Analysis on Comparison of Factors Influencing the Success of Sustainable Construction

Vignes Ponniah, Mohd Wira Mohd Shafiei, Radzi Ismail, Gunavathy Kanniyapan, Mohandass Mohan

Abstract: Malaysia started to implement several national policies related to sustainable development since 1980's such as National Energy Policy (1980), National Depletion Policy (1980), Four Fuel Diversification Policy (1981) and Fifth Fuel Policy (2000). Subsequently, sustainable construction already started to evolve since the beginning of Eight Malaysia Plan by integration of social, economic and environment. But sustainable development in Malaysia is still in initial stage as more research and development in terms of facilities and renewable energy resources are needed. Based on the previous researchers, there are six factors which influenced the development of sustainable construction. The six factors are factor related to project, factor related to project manager, factors related to project team, factor related to material and equipment, factors related to client and factors related external. Furthermore, identification of success factors will eventually leads to development of theoretical framework of success factors of sustainable construction. The findings from this study through the identification and comparison of success factors will reveal the weakness and advantages of existing factors and help to improve the success factors of theoretical framework. This research study uses survey method or questionnaire for data collection process. There are total of 120 questionnaires distributed to respondents which consists of contractors in location around Peninsular Malaysia. The research data have been analysed with factor analysis method using Smart PLS.

Keywords: critical success factors, sustainable construction, Malaysian construction industry

I. INTRODUCTION

Malaysia ventured into sustainable development since the year 1980's where several important environmental related policies were launched by the Malaysia government Malaysia such as National Energy Policy 1979, National Depletion Policy 1980, Four Fuel Diversification Policy 1981 and Fifth Fuel Policy 2000 (Chua and Oh 2011). Further enhancement in sustainable development in Malaysia is carried out by the Malaysian government through the integration of social, economic and environment in Eight Malaysia Plan. Other development related to sustainable development in Malaysia includes implementation of policy to motivate the application of green technology and construction of green building in the country such as the National Green Technology Policy which was started in the year 2009. Subsequently, there are several green rating tools started to be implemented in Malaysia including GreenRe and Green Building Index rating tools. Green Re rating tool was created by Rehda Malaysia in the year 2013 which was based on Singapore BCA Green Mark tool and recognised across 71 countries and cities globally (GreenRe, 2017). According to Green Re Sdn Bhd (2017), there are a total of 76 projects certified under GreenRe certified project which are equivalent to more than 40 million square feet in assessed area since 2013. While, Green Building Index or GBI was incorporated in 2009 and certified projects equivalent to 200.4 million square feet as of November 2017. Construction Industry Development Board or CIDB Malaysia has implemented several effort aligned with the Malaysian government towards embracing sustainable development in Malaysia by establishing low carbon building assessment system which is 100% based on actual carbon emission from construction activities. But as mentioned by several researchers, sustainable development in Malaysia still at modest level compared with other developed nation (Puvanasvaran *et al*. 2012). While others as stated that the response is still not encouraging among Malaysian although the government was able to provide better facilities for acquiring renewable energy resources in Malaysia (Bakar *et al*. 2011).

Factors influencing the Success

According to previous researchers, there are six factors which influence the success of sustainable construction which are factors related to project, construction manager, construction team, material and equipment, client and external factors. The design of the questionnaire are formed according to list of factors mentioned below.

Revised Manuscript Received on March 08, 2019.

Vignes Ponniah, Faculty of Engineering and Green Technology, University Tunku Abdul Rahman, 31900 Kampar, Perak, Malaysia.

Mohd Wira Mohd Shafiei, School of Housing, Building, and Planning, University Science Malaysia, 11800 Minden, Pulau Pinang, Malaysia.

Radzi Ismail, School of Housing, Building, and Planning, University Science Malaysia, 11800 Minden, Pulau Pinang, Malaysia.

Gunavathy Kanniyapan, Faculty of Built Environment, Tunku Abdul Rahman University College, 53300 Setapak, Kuala Lumpur, Malaysia.

Mohandass Mohan, Academies Australasia Polytechnic, Level 7, 628 Bourke Street, Melbourne 3000 Australia.

