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RESEARCH ARTICLE

Critical success factors for small contractors to conduct green building construction projects in Singapore: identification and comparison with large contractors

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Abstract

As a major participant of the construction industry, small contractors have been increasingly involved in green building construction projects in recent years. However, existing literature indicates that little research has been done to investigate the critical success factors for small contractors to conduct green building construction projects. As a result, this study aims to fill up the gap by identifying the most critical success factors of small contractors and comparing them against large contractors. To achieve these goals, a comprehensive literature review and pilot interviews with experienced industry experts were conducted first, followed by a questionnaire survey administered to 30 small contractors from the construction industry of Singapore. Non-parametric statistical tests were used to analyze the data. Results reported that "laborers with experience in conducting green building construction projects," "incentives/subsidies provided by government," "support of senior management," "return on investment," "commit to changing behavior," "effective communication between stakeholders on goals for sustainable construction," "early contractor involvement," "engaging experts with sound knowledge of green building construction," "cost control," and "competency of project manager" were the top ten critical success factors for small contractors to conduct green building construction projects. Additionally, the comparison results between small and large contractors revealed that eight factors were statistically different assessed by industry practitioners. These factors are "procurement process," "cost control," "commit to changing behavior," "educating clients on benefits in sustainable construction," "laborers with experience in conducting green building construction projects," "hefty levy and tax on unsustainable construction practices," and "public demand for green building construction" and "industrial culture." This study enriches the knowledge by exploring the critical success factors for small contractors to conduct green building construction projects. Furthermore, this study is informative to industry practitioners as well, especially to those small contractors who plan to conduct green building construction projects in the future.

Keywords Small construction contractor · Green building construction · Critical success factors · Singapore

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Introduction

Construction industry is major consumer of natural resources and it is responsible for a large number of issues that have occurred in terms of environment and ecological stability (Thakur et al. 2018). According to the United Kingdom Green Building Council, construction industry consumes more than 400 million tons of materials each year, and the use of these materials exerts a negative impact on environment largely. Similarly, in the USA, the US Environmental Protection Agency (EPA) reported that the construction industry in the USA produces 160 million tons of non-industrial waste every year, accounting for 25% of total non-industrial waste (Initiafy 2017). To reverse this situation, green building construction has been increasingly promoted worldwide over the past years. For example, European Commission launched the Innovation-Horizon 2020 to support sustainable development and the commercialization of eco-efficient construction and building materials in the European Union countries (Pacheco-Torgal 2014). In Canada, several incentives like LEED Canada for Homes Affordable Housing Program were established at the federal, provincial, and municipal levels to promote green building construction practices (Ruparathna and Hewage 2015). Singapore launched many initiatives and regulations such as Sustainable Construction Master Plan 2008, Singapore Green Plan 2012 (also known as SGP 2012), Green Mark Scheme, and Environmental Management System (EMS) with the intention of encouraging the adoption of green building construction (Yin et al. 2018). Apart from the efforts from the government, a lot of academics from research institutions have also shifted their focus to the area of green building construction. At present, plenty of research outputs have been produced in this regard, which cover a wide scope including the delivery of green buildings, the design and procurement of green building construction, barriers on implementing green building construction, and the strengths, weaknesses, opportunities, and threats of adopting green buildings (Abduh et al. 2018; Durdyev et al. 2018; Gunhan 2019; Hwang et al. 2018; Yu et al. 2018).

Contractors play a key role in the construction industry as they are the party responsible for delivering built environment (Holloway and Parrish 2015). Contractors vary significantly in size, and an interesting fact is that most of the contractors in the existing construction industry are small contractors. In the construction industry of the UK, for instance, 99.8% of the contractors are small contractors (Lu et al. 2008a). In the construction industry of the USA, 97% of specialty trade contractors and 96% of homebuilders are small contractors (SINIAVSKAIA 2015).

Now the global construction industry is shifting to green dramatically. This makes contractors, including small contractors, must embrace green building construction projects actively. Although small contractors may have an advantage of being more flexible in innovating (Barrett and Sexton 2006), they have more limitations in labor, resources, equipment, capital, and many other aspects when comparing with large contractors (Jaafar 2005). This means small contractors would face more difficulties in achieving success if they decide to conduct green building construction projects. Thus, it is necessary and important to find out the critical success factors for small contractors to conduct green building construction projects, especially in consideration of the high proportion small contractors have taken in the market.

The research work of this study was conducted in the context of Singapore, which is an island state with limited land area and scarce natural resources. Thus, Singapore has no choice but to adopt sustainability as national development strategy. As for the sustainability in the building and construction sector, it mainly refers to the promotion of green buildings across the country. In the past two decades, Singapore has made a lot of efforts in this regard. For example, since 2005, the Building and Construction Authority of Singapore has put forward three rounds of green building master plans (BCA 2014) to encourage the local developers and contractors to develop and construct green buildings. Meanwhile, similar to the construction industries of the UK and USA, the majority of the contractors active in the construction market of Singapore are small contractors (BCA 2017a), which implies that most of the small contractors in the country have already engaged with green building construction projects or will do in the future. Such fact indicates that Singapore is a proper context for the research.

