INTERNATIONAL JOURNAL OF SUSTAINABLE CONSTRUCTION ENGINEERING AND TECHNOLOGY
Vol. 12 No. 1 (2021) 110-119

IJSCET

http://penerbit.uthm.edu.my/ojs/index.php/ijscet
ISSN : 2180-3242 e-ISSN : 2600-7959

International Journal of Sustainable Construction Engineering and Technology

The Structural of Effective Materials Management Factors Model: A PLS-SEM Approach

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DOI: https://doi.org/10.30880/ijscet.2021.12.01.011
Received 17 August 2020; Accepted 30 October 2020; Available online 18 May 2021

Abstract: Effective materials management has a significant role in the success of any construction projects. Understanding the factors related to the management effectiveness may assist the decision-makers of construction firms to allocate resources in the best possible manner in managing materials when implementing construction projects. However, limited studies have explored and investigated the associated factors of effective materials management related to project performance, especially in the Malaysian construction industry context. Thus, this research paper aims to investigate the influential factors of effective materials management and their effects on project performance. A partial least square-structural equation modelling (PLS-SEM) approach was employed to analyse 202 pieces of data collected from a questionnaire survey. The results indicate that the effective materials management has a positive significant impact on project performance. The top three groups of factors that contribute to this management effectiveness are transportation, management, and purchasing; meanwhile, the most implied factors of the effective materials management are waste, cost and time of project performance. To increase project performance, more resources should be allocated to improve the transportation, management and purchasing components of materials management.

Keywords: Materials management, project performance, influential factors, effect factors

1. Introduction

Resource management is a part of project management. It has been claimed that the efficient utilisation of construction materials, equipment and labour are the key dynamics for good project management (Othman & Potty, 2014). More importantly, resource management plays a significant role in the success of every construction project (Rahman et al., 2013; Reddy et al., 2015; Kasim et al., 2019; Gurmu, 2019). Several studies have proven that due to the problems arising in resource management, construction projects suffer from poor performance like delay, cost overrun, low productivity and wastage (Enshassi et al., 2007; Abd El-Razek et al., 2008; Ahmadian et al., 2015). Hence, it seems that efficient management of resource is essential to enhance construction projects performance.

However, despite the importance of resource management to project performance, materials management has received little attention from researchers and academicians (Navon & Berkovich, 2006; Donyavi & Flanagan, 2009; Okorocha, 2013). In the Malaysian context, this contention appears correct as only a few studies related to materials

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management have been published (Rahman & Alidrisyi, 1994; Kasim, 2011; Mustapa et al., 2012). Due to the lack of local literature, it has been asserted that very limited research has been conducted on the problems faced by the industry (Razak et al., 2010). Indeed, the subject of local materials management is an important area to explore as it has much room for improvement. Accordingly, since the identification and assessment of the associated factors are an important step to find a viable solution (Chan et al., 2002; Memon, 2013), this investigation has been carried out related to the influential factors of effective materials management and their impact on the performance of construction projects. Therefore, this paper aims to investigate on the relationship between effective materials management and project performance. A statistical technique known as the Partial Least Square-Structural Equation Modelling (PLS-SEM) is used to carry out this investigation. In achieving the aim, the overriding objectives of this study are as follows:

- To identify the influential factors of effective materials management and their effects on project performance
- To develop a structural model of effective materials management to represent the relationship between effective materials management and project performance.

2. Literature Review

Prior studies have briefly highlighted the factors affecting materials management effectiveness and its association with project performance (Okorocha, 2013; Caldas et al., 2014; Arijole & Akinradewo, 2016). Accordingly, this section summarises the literature review of the influential factors of effective materials management as well as other factors that affect project performance. Factors affecting materials management effectiveness are varied and complex. The root cause might originate from the contractors, suppliers, transportation providers, consultants, clients and governmental interference (Wang et al., 2013; Liu & Lu, 2018; Gurmu, 2020). Previous studies have pointed out many influential factors that contributed to or adversely affect the materials management effectiveness. They are exhaustively listed as follows: adequate planning, appropriate site management, efficient supervision, efficient handling, proper storage, efficient control of materials, adequate storage space, proper inventory control, good site accessibility, unsystematic flow of materials, fluctuation of material prices, improper sorting of materials, poor layout for material handling, improper material deliveries, unavailability of up-to-date inventory status, delay in materials deliveries, excessive paperwork, excessive handling, equipment breakdown, shortage of equipment, poor coordination, inefficient communication, delay in procuring of materials, errors in ordering, lack of material storage, poor material planning and others (Navon & Berkovich, 2006; Ayegba, 2013; Okorocha, 2013; Arijeloye & Akinradewo, 2016).