Factors Related to Project	
1.	Able to manage project cost from initial until inception stage
2.	Good level of quality after completion of project
3.	Proper planning of schedule before start of a project
4.	Usage of proper checklist document to monitor the performance of project
5.	Top management support throughout the project
6.	Adaptable contractual terms for all the parties for smooth project progress
7.	Effective method of procurement finalised before commencement of construction activities
8.	Effective construction procedures during construction activities
9.	Proper coordinated project objectives
10.	Finalization of green features in a project before commencement
11.	Concentrated energy modelling before commencement of project
12.	Successful project management from inception until completion
13.	Organised monitoring process of project stages
14.	Proper method of financing until the end of construction process
15.	Adaptable construction activities which involves high technical aspect
16.	Better functional approval process for all stages of construction activities
Factors Related to Construction Manager	
1.	Capable construction manager
2.	Ability to review matter of concern before long term solution taken by construction manager
3.	High capability to solve matter of concern related to project activities by construction manager
4.	Apply incentive method to improve work performance of workers by construction manager
5.	Knowledgeable construction manager in terms of technical aspects
Factors Related to Construction Team	
1.	Well organised construction team
2.	Well behaved construction team in terms of profession ethics
3.	High awareness of construction activities through experience by construction team
4.	Properly manage the available resources by construction team
5.	Good relationship among team members involved in construction project
6.	Proper sustainable construction consultation among construction team members in construction activities
7.	Adequate level of training for construction team in a project
8.	Proper requirement of construction team members in a project
9.	Effective communication between construction team members in a project
10.	Significantly involved in project stage utilization by construction team members
11.	Smooth flow of information among construction team member during construction process
12.	Proper innovation in terms of green design from construction team members in a project
13.	Better inclusion of green design features by the construction team members
14.	Project team members well aware about the green rating tools to ensure good flow of green certification process
15.	Productive cooperation between the construction team members from inception to completion
Factors Related to Material and Equipment	
1.	Good level of durability in terms of construction materials
2.	Productive usage of computer software to smoothen the construction process
3.	Evaluation of construction process using latest equipment
4.	Assessment of Life Cycle Analysis (LCA) on green materials before commencement of construction process
Factors Related to Client	
1.	Knowledgeable client in overall process of construction
2.	High level of commitment from client to ensure success of project
3.	High acceptance level of client regarding project
4.	Effective involvement of client from inception to completion
5.	Non-delay payment by the client for completion of each stage of production
Factors Related to External Factors	
1.	National economy in stable condition during construction process
2.	High level of environmental regulation requirement by regulators
3.	Flexible policy usage by government related to low carbon or green construction
4.	National politics in stable condition during construction process

Research Methodology:

This research study is based on quantitative method by using questionnaire. There are total of 6 categories of success of sustainable construction which are factors related to project, construction manager, construction team, material and equipment, client and external factors. Questionnaire was used to identify most imparting factors of success of sustainable construction. Likert scale was used to express the factors on the Likert Scale of 1(strongly disagree) to 5 (strongly agree).

Profiles of Respondents:

The research studies involves total of 120 respondents which represent contractors involved in sustainable construction across Malaysia.

Data Analysis and Result Discussion:

Table. 2 Designation of Respondents

Respondent Designation	Frequency	Percentage of Total	Cumulative Percentage
Executive	11	9.2	9.2
Senior Executive	5	4.2	13.4
Manager	46	38.3	51.7
Senior Manager	51	42.4	94.1
Executive Director and above	5	4.2	98.3
Others	2	1.7	100
Total	120	100	

Table. 3 Respondents Working Experience in Construction Industry

Years of Experience	Number of Respondents	Percentage	Cumulative Percentage
1-5 years	15	12.5	12.5
6-10 years	8	6.7	19.2
11-15 years	69	57.5	76.7
16-20 years	22	18.3	95
21-25 years	2	1.7	96.7
26-30 years	3	2.5	99.2
31-35 years	0	0	99.2
36 and above	1	0.8	100
Total	120	100	

Table. 4 Respondents Working Experience in Sustainable Construction

Number of Projects	Frequency	Percentage	Cumulative Percentage
1-3	21	17.5	17.5
4-6	36	30	47.5
7-9	63	52.5	100
Total	120	100	

Based on Table 2, respondents participated in this survey consists of Executive; 9.2%, Senior Executive; 4.2%, Manager; 38.3%, Senior Manager; 42.4%, Executive Director and above; 4.2%, and others; 1.7%. While table 3 shows that majority of respondents; 57.5% have 11 to 15 years of experience in construction industry and lowest; 0.8% have more than 36 years of experience.