Although plenty of research have been conducted in the area of green building construction (e.g., Brooks and Rich 2016; Durdyev et al. 2018; Lavanya et al. 2018; Li et al. 2018; Schropfer et al. 2017), few of them systematically examined the critical success factors for small contractors to conduct green building construction projects. Therefore, this study can contribute to the current body of knowledge. Additionally, this study is helpful to industry practitioners as well, because it developed a comprehensive list of critical success factors that can help small contractors to improve their implementation of green building construction projects.

Background

Green buildings in Singapore

The government of Singapore has put in a great deal of effort in promoting green building across the country in the past years. For instance, in 2005, Singapore government launched the BCA green mark scheme, which is a comprehensive system assessing the green performance of a given building from five aspects: energy saving, water saving, environmental protection, indoor environmental quality, other green

characteristics, and innovation (Low et al. 2014; BCA 2017b). In addition, since 2006, the government of Singapore has launched three rounds of national plans to promote the country's active adoption of green buildings (BCA 2017c). Furthermore, the Singapore government also introduced a series of incentive mechanisms (e.g., Green Mark Incentive Scheme for Existing Buildings in 2009 and Building Retrofit Energy Efficiency Financing Scheme in 2011) to encourage local developers, owners, and contractors to engage with green buildings in the past decade (BCA 2015). Apart from the Singapore government, the private sector of Singapore also showed its passion on green buildings. For example, in 2009, the non-profit organization Singapore Green Building Council was established, and 89% of the founding members are construction-related companies who have strong interests in green buildings (SGBC Member Directory 2019). In addition, evidence from existing research also showed that the private sector of Singapore has become increasingly eager to use green features (e.g., solar panels) in their construction business over recent years (Siva et al. 2017).

Small contractors in Singapore

According to the existing literature, the definition of what constitutes a small business has been problematic and it varies significantly in different countries (Eyiah 2001; Eyiah and Cook 2003). In the USA, small companies are defined as companies who have an average annual income of less than USD 36.5 million (U.S. Small Business Administration 2017). In European countries, small companies are those who have employees less than 50, sales less than EUR 50 million (about USD59 million), or annual assets and liabilities less than EUR 43 million (about USD50 million) (European Commission 2011). The Bolton Committee came up with different definitions for small businesses from different sectors (Bolton 1971). The Committee categorized construction organiztions with 25 employees or less as small businesses. Such a definition is realistic considering the wide range of subcontracting in the construction sector.

In Singapore, although the definition for small contractors is lacking, small businesses are clearly defined. According to the Ministry of Trade and Industry of Singapore, those companies who have at least 30% local shareholding, annual sales of SGD 100 million (about USD74 million) at the utmost, and empolyees less than 200 can be considered as small businesses. As for the construction companies in Singapore, most of them are included in a contractor registration system which is maintained by BCA (BCA 2017d). The system classifies the registered contractors according to their paid-in capital and net assets, relevant technical personnel, management qualifications, and performance records (BCA 2015), as shown in Table 1. According to Singapore government's definition of small business and the BCA contractor registration system, it can be found that all the contractors registered with BCA can be considered as small contractors to a certain extent, as they meet the requirments in annual sales and the number of employees. This also indicates that Singapore is a suitable context for the research.

Critical success factors for conducting green building construction projects

In construction engineering and management research, papers investigating critical success factors are plenty and can be referred for identifying the critical success factors for small contractors to conduct green building construction projects. Thus, the research team carried out a comprehensive literature review of the existing literature and gathered 30 factors that might be critical for small contractors while implementing green building construction projects, as shown in Table 2.

According to Li et al. (2019), critical success factors (CSFs) are the key factors that an organization or a project

Table 1 Various levels of contractors registered with the contractor registration system of BCA

Level	Capital position (SGD[a])	Performance records (past 3 years) (SGD)	Personnel	No. of registered contractors[b]
A1	15 million	150 million	24	91
A2	6.5 million	65 million	12	46
B1	3 million	30 million	6	79
B2	1 million	10 million	3	84
C1	300,000	3 million	1	329
C2	100,000	1 million	1	117
C3	25,000	100,000	1	1129
Total				1875

[a] 1 SGD is approximately USD 0.74

[b] Data of December 2017; "Capital Position" includes minimum paid-in capital and minimum net assets that must be met separately; "Performance Records" show all accomplished projects in the past three years. "Personnel" means technical personnel with qualifications or recognized academic degrees

Table 2 CSFs for small contractors to conduct green building construction projects

