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Safety and Health Factors Influencing Performance of Malaysian Low-Cost Housing: Structural Equation Modeling (SEM) Approach

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Abstract

Current sustainable building, design and construction practices in Malaysia are primarily aimed at minimizing environmental and resource impacts and improving the safety, health, and productivity of a building's final occupants. The primary objective of this study is to construct a valid and reliable instrument to quantitative measure the level of conformance by construction practitioners towards building safety and health performance of low-cost housing in Malaysia. The proposed research model was tested empirically using through a survey of 268 construction practitioners using partial least squares (PLS) and structural equation modeling (SEM) tool. Statistical results confirm that architecture, building services, external environment, management approaches and maintenance management positively influences safety and health performance of low-cost housing in Malaysia. The results, besides indicating the suitability of the PLS in statistical analysis, has also contributed to a better understanding of safety and health performance of low-cost housing in Malaysia. Findings are useful for organisations, market participants and practitioners to enhance Malaysian sustainable construction.

Keywords: Low-cost housing; Health; Safety; Partial Least Square.

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1. Introduction

The creation of the sustainable development is one of the main priorities of construction industry in Malaysia. Quality of housing has huge impacts on three dimensions of the sustainable development to achieve simultaneously acquire balance and achievement between economic, social and environmental objectives and priorities (Said et al., 2009). In fact, the relationship between sustainable development and the housing quality is complex. Housing quality is a very complicated issue, which is related to people's daily lives. Therefore, there is a need for a sustainable strategy especially towards building a safer, healthier, and more sustainable built environment. Indeed, safety and health is an important aspect for the wellbeing of individuals and society, which may contribute for economic productivity and prosperity. In order to enhance higher quality construction, Construction Industry Development Board (2009), further introduced the Construction Industry Master Plan (CIMP) that spans from 2006 to 2015. The CIMP outlines seven strategic thrusts that will guide the development of the Malaysian construction. The CIMP has identified the future challenges on environmental practice and new construction method to enhance for the highest standard of quality, safety and health and environmental practices as mentioned in strategic thrust. Furthermore, to gauge the success of its strategic thrust, key performance indicators have been set to 1) promote and encourage all local construction companies to attain ISO 9001, ISO 14001 and OHSAS 18001 certification to ensure a balanced environment exists 2) develop safety and health standards, guidelines, and code of practices for the construction industry. Therefore, comprehensive framework must be developed to determine performance indicators and criteria for safety and health building with the focus generally on the prevention of safety and health problems (Akasah et al., 2011).

2. Literature Review

Quality assessment of a building has been made in various countries toward a more complete understanding of design and management requirements for safe and healthy buildings. The significance of building assessment is emphasized in almost all primary documentation and legislation for safety and health building performance. Levin (1995) defined healthy building as "one that adversely affects neither the health of its occupants nor the larger environment". On the other hand, Constitution of the World Health Organization (WHO) defines health more broadly with no clear distinction between design and management. It was argued by Yau et al. (2008) that in the context of healthy building, there is a clear distinction between design and management. They pointed out that design aspects of a building is usually hard to change technically or economically, whereas management is dynamic to changes according to the current needs. Concerning the contributors of unsafe conditions, Wong, et al. (2006) defined a safe building as "one that protects occupants and also the public from death and physical injury". A more elaborate definition was made by Yau et al. (2008) where they defined them as "built environment that safeguards its occupants and the general public as a whole from physical, psychological, or material harms originating from the built environment, aims to reduce injuries and deaths, and hence, encourages the positive well-being of humanity". In recognizing the prominence of design and management, Ho et al. (2008) suggested an establishment of building assessment schemes would help all groups in the life-cycle of buildings to better understand and apply the principles of safe design as an integral part of management processes. On the property prices of the buildings, Yau et al. (2008) pointed out that the safer properties generally commanded higher market prices. It is clear that the value of buildings form the basis for adopting a different approach in the design and management process. The safety and health of building has invaluable significance which must be retained maximally. It is clear that housing condition is an important issue in all over the world to enhance safety, health and sustainability of built environment. Therefore, it needs to be concise enough in order to present building safety and health factors in a systematic manner. Several others researchers have conducted survey in different areas of the world contributing to identify the safety and health building performance factors (Table 1 & Table 2).

