Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2017, 4(12):83-91**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Factors that Influence Respondents' e-Waste Awareness in Universiti Kebangsaan Malaysia

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Abstract This study investigated the influence of various independent (explanatory) variables on the e-waste awareness level of consumers. A logistic regression model was used to evaluate the impact of the independent variables on e-waste awareness level among employees and students of UKM. Two sets of independent variables were applied to two categories of consumers (employees and students). The independent (explanatory) variables for the employee category were income, academic qualification, age, job position, faculty/institute and residence whereas faculty/institute, residence, program of study, opinion on e-waste collection and recycling and perception on repair and refurbishment of personal EEEs were the independent (explanatory) variables for the student category. The finding of the model shows that academic qualification (X_2) and job position (X_4) were significantly related with the employees' awareness on e-waste with a p-value of 0.01 respectively. In the student category, the results of logistic regression show that students' opinion on e-waste collection and recycling (X_4) was significantly related to student awareness with a coefficient of 1.3. The results of the logistic regression for both categories have shown the independent variables that influences consumer e-waste awareness in UKM. These results can serve as a basis for further improvement on e-waste awareness in UKM.

Keywords Awareness, e-waste, electrical and electronic equipment, respondents

Introduction

Electrical and electronic equipment (EEE) is considerably the fastest growing waste stream in the world with an annual growth rate of 3-5% [1]. The generation and management of e-waste has become an issue of global concern due to its deleterious effects on human health and the environment. Worst still is the inevitable use of electrical and electronic gadgets due to its importance in our daily lives. The rapid generation of waste electrical and electronic equipment (WEEE) is potentially caused by the fast technological advancements and innovations, fast growing information and telecommunication industries, high economic growth, integration of EEEs into our daily life, advanced features of most EEEs and affordability [2, 3]. However, these technological advancements have come at extra cost to human health and the environment.

Electrical and electronic equipment (EEE) are widely used in various Universities. Lectures, research, experiments and administrative works are harmoniously conducted using EEEs. This has contributed to the increased quantity of EEEs used in various Universities. In the European Union (EU), WEEE is considered the fastest growing waste stream with an estimate of about 20 kg person/annum [4]. It is annually estimated that

about 40 million tons of WEEE is generated globally, both functional and slightly defective [5]. These EEEs are constantly replaced with more advanced EEEs when they become obsolete. However, the disposal method of the obsolete EEEs has continued to elicit concerns regarding their impact on human health and the environment.

Previously, the EEE industry was perceived as a clean industry. However, recent developments have shown it is one of the most polluting industries associated with various hazardous compounds, components and processors [4]. Inappropriate and indiscriminate disposal of WEEE has been associated with several environmental and health related hazards [6-7]. The contaminants present in e-waste are numerous and exceed 1000 toxic substances. However, the common substances include toxic metals, polycyclic aromatic hydrocarbons (PAHs), brominated flame retardant (BFRs), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polyvinyl chloride (PVC) and other toxic compounds [8]. Additionally, it also leads to a significant loss of secondary materials which could be re-integrated into the action plan of reduce, re-use and recycle within the waste management hierarchy. However, poor e-waste recycling habit by consumers and the short lifespan of EEE also contribute to WEEE problems [9].

Public awareness is pivotal for the successful establishment and implementation of any WEEE recycling and management programs [10]. It is estimated that about 70% of end-of-life EEE products are stored in homes or offices which hinders the recycling of these reusable products [11]. This could be attributed to lack of appropriate reclaiming channels.

The logistic regression model is a special form of the general log-linear model and therefore has become increasingly important as a unifying framework for categorical data analysis. Logistic analysis provides an interpretable linear model for a categorical response, and therefore offers a number of advantages. Logistic analysis provides a global test for the significance of a given predictor that controls all predictors in the model, as well as test for the significance of a set of predictors that controls other effects. Additionally, the impact of a given predictor on the dependent variable adjusted for other effects in the model can be summarized by parameters that translate into odd ratio.