Based on the factors listed above, apparently, there are several of them that have negative connotations. Meanwhile, previous studies have also stressed on the importance of avoiding negative words or phrases as they might cause problems in terms of correlation (Mcknight et al., 2002; Mohamed, 2003; Devellis, 2012). Following to this line of reasoning, all the influential factors are viewed from the ‘positive perspective’ and constitute the influential factors that contribute to the effective materials management, instead of the factors that adversely affect the materials management effectiveness. Table 1 summarises the identified influential factors in this reviewing process.

Table 1 - Summary of influential factors

Item Code	Construct	Item
Con1	Contractual	Clear in materials specification
Con2		Materials meet specification
Con3		No discrepancy between specification and drawing
Con4		Minimisation in changes of design.
Con5		Minimisation in changes of material specification.
Exp1	Expediting	Efficient use of equipment while handling
Exp2		Efficient communication on sites.
Exp3		Easy movement of equipment.
Exp4		Systematic flow of material.
Exp5		Adequate qualified & experience staff.
Gov1	Governmental Interference	Minimisation in changes of government regulation.
Gov2		No bureaucratic procedure.
Gov3		On time in custom clearance for imported materials.
Gov4		Appropriate policy in materials procurement.

Table 1 - Summary of influential factors (Cont'd)

Item Code	Construct	Item
Man1	Management	Proper material usage.
Man2		Adequate IT infrastructure & application.
Man3		Proper material control.
Man4		Efficient site management.
Man5		Proper training on new technologies.
Man6		Efficient supervision.
Man7		Reasonable and systematic paperwork.
Man8		Efficient co-ordination.
Man9		Systematic inventory documentation.
Man10		On time informing material specification
Man11		Acceptance of new technologies.
Man12		Proper planning.
Pur1	Purchasing	Sufficient of raw materials in market.
Pur2		On time delivery of materials.
Pur3		Correct delivery as ordered.
Pur4		Financial capabilities.
Pur5		Acceptable quality of materials.
Pur6		Correct in ordering.
Pur7		Accurate in taking off.
Pur8		On time in material procurement.
Sit1	Site Storage & Condition	Enough of material storage.
Sit2		Suitable location of site storage.
Sit3		Satisfactory of site condition.
Sit4		Accessible of site access.
Sit5		Efficient function of site layout.
Sit6		Uncrowded site.
Sup1	Supplier	Materials supplied with pallet.
Sup2		Constant demand of materials in market.
Sup3		Sufficient of competent suppliers.
Sup4		Equal materials control among suppliers.
Sup5		Properly marked materials.
Tra1	Transportation	Proper material delivery to site.
Tra2		Functional of equipment.
Tra3		Sufficient protection during unloading.
Tra4		Proper storing of materials.
Tra5		Materials are not damage while handling.

Effective materials management is beneficial to the performance of a project. Such as time and cost saving, increased productivity, higher quality of work, waste reduction and avoidance are features that guarantee high performance of a project (Caldas et al., 2014; Safa et al., 2014; Naoum, 2016). From the literature review, it appears that most of the authors mentioned briefly about the influence of effective materials management towards project performance without much empirical investigation (Navon & Berkovich, 2006; Donyavi & Flanagan, 2009; Rahman et al., 2013; Caldas et al., 2014). Therefore, the effect factors according to the specific criteria of project performance have been identified and are summarized in Table 2. Identification of effect factors is important to probe the relationship of effective materials management to high performance of construction projects. As limited study focus on the relationship model specifically in materials management, this study adopted the conceptual models that consist of 'enablers' and 'results' character (Din et al., 2011; Vukomanovic et al., 2014). This characters appears suitable to represent the causes and effects of effective materials management.