Code	Critical success factors	Reference																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
F01	Design integration		√		√							√			√				√	
F02	Procurement process						√												√	√
F03	Nature of project						√		√					√						
F04	Engaging experts with sound knowledge of green building construction	√	√	√		√														
F05	Simple sustainable construction framework for stakeholders to follow					√									√		√	√	√	√
F06	Life cycle management																			
F07	Effective communication between stakeholders on goals for sustainable construction	√	√	√	√		√									√				√
F08	Setting clear goals and objectives at the start of project	√		√	√	√	√	√	√										√	
F09	Risk Identification and Management					√		√												
F10	Cost control	√												√				√		
F11	Minimal changes in schedule			√																
F12	Return on investment	√												√				√		
F13	Competency of project manager						√	√	√											
F14	Toolbox and frequent on-site meetings	√	√																	
F15	Basic courses on sustainable construction practices for staff involved												√			√				
F16	Support of senior management			√			√													
F17	Commit to changing behavior			√											√					
F18	Client's experience/insistence in green building construction						√	√										√		
F19	Educating clients on benefits in green building construction				√							√	√		√	√				
F20	Clients' ability to make decisions							√	√	√	√							√		
F21	Early contractor involvement	√																		
F22	Ease of availability of materials for sustainable construction			√									√		√				√	
F23	Laborers with experience in conducting green building construction projects						√					√							√	
F24	Incentives/subsidies provided by government	√	√		√	√				√		√		√				√		√
F25	Hefty levy and tax on unsustainable construction practices															√		√		
F26	Code and regulations	√			√	√	√							√	√	√		√		
F27	Legal support																			
F28	Awareness of green building construction										√	√		√				√	√	√
F29	Public demand for green building construction	√	√		√		√			√				√				√		
F30	Industrial culture	√	√		√		√			√				√						

[1] (Robichaud and Anantatmula 2011), [2] (Hwang and Tan 2012), [3] (Wai et al. 2012), [4] (Bossink 2002), [5] (Hill and Bowen 1997), [6] (Yong and Mustaffa 2013), [7] (Gudiene et al. 2013), [8] (Gudiene et al. 2014), [9] (Ametepey et al. 2015), [10] (Kibwami and Tutesigensi 2016), [11] (Zainul Abidin Nazirah 2010), [12] (Shi et al. 2013), [13] (Yung and Chan 2012), [14] (Alsanad 2015), [15] (Chan et al. 2004), [16] (Ding 2008), [17](Pitt et al. 2009; Shi et al. 2013), [18] (Häkkinen and Belloni 2011), [19] (Sourani and Sohail 2011)

must pay attention to in order to achieve its mission. They are vital elements for ensuring the success of the organization or the project (Yong and Mustaffa 2013). Current literature shows that several studies have examined the CSFs for implementing green building construction projects. For instance, Li et al. (2011) identified 19 controllable critical project management factors of delivering green building projects and grouped them into 5 major categories: technical and innovation-oriented factors, human resource-oriented factors, project manager's competence, support from designers and senior management, and coordination of designers and contractors. Li et al. (2011) also conducted multiple regression analysis of these five categories and found that the coordination of designers and contractors and technical and innovation-oriented factors were the most critical categories. Low et al. (2014) investigated the critical success factors for renovating existing buildings toward a certain sustainability standard, which include effective planning and control, top management support, cost management, building owner's involvement, responsiveness of building owners, priorities of stakeholders, and legislation and clear scope. Banihashemi et al. (2017) identified 43 factors that may affect the

integration of sustainability into construction project management practices in developing countries. Banihashemi et al. (2017) also categorized these 43 factors into 6 categories: knowledge management in evaluation, role of clients in identification, commitment to high quality workmanship, having a strategic direction and incorporating health and safety protocols, project managers' knowledge, skills and abilities, and enforcing tighter controlling regimes over construction activities. Hwang et al. (2017a) investigated the critical success factors for developing green business park projects. They stressed three top factors: top-management support, strong financial capability, and adequacy of design details and specifications. Additionally, Shen et al. (2017) identified critical success factors for implementing green building projects in Thailand and grouped those factors into five categories: competence of project participants, integration of green building project team, technical and management innovation, external environment, and project characteristics. Although the critical success factors summarized above do not pertain to small contractors directly, they could be used as reference to generate those ones for small contractors.

In addition to those who have particularly investigated critical success factors concerning green building construction, studies examining critical success factors of implementing generic construction projects are also helpful to the research. For instance, Lu et al. (2008b) identified 35 factors that contributed the competitiveness of contractors in China and grouped them into 8 categories: project management skills, organization structure, resources, competitive strategy, relationships, bidding, marketing, and technology. Ng and Tang (2010) identified nine critical success factors from the perspective of sub-contractors. These factors include timely completion, profit, program planning, cash flow, management level of the leadership, relationships with other project stakeholders, project team culture, project team skills, and growth in revenue. Hwang and Lim (2012) identified 32 critical success factors for the key project players in the construction industry of Singapore and classified them into 4 major categories: project characteristic-related factors, contractual arrangement-related factors, project participant-related factors, and interactive process-related factors. Jin et al. (2012) identified factors that contribute to the successful development of infrastructure projects in Malaysia from main contractor's perspective and examined their possible impacts on project objectives in scope, time, cost, and quality. Ofori-Kuragu et al. (2016) revealed eight critical success factors for the contractors in Ghana, which were quality and zero defect culture, organizational design, work culture and work environment, client satisfaction, strategy, leadership, measurement, analysis of information and knowledge management, and implementation of lean principles. All knowledge presented above contributed to the formation of the 30 critical success factors presented in Table 2.

