INTERNATIONAL JOURNAL OF SUSTAINABLE CONSTRUCTION ENGINEERING AND TECHNOLOGY
VOL. 12 NO. 5 (2021) 197-204

IJSCET

http://publisher.uthm.edu.my/ojs/index.php/ijscet

ISSN : 2180-3242 e-ISSN : 2600-7959

International Journal of Sustainable Construction Engineering and Technology

Analysing Factors Affecting Green Construction Productivity: Exploratory Factor Analysis Noor Aisyah

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DOI: https://doi.org/10.30880/ijscet.2021.12.05.020
Received 19 October 2021; Accepted 31 December 2021; Available online 31 December 2021

Abstract: Construction sector productivity is substantial significance for the government and policymakers because it creates a competitive industry environment as well as determines a nation's expectancy. Addressing the factors influencing productivity especially in Green Construction Project (GCP) is essential and its significantly need to align with the target goal in Malaysia Green Technology Master Plan (2017–2030). In lieu to the scenario, this research aims to identify the important factors affecting the productivity of GCP, by evaluating the criticality factors that may contribute to project productivity. Based on the previous studies, five (5) key component factors were identified with a total of forty-four (44) associated items. The key component factors can be broadly categorized into i) Project, ii) Manpower, iii) Management, iv) Technical and v) External aspect. These factors with their associated items, are then used to develop questionnaire survey to gather data. The Exploratory Factor Analysis (EFA) was employed to the collected data which emphasize to the five (5) component factors with forty-four (44) items affecting green construction productivity with the total variance percentage is 72.113%. Each of the components consists of at least seven (7) variables, so the components complied with the requirement that each component must have at least three variables. According to the findings, the KOM (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) is 0.9, which is very similar to 1. Each factor loading variable is greater than 0.4 indicating that all components satisfied the Factor Analysis rule. The highest Eigenvalue is on Project Factors (18.175), and the lowest is External Factors (1.154). It is important to understand all key factors affecting the construction productivity, so that the industry practitioners can effectively strategies a plan to improve the productivity in GCP, for prompt delivery of construction projects with lower cost, higher quality and remarking sustainability.

Keywords: Productivity, green construction, construction management, Exploratory Factor Analysis (EFA)

1. Introduction

The construction industry plays a critical role to the country's economic well-being. Its intensity of productivity has a crucial impact on national economic and contributes to Gross Domestic Product (GDP) growth and has been prioritised as part of the nation agenda. According to Construction Industry Development Board (CIDB) (2016), the Construction Industry Transformation Programme (CITP) 2016 – 2020 aims to empower and strengthen the construction industry, which the Programme is outlined in the Thrusts of the 11th Master Plan. Under strategic thrust number three, productivity is the primary engine of growth towards Malaysia's high-income target. Henceforth, the construction industry growth is a deliberate mechanism to increase the construction industry's efficiency, capability, and effectiveness in order to meet the demand for building and civil engineering, as well as to support long-term national economic and social development goals. Since 2006, Malaysia has progressively improved the delivery of Green Construction Projects (GCP). The

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Malaysian government intends to implement sustainable building and infrastructure growth in the country by developing policies and strategic planning to facilitate the construction industry in moving toward sustainability (CIDB, 2009; EPU, 2014, CIDB, 2015). It has courageous expectations to increase GCP delivery in order to achieve certain ambitious goals in the areas of energy productivity, resource savings, and zero-carbon building. As reported in Green Building Index (GBI), as of December 2018, there is 467 numbers of certified GCP in Malaysia. As the target goal in Green Technology. Master Plan (2017 – 2030), the statistics will be growth by 550 number of GCP by 2020, inclusive of green certified by various agencies and organisations such as MyCREST, Green Construction Index, Green RE etc.