In Malaysia, It is estimated that the generation of WEEE will increase at an annual average of 14% and could reach 1.17 billion tonnes by 2020 [12]. WEEE recycling, disposal and management in Malaysia are currently disorganized unlike municipal solid waste management. Due to the rising increase in WEEE generation, an e-waste regulation was established in Malaysia by 2005[12].There is considerably a few range of research on WEEE management focusing on consumer awareness. Most of the study has focused on recycling of waste. A thorough evaluation of consumer awareness, recycling attitude and behavior is required for the success of the WEEE directive. This will enable the consumers change their current disposal habits. This study is vital in order to meet the future targets of the WEEE directive and the 2020 action plan. Therefore, the objective of this study was to evaluate how various independent (explanatory) variables influence the e-waste awareness level of employees and students at Universiti Kebangsaan Malaysia (UKM).

Methodology

A survey questionnaire was developed for this study to investigate how the independent (explanatory) variables influence the e-waste awareness level of employees and students at UKM. A total of 500 questionnaires were distributed to the employees and students of 10 selected Faculties in UKM. The questionnaires were distributed to 300 employees and 200 students (postgraduates and undergraduates). A total of 50 questionnaires were distributed in each Faculty (30 questionnaires for employees and 20 for students). Of the 300 questionnaires distributed to employees, a total of 270 were acceptably completed and returned, indicating a collection rate of 90% for employees' category. Of the 200 questionnaires distributed to students, a total of 200 questionnaires were acceptably completed and returned, indicating a 100% collection rate for student category. The data from the employee and student categories were separately analyzed since they belong to different demographic groups. For the employee category, questionnaires were distributed by dropping them in their letter box and "one on one" personal conversation and interviews. For the student category, questionnaires were randomly distributed. The collated data were analyzed using SPSS 12.0 statistical package to evaluate how the independent (explanatory) variables influence the e-waste awareness level of the respondents.

a. Characteristics of respondents

In the employee category, the respondents were mainly Professors, lecturers, clerical officers and research officers. In the student category, the questionnaires were mainly distributed to undergraduates and postgraduates students in the 10 selected Faculties. The first part of the questionnaire focused on familiarity questions about the employees and students residential condition, income level, education and other demographic connotations. The second part dwelled on the perception of the respondents towards e-waste awareness. The third part dwelled on the respondents' e-waste management method. The fourth and final part dwelled on respondent's patterns of e-waste recycling. Data for this paper was collected using 500 questionnaires distributed to employees and students of UKM.

b. The Logistic regression model

The logistic regression model was used to analyze some factors influencing respondent's awareness towards e-waste management in UKM. To reduce the degree of error in samples and evaluate the relationship between dependent and independent variables, inferential statistics was integrated into the logistic regression model. The maximum likelihood method (ML) was used to estimate the parameters in the logistic regression model. The significant relationship between dependent and independent variables were examined from the value of the correlation coefficient (R^2) in two variable cases and for t-values, adjusted R^2 values and F values in the multivariate cases.

c. E-waste awareness of UKM students and employees

The e-waste awareness of UKM students and employees was measured through their knowledge of e-waste. If the respondents knows or have heard about e-waste, it is considered as awareness and vice-versa. If they are aware, we put a dummy variable. This model tests how the dependent dummy variable of students and employees' awareness is regressed by the related explanatory variables, such as income, education, age, position, faculty and residence. The dependent variable is designed as a dichotomous dummy that assumes whether employees' awareness is adequate or not. The model is expressed in equation 1,

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

Where,

P_i is 1 if employees awareness regarding e-waste management is adequate, Pi is 0 forotherwise, X_i is Independent variables, β_0 is Constant term, $\beta_i$is Coefficient ofindependent variables, e is The error/disturbance term, i is 1,2,3,---------n