Methods and data presentation

Research methods

Qualitative and quantitative research methods such as literature review, pilot interview, questionnaire, and post-survey interview were adopted in this study.

Literature review refers to research activities that collect, identify, and sort out literature to form a scientific understanding of some subject. To identify the critical success factors for small contractors to conduct green building construction projects, this study conducted a comprehensive literature review first. In order to ensure the comprehensiveness of the literature review, a wide variety of documentary sources including books, journal articles, papers, government documents, and website information were carefully reviewed.

Pilot interview is a commonly used method for collecting opinions and ideas of industry experts. In this research, pilot interviews were conducted with three industry experts identified from the network of the research team. To ensure the quality of the interview, these experts were required to have at least 10 years of experience in conducting conventional construction projects and at least 3 years of experience in conducting green building construction projects. During interview, the experts were asked to verify the critical success factors gathered from the literature review in light of the real construction industry of Singapore. The interview also contained two open questions for the industry experts. One question asked the experts to comment the identified factors in terms of their statement accuracy. The other question checked the possible supplement of the factors.

Questionnaire is a widely used method of collecting professional opinions on a subject in green building research (Chan et al. 2018). As a result, this study adopted questionnaire to collect the opinions of professionals on critical success factors. Based on the outputs of the literature review and the pilot interviews, a questionnaire was developed, which consists of two sections. The first section was designed to record the background information of the respondents, including their work scope, years of experience in the construction industry and sustainable construction, and the number of the green construction projects they have carried out. As for the second section, it asked respondents to rate the importance of critical success factors from two perspectives: small contractors and large contractor, using a five-point Likert scale (i.e., 1 = least important; 2 = less important; 3 = neutral; 4 = important; and 5 = most important).

Lastly, post-survey interviews were conducted with four experts who were randomly selected from 30 experts responding to the questionnaire. During interview, the experts were provided with the results obtained from the questionnaire and were asked to evaluate the results in sense of validity. Furthermore, in order to gain deeper insight into the results,

experts were also requested to explain the results based on their practical experiences wherever they want.

Data presentation

The sampling frame of the questionnaire is 1875 contractors registered with the BCA Contractor Registration System, as shown in Table 1. Referring to commonly used sample rate of 10% (Sommer and Steland 2019), 188 contractors were randomly selected from the registration system as potential respondents. Through online search and telephone enquiries of the scope of these contractors, 142 contractors were found to have conducted green building construction projects previously. Therefore, these 142 contractors were finalized as target respondents. Subsequently, electronic version of the questionnaire was distributed to the 142 contractors via email. As this study plans to investigate the critical success factors in two environments: small and large contractors. Therefore, the questionnaire was requested to be filled out by the person who used to work with an international contractor which can be considered as a large contractor largely. In order to ensure a high response rate, phone calls and email reminders were sent out every week to remind all target respondents to submit their inputs. Lastly, 30 contractors submitted their data, yielding a norm response rate of 21% for the construction industry survey (Hwang et al. 2017b). The profile of the respondents of the 30 contractors, as well as the detailed information of the sustainable construction projects they have conducted are shown in Table 3. It can be found that the respondents are doing different jobs including project managers, quantity surveyors, engineers, and on-site supervisors. About 63% of the respondents have more than 3 years of experience in conducting green building construction projects. Moreover, the green building construction projects undertaken by the respondents vary greatly in terms of project nature and cost. Such large diversity and heterogeneity of the respondents can help ensure the quality of the data and generate some research findings that are more reliable.

Data analysis methods

Several statistical tests were conducted to analyze the data collected by the questionnaire. Since a large number of statistical tests require the tested data to follow the normal distribution (Kim 2015), Kolmogorov-Smirnov test was conducted to test the normality of the data first. The null hypothesis of Kolmogorov-Smirnov is that the tested data is normally distributed (Nguyen 2018). If the p value obtained from the test is less than the selected alpha value (e.g., 0.05), then the null hypothesis is rejected, suggesting that the tested data does not follow normal distribution (Abachi et al. 2018). In this study, the alpha level was set as 0.05. The software of IBM SPSS Statistics was used to conduct the statistical test.

