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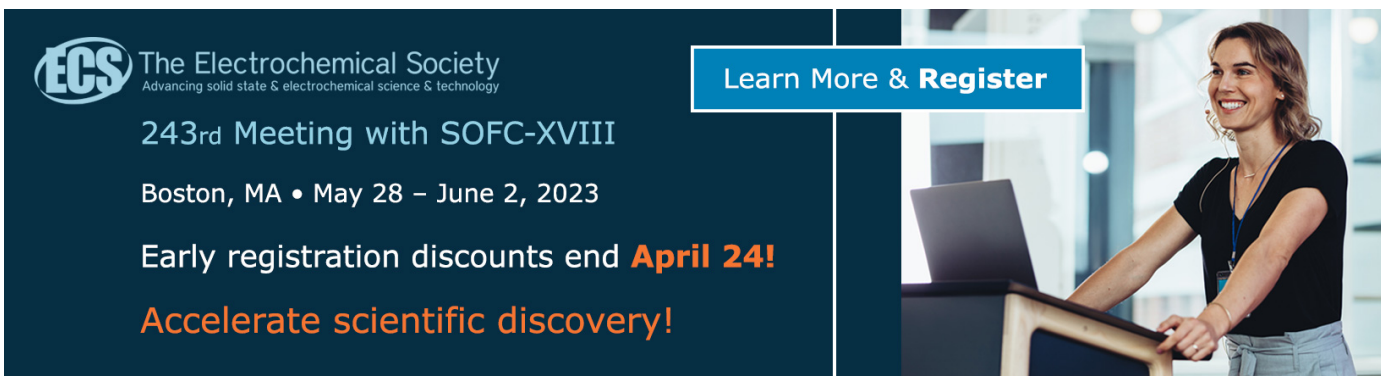
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Determinants of Green Highway Implementation Factors by Using Partial Least Squares

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Abstract. Malaysia was officially launched Malaysia Green Highway Index (MyGHI) manual as a guideline to confirm the green credential of a highway, this concept is at the conforming stage in Malaysia with seventeen (17) operated tolled highway projects and eleven (11) other registered and awaiting assessment for certification. Subsequently, INFRASTAR developed as an evidence-based rating system for infrastructure projects. Further measurement should be taken into account from the perspectives of highway concessions and stakeholders. Thus, this is not only to focus on the rating scores; as well as to highlight the driven factors that lead to Malaysia's green highway implementation. The primary constructs of this research model namely green highway challenges, green highway characteristics and green highway implementation are assessed. A total of 63 surveys from 81 surveys were responded (77.8% of responses rate). The response rate was high, and there was no evidence of bias noted. The statistical result of this study corroborates the exploratory study interviewed earlier which suggested a positive relationship between green highway characteristics and green highway implementation. Besides, all the constructs represent 12.8%, 37.7% and 96.2% of factors for challenges and characteristics towards green highway implementation in Malaysia's operated tolled highway projects, respectively. Implications and future research directions of this study are discussed.

1. Introduction

Recently, green initiatives have received increasing attention from government organisations and society towards sustainable development. In the construction industry, sustainable development is overemphasised and always been question by different stakeholders [1]. For that reason, to achieve a green highway in the future, several areas should be taken into account, which includes highway planning, design, construction, operation, and maintenance. In line with the government initiatives and



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aspirations, Malaysia Highway Authority (MHA) has been promoting the Malaysia Highway Index since November 2013 and Construction Industry Development Board (CIDB) developed INFRASTAR rating tools which exert an objective and evidence-based rating system that assesses land use planning and management, resource management, energy and water management, biodiversity and other ecosystem services, social and cultural protection and stakeholder coordination for better infrastructure development in Malaysian construction industry [2-4]. Some of the green highway aspects such as reducing energy consumption during construction, recycling water runoff, installing the Electronic Toll Collection (ETC) system to reduce vehicle idling, recycling materials such as old tyres, processing used asphalt and other types of solid waste to produce well-disposed material, reducing the greenhouse gas emissions produced by the asphalt fumes during the construction process, using low energy consumption equipment for road construction such as the Light Emitting Diode (LED) for the street light to reduce the electricity usage are taken into account in the guideline [2, 3, 5-11]. Seventeen (17) out of twenty-eight (28) operated tolled highway projects certified with Malaysia Green Highway Index (MyGHI) (MHA, 2019). Therefore, there is a need for a model of green highway projects as for now MyGHI manual is relatively new to such endeavour in the Malaysian context. It is also feasible for Malaysia to conduct a full implementation of green highway in the industry since there are various governments' and stakeholders' initiatives available to enhance green technology development.