Table 2 - Summary of effect factors

Item Code	Construct	Item
Cost1	Cost	Appropriate quality of materials reduce replacement cost.
Cost2		Proper material handling reduces replacement cost.
Cost3		Minimisation of double handling reduces the handling cost.
Cost4		On time delivery of materials reduces the cost of additional storage spaces.
Cost5		Sufficient stock of materials stock effectively saving labour cost (overtime).
Pro1	Productivity	Minimisation of double handling reduce loss of workers productivity
Pro2		Suitable storage location increases work productivity.
Pro3		Proper materials planning increases workers' productivity.
Pro4		Availability of materials increases the work productivity.
Pro5		Sufficient of materials, tools and equipment increase workers' productivity.
Qua1	Quality	Suitable tools and equipment improve quality of workdone.
Qua2		The risk quality errors reduce by not pressuring workers.
Qua3		Appropriate quality of materials leads to acceptance of workdone.
Tim1	Time	On time materials procurement reduces the idling time.
Tim2		Proper inventory record reduce time to track of materials.
Tim3		Minimisation of changes in drawing reduces additional time.
Tim4		On time arrival of materials improve the work progress.
Tim5		Suitable equipment reduce time to finish the works.
Tim6		Appropriate quality of materials reduces of rework.
Was1	Waste	Minimisation of double handling reduce materials waste.
Was2		Proper controlling of materials minimise the materials waste.
Was3		Appropriate quality of materials reduces materials waste.
Was4		Suitable materials storage avoid materials from deterioration (e.g. rust, crack, etc).
Was5		Proper materials handling reduce damage of materials.
Was6		Lower percentage of surplus occurs due to accurate ordering.

3. Methodology

This study has adopted the quantitative research approach by means of a questionnaire survey. In the instrument development process, several steps have been undertaken in order to refine the measuring scale. This process began with a preliminary study of 10 experienced practitioners to refine and verify all the identified factors. The questionnaire was pre-tested by 2 academicians and 7 practitioners. The purpose of this pre-testing is to improve the research instruments and establish the content validity of the instruments (Sarantakos, 2005; Furneaux & Wade, 2011). Finally, a pilot study was conducted by distributing 150 survey questionaires. A total of 111 responses were received and completed to analyse. Prior the initial data screening i.e missing data and outliers (Field, 2009), only 95 responses were valid for further analysis. This obtained data were examined by way of initial examination of item performance, factor analysis and coefficient alpha. Collectively, the results of the pilot study showed only 50 influential factors that are relevant to the local context. Those factors were clustered into 8 groups, namely contractual, expediting, governmental interference, management, purchasing, site storage and condition, supplier and transportation (Jusoh et al., 2018). The effect factors were reduced from 26 to 25 and grouped into these headings i.e cost, productivity, quality, time and waste of project performance. Consequently, the outcome from the pilot study was used in the main survey of this study.

A questionnaire survey with Seven-Point Likert Scale was used in this study. The questionnaire consists of three parts: Part A captures the respondents' background; Part B solicits the perception of influential factors for effective materials management; Part C implores the perception on the effect factors of the materials management to project performance. The adopted sampling frame is non-probability sampling with the population is the practitioners who employed in contractor organisations. Regarding the sample size, recent development has recommended the use of G*power programme to calculate minimum sample size (Yeap et al., 2016). Hence, this study would need minimum 160 samples to achieve the statistical of 95% respectively. Despite this minimum sample size, 700 survey questionnaires were randomly distributed to the contractor organisations that are registered with the Construction Industry Development Board (CIDB) of Grade 6 and 7. Only practitioners who have been working in the contractor organisations were selected due to the facts that materials management is handled by contractors in every construction projects (Gurmu, 2019).

In the ten-month duration data collection period, 215 responses were received but only 211 were valid for further analysis. It represents 30% response rate. This percentage is considered sufficient and satisfactory for the PLS-SEM analysis. Nonetheless, several authors have recommended the ideal sample size of between 50 and 200 observations (Wong, 2013; Astrachan et al., 2014).