Two statistical test methods, namely one sample t test and one sample Wilcoxon signed-rank test, were considered for checking whether the critical success factors in questionnaire are significant to small and large contractors. One sample t test is a method to test whether the mean of a sample is statistically

Table 3 Respondent profile

Variable	Category	Number	Percentage (%)
Job position	Project manager	13	43.33
	Quantity surveyor	3	10.00
	Engineer	12	40.00
	Site supervisor	2	6.67
Year of experience in traditional construction	Less than 3 years	5	16.67
	3 to 5 years	4	13.33
	6 to 10 years	11	36.67
	More than 10 years	10	33.33
Year of experience in green building construction	Less than 3 years	11	36.67
	3 to 5 years	8	26.67
	6 to 10 years	6	20.00
	More than 10 years	5	16.67
The nature of green building construction projects conducted	New construction	131	59.55
	Addition and alteration	89	40.45
The cost of green building construction projects conducted (SGD*)	0.1–1 million	10	4.55
	1–5 million	102	46.36
	5–10 million	43	19.55
	> 10 million	65	29.55

equivalent to a test value, where the sample data must follow a normal distribution (Wendler and Gröttrup 2016). By contrast, one sample Wilcoxon signed-rank test is an alternative to one sample *t* test in the case that the sample data are not normally distributed, which checks whether the median of the sample is equal to a test value (Thas et al. 2005). Thus, the normality test result generated by Kolmogorov-Smirnov test will determine the method to be used for the check. For this study, 3 was selected as the test value, which means the critical success factor is important to small and large contractors, according to the rating scale adopted by the questionnaire.

In addition, this study conducted inter-group comparison to check whether there are statistical differences among the respondents having different job positions. Two statistical tests, analysis of variance (ANOVA) and Kruskal-Wallis, were considered for the comparison. ANOVA is a widely used statistical test method to examine potential differences between two or more independent groups (Kim and Cribbie 2018). Kruskal-Wallis test is a rank-based statistical test to check the potential differences between two or more different groups (Mahoney and Magel 1996). The difference between ANOVA and Kruskal-Wallis is that ANOVA requires normal distribution data while Kruskal-Wallis is a distribution free method. Therefore, the data normality test results obtained from Kolmogorov-Smirnov test will determine which method would be used for the comparison.

As the critical success factors were assessed in two different contexts, namely small and large contractors, it is necessary to conduct statistical test to check whether there is a significant difference between the two kinds of assessments. According to Blair and Higgins (1985), paired sample *t* test and Wilcoxon signed-rank test were suitable for such a comparison. Paired sample *t* test is a statistical test used to check whether the means of a subject obtained from two sets of observations are different. The test requires the measured data should follow a normal distribution (Pollak and Cohen 1981). Wilcoxon signed-rank test is a statistical method to compare the ranks of a subject between two matched samples. It is a substitute for the paired sample *t* test under the condition that the data of the subject is not normally distributed (Harris and Hardin 2013). Therefore, the results of the Kolmogorov-Smirnov's test will determine which method ought to be used for the comparison between small and large contractors.

Results and discussions

Statistical test results

Table 4 presents respondents' assessments of critical success factors and the relevant statistical test results. Kolmogorov-Smirnov test results in Table 4 showed that assessments of all critical success factors were significant at the significance level of 0.05, indicating the data were not normally distributed. Hence, one sample Wilcoxon test was adopted to check whether the identified critical success factors were significant to contractors; Kruskal-Wallis test was used for inter-group comparison; and Wilcoxon signed-rank test was used for paired comparison between large and small contractors.

According to Table 4, *p* values of all factors generated by Kruskal-Wallis test are greater than 0.05, suggesting respondents provided similar assessments even though they are from different stakeholders. Furthermore, the one sample Wilcoxon signed-rank test results in Table 4 show that the assessments of all factors are statistically equal to or greater than the test value of 3, indicating all factors are important to both small and large contractors. Moreover, the Wilcoxon signed-rank test results in Table 4 show that the assessment results of F02, F10, F17, F19, F23, F25, F29, and F30 in the context of small contractors are statistically higher than those in the context of large contractors, suggesting that these factors are more critical to small contractors than to large contractors.

Top ten critical success factors for small contractors to conduct green building construction projects

Due to word limit, discussing all critical success factors in the paper is difficult. Thus, the research team decided to discuss the top ten factors only in the paper. Such a strategy has been used by many construction engineering and management studies. For example, Ke et al. (2011) identified 37 potential risks to managing public-private partnership projects in China and discussed the top ten risks only. Zou et al. (2007) identified 85 risks that may affect the construction projects in China and discussed the top ten risks only in their paper. The top ten critical success factors for small contractors in conducting green building construction projects are presented in Table 5 below.

Receiving the highest assessment of 4.57, F23 "laborers with experience in conducting green building construction projects" was assessed as the most important critical success factors for small contractors to conduct green building construction projects. Talents with green building construction experience can help the projects to be accomplished more efficiently and in higher quality (Häkkinen and Belloni 2011). Thus, it is very important for small contractors to have enough workers who are equipped with green building construction experiences in the organization. However, most of the small contractors in the market may not have such workers because of the narrow business scope of the organizations, as stated by an expert attending the post-survey interview. To overcome this barrier, implementing continuing professional develop training would be a good strategy.