$\beta_i X_i$ can be expressed as follows,

$$\beta_i X_i = \beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_4 X_4+\beta_5 X_5+\beta_6 X_6 \quad (2)$$

d. Independent variables of the model

Two sets of independent (explanatory) variables were used to evaluate the e-waste awareness level among students and employees in UKM. The first set of independent variables was applied to the employees category whereas the second set was applied to the student category. The Independent variables for the employees and student categories is expressed in Table 1

Table 1: Independent variables for employee and students categories

Employee Category		**Student Category**	
Variables	**Terms**	**Variables**	**Terms**
Constant	α	Constant	
Employees income	x_1	Student Faculty/Institute	x_1
Educational Qualification	X_2	Student Residence	X_2
Age of Respondents	X_3	Student Program of study	X_3
Employee Job position	X_4	Student opinion on the need to collect and recycle e-waste	X_4
Employee Faculty/Institutes	X_5	Student perception on repair and refurbishment of personal EEEs	X_5
Employee Residence	X_6		

Results and Discussion

a. Social Economic characteristics of respondents

The social economic characteristics of the two categories of respondents are summarized in Table 2. In the employees category, it was found that 37.4% hold a School Certificate as their highest qualification, 21.9% Diploma, 19.3% Bachelors' degree, 11.9% Masters' degree and 9.6% PhD degree, respectively. The level of education per Faculty member for all 270 respondents interviewed varies with high margin between individuals with school certificate and degrees. The high percentage of respondents amongst individuals with school certificate, diploma and degree, is due to their regular presence in their place of work as majority are administrative staffs, while respondents with masters and PhD degree are hardly found in their offices as they have to go for classes and academic assignments.

Table 2: Respondents social economic characteristics

Category	Independent variables	Levels	No of respondents	Percentage
Employee	Employee Education	School Certificate	101	37.4
		Diploma	59	21.9
		Bachelors	52	19.3
		Masters	32	11.9
		PhD	26	9.6
		Total	270	100
	Employee Income (RM)	<1,000	8	3.0
		1,001-3,000	99	36.7
		3,001-5,000	44	16.3
		5,001-7,000	50	18.5
		7,001-10,000	42	15.6
		10,001-15,000	23	8.5
		>15,000	4	1.5
		Total	270	100
	Residential Status	University Hostel	22	8.1
		Outside University	248	91.9
		Total	270	100
	Job position	Clerical Officers	89	33
		Research Officers	24	9
		Lecturers	124	46
		Professors	33	12
		Total	270	100
Student	Program of study	Undergraduate	110	55
		Masters	58	29
		PhD	26	13
		Others	6	3
		Total	200	100
	Residence	Hostel	106	53
		Rented Houses	66	33
		Family	22	11
		Others	6	3
			200	100
	Repair/Refurbish EEE	Yes	106	53
		No	94	47
		Total	200	100
	Opinion on need for recycling	Yes	160	80

	No	40	20
	Total	200	100

There are clear differences among individual monthly income among the employee respondents. The respondents with a salary range of RM 1001-3000 are the majority at (36.7%), between RM 5001-7000 (18.5%), between RM3001-5000 (16.3%), between RM 7001-10000 (15.6%) between the range of 10001-15000 (%) below RM 1000 (3.0%) and above RM 15000 is only (1.5%). It was found that level of education and job position are the major factors that influence respondents' salary. The respondents job position indicate that about 33% were clerical officers, 9% were research officers, 46% were lecturers and 12% were professors. Table 2 also shows the residential locations of the employees' respondents. The result shows that only 8.1% of the respondents resides within campus hostel while, 91.9% of the respondents resides outside the University campus either in their owned homes or rented apartments. This finding is of great importance to this study since majority (91%) of the employee respondents live at the municipal level.

