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HYPOTHESIS TESTING BETWEEN SUSTAINABILITY FACTORS AND CONSTRUCTION WASTE GENERATION

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ABSTRACT

Generated construction waste is influenced by various aspects which are necessary to be identified for better understanding of their impact towards sustainability. Hence, this paper aims to test the hypothesis between construction waste and the sustainability elements by developing a structural model of the waste generation. The data are gathered using questionnaire technique which consists of 13 effects factors under 3 main groups (Environment, Economic and Social). In 7 months, a total of 500 questionnaires are distributed and 302 questionnaires are returned with a response rate of 60%. From these returned questionnaires, only 277 questionnaires are valid and reliable responses which are received from contractors, consultants and clients. A structural model is developed based on the 3 groups of effect factors via Partial Least Squared-Structural Equation Modelling (PLS-SEM) approach. The hypothesis testing is carried out using the bootstrapping procedure by generating 5000 random samples. From this testing, it's found that the 3 groups are significant with a t-value ≥ 2.58 (99% confidence level). Therefore, it indicates that the generated construction waste are directly affected by the environment, economy and social aspects. The study suggested to all construction personnel and related authority for taking part actively in minimizing the construction waste generation in order to achieve green nation status.

Keywords: construction, environment, hypothesis, sustainable, waste, bootstrapping.

INTRODUCTION

Construction sectors typically provide facilities such as road, airports, schools, hospitals, colleges, residential houses, condominiums and shopping mall which are needed by people to live in a good manner. It also has contributed to Gross Domestic Product of many developing countries. However, this construction sector heavily generates construction waste and give unconstructive impact to the environment, economy and social (Rahman & Nagapan, 2015; Katz & Baum, 2011; Nagapan, *et al.,* 2013; Ann *et al.,* 2013; Rahman *et al.*, 2012). Therefore, it is important to identify the relationship between generated construction waste and the sustainability elements (environmental, economic and social). This paper is aimed to identify the relationships between multiple factors using the PLS-SEM bootstrap procedure.

CONSTRUCTION WASTE EFFECTS

Construction wastes are always considered as an unsupportive and a useless element of a country. It has always given many negative effects to the surrounding. In Malaysia, construction waste is getting worse with the illegal dumping issues (Rahman and Nagapan, 2015; Nagapan *et al.,* 2013, Azis *et al.,* 2012). From the review of literature, it has been identified that there are three main groups of effect factors for construction waste generated that are environment, economic and social. The effect factor of construction waste is looking into these three elements as indicated in Table-1.

Table-1. Sustainability factors.

Factors		Source
Environmental	Environmental pollution	Che Hasan et al. (2013); Liu & Huang (2013)
	Shortage of land	Kofoworola & Gheewala (2009); Ortiz et al. (2010)
	Increasing of Illegal dumping	Seror et al. (2014); Kofoworola & Gheewala (2009)
	Ecological damage	Yunpeng (2011); Lu & Yuan (2011)
Economic	Increase in the transportation charge of construction waste	Faridah et al. (2004); Ekanayake & Ofori (2000)
	Increase cost of projects	Urio & Brent (2006); Ndihokubwayo & Haupt (2009)
	Increase landfill fee	Gavilan & Bernold (1994); Wang et al. (2008)
	Increase in price of raw materials	Faniran & Caban (1998); Khairulzan & Halim (2006)
	Delay of projects	Khairulzan & Halim (2006); Ndihokubwayo & Haupt (2009)

Social	Mental health effects	Llatas (2011); Wang & Li (2011)
	Physical health effects	Noor (2013); Wu et al. (2014)
	Injury to public	Mokhtar & Mahmood (2008); Ortiz et al. (2010)
	No aesthetic	Seow & Mohamad (2007); Seror et al. (2014)

Table-1 is reflect the 13 sustainability factors due to construction waste generation. These factors are briefly explained as follows:

- Environmental pollution - Construction waste relates to the environmental pollution because it causes soil contamination when materials such as asbestos, paint and toxic materials are dumped on the ground. The surrounding soil polluted when the rainwater seeps into it.
- Shortage of land - Construction waste is an inert and bulky type of waste (concrete, brick and metal). It's shortens the life span of a landfill and it is forcing the government to allocate more land to be used as landfills.
- Increasing of illegal dumping - Huge amount of waste generated on site and it becomes a burden to contractor for transporting it. The management cost, far/remote landfills and irresponsible contractor's attitude are causing the illegal dumping cases in the country. The waste always throws at roadside, forest, oil palm plantation, river, sea and buried underground.
- Ecological damage - If construction waste is dumped into a mangrove swamp, it is causing ecological damage. The irresponsible act of some construction workers may cause the habitat system in the swamp is disturbed and damaged.
- Increase in the transportation charge of construction waste - The more amount of waste stockpile at the site, the more cost will be incurred. This is because many lorries and litres of diesel need to be used for transporting the waste to the nearby landfills.
- Increase cost of projects - The total cost of the project will be increased if the waste generated is not being controlled or reduced.
- Increase landfill fee - Shortage of landfill lifespan and limited land allocated by government are causing to the increase of landfill fees/tipping fee. This situation happens because thousands metric tons of construction waste are dumped on their land.
- Increase in price of raw materials - Construction material such as bricks is heavily used in construction project. Due to the waste generation, the price of raw material is going up.
- Delay of projects - The non-physical waste such as delay in construction and waiting time during material delivery. These wastes can affect the construction project and cause delay of the projects.
- Mental health effects - Construction waste also can cause mental effects for the resident at housing area. If the neighbour dumped waste beside house, it can cause the neighbour stress and maybe end up with quarrels.
- Physical health effects - Construction waste consisted of asbestos and paints which are used for building is unsafe for human being. With the presence of rainwater, it is able to contaminate and permeates into the ground. This is causing vegetables or plants near the construction waste is polluted with chemical composition. The people who consume this polluted vegetable able to cause critical health problems.
- Injury to public - The construction waste can be harmful to people if the waste exposes or dumped nearby them. The public accidently can step/kick the rusted nail, steel bar, formwork and other used waste.
- No aesthetic - Some of the waste is dumped illegally near the roadside and open football field, this cause the bad scenery to the surroundings.

DEVELOPMENT OF THE EFFECT MODEL

In order to develop the effect factors of construction waste generated using PLS-SEM, it is important to develop a hypothetical model showing the relationships between the factors/variables. Hypothetical model is developed as a basis for testing the relationships among variables (Fellows & Liu, 2008; Rahman *et al.* 2014). Hence, for this paper the hypothetical model represents 3 hypotheses as illustrate in Figure-1.

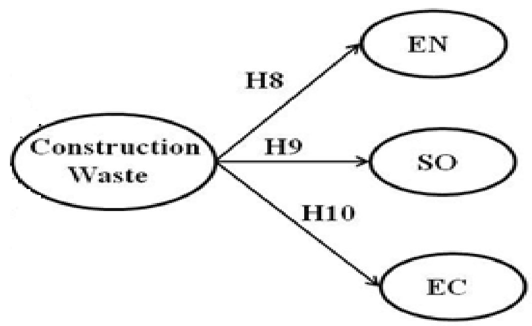

Figure-1. Effect model of construction waste.

In this model, the relationships between the variables (EN, SO and EC) and dependent variable (Construction waste) forms the basis to formulate the hypotheses are as listed below:

- H_8: Construction waste has a significant effect on EN (environment)
- H_9: Construction waste has a significant effect on SO (social)
- H_{10}: Construction waste has a significant effect on EC (economy)

The model is concern of understanding relationships of cause and effect of factors in construction waste domain. Furthermore, the linkages between effects (environment, economic and social) and construction

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waste have been integrated into one relationship model. This addresses a gap in the literature by providing an effective model within the context of relationship in construction waste domain. In this model, the effects known as latent variables (independent), while relationship of construction waste as dependent variables (endogenous). The latent variables are not observable, they exist by the relations they have with the manifest variables (Hair *et al.* 2014). In this model, the observed variables are called factors (manifest variables). There are 13 factors for effects.

DATA COLLECTION FOR THE MODEL

Five hundred (500) sets of questionnaire were distributed for data collection to contractors, consultants and clients. In the period of seven months, a total of 302 questionnaires is returned for a response rate of 60%. It is considered acceptable because the normal response rate in construction research is around 20-30% (Akintoye & Fitzgerald, 2000 and Yong & Mustaffa, 2011). Of these 302 questionnaires, 25 questionnaire sets were incomplete, which were considered invalid and the remaining 277 questionnaire sets were considered valid for analysis. The majority of the respondents were contractors (69.3%) and followed by consultants (15.5%) and clients (15.2%). The questionnaire responses show that the majority of the respondents (81%) had over 10 years of experience in the construction industry.

SAMPLE SIZE

The rule of sample size should be ten times the largest number of structural paths directed to a particular variable (Hair *et al*., 2011; Hair *et al*., 2014). As indicated in Figure-1, the hypothetical model for this study contains 3 structural paths directed to the environment, social and economic. This means that, for analysis of the developed model, the required minimum sample size is $10 \times 3 = 30$. Since the samples collected for the analysis purpose are 277 which are more than the required number, thus it can be concluded that the sample size used for current PLS-SEM analysis is adequate to achieve satisfactory results.