The obtained data were processed by means of univariate analysis via the SPSS and Multivariate Analysis, using the Structural Equation Modelling (SEM). The SEM is the second generation technique for Multivariate Analysis (Hair et al., 2014). Prior studies in the construction field have recognised the use of SEM in assessing the relationship between the variables studied (Rahman et al., 2014; Samee & Pongpeng, 2015; Durdyev et al., 2018). The PLS-SEM technique is more appropriate to be adopted in this study due to the following reasons: 1) this study is limited in theory 2) there is little knowledge about the relationship between the constructs of the effective materials management and 3) the research goal is to predict. As such, the software packages used for the analysis are IBM SPSS Statistic 21 for univariate analysis and SmartPLS 3.0 (Ringle at al., 2015) for PLS-SEM technique.

4. Result and Discussion

Initial Data Screening

Data screening was conducted to detect any error in the data entry and to check if there was any violation of statistical assumption in the data (Pallant, 2011). This screening process consists of checking the missing data, data normality and outliers (Hair et al., 2010). Subsequently, the results of this process showed that there were no missing data in this study. Meanwhile, the data normality was computed using two tests, namely Kolmogorov-Smirnov analysis and skewness and kurtosis. The results indicate that the normality assumption was violated. These normality results justify the use of PLS-SEM technique as this technique does not require data to be normal (Hair et al., 2014; Ramayah et al., 2016). The multivariate detection was used to assess the outliers in these data (Chin, 2010). The results indicate that 9 of the 211 observations were identified as multivariate outliers. Hence, these outliers were dropped. Finally, after the data screening process, 202 observations remained and were then analysed using the PLS-SEM technique.

Profile of Respondents

The respondents' profiles are shown in Table 3. Two types of experiences of respondents were gathered. They are working experience in the construction industry and working experience in the managing materials. More than half of the respondents have working experience exceeding 6 years in the construction industry. In contrast, less than half of them have working experience exceeding 6 years in the materials management. The largest number of respondents are categorised as the following: 68 (33.7%) site engineers, followed by 55 (27.2%) quantity surveyors, 33 (16.3%) project managers and 30 (14.9%) site supervisors. The remaining respondents are contract managers, architect managers, and managing directors. Apparently, 92.1% of respondents' positions are directly involved with materials management. Therefore, by asking the years of experience in managing materials and the majority of respondents' positions involved with materials management, the information gathered in this study was considered to be reliable as respondents had a good understanding of materials management.

Table 3 - Profile of respondents

Description	Frequency (n=202)	Percentage (%)
Years of experience in industry:		
Not exceeding 6 years	90	44.6
6 - 10 years	47	23.3
11 - 15 years	23	11.4
16 - 20 years	16	7.9
21 - 25 years	10	5.0
Exceeding 25 years	16	7.9
Years of experience in managing materials:		
Not exceeding 6 years	122	60.4
6 - 10 years	42	20.8
11 - 15 years	14	6.9
16 - 20 years	14	6.9
21 - 25 years	8	4.0
Exceeding 25 years	2	1.0

Table 3 - Profile of respondents (Cont'd)

Description	Frequency (n=202)	Percentage (%)
Position of respondent:		
Managing director	4	2.0
Contract/Architect manager	12	5.9
Project manager	33	16.3
Site engineer	68	33.7
Quantity surveyor	55	27.2
Site supervisor	30	14.9

PLS-SEM Analysis

Prior to the PLS analysis, two types of assessments were required, namely the measurement model assessment, and the structural model assessment. All the criteria in the measurement model assessment need to be fulfilled before the structural model assessment can be carried out.

The measurement model assessment relates to the examination between the indicators and the constructs (Hair et al., 2014). The focus of this assessment is on the reliability and validity of measures represented in each construct (Chin, 2010). The summary of results for reliability and convergent validity assessment are illustrated in Table 4.

