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 viewpoint 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...
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,
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
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

| 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
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

#### Planning activities-related challenges

| Code | Challenges                                                                 | References                                      |
|------|-----------------------------------------------------------------------------|-------------------------------------------------|
| 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

| Code | Challenges                                                                 | References                                      |
|------|-----------------------------------------------------------------------------|-------------------------------------------------|
| 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

| Code | Challenges                                                                 | References                                      |
|------|-----------------------------------------------------------------------------|-------------------------------------------------|
| 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) |

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

| 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.
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
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
the model. Next, convergent validity was assessed using the Cronbach’s \( \alpha \) 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 \( \alpha \) 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
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.

| Code | Components | 1   | 2   | 3   | 4   | New codes |
|------|------------|-----|-----|-----|-----|-----------|
| C1   | 0.857      | –   | –   | –   | –   | PA1       |
| C2   | 0.677      | –   | –   | –   | –   | PA2       |
| C3   | 0.889      | –   | –   | –   | –   | PA3       |
| C4   | 0.781      | –   | –   | –   | –   | PA4       |
| C5   | 0.779      | –   | –   | –   | –   | PA5       |

| C7   | –          | 0.676| –   | –   | –   | OA1       |
| C8   | –          | 0.879| –   | –   | –   | OA2       |
| C9   | –          | 0.680| –   | –   | –   | OA3       |
| C10  | –          | 0.611| –   | –   | –   | OA4       |
| C12  | –          | 0.608| –   | –   | –   | OA5       |
| C13  | –          | 0.667| –   | –   | –   | OA6       |

| C17  | –          | –    | 0.680| –   | –   | OMA1      |
| C18  | –          | –    | 0.770| –   | –   | OMA2      |
| C19  | –          | –    | 0.644| –   | –   | OMA3      |
| C20  | –          | –    | 0.743| –   | –   | OMA4      |
| C21  | –          | –    | 0.650| –   | –   | OMA5      |
| C22  | –          | –    | 0.775| –   | –   | OMA6      |

| 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)
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](image-url)

**Figure 3.**
Average rankings of significance of the identified components

![Figure 4](image-url)

**Figure 4.**
The initial PLS-SEM
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
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.

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