Table 1. Building safety and health factors from previous studies

Construct	Item	Parameters	Sources
Architecture	ARCHI1	Means Of Escape	Al-Homoud & Khan(2004), Wong et al. (2006), McDermott et al. (2007), Yau et al. (2008), Omar (2008) , Keall et al. (2010), Ali et al. (2012)
	ARCHI2	Means of Access	Al-Homoud & Khan(2004), Wong et al. (2006), McDermott et al. (2007), Yau et al. (2008), Omar (2008) , Keall et al. (2010), Ali et al. (2012)
	ARCHI3	Structural and Finishes Integrity	Kim et al. (2005), Wang et al. (2005), Lee et al. (2011), Husin et al. (2011), Chohan et al.(2011), Ali et al. (2012), Zainal et al. (2012)
	ARCHI4	Building Material	Kim et al. (2005), Wang et al. (2005), Lee et al. (2011), Husin et al. (2011), Chohan et al.(2011)
	ARCHI5	Amenities	Wong et al. (2006), Yau et al. (2008), Omar (2008) , Keall et al. (2010), Salfarina et al. (2010), Lee et al. (2011), Hashim et al. (2012), Aziz & Ahmad(2012a)
	ARCHI6	Space Functionality	Kim et al. (2005), Wong et al. (2006), Omar (2008) , Keall et al. (2010), Salfarina et al. (2010), Hashim et al. (2012), Isnin et al. (2012), Aziz & Ahmad(2012a)
	ARCHI7	Fire Resistant Construction	Al-Homoud & Khan(2004), Wang et al. (2005), Wong et al. (2006), McDermott et al. (2007), Yau et al. (2008), Keall et al. (2010), Husin et al. (2011)
Building Services	BS1	Electricity Supply	Al-Homoud & Khan(2004), Kim et al. (2005), Wang et al. (2005), Yau et al. (2008), Keall et al. (2010), Husin et al. (2011), Chohan et al.(2011), Ali et al. (2012)
	BS2	Lighting	Al-Homoud & Khan(2004), Kim et al. (2005), Keall et al. (2010), Bluyssen (2010), Lee et al. (2011), Hashim et al. (2012), Ali et al. (2012)
	BS3	Ventilation	Kim et al. (2005), Keall et al. (2010), Bluyssen (2010), Lee et al. (2011), Chohan et al.(2011), Hashim et al. (2012), Ali et al. (2012)
	BS4	Air-conditioning	Ali et al. (2012), Sani et al. (2012)
	BS5	Plumbing	Al-Homoud & Khan(2004), Kim et al. (2005), Wang et al. (2005), Keall et al. (2010), Lee et al. (2011), Husin et al. (2011), Hashim et al. (2012), Ali et al. (2012),
	BS6	Sanitary Services	Al-Homoud & Khan(2004), Kim et al. (2005), Wang et al. (2005), Keall et al. (2010), Lee et al. (2011), Hashim et al. (2012), Ali et al. (2012), Karim (2012)
	BS7	Fire Services	Al-Homoud & Khan(2004), Yau et al. (2008), Omar (2008) , Husin et al. (2011)
	BS8	Lifts	Husin et al. (2011), Ali et al. (2012), Karim (2012)
External Environment	EX1	Emergency Services	Yau et al. (2008), Lee et al. (2011), Hashim et al. (2012)
	EX2	External Hazards	Kim et al. (2005). Lee et al. (2011), Isnin et al. (2012)
	EX3	Location	Keall et al. (2010), Bluyssen (2010)
	EX4	Air Quality	Kim et al. (2005), Keall et al. (2010), Bluyssen (2010), Lee et al. (2011), Hashim et al. (2012), Isnin et al. (2012), Aziz & Ahmad(2012a)
	EX5	Peaceful Environment	Omar (2008) , Keall et al. (2010), Bluyssen (2010), Salfarina et al. (2010), Lee et al. (2011), Hashim et al. (2012), Isnin et al. (2012)
	EX6	Aesthetics	Kim et al. (2005), Omar (2008) , Hashim et al. (2012), Isnin et al. (2012), Aziz & Ahmad(2012a), Zainal et al. (2012), Bajunid & Ghazali (2012)

