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## **A Logistic Regression Analysis of the Contractor's Awareness Regarding Waste Management**

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**Abstract:** This study has highlighted a number of factors affecting contractor's awareness regarding construction waste management to the construction industry. The data in the present study is based on contractors registered with the Construction Industry Development Board of Malaysia. Binary logistic regression analysis is employed for exploring the factors affecting the awareness. Contractor's awareness regarding waste management will tend to be significantly adequate with the increasing values in the factors of having waste management plan, awareness of source reduction of waste minimisation measures, awareness of reusing and recycling of waste materials, sorting waste materials, perception on harmfulness of construction waste to the human health and willing to pay more for improved waste collection and disposal services. The findings generated from the study could help the environmental and waste management planners in their decision making for managing construction waste and reducing environmental pollution.

**Key words:** Construction waste management, source reduction, reuse and recycling, awareness, construction industry

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### **INTRODUCTION**

The World Bank (1992) identified solid waste as one of the three major environmental problems faced by most municipalities in Malaysia. The amount of waste generated continues to increase in response to rapid growing population, urbanisation and industrialisation process. At the same time, the techniques and facilities for waste management and treatment are being developed slowly. Development in Malaysia seeks for a better and more efficient waste management over the country. The local authorities in Malaysia generate different sources and quantities of municipal solid waste depending on the size of township and level of economical standard, that as low as 45 tonnes of MSW are generated in Kluang (a small town in southern part of Peninsular Malaysia) to as high as 3000 tonnes in Kuala Lumpur (Agamuthu and Dennis, 2004). The issue of household waste and recycling has recently attracted much attention. Yet, it is construction waste which represents a greater proportion of total waste and create greater problems such as illegal dumping which should receive greater attention.

Creating awareness is clearly a pre-requisite for the development of recycling schemes (McDonald and Ball, 1998). They also showed the relationship between awareness and behaviour. The results indicated in connection with motivational issues that the Falkirk policy of house to house leafleting has been highly successful. It has created a high degree of awareness of the recycling scheme, produced a relatively low proportion of contraries, a good knowledge of the recyclability of plastics and the availability of local facilities as well as a much higher likelihood of the public it serves being able to offer a reason for the scheme being set up. Chung and Poon (1999) found their study that people with lower environmental awareness generally perceived less of their waste avoidable. The hypothesis that people who are more concerned with general environmental issues are more likely to recycle is a special case of the issue of correspondence between attitudes and behaviour (Ajzen and Fishbein, 1977; Rokeach, 1979). In Malaysia, Taylor *et al.* (2001) assessed knowledge, attitude and behaviour concerning municipal solid waste management of households. However, in spite of the research into household waste management, comparatively less

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attention has been paid to the construction waste management in nationally and internationally. The present study highlights a number of factors affecting contractor’s awareness regarding construction waste management to the construction industry. The findings generated from this study could help the environmental and waste management planners in their decision making for managing construction waste and reducing environmental pollution.

**MATERIALS AND METHODS**

**Survey design and sampling method:** Data was collected through interviews with contractors registered with the Construction Industry Development Board (CIDB) of Malaysia (Begum, 2005). In the present study, the purposive stratified random sampling method was used focusing on three major groups of contractors registered with CIDB. These are Group A comprising G6 and G7 contractors, Group B comprising G4 and G5 contractors and Group C for G1, G2 and G3 contractors. The final survey was based on 130 samples of contractors i.e., 35 from Group A, 35 from Group B and 60 from Group C. Interviews were based on a set of questionnaires that was pre-tested and modified before being used in the survey.

**Logistic regression model:** The present study has been designed with the model techniques of logistic regression analysis. The Maximum Likelihood (ML) method is

employed to estimate the parameters in logistic regression model. The significant relationships between dependent and independent variables is examined by the value of the correlation coefficient (R) in two variable cases and for the multivariate case, t values, R<sup>2</sup>, adjusted R<sup>2</sup> and F-values are estimated. The likelihood ratio index has been measured as an indicator of goodness of fit for the logistic model. To determine the factors, which affect contractor’s awareness regarding waste management, the study is followed a logistic regression model. As such, the model assesses the relationship between various factors and the contractor’s awareness regarding waste management. The dependent variable is designed as a dichotomous dummy because of assuming whether contractor’s awareness is adequate or not. The model is as,

$$\text{Log } P_i / (1-P_i) = Z_i = \beta_0 + \beta_i X_i + e \quad (1)$$

Where,

- $P_i$  = 1 if contractor’s awareness regarding construction waste management is adequately aware
- $P_i$  = 0 for otherwise
- $X_i$  = Independent variables
- $\beta_0$  = Constant term
- $\beta_i$  = Coefficient of independent variables
- $e$  = The error/disturbance term
- $I$  = 1, 2, 3, ----- n