2. Literature Review

2.1. Drivers for Green Highway Model Update

Literature is satiated with several identifiable drivers of green highway implementation in the built environment existing all over the world. The key drivers of green highway implementation involve government enforcement on legislation and meeting other regulatory requirements and incentives. Apart from that, stakeholders' attempt to implement green highway in response to the current practice of highway projects in Malaysia has become a crucial agenda towards sustainable development [12-18].

However, according to [9, 19-21], the sustainable development is not well understood by the stakeholders in the highway projects, but it is well agreed as a beneficial approach if there is an improvement along with it such as a guidelines, model, or framework that can be used for assessing green highway projects in Malaysia together with the environmental aspect considerations in order to upgrade the ways highway projects are being planned and executed.

The existing MyGHI emphasises five (5) areas of green highway namely material and technology; sustainable design and construction activities; energy efficiency; environmental and water management and social and safety [2]. However, there is a need to have a model for an extensive study that manifests the variables as for now MyGHI manual and INFRASTAR are relatively new to such endeavour in the Malaysian context.

3. Methodology

This study describes the detailed findings received from a questionnaire survey. There are three (3) sections of data analysis involved in which the first section starts with checking the assumptions, statistical analysis involving data input checking, data screening, examination of normality, examination of outliers, and non-response bias assessment. Next, the second section of data analysis continues with the criticality index assessment to establish the opinions of stakeholders in highway projects regarding the green highway characteristics, green highway challenges, and success factors towards green highway implementation. Finally, the last sections of data analysis for this paper present a model that relates the driving factors of characteristics and challenges of green highway with the success factors to implement green highway in the Malaysian context developed using Partial Least Squares – Structural Equation Modelling (PLS-SEM) and concludes with the examination of hypotheses on the results generated from the developed model in order to test the green highway implementation model as well as to compare findings gathered from the unstructured interview.

4. Research Model

Figure 1 shows the conceptual model of green highway implementation. The proposed model illustrates a reflective measurement model with all arrows from the latent variables is pointed out. According to [22], a reflective measurement model is directly based on a classical test theory and manifestations effects of an underlying construct and has a long tradition in the social sciences. The hypotheses in the model were introduced and established from the literature (concept/theory) and exploratory data (interview). The research hypotheses are shown in Table 1, which illustrate the reciprocal relationship between green highway challenges, characteristics, and success factors.

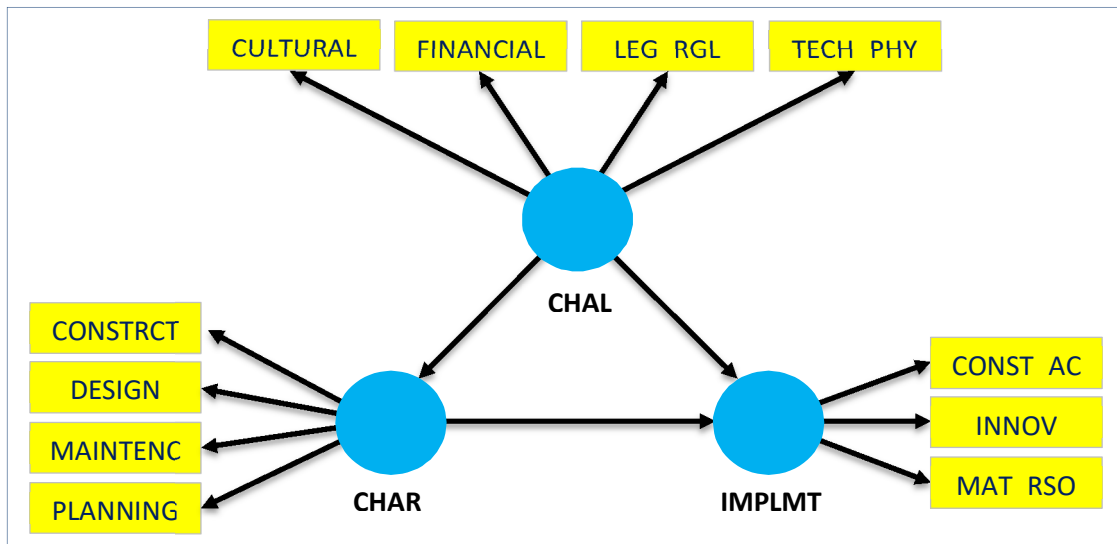


Figure 1. Conceptual Model.

The results explained the key and determinant indicators that have weightage to implementation of green highway concept in Malaysia as the output factors. The hypotheses of the study are shown in Table 1. Different hypotheses were listed out for each construct.

Table 1. Research Hypotheses.