Table 2. Continue

Construct	Item	Parameters	Sources
Operation & Maintenance	OM1	Building Peripherals	Yau et al. (2008), Hashim et al. (2012)
	OM2	Structural and Finishes Integrity	Wang et al. (2005), Yau et al. (2008), Lee et al. (2011), Ali et al. (2012), Zainal et al. (2012), Karim (2012)
	OM3	Building Services Conditions	Al-Homoud & Khan(2004), Lai & Yik (2004), Wang et al. (2005), Yau et al. (2008), Keall et al. (2010), Salfarina et al. (2010), Lee et al. (2011), Mustafa et al. (2011), Hashim et al. (2012), Ali et al. (2012)
	OM4	Transformation of Building	Lai & Yik (2004), Hashim et al. (2012), Isnin et al. (2012)
	OM5	Fire Compartment Integrity	Al-Homoud & Khan(2004), Wang et al. (2005), Yau et al. (2008), Keall et al. (2010), Lee et al. (2011)
Management Approaches	MA1	Emergency Evacuation Plan	Al-Homoud & Khan(2004), Yau et al. (2008), Deng et al.(2008), Bottani et al. (2009)
	MA2	Documentation & Evaluation	Lai & Yik (2004), Wang et al. (2005), Yau et al. (2008), Deng et al.(2008), Bottani et al. (2009), Salfarina et al. (2010), Lee et al. (2011)
	MA3	Safety Education	Deng et al.(2008), Bottani et al. (2009), Ali et al. (2012)
	MA4	Security Management	Lai & Yik (2004), Kim et al. (2005), Yau et al. (2008), Deng et al.(2008), Bottani et al. (2009), Lee et al. (2011), Mustafa et al. (2011)
	MA5	Occupant Safety Management	Deng et al.(2008), Omar (2008) , Bottani et al. (2009), Mustafa et al. (2011), Isnin et al. (2012), Zainal et al. (2012), Latif et al. (2012)
	MA6	Waste and Cleaning Services	Lai & Yik (2004), Keall et al. (2010), Lee et al. (2011), Mustafa et al. (2011), Hashim et al. (2012), Latif et al. (2012), Karim (2012)

3. Research method

The target population in this research is defined as consisting of an architects, engineers, quantity surveyors and developers throughout Malaysia. Based on the general rule, a sample size of minimum 200 is a good basis to perform a maximum-likelihood based estimation, which is one of the most common Structural Equation Modeling (SEM) estimations (Hair et al, 2010). Non-probability cluster sampling was used in this study.

3.1. Data collection

Four hundred (500) self-administered questionnaires were used for gathering data from the respondents. A multiple method of data collection was employed, whereby some questionnaires were mailed to the respondents, some were e-mailed and some were personally administered. The process of distribution and collection of questionnaires was carried out over a period of three (3) months. A total of 268 were received and used for this analysis which translates to about 54% response rate.

3.2. Measures and assessment of goodness of measures

Measure validation and model testing were conducted using SmartPLS 2.0, a structural equation modeling tool that utilises a component-based approach to estimation. Smart PLS 2.0 involved a two-step approach to data analysis. First, the measurement model was used to evaluate and develop the reliability and validity of the research instrument. Second, after the adjustment of items and acceptance of the measurement model, the structural model was evaluated to assess the hypothesised relationships among constructs in the conceptual model. This two-step process helped ensure that the scale items are statistically consistent and the constructs measure what they intended to measure before any attempts were taken at drawing conclusions regarding the structural model.