Questionnaires which was used to collect data for this research study were analysed using Smart PLS software. In this research study, factor analysis was carried out to make comparison between the factors which influence the success of sustainable development.

Descriptive Statistic for Variables

Descriptive statistic for this research study was carried out to identify the mean and standard deviation for all the seven variables of dependent and independent variables. The descriptive statistical analysis need to be conducted to identify responses of all the variables involved in this research study.

Table. 5 Descriptive Statistic for Variables

Latent Variables	Mean	Standard Deviation
Factors Related to Project	3.7292	.44912
Factors Related to Project Manager	3.7750	.46374
Factors Related to Project Team	3.7875	.44012
Factors Related to Material and Equipment	3.7875	.50068
Factors Related to Client	3.7306	.47001
Factors Related to External	3.8542	.46920
Success of Sustainable Construction	3.8125	.45440

According to Table 5 above, factors related to external recorded the highest value of mean at 3.8542 while factors related to client achieved the lowest number of mean at 3.7306. The highest number of mean for factor related to external factors shows that respondents identified factor related to external factors as the most influence factor which affect the success of sustainable construction by positive way. While the lowest number of mean recorded by factors related to client shows that respondents identified factor related to client as the least influence factor towards success of sustainable construction. While the one and only dependent variable; success of sustainable construction achieved mean at value of 3.8125. Factors related to project team and factors related to material and equipment achieved the same value of mean at 3.7875 respectively although with different standard deviation values. Finally, the last two independent variables; factors related to project and factors related to project manager gained mean value of 3.7292 and 3.7750 respectively. This shows that factors related to external factors emerged as highest level of responses among other group of critical success factors. Therefore, it is revealed that factors related to external factors which consists of economic stability, high green environmental requirement and political stability are selected as most important elements that influence the success of sustainable construction by the targeted respondents.

The analysis part of this research study uses the Structural Equation Modelling (SEM). According to several researchers such as Westland (2007), Structural Equation Modelling (SEM) helps to analyse the hypothesized relationship among the said constructs while measured the theoretical constructs. SmartPls version 2.0 which uses the Structural Equation Modelling (SEM) has been selected for this research study as Partial Least Square Analysis (PLS) was designed for formative and reflective indicators whereas other SEM techniques do not allow to do so. (Wold, 1981). During the process of applying of Partial Least Square Analysis (PLS) in developing the model, there are two important points to be taken for consideration;

i) Assessment in measuring model and
ii) Assessment of structural model.

Assessment of Measuring Model

According to Rossiter (2002), in order to conduct assessment of measuring model, convergent and discriminate validity need to be determined while evaluating the reliability of the scale items.

i) The Convergent Validity

The convergent validity of the scale item needs to pass through the total of three important criteria's which are;

1) The factor loading must be greater than 0.50
2) Composite reliability of each construct greater than 0.70 (Hair et al., 2006)
3) Average Variance Extracted (AVE) need to be greater than 0.50 (Fornell and Larker, 1981)

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Table. 6 Measurement Model of PLS (n=120)