Table 4 - Summary results of reliability and convergent validity assessment

Construct	Items & Loading	AVE	CR
Contractual	con1 (0.854); con2 (0.835); con3 (0.836); con4 (0.813); con5 (0.826)	0.694	0.919
Cost	cos1 (0.854); cos3 (0.832); cos4 (0.828); cos5 (0.862)	0.713	0.909
Expediting	exp1 (0.862); exp2 (0.770); exp3 (0.854); exp4 (0.792)	0.673	0.892
Governmental Interference	gov1 (0.880); gov2 (0.827); gov3 (0.866); gov4 (0.840)	0.729	0.915
Management	man1 (0.839); man10 (0.736); man3 (0.809); man4 (0.848); man6 (0.814); man8 (0.840); man9 (0.770)	0.654	0.930
Productivity	pro1 (0.821); pro2 (0.742); pro3 (0.821); pro4 (0.797); pro5 (0.792)	0.632	0.896
Purchasing	pur2 (0.813); pur3 (0.822); pur5 (0.799); pur6 (0.772); pur7 (0.763); pur8 (0.806)	0.634	0.912
Quality	qua1 (0.754); qua2 (0.890); qua3 (0.890)	0.718	0.884
Site Storage & Condition	sit1 (0.852); sit2 (0.809); sit3 (0.743); sit4 (0.858); sit5 (0.796)	0.660	0.907
Supplier	sup1 (0.787); sup3 (0.861); sup4 (0.880); sup5 (0.836)	0.708	0.906
Time	tim1 (0.828); tim2 (0.828); tim3 (0.779); tim4 (0.805); tim5 (0.827); tim6 (0.740)	0.643	0.915
Transportation	tra1 (0.868); tra2 (0.862); tra3 (0.816); tra5 (0.838)	0.716	0.910
Waste	was1 (0.810); was2 (0.837); was3 (0.846); was4 (0.835); was5 (0.857); was6 (0.794)	0.689	0.930

The results indicate that all the item loadings and composite reliability exceeded the threshold value of 0.70, while the AVE values also exceeded the threshold value of 0.50. These are recommended by the previous authors (Hair et al., 2014; Ramayah et al., 2016). Meanwhile, the discriminant validity was examined by means of the Fornell-Larcker criterion. As shown in Table 5, the values in bold fonts are greater than the corresponding values in the row and column, indicating that the measures are discriminant (Hair et al., 2014; Ramayah et al., 2016; Yeap et al., 2016). In summary, the reliability and both convergent and discriminant validity achieved the satisfactory level. Therefore, the structural model assessment is accepted.

Table 5 - Results of fornell-larcker criterion

	CON	COS	EXP	GOV	MAN	PRO	PUR	QUA	SIT	SUP	TIM	TRA	WAS
CON	**0.833**												
COS	0.654	**0.844**											
EXP	0.634	0.574	**0.821**										
GOV	0.684	0.599	0.714	**0.854**									
MAN	0.702	0.653	0.765	0.675	**0.809**								
PRO	0.550	0.716	0.537	0.547	0.535	**0.795**							
PUR	0.759	0.610	0.742	0.644	0.772	0.555	**0.796**						
QUA	0.563	0.634	0.497	0.421	0.526	0.606	0.524	**0.847**					
SIT	0.741	0.695	0.703	0.676	0.719	0.642	0.738	0.588	**0.813**				
SUP	0.559	0.511	0.747	0.683	0.615	0.477	0.606	0.452	0.642	**0.842**			
TIM	0.618	0.742	0.549	0.579	0.601	0.677	0.588	0.590	0.689	0.476	**0.802**		
TRA	0.727	0.634	0.765	0.700	0.764	0.615	0.791	0.554	0.756	0.644	0.579	**0.846**	
WAS	0.677	0.791	0.627	0.613	0.668	0.715	0.688	0.697	0.749	0.545	0.771	0.720	**0.830**

As the conceptual model is a higher-order model, therefore the second-order component needs to be estimated separately using a mixture of indicator approaches and the use of latent variable scores in a two-stage approach (Chin, 2010). Then, the structural model assessment was conducted. This structural model was assessed to determine the explanatory power of the model that involved evaluating the coefficient of determination (R^2), path coefficient (beta) and the t-values (Hair et al., 2014). The result of R^2 indicates that the value is 0.628. It means that the effective materials management explains 62.8% of the variance in project performance. This R^2 value of above 0.26 represents the predictive strength of the model in substantial capacity (Ramayah et al., 2016). To obtain the t-value, a bootstrapping procedure with 500 samples were computed (Yeap et al., 2016; Liew et al., 2016). The results of this procedure indicates that the effective materials management (β = 0.793, p<0.01) has a positive effect on project performance.

Apart from that, Figure 1 demonstrates the path coefficient between effective materials management and all the factor groups. The top three of the most significant groups that contribute to effective materials management are transportation, management, and purchasing. On the other hand, the effective materials management has the largest effect on waste, cost and time of project performance.