3.2.1 *Measurement Model Assessment*

Reflective measurement models should be assessed with regard to their reliability and validity. It is requires the examination of internal consistency reliability, indicator reliability, convergent validity and discriminant validity. For reflective constructs the reliability of the measures are normally illustrated by high Cronbach alpha or composite reliability (Henseler et al., 2009). Composite reliability was considered as an ideal statistical technique, which depicts the degree to which the construct indicators indicate the latent (Hair et al., 2011). Composite reliability values (see Table 4) for iteration 1 and iteration 2 were ranged from 0.870 to 0.894 and 0.880 to 0.909, respectively. The composite reliability values exceeded the recommended value of 0.6 (Fornell & Larcker, 1981; Henseler et al., 2009 and Hair et. al., 2010).

Individual item reliability was assessed by evaluating the individual item loadings with values greater than 0.7, which indicates adequate indicator reliability or simple correlations of the measures as they related to each construct (Henseler et al., 2009; Gotz et al., 2010). However, Hair et al. (2010) further suggest the acceptable factor loading (outer loading) of 0.4 if the sample size is 200 or more. Table 4 shows that in iteration 1 almost all manifest items had outer loading more than 0.4 except BS4 and OM1. As depicted in results of iteration 2, the omitting of item BS4 and OM1 resulted in improving the value of outer loading which exceeded than cut-off value. Next we tested the convergent validity which is signifies the degree to which a set of indicators represents one and the same underlying construct. Convergent validity could be evaluated using the average variance extracted (AVE) measure and it should be greater than 0.50. The value of AVE indicating adequate degree of convergent validity, which is at least 50% of measurement variance, is captured by the construct (Fornell and Larcker, 1981; Gotz et al., 2010; Hair et al., 2010). Table 4 shows that in iteration 1, AVE were more than 0.5 except Building Services. Using the iterative process of deletion, in iteration 2, the AVE value of Building Services and Operation and Maintenance was improved to 0.564 and 0.714, respectively.

Finally, discriminant validity is assessed based on the Fornell-Lacker criterion which refers to the condition where a latent variables share more variance with its assigned indicators than with any other latent variable. The criteria for assessing adequate discriminant validity is the use of the measure average variance extracted (AVE) of each latent construct should higher than the variance shared between the construct and other constructs (Hair et. al, 2010). As shown in Table 3, the squared correlations for each construct is less than the square root of the average variance extracted by the indicators measuring that construct indicating adequate discriminant validity.

Table 3. Correlation matrix

	Architecture	Building Services	External Environment	Management Approaches	Operation & Maintenance
Architecture	0.718				
Building Services	0.382	0.751			
External Environment	0.459	0.402	0.766		
Management Approaches	0.356	0.684	0.334	0.845	
Operation & Maintenance	0.409	0.377	0.639	0.386	0.777

