Assessing Green Practices and their Impact on the Environmental and Financial Performances of Construction Projects

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Abstract— Construction activities have been blamed as one of the polluters to the environment. Industry players are urged to adopt green practices in their projects to address this problem. Despite an increasing adoption of green practices by construction players, it is still unclear whether such practices have improved projects' environmental and financial performances. Previous studies are not unified on whether the green practice will yield a cleaner environment and better financial outcome. This study aims to investigate the relationships between green practices implemented in construction projects and their impact on the projects' environmental and financial performances. A structured questionnaire survey with 28 items was used to gather information about the impact of green practices on construction projects' performances. The targeted respondents were members of a project team, such as architects, engineers, and project managers. The results revealed two areas of green practices – green project integrated practice and waste management practice, which had a significant and positive relationship with the project's environmental and financial performances. However, the study showed insufficient evidence about the relationship between resource minimisation and the project's environmental and financial performances. The results have provided empirical evidence about the benefit of green practices on a project's performances and rebuts the previous findings on the negative impact of green practices on a project's performances. The results imply that different types of green practices will have a varying degree of effect on a project's environmental and financial performances. It is important for the clients and project manager to focus on green project integrated practices and waste management to boost the project's environmental and financial performances.

Keywords—green practice; environmental performance; financial performance; construction project

I. INTRODUCTION

Construction activities have been blamed as one of the polluters to the environment. Industry players are urged to adopt green practices in their projects to address this problem. Construction projects in Greece and China have started to employ measures to minimise carbon emission [1, 2], and there is rising awareness about ISO 140001 amongst the construction firms [3]. In 2016, MyCREST (Malaysian Carbon Reduction and Environmental Sustainability Tool) was adopted in all federal government projects and 20 private projects in Malaysia [4]. In that year too, the Low Carbon Cities Framework and Assessment System (LCCF) was adopted to evaluate the carbon emission of cities and towns in Malaysia [5]. Despite an increasing adoption of green practices by construction players, it is still unclear whether such practices have improved the projects' environmental and financial performances.

Previous studies are not unified on whether green practices will yield a cleaner environment and better financial outcome. In the case of the link between green practice and environmental performance, adoption of ISO14001 in a country where environmental regulations are indirect but costly will lead to a higher environmental performance [6]. In contrast, Ferrón-Vílchez [7] argued that green practices will not necessarily result in better environmental performance and thus, a cleaner environment. Similarly, in Yin and Schmeidler [8], they found that ISO14001 adoption did not necessarily result in improved environmental performance. In the case of the link between green practice and financial performance [9] revealed that green practices implemented in supply chain management in manufacturing, utilities, and transportation industries led to a firm's higher financial performance. However, ISO 14001 adoption reduced the firm's profit [9]. Studies in the construction sector showed an insignificant relationship between green practices and financial performance (see Kusuma and Koesrindartoto (2014) and Renard, Maria [10]).

This study has aimed to shed light on the relationships between green practices implemented in construction projects and their impact on the projects' environmental and financial performances. Practically, the results will help construction managers and clients to be selective and invest only in green practices that yield better environmental performance and higher profit.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Generally, environmental performance can be defined as the consequence of doing construction in a responsible manner, such as with less pollution or with a cleaner environment [11]. Compliance to environmental standards, uses of green materials, minimising waste, and reduction in pollution are conceptualised as a project's environmental performance [12, 13]. In the wake of the increasing stakeholder demand for a cleaner environment, construction organisations with higher environmental performance will be ahead of their competitors, able to gain public trust, and secure goodwill [14].

Reduction in project costs, high profits, and improved investment yield are indicators of financial performance [15-17]. A seminal work by Porter and Van der Linde [18] argued that leaders of green practices enjoyed better prices for green products and services. Although the financial performance of green practices takes a longer time before it can be observed [13]; at the very least, projects that adopt green practices can avoid fines due to noncompliance [16].

Three dimensions are used to conceptualise green practices in construction projects: green project integrated practice, resource minimisation, and waste management. The green project integrated practice can be defined as desegregating the disjointed phases of the project cycle, from initiation until completion, in line with the environmental mission [19, 20]. In project integrated practices, the involvement of project members is at the start of the project [21]. In such an arrangement, the client and project manager can convey the green practice agenda prior to project implementation [22, 23]. Effective green practice adoption in construction projects is shown through low carbon emission, and less air, water, and soil pollution; or in other words, better project environmental performance [24]. Likewise, effective green practice adoption at each project phase will also mean less wastage, avoidance of charges due to noncompliance, and result in higher profits [15]. Therefore, the first and second hypotheses are:

H1: Green practices in project integrated practices significantly influence the project's environmental performance.