Latent Variables	Question Items	Main Loading	AVE	Composite Reliability	R Square
Factors Related to Project	FRTP1	0.759	0.502	0.909	
	FRTP10	0.907			
	FRTP11	0.605			
	FRTP12	0.631			
	FRTP2	0.591			
	FRTP3	0.667			
	FRTP4	0.771			
	FRTP5	0.724			
	FRTP6	0.782			
	FRTP7	0.660			
	FRTP8	0.682			
	FRTP9	0.663			
Factors Related to Project Manager	FRTPM1	0.691	0.541	0.778	
	FRTPM2	0.822			
	FRTPM4	0.685			
Factors Related to Project Team	FRTPT1	0.622	0.502	0.909	
	FRTPT9	0.865			
	FRTPT8	0.734			
	FRTPT5	0.761			
	FRTPT4	0.613			
	FRTPT3	0.635			
	FRTPT2	0.643			
	FRTPT10	0.715			
	FRTPT11	0.798			
	FRTPT13	0.650			
Factors Related to Material and Equipment	FRTME1	0.613	0.627	0.763	
	FRTME2	0.937			
Factors Related to External Factors	FRTE1	0.692	0.587	0.738	
	FRTE2	0.833			
Factors Related to Client	FRTC1	0.748	0.609	0.821	
	FRTC2	0.912			
	FRTC4	0.659			
Success of Sustainable Construction	SF1	0.816	0.511	0.912	0.604
	SF10	0.597			
	SF2	0.713			
	SF3	0.693			
	SF4	0.669			
	SF5	0.716			
	SF6	0.744			
	SF7	0.693			
	SF8	0.733			
	SF9	0.754			

According to Table 6 which shows the measurement model of this research study, convergent validity analysis conducted for this research study passes all the three important criteria which were identified as a guideline for this convergent validity analysis.;

1) The factor loading must be greater than 0.50 (Hair et al., 2006). All the items main loading exceeding 0.50. The value of main loadings are within the range of 0.591 to 0.937.

2) Composite reliability of each construct greater than 0.70 (Hair et al., 2006). All the constructs greater than 0.7. Success of low carbon construction as dependent variable recorded the highest composite reliability at 0.912 while factors related to external as one of the

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

3) independent variables which are consists of two dimensions; stability and regulation and policy recorded the lowest composite reliability at 0.738.

4) Average Variance Extracted (AVE) need to be greater than 0.50 (Fornell and Larker, 1981). All the constructs greater than 0.50. Factors related to material and equipment achieved highest figure of AVE at 0.627. While factors related to project and project team achieved lowest figure of AVE at 0.502 respectively

ii) Discriminant Validity

The following process based on Table 7, the discriminant validity referring to specialized analysis which results will not represent each other variables although a portion of similarity exists (Peter and Churchill, 1986). Discriminant validity analysis is carried out by analysing the cross loadings of each item in the constructs and the square root of AVE calculated for each construct. While Hair *et al*. (2014), mentioned that the discriminant validity assessment which performed in PLS path model has the objective to ensure that a reflective construct has the strongest relationships with its own indicators.

Table.7 Discriminant Validity of Measurement Model (n=120)

Latent Variable	FRTC	FRTE	FRTME	FRTP	FRTPM	FRTPT	SF
FRTC	**0.780**						
FRTE	0.265	**0.766**					
FRTME	0.367	0.218	**0.792**				
FRTP	0.192	0.347	0.486	**0.709**			
FRTPM	0.282	0.457	0.173	0.336	**0.735**		
FRTPT	0.366	0.330	0.365	0.388	0.319	**0.708**	
SF	0.508	0.526	0.505	0.506	0.528	0.502	**0.715**

Note: Values in the diagonal (bolded) represent the square root of the AVE while the off diagonals are correlation.
FRTC represent factors related to client
FRTE represent factors related to external
FRTME represent factors related to material and equipment
FRTP represent factors related to project
FRTPM represent factors related to project manager
FRTPT represent factors related to project team
SF represents success of low carbon construction

Assessment of Structural Model.

SmartPLS version 2.0 was used to create the structural model. The structural model created after evaluation process using the three important criteria as mentioned by Ringle *et al*. (2012) which are;