F24 "incentives/subsidies provided by government" was also rated as the most important critical success factor, same as F23. Singapore government has launched many schemes

Table 4 Assessments of critical success factors and statistical test results

Code	Small contractor					Large contractor					Comparison	
	Mean	*P* value (Kolmogorov-Smirnov test)	*P* value of Kruskal-Wallis test (Job position)	*P* value of one sample Wilcoxon signed-rank test	Rank	Large contractor	Large contractor	Large contractor	Large contractor	Large contractor	Difference	*P* value (Wilcoxon signed-rank test)
F23	4.57	0.000*	0.361	0.000**	1	4.03	0.000*	0.523	0.000**	8	0.27	0.002#
F24	4.57	0.000*	0.780	0.000**	1	4.30	0.000*	0.872	0.000**	2	0.54	0.065
F16	4.50	0.000*	0.673	0.000**	3	4.30	0.000*	0.984	0.000**	2	0.20	0.227
F12	4.40	0.000*	0.573	0.000**	4	4.33	0.000*	0.757	0.000**	1	0.07	0.527
F17	4.37	0.000*	0.379	0.000**	5	3.90	0.000*	0.585	0.000**	12	0.47	0.035#
F07	4.30	0.000*	0.770	0.000**	6	4.03	0.001*	0.522	0.000**	8	0.10	0.096
F21	4.30	0.000*	0.747	0.000**	6	4.20	0.000*	0.689	0.000**	4	0.27	0.317
F04	4.27	0.000*	0.444	0.000**	8	4.20	0.000*	0.734	0.000**	4	0.07	0.593
F10	4.23	0.000*	0.674	0.000**	9	3.90	0.000*	0.826	0.000**	12	0.33	0.025#
F13	4.13	0.000*	0.762	0.000**	10	4.07	0.000*	0.980	0.000**	6	0.06	0.592
F29	4.03	0.000*	0.573	0.000**	11	3.67	0.000*	0.702	0.002**	18	0.36	0.038#
F11	4.00	0.000*	0.832	0.000**	12	3.80	0.000*	0.654	0.000**	15	0.20	0.370
F19	4.00	0.000*	0.936	0.000**	12	3.57	0.000*	0.121	0.001**	25	0.43	0.015#
F25	4.00	0.000*	0.734	0.000**	12	3.33	0.000*	0.869	0.026**	28	0.67	0.001#
F01	3.97	0.000*	0.705	0.000**	15	3.87	0.000*	0.595	0.000**	14	-0.10	0.180
F09	3.97	0.001*	0.849	0.000**	15	4.07	0.001*	0.661	0.000**	6	0.04	0.405
F22	3.97	0.000*	0.943	0.000**	15	3.93	0.000*	0.500	0.000**	10	0.10	0.936
F02	3.93	0.000*	0.558	0.000**	18	3.63	0.000*	0.563	0.001**	21	0.30	0.029#
F20	3.90	0.000*	0.864	0.000**	19	3.93	0.000*	0.460	0.000**	10	-0.03	0.794
F28	3.83	0.000*	0.962	0.000**	20	3.63	0.000*	0.999	0.000**	21	0.20	0.058
F06	3.77	0.000*	0.970	0.000**	21	3.80	0.000*	0.779	0.000**	15	-0.03	0.822
F08	3.77	0.000*	0.811	0.001**	21	3.60	0.000*	0.642	0.003**	24	0.10	0.380
F18	3.77	0.000*	0.980	0.001**	21	3.67	0.000*	0.121	0.002**	18	0.17	0.541
F15	3.70	0.025*	0.718	0.001**	24	3.40	0.000*	0.253	0.018**	27	0.07	0.104
F26	3.70	0.000*	0.171	0.000**	24	3.63	0.000*	0.127	0.000**	21	0.30	0.593
F27	3.67	0.000*	0.866	0.001**	26	3.67	0.000*	0.726	0.001**	18	0.00	1.000
F03	3.63	0.000*	0.855	0.002**	27	3.73	0.000*	0.475	0.001**	17	-0.10	0.417
F05	3.60	0.006*	0.961	0.046**	28	3.30	0.000*	0.981	0.224	29	0.30	0.090
F30	3.03	0.000*	0.976	0.971	29	3.50	0.000*	0.523	0.080	26	-0.47	0.036#
F14	2.87	0.000*	0.291	0.506	30	2.83	0.001*	0.919	0.365	30	0.04	0.854

*The Kolmogorov-Smirnov test was significant at the significance level of 0.05, suggesting the data were not normally distributed

**The one sample Wilcoxon signed-rank test was significant at the significance level of 0.05, suggesting the respondents' assessment was different from the test value of 3

The Wilcoxon signed-rank test was significant at the significance level of 0.05, suggesting the CSF was assessed differently between small and large contractors

that encourage contractors to adopt green building construction practices over the past years. These schemes contain a large number of incentives and subsidies which can help contractors reduce the cost in adopting green building construction. These incentives and subsidies are especially important to small contractors, as most of small contractors have a financial condition fairly fragile and these incentives and subsidies can alleviate their financial pressure effectively.