H2: Green practices in project integrated practices significantly influence the project's financial performance.

Resource minimisation refers to optimising the use of resources which also covers the 3Rs – reduce, reuse, and recycle activities throughout the project's cycle [21, 25]. According to Martens and Carvalho [26], a vital challenge in resource minimisation during project implementation is to minimise the use of water and energy. Effective resource management at the start of a project will optimise the use of resources, subsequently reducing project costs and gaining better profits [27] . Investment in energy efficient technology during housing development has resulted in less carbon emission and better sale prices for low energy houses [28]. Thus, the third and fourth hypotheses are:

H3: Resource minimisation significantly influences the project's environmental performance.

H4: Resource minimisation significantly influences the project's financial performance.

Waste management is part of green practices, which includes monitoring of waste production during project implementation and ensuring construction waste to the landfill is minimised and properly destroyed [23, 29]. Recently, waste minimisation through effective waste management has become a serious issue and this is evident by many governments setting targets to reduce construction waste [30]. In Malaysia, it was reported that 30 per cent of the total waste was from construction and only 15 per cent of this waste was collected by the waste management contractor [31]. The industry players are urged to reduce this percentage through proper waste management, such as waste categorisation, reuse, and recycling to achieve zero waste at the construction site by 2030 [4]. It is argued that waste management can help to reduce pollution thus resulting in a cleaner environment [19]. Similarly, Begum, Siwar [32] argued that if implemented properly, waste management could result in 2.5 per cent cost savings of the overall project costs. The fifth and sixth hypotheses are:

H5: Waste management significantly influences the project's environmental performance.
H6: Waste management significantly influences the project's financial performance.

III. RESULTS

A structured questionnaire survey with 28 items was used to gather information about the impact of green practices on construction projects' performances. All items were measured using a five-point Likert scale, ranging from strongly disagree - 1 to strongly agree – 5. Targeted respondents were members of a project team, such as architects, engineers, and project managers. A total of 210 usable responses were received, exceeding the minimum required sample size of 146, which was calculated using the gamma-exponential method.

Two stages of analysis were performed to analyse the data using the Warp partial least squares technique (WarpPLS) Version 6.0. In stage 1, where the measurement model was evaluated, we performed indicator reliability, convergent validity, internal consistency, and discriminate validity tests for the reflective latent variables, and Variance Inflated Factor (VIF), significant outer weights, and full collinearity VIF tests for the formative latent variables.

The loadings for all of the items were higher than 0.5 with the P values significant at <0.001, fulfilling Kock's [33] rules for indicator reliability. The latent variable's convergent validity was evaluated using the Average Variance Extracted (AVE) and the AVE of all of the latent variables exceeded 0.5, in accordance to Fornell and Larcker's [34] criteria; suggesting the measurement model's convergent validity. Composite reliability (CR) was used to evaluate the internal reliability of the latent variables. All of the latent variables showed CR of above 0.8 fulfilling Kock's [35] and Hair, et al.'s [36] minimum criteria. Table 1 presents the results for the indicator reliability, convergent validity, and internal consistency tests for the reflective latent variables.

TABLE 1: Reliability and Validity of the Reflective Latent Variables

Latent Variable/Item	Loading	P values	AVE	CR
Project Integrated Practice			0.705	0.877
P1	0.878	<0.001		
P2	0.874	<0.001		
P3	0.761	<0.001		
Resource Minimisation			0.673	0.911
R1	0.786	<0.001		
R2	0.854	<0.001		
R3	0.852	<0.001		
R4	0.820	<0.001		
R5	0.788	<0.001		
Waste Management			0.649	0.881
W1	0.758	<0.001		
W2	0.829	<0.001		
W3	0.818	<0.001		
W4	0.816	<0.001		

Next, the discriminate validity of the reflective latent variables was evaluated using the cross-loadings and inter-correlation indicators. The measurement model revealed that the indicator loads were greater than each opposing latent variable, meeting Hair, et al.'s [37] rules. Also, the square root of the AVE of a single latent variable was less than the value of the inter-correlations between the latent variable and other model latent variables (see Table 2). These tests confirmed the discriminant validity of the reflective latent variables.