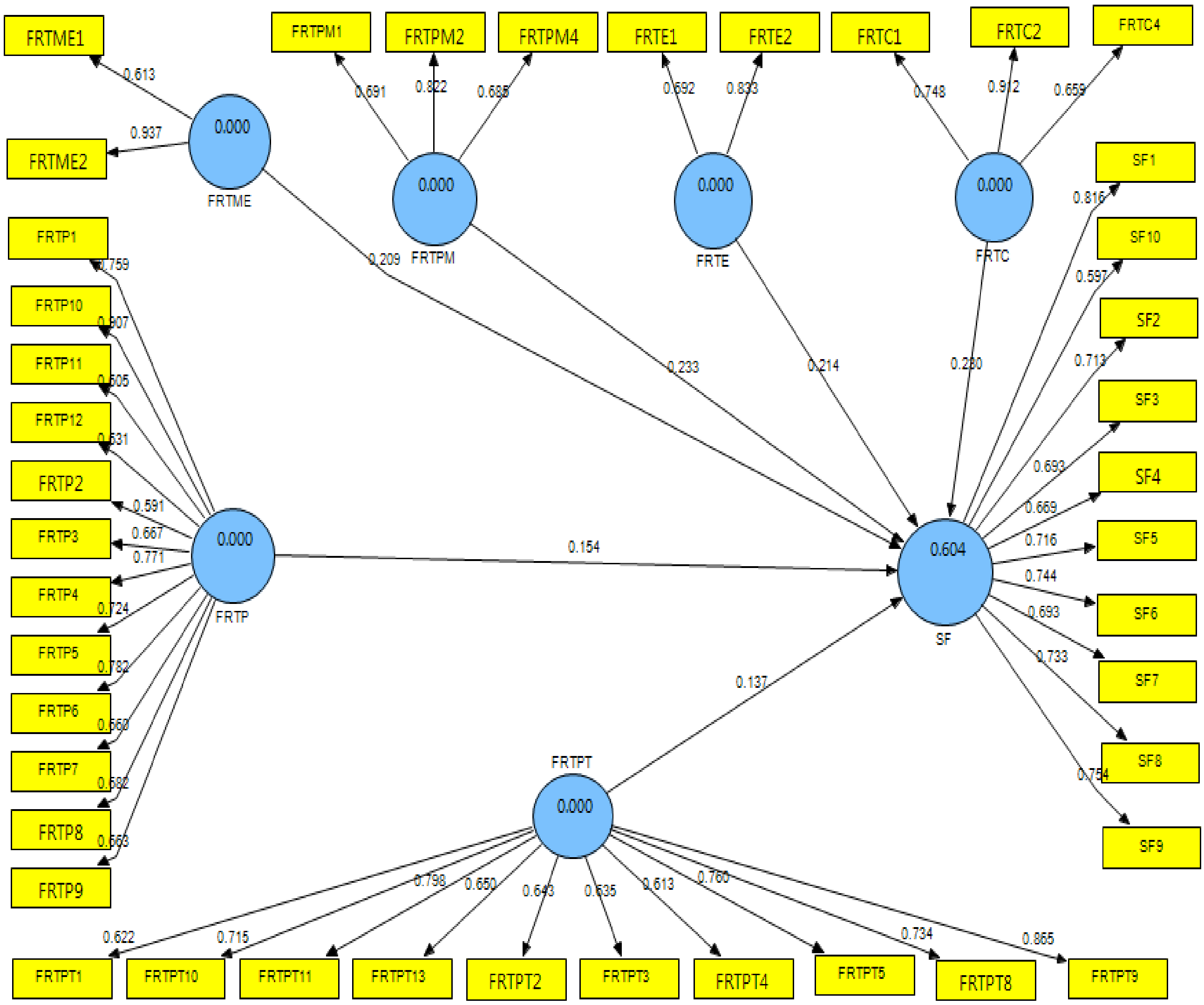
1) Path Coefficient (β)
2) Path Significance (p-value)
3) Variance Explain (R^2)

Rossiter (2002) added that path coefficient analysis performed for the structural model should result in t-value greater than 2.0 and latent variable R-Squares (R^2) greater than 50% although Hair *et al*. (2006), have maintained that the cut off criteria for analysing purpose of Path Coefficient is based on t-value greater or equal to 1.645 for an alpha level of 0.05.