Since there will be a significant number of green building projects in the future, construction productivity will be a critical and decisive factor in achieving this goal. However, the Malaysian construction industry's slow productivity growth casts serious doubt on the achievement of this target. The Malaysian construction industry's labour productivity, which is a critical productivity measure, has been gradually declining from 12.4 percent in 2016 to –7.3 percent in 2019.The expansion rate of commercial buildings rise at a rate of 3-6 percent per year, depending on the building type. Building/construction industry forecasts beyond 5-7 years are harder to achieve by since they are highly dependent on the country's economic outlook. As stated in Green Technology Master Plan 2017 – 2030 Report (KeTTHA,2017), currently, Malaysia lacks a holistic strategy led by a single agency that brings all players in the building and construction industry together to develop and agree on future green building goals. As a result, agreement on a prospective green building target would necessitate collaboration among these agencies to improve the entire system that can produce a green building.

In general, adopting sustainable building and construction practises necessitates a substantial time and financial commitment. The lack of a regulatory push factor, as well as uncertainties about real costs, lead to developers and contractors' lack of interest in investing in green building technology. The higher costs of producing green products and technologies also holds back the transition to sustainability. Therefore, understanding the factors contributing to productivity in GCP is relevant and significant to accommodate the targeted number of Green Construction project in the future.

2. The Productivity of Green Construction Project in Malaysia

Productivity has traditionally been defined as the ratio of input/output, or the ratio of an associated resource's input (usually, but not always, expressed in p-hs) to real output (in creating economic value). The output can be any process result, such as a product or service, and the input factors can be any human or physical resources used in the process. Issues related to the productivity can be divvied into two categories: micro and micro. Contracting processes, labour law, and labour organisation are dealt with at the macrolevel; on the other hand, management and execution of a project, mostly at the job site, are dealt with at the microlevel. Henceforth, the productivity in the construction industry must be underpinned by the drivers of workforce, technology, and processes (CITP, 2016).

In practice of construction process, there is a need for efficiency steps for measures of construction productivity at three levels: (1) task, (2) project, and (3) industry. Concrete placement and structural steel erection are examples of tasks. Projects are a range of operations needed for the construction of a new facility (e.g., a new commercial office building) or the reconstruction of an existing facility (i.e., extensions, alterations, and significant replacements. The industry factors depend on the Malaysia Productivity Corporation's (MPC) productivity output report for the construction sector, and they reflect the full spectrum of projects. According to the MPC Report 2018, the construction sector contributed 4.9 percent of GDP, with the total sum of RM66.2 billion to the economy. The construction sector had the lowest productivity level as compared to the other major economic sectors, but it still showed substantial growth. Because of its low productivity, the industry players must be more aggressive, and construction productivity must increase.

Previously, a lot of research has been done on the factors that influence construction productivity in order to enhance it. However, only few have attempted to study on factors affecting the productivity of concerning the GCP. Such kind of study is essential because the construction of green projects is differing from that of traditional in terms of the design, materials, and processes (Mokhlesian and Holmén (2012). In Malaysia construction industry context, the convergence of aspects of construction project productivity and sustainability is still uncommon, and the integration of productivity in green construction projects receives almost no attention. Based from the previous research (2009 – 2018), it is shows that most of the researcher are studies on the Productivity in Construction Industry in Malaysia are limited to conventional building (Chia F.C et. al (2012) (2014), R Ismail et al. (2012), M Hamza et. al (2019); Ohueri et al (2018); Serdar Durdyev et al. (2016); M. Waris et. al (2016) N. A Karim et. al (2012); Abdul Kadir et al (2005), Z. A Rashid et. al (1997). The limited references make it challenging for the stakeholders to put together holistic strategies for productivity improvement to endeavour a sustainable construction development. Since the Malaysian government intends to implement sustainable building and infrastructure growth by developing policies and strategic planning to support the industry's transition to sustainable construction, this issue must be resolved urgently. Although previous studies have established numerous factors influencing productivity at all levels of the construction industry, the aspect of productivity in Green Construction Projects (GCP) has not been prioritised. Prioritization is crucial because it allows the project team to focus the limited resources available on the factors that have the utmost effect on productivity. Therefore, this study aims to contribute to filling this gap and thus, the specific objectives of this research paper are to identify the significant factors influencing Green Construction Productivity in Malaysia.