F16 "support of senior management" received the assessment of 4.50 and was assessed as the third most important critical success factor. It is well known that senior management can have a huge amount of influence over their subordinates and the projects they are managing and thus, senior management is important to the success of a given project. For small contractors, senior management is even more important because the organizational structure of small

Table 5 Top ten critical success factors

Code	Critical success factor	Mean	Rank
F23	Laborers with experience in conducting green building construction projects	4.57	1
F24	Incentives/subsidies provided by government	4.57	2
F16	Support of senior management	4.50	3
F12	Return on investment	4.40	4
F17	Commit to changing behavior	4.37	5
F07	Effective communication between stakeholders on goals for sustainable construction	4.30	6
F21	Early contractor involvement	4.30	7
F04	Engaging experts with sound knowledge of green building construction	4.27	8
F10	Cost control	4.23	9
F13	Competency of project manager	4.13	10

contractor tends to be flat (Ghobadian and Gallear 1997), which implies that senior management can influence the project more significantly.

F12 "return on investment" was scored 4.40 and was assessed as the fourth most important critical success factor. Conducting green building construction project requires a lot of up-front investments which can fall in purchasing new technologies and equipment and in training the existing workforce. These investments are especially crucial to small contractors, because few of them have sufficient financial capacity to fuel their green building construction practices. It is less likely for small contractors to embrace green building construction actively unless they see good return on the investments ahead. This factor was also highly endorsed by all experts attending the post-survey interviews.

F17 "commit to changing behavior" was assessed as the fifth most important critical success factor, with a score of 4.37. According to Hwang et al. (2018), small contractors in Singapore are still relying on conventional construction method in practice. To encourage higher uptake of green building construction for small contractors, there must be a commitment to change the current mentality and working style of employees. This is similar to the view of Battistelli et al. (2014) that employees should understand the commitment to change behavior so that they can practice more skillfully and consistently and loyally; otherwise, the failure on projects will occur.

F07 "effective communication between stakeholders on goals for sustainable construction" was rated as the sixth most important critical success factor for small contractors with a score of 4.30. Having effective communication between stakeholders on goals for sustainable construction is crucial to the success of green building projects. By doing so, all stakeholders are able to have a clear goal and they can also stay on the same page during the process of construction. This factor is even more important to small contractors, because small contractors normally take the role of subcontractors in construction projects, which is a contracting party might not have direct communication channels with the client or other contracting parties.

Receiving an assessment of 4.30, F21 "early contractor involvement" was assessed as the seventh most important critical success factor for small contractors to conduct green building construction projects. Early contractor involvement can get the opinions of contractors before the start of the project and can help choose the best construction method and the materials most available. This also applies to small contractors who are about to conduct green building construction projects. In addition, an expert attended post-survey interviews pointed out that getting small contractors involved at an earlier stage can bring additional benefits to small contractors as they can charge more, because of the additional service provided.

F04 "engaging experts with sound knowledge of green building construction" was rated as the eighth most important critical success factor, with a score of 4.27. It has been mentioned earlier that not every small contractor in the market do not have enough manpower equipped with knowledge of green building construction. In this case, engaging external experts would be a good strategy to address the issue. An expert attending post-survey interviews stated that it is fairly common for small contractors in Singapore to call for external help when they encounter some problems they cannot handle during project implementation.

Receiving the assessment of 4.23, F10 "cost control" was evaluated as the ninth most important critical success factor. As a very competitive industry dominated by price, cost control is vital for contractors in the construction industry, especially for those small ones who have low financial capacity or in fragile financial conditions.

Receiving 4.13, F13"competency of project manager" was assessed as the tenth most important critical success factor for small contractors to conduct green building construction projects. The leadership ability and capability of the project manager have considerable impact on the success of organizations and projects. Thus, it is highly necessary for every small contractor to appoint a capable project manager that can lead the implementation of the green building construction project.

After all, the success of the project relates to the reputation and to the future business opportunities of the company.

Critical success factors for conducting green building construction projects: small versus large contractors

Currently, both large and small contractors are confronted with the challenge of implementing green building construction projects. Large and small contractors are different from each other in many aspects including employee number, financial capability, and the possession of equipment and technologies. This may make the critical success factors of implementing green building construction projects vary between small and large contractors. To test this assumption, this study proposed a research hypothesis that the critical success factors will be differently assessed between the contexts of small and large contractors. The Wilcoxon signed-rank test results in Table 4 report that eight factors, namely F02, F10, F17, F19, F23, F25, F29, and F30, were statistically different assessed by respondents, which proves the assumption.

According to the test result, F02 "procurement process" is more critical to small contractors than to large ones. The main reason for the difference might be that small contractors have many limitations in tendering projects (e.g., the size of the project that small contractors can tender), while these limitations are not applicable to large contractors. Thus, small contractors must pay more attention to the procurement process, if they want to secure the projects eventually.