Table 4. Individual item reliability and construct validity

Iteration 1					Iteration 2				
Construct	Item	Loading	CR	AVE	Construct	Item	Loading	CR	AVE
Architecture	ARCHI1	0.831	0.878	0.515	Architecture	ARCHI1	0.831	0.880	0.515
	ARCHI2	0.811				ARCHI2	0.811		
	ARCHI3	0.652				ARCHI3	0.652		
	ARCHI4	0.563				ARCHI4	0.563		
	ARCHI5	0.626				ARCHI5	0.626		
	ARCHI6	0.709				ARCHI6	0.709		
	ARCHI7	0.791				ARCHI7	0.791		
Building Services	BS1	0.673	0.876	0.495	Building Services	BS1	0.676	0.898	0.564
	BS2	0.874				BS2	0.874		
	BS3	0.590				BS3	0.595		
	BS4	0.153				BS4	Omitted		
	BS5	0.873				BS5	0.872		
	BS6	0.609				BS6	0.611		
	BS7	0.684				BS7	0.684		
	BS8	0.876				BS8	0.877		
External Environment	EX1	0.815	0.894	0.586	External Environment	EX1	0.815	0.894	0.586
	EX2	0.790				EX2	0.790		
	EX3	0.846				EX3	0.846		
	EX4	0.700				EX4	0.700		
	EX5	0.751				EX5	0.751		
	EX6	0.678				EX6	0.678		
Operation & Maintenance	OM1	0.326	0.870	0.592	Operation & Maintenance	OM1	Omitted	0.909	0.714
	OM2	0.811				OM2	0.810		
	OM3	0.890				OM3	0.892		
	OM4	0.846				OM4	0.846		
	OM5	0.829				OM5	0.829		
Management Approaches	MA1	0.822	0.884	0.604	Management Approaches	MA1	0.822	0.884	0.604
	MA2	0.787				MA2	0.787		
	MA3	0.805				MA3	0.805		
	MA4	0.765				MA4	0.765		
	MA5	0.700				MA5	0.700		

3.2.2 Assessment of structural model

Subsequent to the examination of the outer model in terms of reliability and validity, the structural model can be analyzed. The first essential criterion for judging the inner model is the endogenous variables' determination coefficient (R^2). The R^2 value for the dependent construct measures the relationship of latent variables explained variance to its total variance. Therefore, the acceptable R^2 values of 0.67, 0.33, or 0.19 for endogenous latent variables in the structural model can be described as substantial, moderate, or weak, respectively (Henseler et al., 2009).

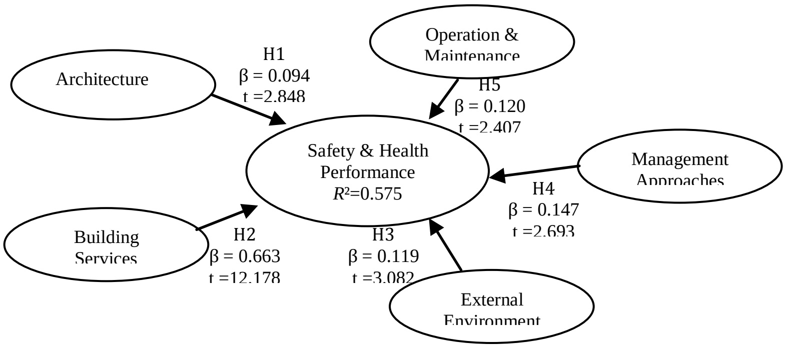

Figure 1. Structural model results

Another assessment of the structural model involves the evaluation of the individual path coefficients. The individual path coefficients of the PLS structural model can be interpreted as standardized beta coefficients of ordinary least squares regressions. Through non-parametric bootstrap procedure, the hypotheses are tested by examine the magnitude of the standardized parameter estimates between constructs together with the corresponding t-values that indicate the level of significance. The R^2 value was 0.575 suggesting that 57.5% of the variance in extent of safety and health performance can be explained by architecture, building services, external environment, operation and maintenance and management approaches (Figure 1). The entire hypothesis (H1, H2, H3, H4, H5) of this study were supported exceed 1.96 at significance level of 5 % (0.05) (Hair et al, 2010).

4. Conclusion

This study investigated various factor influencing building safety and health performance of low-cost housing in Malaysia. Results indicated that architecture, building services, external environment, management approaches and maintenance management, have a significant effect on the safety and health performance. Building services factors were major (β = 0.663) contributing causes of safety and health performance. These findings were supported by Lai and Yik (2004) highlight that assessment of building services conditions is important to safeguard the safety, health, and well-being of people, and to protect the environment.

It is important to note that these results should be interpreted in light of the study's limitations. A larger sample size can be used in future studies to improve the statistical power of the results. Future studies could perhaps identify and examine specific relationships between safety and health performance and perceive personal responsibilities among construction practitioners so that the issue of sustainable construction could be better understood

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