Determinants of e-waste recycling behavior among UKM employees and students

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Abstract This study investigated the respondent's characteristics of recycling behavior and preference of e-waste recycling method of Universiti Kebangsaan Malaysia (UKM) employees and students using a logistic regression analysis in SPSS. Willingness to participate (WTP) was used as the dependent variable. The study found that the significant influencing factors for the behavior of the respondents were awareness on e-waste, perception on repair or refurbishment of EEEs, attitude towards disposal, perception on the establishment of e-waste scheme and concern on toxic content in e-waste for the employee category. The significant influencing factors for the student category were awareness on e-waste and perception on the establishment of e-waste scheme. The coefficient of the predicting power of the dependent variables at 95% confidence level for the employee and student categories were 77.4% and 83.3%, respectively. It is pertinent to understand the behavioral and psychological factors influencing household recycling activities and form effective recycling programs and government strategies based on this information.

Keywords Determinants, e-waste recycling, UKM employees

Introduction

The rapid technological advancement in the electrical and electronic industry has led to the production of devices with sophisticated and advanced features and haa also increased the obsolete rate of the lower devices, creating a huge amount of waste electrical and electronic equipment (WEEE). E-waste is considered the fastest growing waste stream in the US and many other Countries [1, 2]. Population growth, rising living standards, rapid economic development and urbanization are some of the factors influencing the production of household waste [3].

In Malaysia, annual e-waste generation has continued to increase. For instance, the annual e-waste generation in 2006, 2007, 2008 and 2009 were 40,275, 52,718, 102,808 and 134,035 metric tonnes, respectively [4]. Due to the desire for better and more advanced EEEs with sophisticated features, the life span of most EEEs are generally in decline and are within the range of 2-3 years [5].

The significant success of e-waste management in most developed countries can be attributed to the formulation of effective legislations, appropriate recycling infrastructures, adoption of the extended producer responsibility (EPR) principle and residents' participation. In contrast, e-waste management in developing countries are poorly executed and have become source of environmental concerns due to rising rate of illegal smuggling of e-waste products, unsuitable technologies, insufficient legislation, indiscriminate dumping of e-waste and low resident awareness [4].

In developed economies, e-waste recycling activities are conducted through formal processes supported by the high level of environmental awareness whereas in less developed economies, informal recycling route dominate e-waste sector and poses severe environmental problems. Disposal of e-waste into landfills can cause severe environmental pollution. Some of the challenges of informal recycling include the release of heavy metals and persistent organic pollutants such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in soil, air and water [6]. In the USA, an estimated 70% (mercury and cadmium) and 40% (lead) pollution has been associated to e-waste products in landfills [4]. Manomaivibool and vassanadumrongdee [7] found that residents can be encouraged to return their obsolete e-waste to the formal recycling sector by creating standardized programs to buy back these WEEEs.

E-waste contains hazardous and toxic substances which can be deleterious to human health and environment. At the same time, it contains precious recoverable raw materials. Therefore it cannot be managed through conventional waste management techniques such as land filling and incineration [8].

It is pertinent to understand the behavioral and psychological factors influencing household recycling activities and form effective recycling programs and government strategies based on this information. Therefore, the objective of this study was to investigate the e-waste recycling attitude of UKM employees and students

Methodology

This study was conducted by the means of a survey questionnaire. About 500 questionnaires were administered to the employees (300 questionnaires) and students (200 questionnaires) of 10 Faculties (50 questionnaires each) in Universiti Kebangsaan Malaysia. In the employee category, a total of 270 questionnaires (90%) were acceptably completed and returned whereas all questionnaires were validly returned in the student category. The data from both categories were separately analyzed. In the employee category, questionnaires were administered by dropping them in their letter box and "one on one" personal conversation and interviews whereas it was randomly administered in the student category. The data were analyzed using SPSS 12.0 statistical package to evaluate how the independent (explanatory) variables influence the e-waste recycling attitude of the respondents.