2.1 Factors Affecting Productivity in Green Construction Project

Many researches have been performed to determine the factors that influence construction productivity. Since labour information is readily available, some researchers focused on labour efficiency by directly surveying the workforce rather than management (Chan 2002; Kaming et al. 2006). Factors which influence construction productivity, as well as their classifications may differ subject on the opinions held by scholars. Many researchers have done research on factors influencing productivity in construction projects. In Singapore Construction Industry, a relevant study done by Bon-GangHwang et al. (2017) identified the critical factors affecting the productivity of green building construction projects, by reviewing the probability, impact, and criticality of the factors parallels against traditional projects. This research is muchrelated to this paper and the result from the studies shows that there are twenty-six (26) factors were identified from a comprehensive literature review and interviews with industry experts. The results revealed that workers' skill level and experience, technology, design changes, and planning and sequencing of work were the highest critical factors affectingthe productivity of GCP. As shown in Table 1, various author has given information about the list of factors influencingconstruction productivity, henceforth, the finding from BG Hwang (2017) will be the primary basis for this research variables. This information was gathered from a variety of sources, including construction management books, journals,articles, and online portals. The relevant papers were studied in detail and reviewed to identify the reasons for productivityin the mainly focusing on traditional projects. The topic defines the various issues in factors that affect productivity in construction industry. To resolve the hurdles, specific changes to standard or traditional project management methods and processes shall be adjusted to suit with this GCP research element.

Table 1 - Literature review on factors influencing productivity in construction project

Factor		Item influencing productivity	References
1.Project Factors	P1	Type of procurement/contract adopted	Hwang et al (2017), Jarkas (2010),Durdyev et al (2019), and Abdul Kadir et al (2005)
	P2	Adequacy of method of construction	
	P3	Timely Payment	
	P4	Proportion of outsourced work	
	P5	Reworks	
	P6	Poor buildability design	
	P7	Loss in productivity caused from change orders	
2.Manpower Factors	MP1	Motivation of workers	Hwang et al (2017), Hanafi et al. (2010), Durdyev et al. (2018), Bernold and AbouRizk (2010), and Abdul Kadir et al (2005)
	MP2	Workers skill level	
	MP3	Absenteeism	
	MP4	Labor turnover	
	MP5	Lack of adequacy in supply or high cost of needed resources	
	MP6	Difficulty in recruitment of labor	
	MP7	Health of the workforce	
	MP8	Level of empowerment (training and resourcing)	
	MP9	Level of familiarity with current job and conditions	
	MP10	Incentive programs	
3.Management Factors	MG1	Supervision of labor	Hwang et al (2017), Doloi et al. (2012), Dai et al. (2009), Dainty et al. (2005), Bernold And AbouRizk(2010), Ghoddousi and Hosseini (2012) and Abdul Kadir et al (2005)
	MG2	Planning & Sequencing of work	
	MG3	Competency of project manager	
	MG4	Poor site layout	
	MG5	Inspection delay	
	MG6	Communication of information	
	MG7	Poor instruction	
	MG8	Project management style	
	MG9	Lack of coordination among the construction parties	
	MG10	Adequacy of planning and risk management process	
	MG11	Client's over influence on the construction process	
4. Technical Factors	T1	Material availability	Hwang et al (2017), Alonso et al. (2007), Pratibha and Gaikwad (2015), Kazaz et al. (2008), and Page (2010) and Abdul Kadir et al (2005)
	T2	Tools and equipment	
	T3	Design changes	
	T4	Incomplete design	
	T5	Adequacy of technology employed	
	T6	Rapid technological advances	
	T7	Late supply of construction materials	

5. External Factors	EX1 EX2 EX3 EX4 EX5 EX6 EX7 EX8 EX9	Industry initiatives Poor weather conditions Inflation/fluctuations in material prices Frequent changes in government policies/legislations impacting construction Inappropriate government policies Interest rate/cost of capital On-site accidents/acts of God Slow local authorities' approval	Hwang et al (2017), Ghoddousi and Hosseini (2012), Moselhi and Khan (2010), Durdyev et al. (2017), and Ratcliffe and Stubbs (2003) and Abdul Kadir et al (2005)

3. Methodology

A questionnaire survey was conducted for this study to examine the importance of the different factors influencingGCP efficiency, with comparisons to conventional projects. Based on a comprehensive literature review, a questionnairewas developed. The survey was first checked by a construction expert to ensure that it was free of common errors like leading, ambiguous, or double-barreled questions. After receiving the feedback from them, the relevant changes were made to form the final survey.