**Table 1: Description of the independent variables in logistic regression model**

Independent variable label	Variable name and value level	Type of variable	Expected effect on WTP
Category	Group of contractor’s category 1 = Group C 2 = Group B 3 = Group A	Ordinal categorical	+
Degree	Construction related education among employees 1 = Course Certificate 2 = Diploma 3 = Degree 4 = Others such as post graduate	Ordinal categorical	+
Plan	Having waste management plan 1 = Yes 0 = No	Dichotomous	+/-
Header	Awareness of source reduction measures 1 = Heard about source reduction 0 = Not heard about source reduction	Dichotomous	+/-
Header	Awareness of reusing and recycling of waste materials 1 = Heard about reusing and recycling 0 = Not heard about reusing and recycling	Dichotomous	+/-
Sort	Sorting waste materials 1 = Sort 0 = Otherwise	Dichotomous	+/-
Experience	Experience in construction works (in years)	Continuous	+
Health	Perception on harmfulness of construction waste to the human health 1 = Not harmful 0 = Harmful	Dichotomous	+/-
Willing	Willing to pay more for improved waste collection and disposal services 1 = Agree 0 = Not agree	Dichotomous	+/-

+/- represents that, for example the variable having waste management plan, the value level ‘yes (1)’ shows the positive relation on WTP whereas value level ‘no (0)’ the negative relation on WTP. The other variables also represent the same meaning

Table 1 provides an overview of the explanatory variables used in the logistic regression model of the study. Most of the variables are derived from the survey, in which it is considered relevant from theoretical point of view and included as explanatory variables.

### RESULTS AND DISCUSSION

This model considers the awareness factors among the 130 respondents in the three groups of contractor's category. The responses to the survey provide some attributes of the contractor's awareness in regard to construction waste management such as awareness of source reduction, awareness of reusing and recycling, sorting waste materials, having waste management plan, willing to pay more for improved waste collection and disposal services, waste collection by the private waste contractor and contractor's perception on harmfulness of construction waste to the human health. The objective of this model is to find out the factors which best explain the contractor's awareness regarding waste management.

The estimated results of the logistic regression model of the contractor's awareness for the whole sample are summarised in Table 2. The final logistic regression equation is estimated by using the maximum likelihood estimation for determining factors affecting contractor's awareness regarding waste management as follows:

$$\begin{aligned} \ln \frac{P_i}{1-P_i} = & -2.683 - 0.216 X_1 + 0.498 X_2 + 2.386 X_3 + \\ & (-1.82)(-0.524) \quad (1.15) \quad (3.632) \\ & 1.297 X_4 + 1.613 X_5 + 0.866 X_6 + 0.016 X_7 + \\ & (2.948) \quad (2.80) \quad (2.273) \quad (0.326) \\ & 2.497 X_8 + 1.726 X_9 \\ & (3.957) \quad (4.52) \end{aligned}$$

In the above equation, figures in parentheses are the t-values of the regression coefficients.

Table 2 shows the estimated coefficients, standard error for coefficients, Wald Statistic, level of significance, degrees of freedom and estimation of the log likelihood. The findings of the model show that most of the explanatory variables are significantly related with the contractor's awareness regarding waste management except these variables such as group of contractor's category ( $X_1$ ), construction related education among employees ( $X_2$ ) and experience in construction works (in years) ( $X_7$ ).

- The negative coefficient of the variable contractor's group of category shows that the smaller group of contractor's category exhibited a higher level of awareness in waste management compared to the relatively larger group of contractor's category.

- The positive coefficient of the variable construction related education among employees indicates that contractors with higher level of degree holder among the employees have higher level of awareness regarding waste management.
- The positive coefficient of the variable having waste management plan indicates that the contractors having waste management plan tended to be more adequately aware of waste management compared to the contractors those have no waste management plan.
- The coefficient value of the variable awareness of source reduction measures indicates that contractors who heard about source reduction have higher level of awareness (more adequately aware) regarding waste management compared to the contractors who have not heard.
- The positive relationship indicates that contractors who heard about reusing and recycling have higher level of awareness (more adequately aware) regarding waste management compared to the contractors who have not heard about reusing and recycling.
- The result indicates that the contractors who sort (source separate) waste materials have higher level of awareness compared to the contractors who do not sort. Thus, the contractors who are adequately aware of waste management, are sorting their waste materials which contributes less waste generation and less environmental degradation in the construction sector.
- The positive coefficient of the variable experience in construction works indicates that contractors with more experiences are more adequate aware compared to the contractors with less experiences since other factors are constant.
- The result shows that contractors whose perception's are not harmful to the human health due to the environmental situation of the construction, they are more adequate aware than those perception's are harmful. It seems that construction waste is not more likely toxic or hazardous in their nature.
- However, the result indicates that contractors who agree willing to pay more are more adequately aware of waste management compared to those contractors are not agree. The result also shows that the contractors with higher level of awareness regarding waste management are more aware about the economic and environmental benefits of the construction waste materials as well as they are more concern of the environmental considerations.