According to figure 1, the beta value to check the path coefficient for this research study is in level of acceptable where the t-value for all variables exceed than limit of 2.0 as suggested by Rossiter (2002). The highest t-value recorded by relationship between factor related to client and success of low carbon construction at 3.322 at $p<0.001$ while the lowest t-value recorded for the relationship between factor related to project and success of low carbon construction at 2.130 at $p<0.05$. Based on figure 1, the latent variable R-Square (R^2) achieved 0.604 or 60.4% for this research study which is highly acceptable level if compared to as suggested by Hair *et al*. (2006) at greater than 50%.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Fig. 1 PLS-Path Analysis of Beta Value



II. CONCLUSION

Based on figure 1, all data which were used for analysis which consists of six factors of critical success factors are reliable in terms of composite reliability as indicated by Hair *et al*. (2006). Path coefficient analysis was conducted for this research study significantly indicated positive relationship between independent variables; 1) factors related to project, 2) factors related to project manager, 3) factors related to project team, 4) factors related to material and equipment, 5) factors related to client, 6) factors related to external and dependent variable; success of sustainable construction. Besides that, through factor analysis, an effort to develop and tests the proposed model for achieving success in sustainable construction was carried out which resulted in 6 independent variables as mentioned earlier as the critical success factors of sustainable construction. Therefore, based on figure 2, there are total of six independent variables consists of factors related to project, factors related to project manager, factors related to project team, factors related to material and equipment, factors related to client and factors related to external with eighteen subsection which supports the dependent variable; success of sustainable construction.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