Hypotheses		Definition
H ₁	a	Green highway challenges will significantly influence success to implement green highway
	a	Green highway characteristics will significantly influence green highway challenges
H ₂	b	Green highway characteristics will significantly influence success to implement green highway

Most of the research in field investigation enables the researcher to deal with constructs such as beliefs, perceptions, motivations, attitudes, or judgements of the individuals [23]. In this research, perception and judgement are useful to investigate the constructs for green highway challenges (CHALL) and green highway characteristics (CHAR) towards the success factors to implement green highway (IMPLMT). Theoretically, these constructs can be measured by a set of indicators which is usually modelled as latent variables and finally the 98 structural equation models will describe the relationships between these latent variables using a number of algorithms and software programmes available to calculate the relationship between the latent variables based on a dataset. An empirical analysis of the research model in this research was formulated based on literature review and interviews conducted.

5. Findings and Discussion

The measurement models and structural models need to go through two phases of separate assessment in PLS-SEM. The first phase is to examine the reliability and validity measure whether they are following specific criteria related to the formative and reflective measurement model specifications. Frequently, this step relies on the logical foundation, and if the measure represents the construct of interest to be adequate, there is a second step comprises the assessment of the structural model estimation.

According to [24], PLS-SEM final results (model evaluation) require a thorough assessment similar to other multivariate analysis techniques. Besides, the model evaluation in PLS-SEM is still influenced by Covariance Based (CB-SEM) reporting, especially in the assessment of the measurement model because PLS-SEM reporting follows the notion of an underlying covariance-based latent constructs-generating mechanism.

5.1. Checking the Assumptions

Assessment in this analysis part was conducted in two (2) significant phases. The first phase of preliminary data analysis involved the reliability test and data examination process using SPSS. This process is essential to ensure that the dataset of all items is suitable, normally distributed, and free from missing values, and outliers that become the requirements to use the dataset in PLS-SEM [25].

The second phase dealt with two stages of data analysis using PLS-SEM, which involved measurement model evaluation and structural model evaluation for latent constructs in the model. Measurement model evaluation confirmed the indicator reliability, internal consistency, and average variance extracted validity of all constructs.

In this research, the rate of missing values was below 1.6% (missing values is manageable) mostly for the characteristics of the green highway [26]. Other than that, missing values could be analysed using PLS-SEM 2.0 [27]. This study using Mean Imputation (MI) method (or also known as mean value replacement or case wise deletion) in dealing with classifiers by replacing all missing dataset with a single value [28].

The examination of normality for this study was conducted using the “Descriptive Statistics” option toolbar in the Statistical Package for Social Science (SPSS) version 22. Skewness values for this study were ranging from -0.930 to +0.694, and Kurtosis values were ranging from -2.012 to +3.002. More than 15 items were reported as non-normal items in the distribution as they had a varying degree of skewness and this showed that the delivery was skewed and not normally distributed.

According to [29], data collected in scientific and engineering applications frequently get a lower bound of zero where it is categorised as “skewed right” data. This condition would not affect the reliability process because the percentage of “skewed right” data was only 24% which was less than 50% of the total dataset [30]. Moreover, as mentioned by [31], highly skewed data, as well as the used of formative measures in the PLS-SEM model, will increase the robustness of the results. Therefore, this kind of non-normal distributed data will not affect the path coefficient consistency and the ability to estimate the non-normal condition in PLS-SEM because the goal of using PLS-SEM is for prediction of endogenous variables. Testing for the outlier in this research was not required due to the reason for a distinct group or strata sample size and no extreme suspicious response in this study.

Additionally, the result shows that there was only 4.44% of the total 90 variables had the problem of non-response bias based on the t-test procedure and this small percentage will not consider as a substantial influence because all variables were supported by an exploratory study. Finally, the structural model satisfied the indicative of collinearity where the value of tolerance level was 0.796, and the VIF value was 1.256. Therefore, a step to solve the collinearity problems could be neglected in the context of multi-collinearity [32] and [27] which highlights a high signals variance inflation factor (VIF) value of 3.3.

5.2. Evaluating Measurement Model

According to Hulland (1999), cited by [33], all indicator loadings in a measurement model need to satisfy value above 0.7 to determine the reliability of the individual items to their respective constructs. However, Hulland also stated that in the case of exploratory research, the value of 0.4 or higher for all individual items in a reflective outer model is acceptable. Since this research is exploratory, this section refers to the second opinion from Hulland in measuring the composite reliability value of 0.4 or higher. If the loadings are less than 0.4, the indicator in the reflective model must be eliminated from the measurement model. Table 2 summarises the results for the reflective outer model.

Table 2. Results of Measurement Model.