Table 2: Results of the logistic regression analysis for the determinants of contractor's awareness regarding waste management ( $p_i = 1$  if contractor's awareness is adequately aware and  $p_i = 0$  for otherwise)

Variables	Estimated coefficient ( $\beta$ )	Standard error	Sig.	Wald
Constant	-2.683 (-1.82)*	1.474	0.069	3.312
Group of contractor's category ( $X_1$ )	-0.216 (-0.524) <sup>NS</sup>	0.412	0.600	0.276
Construction related education among employees ( $X_2$ )	0.498 (1.15) <sup>NS</sup>	0.433	0.250	1.325
Having waste management plan ( $X_3$ )	2.386 (3.632)***	0.657	0.000	13.194
Awareness of source reduction measures ( $X_4$ )	1.297 (2.948)***	0.440	0.003	8.707
Awareness of reusing and recycling of waste materials ( $X_5$ )	1.613 (2.80)***	0.576	0.005	7.845
Sorting waste materials ( $X_6$ )	0.866 (2.273)**	0.381	0.023	5.163
Experience in construction works ( $X_7$ )	0.016 (0.326) <sup>NS</sup>	0.049	0.739	0.111
Perception on harmfulness of construction waste to the human health ( $X_8$ )	2.497 (3.957)***	0.631	0.000	15.678
Willing to pay more for improved waste collection and disposal services ( $X_9$ )	1.726 (4.52)***	0.382	0.000	20.401
-2 Log Likelihood		66.105		

Figures in parentheses denote the t-values of the logistic regression coefficients, \*\*\* indicates significant at 0.01 level, \*\* indicates significant at 0.05 level, \* Indicates significant at 0.1 level, “NS” indicates estimated odd ratio of the logistic model, <sup>NS</sup> indicates not significant at 0.10 levels

**Goodness of fit of the model:** The results of this model are satisfactory. The Cox and Snell  $R^2$  is 0.542, which means that about 54% of the variation in the dependent variable is explained by the model. The Nagelkerke  $R^2$  also estimated for the modification of Cox and Snell  $R^2$ , is found to be very high (0.748), which indicates that about 75% of the variation in the dependent variable is explained by the logistic regression model. The prediction success table (classification table) shows nicely symmetrical, which indicates the model performs well at predicting both the “yes (adequately aware)” and “no (not adequately aware) responses. This model proves to exhibit a high coefficient of predicting power at about 90.8 %. The present study also estimated the Hosmer and Lemeshow statistic, which provides a useful information about the calibration of the model. The observed significance level for Chi-square value is found to be 0.379 (Hosmer and Lemeshow test), which indicates rejection of the null hypothesis of the model that means there is no difference between observed and predicted values. Thus, the result shows that the model appears to fit the data reasonably well. The Chi-square also tests the null hypotheses of the coefficients for all the terms in the present model except the constant are zero which can be compared to the overall F-test for the regression. The Chi-square value (101.604) of this model at the 0.01 significant level indicates that logistic regression is very meaningful according to the dependent variable in related to each specified independent variables. In the present study, the correlation matrix of the variables is studied to identify the occurrence of the multicollinearity. The model shows no

multicollinearity that means, no two independent variables have a correlation in excess of 0.70.

## CONCLUSIONS

Employing the binary logistic regression model, the study determined the factors which significantly and insignificantly affect contractor's awareness regarding waste management in the construction industry. It can be concluded from the findings that contractor's awareness regarding waste management will tend to be significantly adequate with the increase in the factors of having waste management plan, awareness of source reduction of waste minimisation measures, awareness of reusing and recycling of waste materials, sorting waste materials, perception on harmfulness of construction waste to the human health and willing to pay more for improved waste collection and disposal services. The results also indicated that the awareness of source reduction and awareness of reusing and recycling are most important in the implementation of construction waste management in the construction industry. These factors influence the awareness regarding waste management, which are necessary to be effective for proper waste management and to minimise waste generation as well as environmental degradation in Malaysia.

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