In the student category, it was found that majority of the respondents were undergraduates (55%), Masters' (29%), PhD (13%) and other programs (3%). The majority of the respondents reside in the university hostel (53%), rented houses (33%), family houses (11%) and others (3%). It was also found that about 53% of students were positive towards repair/refurbishment of WEEE whereas 80% accepted that e-waste should be properly collected and recycled within the campus.

b. E-waste awareness level in UKM

The results of the questionnaires clearly indicate that e-waste awareness level in UKM was low in both categories (employees and students) but was worse in the student category. The study found that only about 46% and 33.5% of the entire respondents in the employees and students categories were aware of e-waste. This clearly demonstrates low e-waste awareness among the respondents in UKM. A similar study conducted in UniversitiTeknologi Malaysia (UTM)also indicates that about only 12% of the respondents recycle their e-waste, 34% stores their e-waste at their hostels whereas 24% of the respondents throw their e-waste into normal waste bin [9]. This clearly indicates that awareness level of e-waste recycling among some Universities in Malaysia is low. Tiep et al. [12] also observed that respondents in Melaka, Malaysia stored their obsolete EEE at home. Their results show a range of 14.9%, 16.3% and 25.4% for televisions, personal computers and mobile phones, respectively. This method of e-waste management clearly indicates a low state of awareness on the part of the participants. A survey conducted in University of Dohuk, Iraq indicated that the level of e-waste awareness among students and postgraduate staffs were low. About 39%, 16% and 16% of respondents indicated their e-waste disposal methods were throw in waste bin, store in house and donate to charity or relatives, respectively [1]. This signifies low level of e-waste awareness. In Spanish municipality, it was reported that about 67.1% of consumers dispose their WEEE with other fractions in domestic bins [13]. In the United Kingdom, Darby and Obara[4] also reported an overall response rate of 30% from a questionnaire sent to nearly 5000 households in Cardiff County Council, UK. About 10% did not respond to related question whereas about 7% ignored it.

While our study and other related research in Malaysia indicate a low level of e-waste awareness, other studies have also demonstrated similar level of awareness. This clearly indicates that the low e-waste awareness among respondents may not be peculiar to Malaysians but a global challenge. The e-waste recycling behavior of universities can be improved by providing consumer awareness programs through seminars, convenient recycling infrastructure at accessible locations and accurate information about the benefits of recycling. Additional factors that hinder effective e-waste knowledge include poor incentives, lack of awareness about the formal recovery systems and potential reuse of electronic equipment [14-16]. Although awareness on e-waste is low, there is evidence that it will improve over time if educational programs are promoted.

c. Analysis of the logistic regression model

The logistic regression model was designed to determine the factors affecting UKM employees' and students' knowledge on e-waste awareness. This model considers the awareness factors among 270 employees and 200 students in various faculties. The response to the survey provides some attributes of the employees' and students

awareness in relation to e-waste management. The primary objective of this model was to identify those factors which best explain the employees and students awareness of e-waste.

d. Logistic Regression Model for UKM Employees Awareness

The results of this model are satisfactory. The Cox & Snell R^2 was 0.52 and most of the predictions are correct. The Nagelkerke R^2 also estimated for the modification of Cox & Snell R^2, was found to be good (0.69) and satisfactory. The prediction success table shows a nice symmetry, which indicates that the model performed well at predicting both the yes (do you know what e-waste is - agreed) and no (do you know what e-waste is- not agreed) responses. This model exhibited a good coefficient of predicting power at about 54.4%. Awareness on e-waste could be explained by all the independent variables in the model. The Hosmer and Lemeshow statistic was also estimated, which provides information about the calibration of the model. The Chi-square is a statistical method assessing the goodness of fit between observed values and those expected theoretically. The observed significance level for Chi-square value was 0.180 (Hosmer and Lemeshow test), indicating rejection of the null hypothesis of the model. This implies that there is no observed difference between the predicted values. Thus, the result shows that the model appears to fit the data reasonably well. The Chi-square also test the null hypothesis of the coefficients for all the terms in the present model except the constant 0 which is comparable to the overall F-test for the regression. The chi-square value (14.327) of this model is significant at the 0.05 significant levels. It indicates that logistic regression is meaningful according to the dependent variable related to each specified independent variables. The correlation matrix of the variables was considered in this study in order to identify the occurrence of the multicollinearity. The model does not involve any multicollinearity, meaning that no two independent variables have a correlation in excess of 0.80.