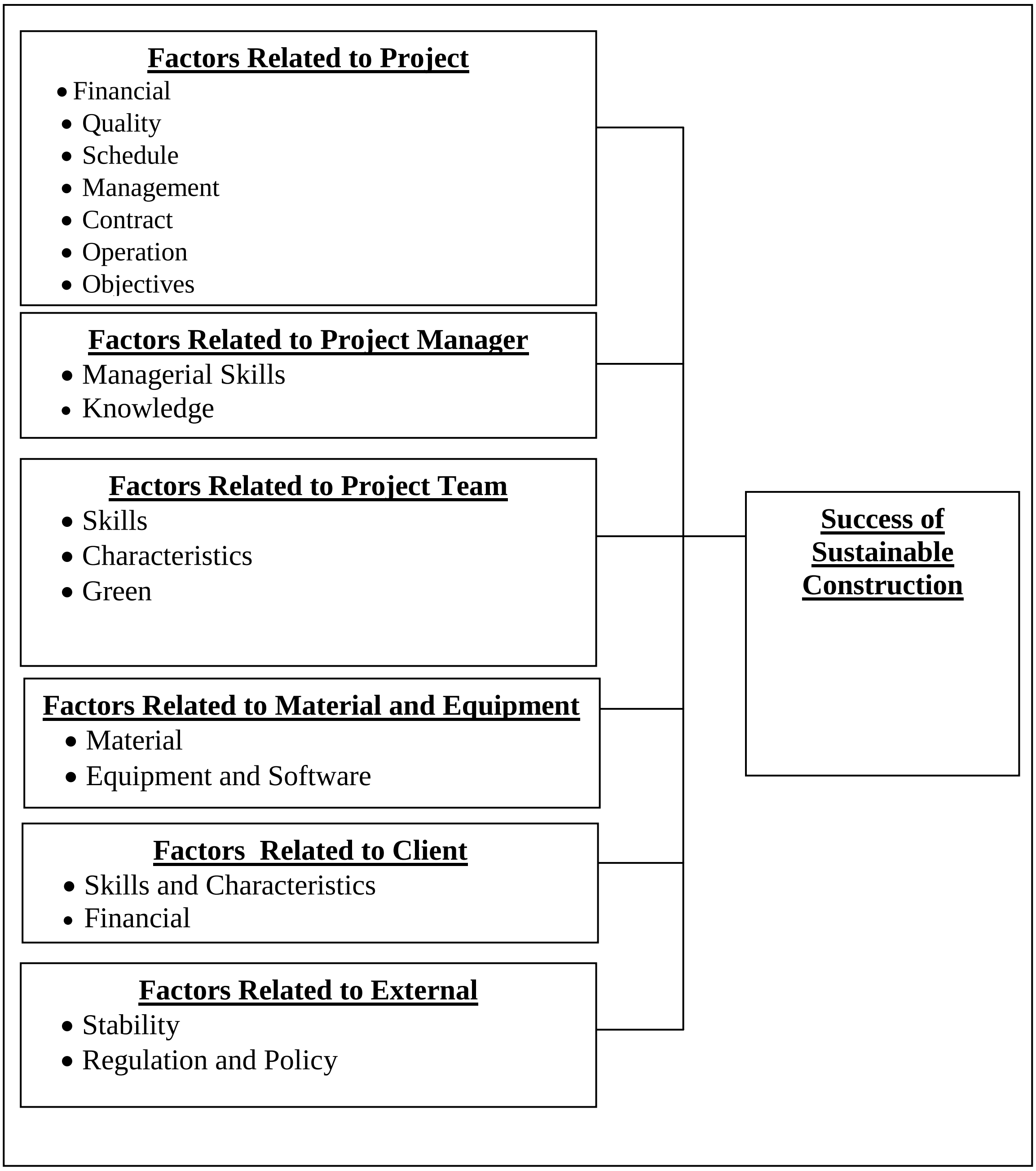


Fig. 2 The Final Proposed Theoretical Model

REFERENCES

1. Bahaudin, A.Y., Elias, E.M., Saifudin, A.M.,(2014) A Comparison of the Green Building's Criteria (http://www.e3s-conferences.org or http://dx.doi.org/10.1051/e3sconf/20140301015) retrieved on 6 January 2017
2. Bakar, K.A. (2011). Green Technology Readiness in Malaysia: Sustainability for Business Development. *International Conference on Business and Economics Research 2*, 1120-1129.
3. BRE Global Limited (2011). BREEAM New Construction, Non Domestic Buildings, Technical Manual
4. (http://www.breeam.org/breeamGeneralPrint/breeam_non_dom_manual_3_0.pdf) retrieved on 10 January 2017
5. Chua, S.C., Oh,T.H. (2011). Green progress and prospect in Malaysia, Renewable and Sustainable
6. Energy Reviews, Vol. 15, pp. 2850– 2861
7. Fornel, C., and Lacker, D.F. (1981). Evaluating Structural Equation Model with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39-50.

8. GreenRe Sdn Bhd (2017) Total Certified Projects http://www.greenre.org/) retrieved on 10 January 2017
9. GreenRe Sdn Bhd (2017) Rating tool based on five pillars ((http://www.greenre.org/) retrieved on 10 January 2017)
10. Green Building Council of Australia (2017). (http://new.gbca.org.au/green-star/rating-system/performance) retrieved on 12 January 2017
11. Green Building Council of Australia (2013). The Value of Green Star - A Decade of Environmental Benefits (http://www.gbca.org.au/uploads/194/34754/The_Value_of_Green_Star_A_Decade_of_Environmental_Benefits.pdf) retrieved on 12 January 2017
12. Hair, J.F.J., Black, W., Babin, B., Anderson, R.E., & Tatham (2006). *Multivariate Data Analysis.* New Jersey. Pearson Education.
13. Ho, C.S., Fong W.K. (2007). Planning for Low Carbon Cities. The Case of Iskandar Development Region, Malaysia (http://eprints.utm.my/6475/) retrieved on 19 September 2012
14. Leadership in Energy and Environmental Design (LEED) (2017). (http://www.usgbc.org/leed), retrieved on 5 January 2017
15. Parlimen of Australia (2013), Mandatory Renewable Energy Target,
16. (http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/Browse_by_Topic/ClimateChange/Governance/Domestic/national/Mandatory, retrieved on 12 January 2017
17. Peter, J. P., & Churchill, G. A. (1986). Relationships among Research Design Choices and Psychometric Properties of Rating Scales. *Journal of Marketing Research, 23*(1), 1–10.
18. Puvanasvaran, A.P., Zain, M.F.Y., Al-Hayali, Z.A., & Mukapit, M. (2012). Sustainability of Green Technology in Malaysia Industry. *International Conference on Design and Concurrent Engineering 1,* 160-165.
19. Rossiter, J. R. (2002). The C-OAR-SE Procedure for Scale Development in Marketing. *International Journal of Research in Marketing, 19*(1), 305 – 335.
20. Wold, H. (1981). *The Fix-Point Approach to Interdependent Systems: Review and Current Outlook in H. Wold (Ed.), The Fix-Point Approach to Interdependent Systems*. Amsterdam. North-Holland Publication.