a.   Characteristics of respondents

The respondents were mainly Professors, lecturers, clerical officers and research officers in the employee category whereas it was mainly undergraduates and postgraduates in the student category. The first part of the structured questionnaire focused on demographic investigations. The second part focused on the respondents' perception of e-waste recycling. The third part focused on the respondent's e-waste recycling method and the final part focused on the respondents' willingness to participate in e-waste programs.

b.   The Logistic regression model

The logistic regression model was used to analyze some factors influencing respondent's e-waste recycling behavior 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 recycling behavior of UKM employees and students

The e-waste recycling behavior of UKM employees and students was measured through their willingness to participate in e-waste programs, their level of awareness and method of e-waste disposal. The respondents behaviour was the dependent variable whereas Faculty/Institute of employees, job position, age of respondents, educational qualification, awareness on e-waste, perception on repair or refurbishment of EEEs, attitude towards e-waste disposal, perception on the establishment of e-waste scheme and concern on toxic content in e-waste for the employee category. In the student category, the independent variables were awareness on e-waste, student Faculty/Institute, perception on the establishment of e-waste scheme, perception on repair and refurbishment of personal EEEs, attitude towards e-waste disposal, perception on toxic contents of e-waste, student program, student's residence and collection strategy to be adopted in UKM. The dependent variable is designed as a

dichotomous dummy that assumes whether employees' behavior is adequate or not. The model is expressed in equation 1,

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

Where,

P_i is 1 if employees behavior regarding e-waste management is adequate, P_i is 0 for otherwise, X_i is Independent variables, β_0 is Constant term, β_i is Coefficient of independent variables, e is The error/disturbance term, i is 1,2,3,---------n

$\beta_i X_i$ can be expressed as follows,

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

Results and Discussion

a. Social Economic characteristics of respondents

The social economic characteristics of the two categories of respondents are summarized in Table 1. For the employees' category, 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, can be attributed to their regular presence in their place of work.

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

Monthly income among the employee respondents' shows a great disparity. 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 education level and job position is 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 1 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 live 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 recycling behavior (Employee category)

The results from the questionnaire survey indicate that the respondents' attitude towards e-waste recycling was poor in both categories (employees and students). When the respondents' were asked if they were willing to participate on e-waste recycling, about 35.2% were positive in the employee category whereas it was only about 19% in the student category. Both the employee and student category have low knowledge of e-waste disposal method in UKM. When the respondents were asked about their satisfaction on the current e-waste recycling method in UKM, about 47.6% and 29% from the employee and student categories were satisfied with the current collection practice. In terms of the proposed collection strategies, majority of the respondents agreed that UKM should take higher responsibility for the e-waste management. About 51.5% of employees' respondents want UKM to take responsibility whereas it was only about 46.0% in the student category. The respondents were further asked about their attitude towards repair and refurbishment of EEEs, about 54.8% and 53% of the respondents in the employee and student category refurbish their EEEs. When the respondents were asked about the consequences of improper e-waste disposal, about 67% of respondents in both categories were aware of the negative consequences of indiscriminate disposal of e-waste. This observation is in agreement with the study of Afroz et al. [4] who found that about 59% of respondents were aware of the health and environmental problems associated with EEEs in Kuala Lumpur, Malaysia. It was also found that about 66% and 65.2% of the respondents in the employee and student categories were willing to join e-waste scheme. However, on the issue of awareness, the result shows that e-waste awareness in both categories were poor. Only about 45.6% of the respondents in the employee category were aware of e-waste whereas about 33.5% of respondents in the student category were aware of e-waste. The results of this study clearly indicate a correlation between the dependent and independent variables investigated in this study. Other authors have reported that some other factors which influence recycling behavior include convenience (closeness of drop-off centers) and accessibility of recycling infrastructures [9, 10]. Attitude of respondents could be dynamic. Our findings clearly show that the respondents' in UKM were highly willing to join e-waste scheme whereas Wang et al., 2011 found that only about 22.57% of Beijing residents were willing to pay for e-waste recycling whereas most residents (54.23%)

required government enforcement to comply with such payment. Our findings clearly demonstrate that these independent variables should be considered when formulating government policies on e-waste management.

c. Analysis of the logistic regression model

The logistic regression model was analyzed for the employee and student categories, respectively.