The estimated result of the logistic regression model of the employee's awareness for the whole sample is given in Table 3. The final logistic regression equation was estimated by using the maximum likelihood estimation for the determination of factors that affects awareness in relation to e-waste management as follows:

$$\text{Ln Pi }/(1\text{-Pi})=1.112+0.039X_1 + 0.465X_2 +0.00X_3 -0.622X_4 +0.053X_5-0.6X_6 \quad (3)$$

The finding of the model shows that the education qualification (X_2) and job position (X_4) are significantly related with the respondent's awareness on e-waste more than the others variables namely monthly income(X_1), age of respondent (X_3), the faculty/institution employees attachment in UKM X_5. Therefore, the variable X_2 (education qualification) proved to be an important determining factor for the employees awareness. This variable was found to be statistically significant at 0.01 and positively related with employee's awareness. The positive coefficient (0.039) of this variable indicates that the respondents who have higher education qualification tends to be more aware compared to the respondents with lower education qualification. In addition, the estimated ratio of employees indicates that the level of awareness among employees with higher education was 1.040 times higher than employees with lower education. On the other hand, respondent's job position was found to be significantly related to respondent's awareness on e-waste. The negative relationship indicates that as the respondent's job position increases, the level of knowledge on e-waste decreases. It was statistically significant at 0.01. In addition, the estimated odd ratio indicates that the level of employees awareness among respondent's with higher job position (e.g Professors) Lecturers-Administrative and Research officers) are 0.53 times lower compared to respondents with lower job position (e.g Research officers, Administrative Officers-lecturers-Professors). Probably, administrative or general staffs are more concern at selling the used EEEs for extra earning due to low income.

Table 3: Logistic Regression Analysis for the Determination of employees' e-waste awareness ($P_i = 1$ if employees awareness is adequate and $P_i = 0$ for otherwise)

Variables	Estimated Coefficient (β)	Std. Error	Exp (β)[a]
Constant (α)	1.112 $(0.822)^{NS}$	1.353	3.039
Employees Income (X_1)	0.039 $(0.228)^{NS}$	0.171	1.040
Education Qualification ((X_2)	0.465	0.169	1.593

	(2.75) **		
Age of Respondents (X_3)	0.000 (0)^{NS}	0.018	1.000
Job Position of Employees (X_4)	-0.622 (-2.740) ***	0.227	0.537
Faculty/Institutes of Employees ((X_5)	0.053 (1.082) *	0.049	1.054
Employees Residence ((X_6)	-0.600 (-1.279) *	0.469	0.549

Number of Observations = 270
d.f. = 6
Chi-square Statistic = 14.327
Cox & Snell R^2 = 0.52
Nelgelkerke R^2 = 0.69
- 2 Log Likelihood = 357.836
Hosmer and Lemeshow Chi-square = 11.403 at 0.180 level of significance

Note: 1. Figures in parentheses denote the t-values of the logistic regression coefficients.

2. *** indicates significant at 0.01 level.

3. ** indicates significant at 0.05 level.

4. * Indicates significant at 0.1 level.

5. "a" indicates estimated odd ratio of the logistic model.

6. ^{NS} indicates not significant at 0.10 levels.

e. Logistic Regression Model for UKM Students Awareness

The results of this model were satisfactory. The Cox & Snell R^2 was 0.295 and most of the prediction was correct. The Nagelkerke R^2 used to estimate the modification of Cox & Snell R^2, was found to be reasonably good (0.406) and satisfactory. The prediction success table show a nice symmetry, which indicates the model performed well at predicting both the yes (do you know what e-waste is?) and no (do you know what e-waste is?). This model exhibited good coefficient of predicting power at about 68.0%.