F10 "cost control" was reported more critical to small contractors than to their large counterparts. This might be because small contractors are more cost-sensitive than large contractors and they must rely more on cost control to earn profit in the projects they have conducted. One of the experts attending post-survey interview highlighted that small contractors in Singapore value cost control a lot and they consider cost control the most important strategy to survive in the local construction market.

F17 "commit to changing behavior" was assessed more critical to small contractors than to large contractors. It has been mentioned earlier in this paper that small contractors in Singapore are still relying on the conventional construction methods they have been used to and many of them have concerns in making the change. However, as stated by one expert attending post-survey interview, small contractors need to recognize that they have to adapt to the ever-changing market where green building construction is actively promoted, by committing to changing their old work style or pattern. Otherwise, they would be eliminated from the market eventually.

F19 "educating clients on benefits in sustainable construction" was assessed more critical to small contractors than to large contractors. Although many clients have nowadays chosen to adopt green buildings in practice, some of them make the choice passively and they are required to do so by the mandatory requirement stipulated by government. Such a passive selection may be because clients do not have a deep understanding of the benefits that could be brought by adopting green building construction practices. For small contractors, the size of the projects they conduct is relatively small and it is common that clients are reluctant to use green building construction methods in projects. At this time, educating clients on benefits in sustainable construction becomes very necessary and important, because it can help small contractors get more support from clients.

F23 "laborers with experience in conducting green building construction projects" is another factor more critical to small contractors than to large contractors. Bringing in experienced laborers is an important enterprise strategy, which is also a critical factor to determine the success and competitiveness of an enterprise in the market (Lorincová et al. 2018). This factor is especially important to small contractors that plan to engage green building construction projects. This is because most of small contractors in Singapore lack experienced laborers in conducting green building construction, as asserted by one expert attending post-survey interviews.

In addition to the above, small contractors are more susceptible to influences from external environment than large ones. F25 "hefty levy and tax on unsustainable construction practices" and F29 "public demand for green building construction" are two external factors more critical to small contractors. To make Singapore resilient and adaptable to an increasingly complex and rapidly changing world, the government has announced a number of tax reforms (EY 2017). Among them, the penalty about hefting levy and tax on unsustainable construction practices can cause enormous financial influence on small contractors, resulting in a much bigger loss of profit for them as compared to larger companies. As such, this may compel small contractors to increase their uptake of green building construction in their projects. Besides, increasing public demand for green building construction is also important to small contractors, as it can create more business opportunities for small contractors in this area.

F30 "industrial culture" is a factor more critical to large contractors than to small contractors. All experts attending post-survey interview agreed with the result. They explained that large contractors have many employees and are more susceptible to industrial culture, while small contractors have a limited number of employees and they are less affected by industrial culture.

Although the top critical success factors for small contractors to conduct green building construction projects were identified, and comparisons of the factors between small and large contractors were performed, this study has some limitations. First, the experts participating in pilot interviews are from personal network of the research team. This may render the research potentially subjective. Second, this research used questionnaire survey, a method mainly relying on people's

perception to collect data. This may cause the issue of subjectivity to some extent. Third, the sample size of the survey is relatively small and thus, caution should be warranted when the results are interpreted. Lastly, this research was carried out in the context of Singapore and the results may have applicability issue when applying to other countries.

Conclusions

The rise of green buildings has been witnessed in the past decade, along with an increasing number of contractors conducting green building construction projects worldwide. Compared with large contractors, small contractors are confronted with more challenges in conducting green building construction projects. Thus, this study investigated the critical success factors for small contractors to conduct green building construction projects. Through literature review, this study first identified 30 factors that are critical to small contractors in conducting green building construction projects. Then, this study used questionnaires to collect evaluations of the critical success factors from 30 small contractors in Singapore. Via data analysis, the top ten critical success factors were revealed, including "laborers with experience in conducting green building construction projects," "incentives/subsidies provided by government," "support of senior management," "return on investment," "commit to changing behavior," "effective communication between stakeholders on goals for sustainable construction," "early contractor involvement," "engaging experts with sound knowledge of green building construction," "cost control," and "competency of project manager." In addition, this study checked the difference of these factors between the contexts of large contractors and small contractors. Results showed that "procurement process," "cost control," "commit to changing behavior," "educating clients on benefits in sustainable construction," "laborers with experience in conducting green building construction projects," "hefty levy and tax on unsustainable construction practices," and "public demand for green building construction" were found more important to small contractors than to large contractors, while "industrial culture" was more critical to large contractors than to small ones.

This study is a comprehensive survey of critical success factors for small contractors to conduct green building construction projects, which expands the existing literature of sustainable construction. Additionally, it provides small contractors with a list of critical success factors which can be used by small contractors to come up with some strategies that can help them improve their implementation of green building construction projects. As for the future research, it is necessary to assess the performance of small contractors in implementing green building construction projects. It would also be interesting to examine the specific factors affecting medium-sized contractors in their implementation of green building construction projects, so that critical success factors for all size contactors could be covered.

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