2018), "Key factors to green building technologies adoption in developing countries: the perspective of Chinese designers", *Sustainability*, Vol. 10, p. 4135.

Wang, W., Zhang, S., Su, Y. and Deng, X. (2019), "An empirical analysis of the factors affecting the adoption and diffusion of GBTS in the construction market", *Sustainability*, Vol. 11, p. 1795.

Zhang, X., Shen, L. and Wu, Y. (2011), "Green strategy for gaining competitive advantage in housing development: a China study", *Journal of Cleaner Production*, Vol. 19, pp. 157-167.

Zhang, J., Li, H., Olanipekun, A.O. and Bai, L. (2019), "A successful delivery process of green buildings: the project owners' view, motivation and commitment", *Renewable Energy*, Vol. 138, pp. 651-658.

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