TABLE 2: Discriminant Validity

Latent Variables	PIP	RS	WM	EnvP	FP
Project Integrated Practice	0.839*				
Resource Minimisation	0.570	0.820*			
Waste Management	0.474	0.448	0.806*		
Environmental Performance	0.499	0.345	0.521	0.832*	
Financial Performance	0.580	0.392	0.420	0.487	0.861*

*Square root of the AVE values are on the diagonal

Our model had two formative latent variables – the environmental performance and the financial performance variables. The Variance Inflated Factor (VIF) or collinearity amongst the indicators, significant outer weights, and full collinearity VIFs were used to evaluate these formative latent variables. Both formative latent variables showed VIFs less than 5 and all items had significant outer weights, fulfilling Chin [38] and Hair, Ringle [36] rules. The full collinearity VIFs of the environmental performance and the financial performance variables were much lower than 3.3, which fulfilled Kock and Lynn [39] threshold. Thus, the formative latent variables presented a satisfactory level of the measurement model. Table 3 depicts the measurement model evaluation for the formative latent variables.

TABLE 3: Measurement Model Evaluation for Formative Latent Variables

Formative Latent Variables	Weights	P-Value	VIF	Full collinearity VIFs
Environmental Performance				1.630
Env1	0.249	<0.001	1.970	
Env2	0.265	<0.001	2.170	
Env3	0.248	<0.001	1.908	
Env4	0.237	<0.001	1.799	
Financial Performance				1.657
FP1	0.352	<0.001	2.403	
FP2	0.373	<0.001	2.658	
FP3	0.275	<0.001	1.496	

In stage 2, the structural model and the hypotheses were assessed using the R^2 measure for the endogenous constructs and the path coefficients. Our model showed 37 per cent and 39 per cent of the variances in the project's environmental and financial performances, respectively, suggesting a moderate relationship between green practices and the project's environmental and financial performances. Also, the Stone–Geisser Q^2 (cross-validated redundancy) for the project's environmental (Q^2=0.406) and financial performances (Q^2=0.389) were larger than zero, displaying the model's satisfactory predictive relevance.

The results revealed that two areas of green practices – green project integrated practice and waste management practice, had a significant and positive relationship with the project's environmental and financial performances; this supported the **H1, H2, H5,** and **H6** hypotheses. Compared to the other green practices, our study revealed that the green project integrated practice had the highest effect on the project's financial performance (f^2 = 0.290) and environmental performance (f^2 = 0.201). However, the study showed insufficient evidence about the relationship between resource minimisation and the project's environmental and financial performances. One possible reason is that resource minimization measures such as the 3Rs – reduce, reuse, and recycle activities or resource management are not widespread in Malaysian construction projects. Figure 1 shows the results of the Structural Model Assessment.

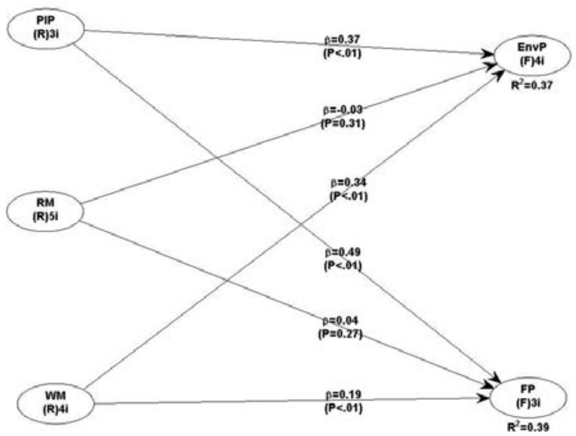

Fig. 1: Structural Model Assessment

IV. CONCLUSION

The results have provided empirical evidence about the benefit of green practices on a project's performance. Construction projects that integrate their planning-design-construction phases with green practices and the local ecosystem, and implement waste management practice, will benefit in terms of a better environmental outcome, such as low carbon emission; less air, water, and soil pollution; and enhanced financial performance, such as reduction in project costs, greater profits, and improved investment yield. The results support Shen, Wu, and Zhang's [24] work on the positive impact of green practices on environmental performance; Rao and Holt [15] and Miroshnychenko, et al.'s [9] work on the positive influence of green practices on financial performance; and Begum, et al. [32] on the positive effect of waste management on a project's financial performance. At the same time, our results rebut the previous findings on the negative impact of green practices on performances (see Ferrón-Vílchez [40], Kusuma and Koesrindartoto [41], and Renard, Maria [10]). However, our study provides insufficient evidence about the relationship between resource minimisation and project performances, indicating the link between the two remains vague and warrants further investigation.

The aforesaid results imply that different types of green practices will have a varying degree of effect on the project's environmental and financial performances; in line with Miroshnychenko, et al. [9] and Arimura, et al.'s [6] earlier postulation on the impact of green practices on performances. Therefore, it is important for the clients and project manager to focus on green project integrated practices and waste management so as to ensure these practices will boost the project's performances.

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