d. The logistic regression model for the employee category

The results of this model were satisfactory. The Cox & Snell R^2 was 0.263 and most of the predictions were correct. The Nagelkerke R^2 was 0.362 and satisfactory. The prediction success table was nicely symmetrical, indicating that the model accurately predicted both the yes (do you recycle your e-waste) and no (do you recycle your e-waste). This model exhibited good coefficient of predicting power at about 77.4%. Thus, the result shows that the model suitably fitted the data reasonably well. The Chi-square value (31.945) of this model at the 0.01 significant levels indicates that logistic regression was meaningful according to the dependent variable which is related to every specified explanatory variable. The correlation matrix of the variables was also investigated to identify the occurrence of multicollinearity. The model shows no multicollinearity, that is, no two independent variables have a correlation in excess of 0.80. The final logistic regression equation is estimated by using the maximum likelihood estimation for the determination of factors that affects behaviour in relation to e-waste management as follows:

$$\text{Ln } Pi /(1-Pi) = -5.961+0.067X_1+0.001X_2+1.803X_3+0.602X_4+0.444X_5+1.121X_6+0.020X_7+0.170 X_8+-0.020X_9+1.210X_{10}$$

The results of the model show most of the independent variables namely awareness on e-waste (x_3), perception on repair or refurbishment of EEEs (X_4) attitude towards e-waste disposal (X_5), perception on the establishment of e-waste scheme (X_6) and concern on toxic content in e-waste (X_{10})are significantly related with employees behaviour. However, the other five independent variables which are the Faculty/Institutes of employees ((X_1) job position of employees (X_2), age of respondent (x_7), and education qualification ((X_8) are not significantly related with employees behaviour.

e. The logistic regression model for the student category

The results of this model were satisfactory. The Cox & Snell R^2 was 0.143 and the prediction was correct. The Nagelkerke R^2 was satisfactory at 0.231. The prediction success table (classification table) was symmetrical, indicating that the model accurately predicted both the yes (do you recycle your e-waste – positive behaviour) and no (do you recycle your e-waste – negative behaviour). This model exhibited good coefficient of predicting power of the dependent variable at about 83.3%. The Chi-square value of 30.372 at the 0.01 significant levels indicates that the logistic regression model is very meaningful according to the dependent variable which is related to every specified explanatory variable. Thus, the result shows that the model accurately fitted the data. The correlation matrix of the variables was also studied to identify the occurrence of multicollinearity. The model shows no multicollinearity, that is, no two independent variables have a correlation in excess of 0.80.The final logistic regression equation is estimated by using the maximum likelihood estimation for the determination of factors that affects behaviour in relation to e-waste management as follows:

$$\text{Ln} Pi/(1-Pi)=-4.59+1.32X_1+0.73X_2+0.07X_3+0.19X_4+0.38X_5+1.43X_6+0.02X_7-0.02X_8-0.09X_9$$

The results of the binary logistic regression revealed the variables namely (awareness on e-waste) and (perception on the establishment of e-waste scheme) are significantly related with student's behaviour. The variable X_1 (awareness on e-waste) was an important determining factor of the student's behaviour. This variable was found to be statistically significant at the 0.01 and positively related with student behaviour. However, the other variables such as perception on repair and refurbishment of personal EEEs (X_2), attitude towards e-waste disposal (X_3), perception on toxic contents of e-waste (X_4), opinion on collection strategy to be adopted in UKM (X_5), students program of study (X_7), students Faculty/Institute (X_8) and students residence (X_9) were not significantly related with students behavior.

Conclusion

This study investigated the factors that influence the respondents' e-waste recycling behavior in UKM and found that the demography of the respondents influenced their recycling behavior. The response between the employee and student category varied according to their need. The logistic regression model employed in this

study further identified the independent explanatory variables that were closely related to the dependent variables. Thus, this study has highlighted the challenges of e-waste management in UKM. It can therefore serve as a basis for the government to formulate polices and laws that can help improve this sector. Additional, educational programs and workshops will significantly contribute to a better e-waste management in UKM and Malaysia, at large.

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