Respondents were chosen at random from the Malaysian construction industry professionals across the country forthis study. Respondents were selected based on their affiliation as a green construction practitioner and the list are extracted from the Green Building Index (GBI) website, CIDB Directory of Construction also from the previous completed GCP. The respondent is namely Project Director, Project Manager, Project Executives, Consultants, Contractors also others (specialist consultant). All the questionnaires were sent out to the respondents manually and through e-mail. A total of 400 sets of questionnaires were sent out and 78 (19.5%) questionnaires were received. Present built-environment survey response, rates range from 7% to 40%, in general (Moyo & Crafford,2010), therefore the received survey respond (19.5%) is accepted.

The questionnaire's topics on construction productivity, directing on GCP were obtained from reviews of the literature, resulting in the development of a two-sections questionnaire. Section one on respondent's profile obtained personal information on existing designation, years of experience in Construction Industry and GCP. Section two sets questions on factors influencing GCP consisting of forty-four (44) variables derived from the literature (see Table 2). Therespondents were required to indicate their level of agreement, with these measures their practices influencing productivity in GCP. The data from these measurements forms the variables used in the Exploratory Factor Analysis (EFA), which analyzed the validity and reliability of the factors was more commonly used as an exploratory method to summarize the structure of a group of variables. EFA is a data reduction technique that reduces many variables to a smallnumber of underlying factors that summarize the data (Richard and Dean, 2007).

A Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity were initially performed to confirm if the dataset was appropriate for factor analysis. In the KMO test, as the values of the test vary from 0 to 1, values above 0.7 are proposed as being suitable for applying EFA (Hair *et al.*, 2006) and a statistically significant Bartlett test ($p < 0.05$) indicates that the variables have sufficient similarities to begin the analysis. (Hair *et al.*, (2006); Pallant, (2013).

4. Results and Discussion

Quantitative approach was used for analysing research data via SPSS version 26. Cronbach's Alpha Coefficient (α)were used to calculated the questionnaire's accuracy. Tavakol & Dennick (2011) indicated that the acceptable values of Cronbach's *alpha* would range from 0.70 to 0.95. Consequently, the coefficient (α) was 0.986 signifying that the questionnaire was highly reliable. Table 2 shows the profile of the survey respondents. The respondent are namely ProjectDirector, Project Manager, Project Executives, consultants, contractors also others (specialist supplier) . In addition, nearly 41.03 percent of respondents have at five to ten years of working experience in the construction industry and about 38.46 percent from the respondents have experience in GCP.

Table 2 - Profile of the survey respondents

Respondent profiles	Categorization	Number of Respondents	Percentage
Type of designation	Project Director	5	6.41%
	Project Manager	12	15.38%
	Project Executives	9	11.54%
	Architect	12	15.38%
	Engineer	8	10.26%
	Quantity Surveyor	17	21.79%
	Contractor	12	15.38%
	Others	3	3.85%

Years of Experience in Construction Industry	1-5 5-10 > 10	18 32 28	23.08% 41.02% 35.90%
Years of Experience in Green Construction Projects	1-5 5-10 > 10	10 18 2	23.08% 12.82% 2.56%