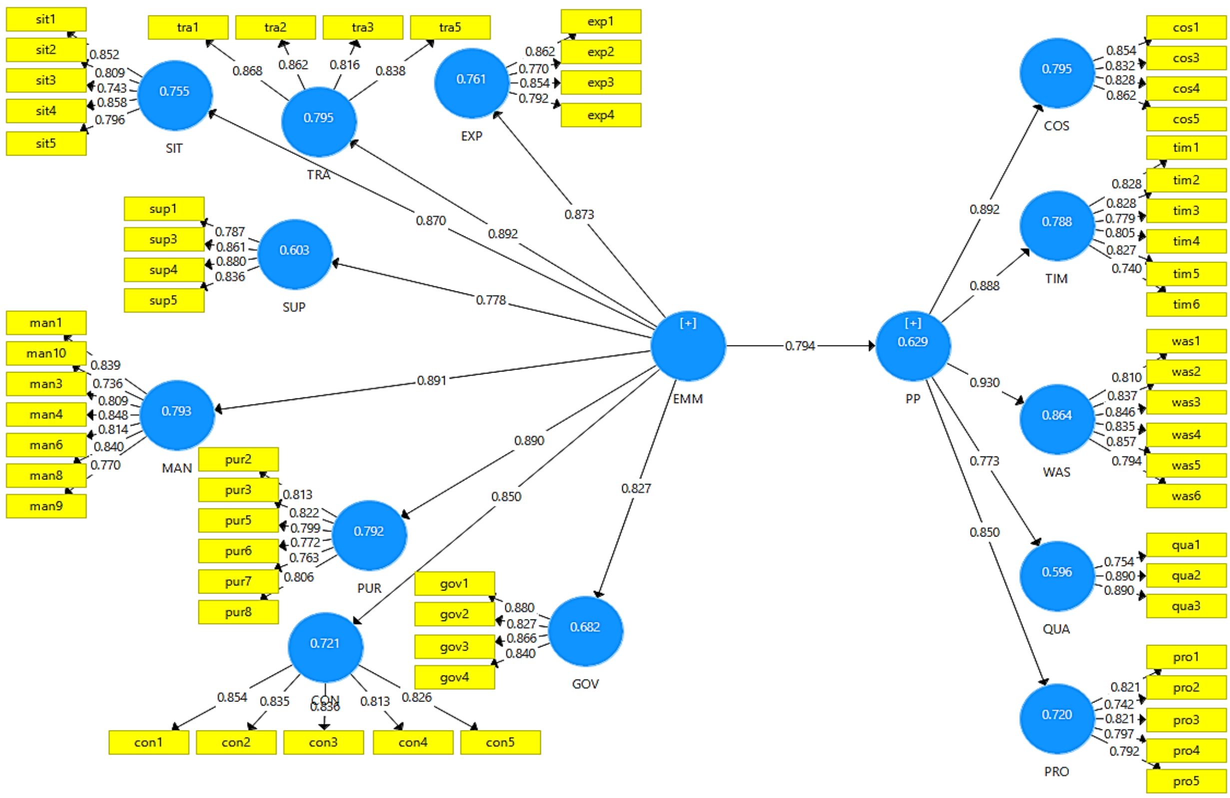

Fig. 1 - Structural of effective materials management factors model

5. Conclusion

The structural factors model can be used as a guideline while managing construction materials. Contractor organizations can consider which factors that become priority to enhance the project performance. For instances, the factors under transportation i.e proper materials delivery to site, functional equipment, sufficient protection during unloading, proper storing of materials and materials are not damage while handling give significant effect on project performance. In conclusion, by considering the positive impacts and influence of effective materials management on project performance, contractor organisations should pay more attention by allocating sufficient resources to implement effective materials management. Moreover, the top management should incorporate the factors as investigated in this study in formulating company strategies to improve the materials management effectiveness, which in turn will enhance the project performance. Essentially, more resources should be allocated to improve on the transportation, management and purchasing components of materials management. The outcome from this analysis can be further adopted to develop a factor model of effective materials management to achieve better construction project performance. Likewise, future research can be conducted on the investigation of materials management practices related to the top three group of factors which are transportation, management and purchasing.

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