BOOTSTRAPPING PROCEDURE

In PLS-SEM, the estimate structural model of the relationships between the independent latent variables and the dependent variable is needed to validate and ascertain whether predict values from the model are accurately predicting the responses on future sample (Hair *et al.* 2014; Ramayah *et al.* 2011). Model validation will be achieved by resampling method to test the significance of the t-value of the path coefficients of the structural model using nonparametric tests of significance known as bootstrapping (Hair *et al.* 1998; Chin *et al*., 1998). Bootstrapping is useful for conducting hypothesis tests and it is a robust alternative to statistical inference (Mooney & Duval, 1993). According to Jack *et al*. (2001), bootstrapping is a versatile tool that enables estimation of the distribution of any statistic for any type of distribution. The bootstrapping analysis allows for the statistical testing of the hypothesis that a coefficient equals zero (null hypothesis) as opposed to the alternative hypothesis that the coefficient does not equal zero (two-tailed test). The effectiveness of the bootstrap depends on the sample's representativeness in terms of the targeted population (Hair *et al.* 2011).

HYPOTHESIS TESTING

The 3 hypotheses are tested to check the model's statistical inference (Banerjee *et al*., 2009) for checking whether the relationships between sustainability factors and construction waste are significant or otherwise. The testing was carried out by assessing the significance of t-value of each path. This was done by re-sampling 5000 samples using the bootstrapping simulation method in SmartPLS (Rahman & Nagapan, 2015). The bootstrap simulation generates the t-value to test the hypothesis for its significance level (Henseler *et al*., 2009; Tan & Ramayah, 2014). The generated t-values for the hypothesis testing for this study are shown in Figure-2.

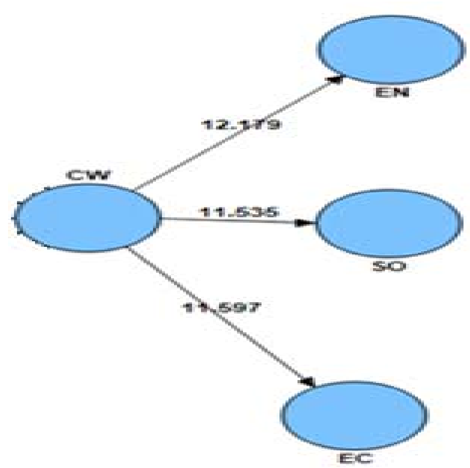

Figure-2. t-value from bootstrapping.

Figure-2 shows the t-values generated from the bootstrapping exercise for all the paths. The values are tabulated as in Table-2.

Table-2. Results of hypothesis test.

Hypothesis/Relationship	t-value	Inference
Construction waste →Environment	12.17	Significant
Construction waste → Social	11.53	Significant
Construction waste → Economy	11.59	Significant

All the paths have t-values of more than 2.58 at 99% confidence level (Hair *et al*., 2011) as in Table-2. This means that all the Environment, Economy and Social are significant and this confirmed the hypotheses are true.

DISSCUSION AND CONCLUSIONS

The study has concluded that there are significant relationships between construction waste and sustainability factors (Environment, Economy and Social). It is giving a clear understanding of the impacts toward sustainability for Malaysia construction industry.

The first relationship testing is between Construction Waste and Environment. It is tested and the t-value generated, 12.17 > the threshold value, 2.58. This means that there are four items having significant impact on the waste generated. These effects, including environmental pollution, shortage of land, increasing of illegal dumping and ecological damage. It is significantly caused and proven by construction waste generation. Therefore, to make our environment better and sustainable, the waste generation need to be reduced.

The second relationship testing is between Construction Waste and Social. The relationship is also verified with t-value, 11.53 > the threshold value, 2.58. This verified value proves the underpinning meaning of the social effect towards construction waste generated in the country. The result shows that the people are having an effect on their mental and physical health. The waste also contributes injury to the public and no aesthetic if the waste is being dumped nearby the residential area or tourist spots. Hence, to make our society live harmoniously and safer in this world the immediate reduction of construction waste generation need to take place among contractors, consultants and clients. Severe action should be taken to the irresponsibility construction personnel if they are involved in breaking law activities under The Solid Waste and Public Cleansing Management Act 2007 (Act 672) which was enforced on 1st September 2011.

The third relationship testing is between Construction Waste and Economic. The t-value is 11.53 > 2.58 (threshold value), which prove that it has a significant relationship. The huge amount of waste generated is highly alarming our country economic growth. The country needs special attention on increase cost of projects, increase landfill fee, increase in price of raw materials, delay of projects and finally about increase in the transportation charge of construction waste.

The identification of these three relationships is helpful in avoiding and minimizing the waste generation. By knowing these effect factors, the construction community will able to take serious actions in controlling the waste generated.

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