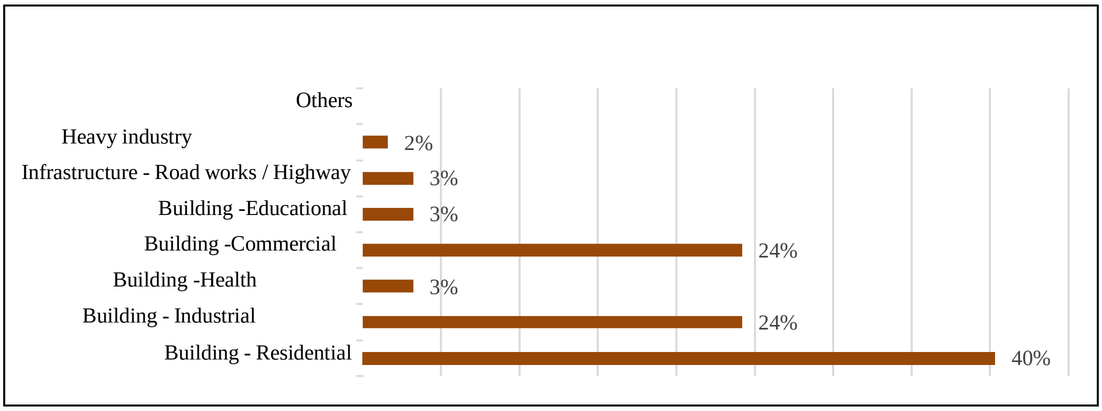

Fig. 1 - Type of Green Construction Projects (GCP)

Figure 1 shows the type of Green Construction Project that are commonly involve by the company. The most GCP involve by the respondent are building residential (40%), followed by commercial & industrial building (24%). Others GCP are educational and health building (3%). However, it has been noted that civil engineering works has been cited less than 5% in implementing Green Construction Project. This includes the infrastructure works (3%) and heavy industry (2%).

4.1 Results of Exploratory Factor Analysis

The parameters and features in this study were grouped using Exploratory Factor Analysis (EFA) in accordance withthe literature findings in Table 2. In this study, five categories of factors influencing productivity has been grouped, namely (i) Project, (ii) Manpower, (iii) Management, (iv) Technical and (v) External Factor. The indicators were rankedon a five-point Likert scale to determine which factors influence Green Construction productivity. Likert-type or frequency scales are designed to quantify attitudes or views and use fixed option response formats. The following scale measurement was used regarding mean scores, where 1 = Not Critical (≥ 1.00 ≤ and <1.80), 2 = Less Critical (≥ 1.81 and ≤ 2.60), 3 = Critical (≥ 2.61 and ≤ 3.40), 4 = Very Critical (≥3.41 and ≤ 4.20), and 5 = Extremely critical.

According to the findings, KOM (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) equals 0.9, which is very similar to one. This indicates that the information is ideal for factor analysis. The Chi-square is equivalent to 14699.628with a p-value less than 0.01 according to Bartlett's test of sphericity, indicating that the correlation matrix is not an identity matrix. As a result, all forty-four (44) variables are correlated to each other and suitable for Factor Analysis. Table 3 presents the number of components, Factors loading, Eigenvalues, percent and the cumulative percent of Eigenvalues. All five (5) components can explain the total variance which is equal to 72.113%.

Table 3 - Exploratory factor analysis result

Component 1 : Project Factors		1	2	3	4	5
P1	Type of procurement/contract adopted.	0.775				
P2	Adequacy of method of construction	0.794				
P3	Timely Payment	0.752				
P4	Proportion of outsourced work	0.759				
P5	Reworks	0.777				
P6	Poor buildability design	0.762				
P7	Loss in productivity caused from change orders	0.766				
P7	Loss in productivity caused from change orders	0.766				
Component 1 : (7) Factors			Eigen Value			18.175
			% of Variance			45.136
Component 2: Manpower Factors						