The Hosmer and Lemeshow statistic was also estimated, which provides good information about the calibration of the model. The observed significance level for Chi-square value was found to be 5.127 (Hosmer and Lemeshow test), indicating rejection of the null hypothesis of the model. This implies that there is no observed difference between the predicted values. Thus, the result shows that the model appeared to fit the data reasonably well. The Chi-square also test the null hypothesis of the coefficients for all the terms in the present model except the constant 0 which is comparable to the overall F-test for the regression. The chi-square value (14.001) of this model is significant at 0.01 significant levels. It indicates that logistic regression was meaningful according to the dependent variable related to each specified independent variables. A study on the correlation matrix of the variables was considered in other to identify the occurrence of the multicollinearity. The model does not involve any multicollinearity, meaning that no two independent variables have a correlation in excess of 0.80.

The estimated result of the logistic regression model of the student's awareness for the whole sample is given in table 4. The final logistic regression equation was estimated by using the maximum likelihood estimation for the determination of factors that affects awareness in relation to e-waste as follows:

$$\text{Ln } Pi/(1-Pi) = -3.15 + 0.11X_1 + 0.20X_2 + 0.22X_3 + 1.30X_4 + 0.11X_5 \quad (4)$$

Table 4: Logistic Regression Analysis for the Determination of students e-waste awareness ($P_i = 1$ if employees awareness is adequate and $P_i = 0$ for otherwise)

Variables	Estimated Coefficient (β)	Std. Error	Exp (β)a
Constant	-3.15 (-4.038)***	0.78	0.04
Students Faculty/Institute X_1	0.11 (1.833) **	0.06	1.12
Students Residence X_2	0.20 $(0.909)^{NS}$	0.22	1.23
Students Program of study X_3	0.22 $(0.916)^{NS}$	0.24	1.25
Opinion on the necessity to collect and recycle e-waste X_4	1.30 (2.653) ***	0.49	3.66
Perception on repair and refurbishment of personal EEEs X_5	0.11 $(0.333)^{NS}$	0.33	1.11
Number of Observations = 200 d.f. = 5 Chi-square Statistic = 14.001 Cox & Snell R2 = 0.143 Nelgelkerke R2 = 0.094 - 2 Log Likelihood = 241.064 Hosmer and Lemeshow Chi-square = 5.127 at 0.744 level of significance			

The results of logistic regression showed that only X_4 (opinion on the necessity for e-waste to be collected and recycled) was significantly related with student awareness. The correlation coefficient indicates (1.3). Any increase in a student with positive opinion, the level of students' awareness will be increased by 1.30. Additionally, the odd ratio of these variables indicates that the students with positive opinion on e-waste awareness were 3.66 times higher than respondents' with negative opinion. However the other variables (which of the faculty/ institution are you attached in UKM (X_1), where do you live (residence) for your study (X_2), what programme of study are you enrolled in UKM (X_3) and do you repair or refurbish your EEEs (X_5)) were non-significant with student awareness, indicating that these variables were not responsible for low e-waste awareness. Our findings for both the employees and student categories are in close agreement with the report of Wang et al. [17] who reported that environmental awareness and attitude towards recycling showed a positive impact on e-waste recycling behavior with influence coefficients of 0.818 and 0.186, respectively in their investigation of the determinants of residents' e-waste recycling behaviour.

Conclusion

This study has provided some econometric analysis in relation to e-waste management in UKM and Malaysia by extension. This study shows that the e-waste awareness level of respondents in UKM was at a lower level. For every nation, the successful implementation of appropriate e-waste management initiatives demands the constructive involvement of various stakeholders and the provision of accessible infrastructures for e-waste collection. The logistic regression model clearly indicated that educational qualification and job position influenced respondents' e-waste awareness in the employee category whereas only opinion on e-waste collection and recycling was found to influence e-waste awareness in the student category. Public awareness is pivotal for the successful establishment and implementation of any WEEE reuse and recycle management systems. The e-waste recycling behavior of universities can be improved by providing consumer awareness

programs through seminars, convenient recycling infrastructure at accessible locations and accurate information about the benefits of recycling.

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