Latent Variable	Indicators	Loadings	Indicator Reliability (i.e. loadings)	Composite Reliability	AVE
CHALL	CULTURAL	0.707	0.500	0.798	0.505
	FINANCIAL	0.769	0.591		
	LEG_RGL	0.824	0.679		
	TECH_PHY	0.499	0.249		
CHAR	CONSTRCTN	0.802	0.643	0.869	0.683
	DESIGN	0.911	0.830		
	MAINTENCE	0.836	0.699		
	PLANNING	0.749	0.561		
IMPLMT	CONST_ACT	0.970	0.941	0.950	0.863
	INNOV	0.890	0.792		
	MAT_RSOR	0.925	0.856		

5.3. Evaluating Structural Model

Results showed that the critical t-value of more significant than 2.57 was suitable as a benchmark in the research model. Based on the outcome, all relationships linked in the model were meaningful and acceptable as shown in Table 3 which indicated that there was enough evidence to support the hypotheses. Therefore, the results confirmed the earlier findings that all path coefficient for the inner model was highly significant with 99.0% chances of hypotheses were valid as depicted in the visual PLS-SEM in figure 1 previously.

Table 3. Path Coefficient and Hypotheses testing.

Hypotheses	Relationship	Path Coefficient	Empirical t-value	Decisions
H _{1a}	CHALL > IMPLMT	0.242	2.624	Supported
H _{2a}	CHAR > CHALL	0.523	5.636	Supported
H _{2b}	CHAR > IMPLMT	0.664	7.220	Supported

Next, the standard path coefficient; the significance of the path coefficient to the structural model and the squared multiple correlations of R² for endogenous constructs were identified. R² is the amount of explained variance of endogenous latent variables in the structural model. According to [27], a higher value of each R² will lead to a good explanation of latent variables by a construct in the structural model which also indicates a good structural model path relationship. The author also added that a high value of R² would provide evidence that the values of the construct are well predicted by the PLS model. Table 4 shows the structural model result as follows:

Table 4. Structural Model Results.

Hypotheses	Relationship	Path Coefficient	Squared Path Coefficient, (R ²)
H ₁	CHALL > IMPLMT	0.242	0.668
H _{2b}	CHAR > IMPLMT	0.664	
H _{2a}	CHAR > CHALL	0.523	0.274

From Table 5, results showed a weak value of squared multiple correlations, (R²) for CHAR>CHALL relationship (R² =0.274) was supported by large effect size, (f²) of 0.377, while moderate squared multiple correlations, (R²) for relationship (R² =0.668) was supported by small and large effect size, (f²) of 0.128 and 0.962. Consequently, results supported the findings from the hypotheses testing in which 12.8% showed relevance to H₁ = green highway challenges would significantly influence success to implement green highway, 96.2% showed significance to H_{2b} = green highway characteristics will significantly affect success to apply green highway which indicate and support that characteristics of green highway is the key construct for green highway implementation, and 37.7% showed relevance to H_{2b} = green highway characteristics will significantly influence green highway challenges.

Table 5. Results of f² Values.

Relationship	Squared Path Coefficient, (R ²)	Effect size, (f ²)
CHALL > IMPLMT	0.668	0.128
CHAR > IMPLMT		0.962
CHAR > CHALL	0.274	0.377

6. Conclusion and Recommendations

Respondents believed that the characteristics and challenges of the green highway are the main factors influencing the success of green highway implementation in Malaysia. Results indicate that the model fits the data well, and nearly all of the hypothesised relations among constructs are supported in the model. The green highway implementation model shows that the key construct in implementing green highway is the characteristics of a green highway. All factors are positively related to each other which expresses that green highway challenges are significantly influencing success to implement green highway, green highway characteristics significantly influence green highway challenges, and green highway characteristics significantly influence success to implement green highway. Results show that there are a significant relationship and positive effect between characteristics and challenges in implementing a green highway. Findings from the hypotheses testing confirmed the views that the characteristics of the green highway have a substantial impact on the success of green highway implementation. Findings from the hypotheses testing also supported the results from the unstructured interview in which green highway challenges does affect the success of green highway implementation.

It is essential to understand that utilising the model in construction projects can help the implementation of the green highway. However, the implementation of green highway in the existing highways in Malaysia needs to be done to achieve a successful implementation of the green highway itself. Besides, this study is aligned with the CIDB where a rating tool to measure greenness level of infrastructure projects (INFRASTAR). INFRASTAR can be applied to most types of infrastructure projects including the highway. Cooperation between the stakeholders in highway construction, government, and private agencies is essential as a first step to initiate, perceive and realise the green highway implementation in Malaysia.

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