MP1	Motivation of workers	0.730			
MP2	Worker's skill level	0.794			
MP3	Absenteeism	0.699			
MP4	Labor turnover	0.651			
MP5	Lack of adequacy in supply or high cost of needed resources	0.721			
MP6	Difficulty in recruitment of labor	0.652			
MP7	Health of the workforce	0.597			
MP8	Level of empowerment (training and resourcing)	0.611			
MP9	Level of familiarity with current job and conditions	0.600			
MP10	Incentive programs	0.599			
	Component 2 : (10) Factors	Eigen Value			2.322
		% of Variance			12.852
Component 3: Management Factors					
MG1	Supervision of labor		0.560		
MG2	Planning & Sequencing of work		0.650		
MG3	Competency of project manager		0.731		
MG4	Poor site layout		0.720		
MG5	Inspection delay		0.665		
MG6	Communication of information		0.797		
MG7	Poor instruction		0.701		
MG8	Project management style		0.699		
MG9	Lack of coordination among the construction parties		0.684		
MG10	Adequacy of planning and risk management process		0.534		
MG11	Client's over influence on the construction process		0.541		
	Component 3: (11) Factors	Eigen Value			1.345
		% of Variance			5.173
Component 4 : Technical Factors					
T1	Material availability			0.786	
T2	Tools and equipment			0.777	
T3	Design changes			0.698	
T4	Incomplete design			0.618	
T5	Adequacy of technology employed			0.700	
T6	Rapid technological advances			0.771	
T7	Late supply of construction materials			0.619	
	Component 4: (7) Factors	Eigen Value			1.255
		% of Variance			3.398
Component 5: External Factors					
EX1	Industry initiatives				0.789
EX2	Poor weather conditions				0.799
EX3	Inflation/fluctuations in material prices				0.801
EX4	Frequent changes in government policies				0.790
EX5	Inappropriate government policies				0.521
EX6	Interest rate/cost of capital				0.631
EX7	On-site accidents/acts of God				0.780
EX8	Slow local authorities' approval				0.888
	Component 5: (8) Factors	Eigen Value			1.154
		% of Variance			5.554
		Cumulative % of variance			72.113

Each of the five (5) components of factors influencing GCP consists of at least seven (7) variables, as a result, the components met the requirement that each component must have at least three variables. Furthermore, each factor loading variable is greater than 0.4, implying that the Factor Analysis rule was fulfilled by all 44 components. The extracted factors are consistent with the five (5) components found in the literature review. The first component is a Project Factor accounted for 45.136 percent of the total variance with an eigen values of 18.175. The component consists of seven items and the factor loading for items in these criteria was varied from 0.752-0.794. Next, second component accounted for 12.852 percent of the total variance with an eigenvalue of 2.322. Factor loading for items in this component ranged from 0.597-0.794. The second criteria reflected the Manpower Factors. Third criteria accounted for 5.173 percent of the total variance with an eigenvalue of 1.345. Factor loading for items in these criteria ranged from 0.534-0.797. The component reflected to Management factors and it consist of eleven items. The fourth criteria accounted for 3.398 percent of the total variance with an eigenvalue of 1.255. Factor loading for items in these criteria ranged from 0.618-0.786. The fourth criteria reflected the Technical factors and it consist of seven elements. The fifth criteria reflected the External Factors. External factors are those which are uncontrollable but would still affect a project. Additionally, fifth component accounted for 72.113 percent of the total cumulative variance with an eigenvalue of 1.154. Factor loading for items in these criteria ranged from 0.521-0.829.

5. Conclusion

Productivity refers to the capability of using resources effectively and efficiently to achieve its goals. The aim of this study is to conduct an Exploratory Factor Analysis (EFA) that influence the productivity of Green Construction Project (GCP) in the Malaysian construction industry. The result shows all the variable identified from a comprehensive literature review are relevant and can be considered ideal for the survey conducted. These empirical results fill a gap in the body of information for green building project management by tackling critical and relevant factors affecting the productivity of GCP. According to the result from this research, there are five (5) components influencing the GCP productivity with the total variance percentage is 72.113%. The five main components namely are (i) Project, (ii) Manpower, (iii) Management, (iv) Technical and (v) External Factor. The outcomes of this study can assist practitioners in making specific changes to standard project management processes and procedures in order to achieve more sustainable green building delivery. Furthermore, by concentrating and acting on variables with high criticality values and a broad mean gap, industry practitioners can increase the productivity in GCP efficiently and effectively.

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