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# Willingness of end users to pay for e-waste recycling

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**ABSTRACT**

**BACKGROUND AND OBJECTIVES:** The sheer volume of electrical and electronic waste (e-waste) has presently been generated in Vietnam, posing a growing concern regarding its impact can have on the environment and human health. Therefore, the need for developing policies and regulations towards the environmentally sound management of e-waste is becoming crucial. Although the municipalities play an important role in e-waste recycling program, there does not appear to be any study involving residents' perceptions on e-waste management. This paper aims to examine the influencing factors of end users' willingness to pay and their payment preferences toward e-waste recycling.

**METHODS:** The logistic regression model was employed to analyze a qualified data set collected through a personal interview survey in Danang city, Vietnam. All analyses were conducted using Statistical Package for Social Sciences software (version 22.0).

**FINDINGS:** The results revealed that the end users' willingness to participate in recycling programs, laws and regulations, inconvenience of recycling and past experience were four key determinants significantly contributing to the willingness to pay for recycling e-waste. With regards recycling payment methods, most of the participants (36%) were in favor of deposit and refund scheme, while pre-disposal fees and advanced recycling fees came in second and third place (25.8% and 21%, respectively), making monthly payment of recycling fees the least preferred (10.2%).

**CONCLUSION:** These findings may provide policy-makers with crucial information for better e-waste management policy development, which helps address the conflict between development and conservation, may be applicable in Vietnam and other countries as well.

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## INTRODUCTION

Electrical and electronic waste (e-waste) is the most emblematic by-product of the transition to a more digital world and it continues to grow at unprecedented rates around the globe (Baldé *et al.*, 2017; Balde *et al.*, 2015). Parallel with the huge number of e-waste generation, the crisis of e-waste management has quickly spread to all regions over the word (Nguyen *et al.*, 2017; Nnorom *et al.*, 2009). Similar to other developing countries, Vietnam is currently facing with an emerging concern on the excessive quantities of e-waste generated without appropriate disposal and treatment (Nguyen *et al.*, 2009). In Vietnam, there are three main sources for the generation of e-waste, those are, the disposal of electrical and electronic equipment (EEE) from households and others organizations, importation of used EEE, and waste from the manufacturing process at electronics companies (Huynh, 2014; Tran and Salhofer, 2016). According to the survey conducted by Nguyen *et al.* (2009), it is predicted that the number of e-waste generated is projected to peak at around 17.2 million pieces in 2025. Even, the quantity of e-waste is estimated to be far larger if other hidden e-waste sources (e.i. from illegal transboundary movement international trash flows under the disguise of "used goods") are detected. In addition, e-waste in Vietnam is predominantly handled by unofficial channels such as scrap dealers or unregistered units, which transfer waste to craft villages for recycling (Nguyen *et al.*, 2009; Tran and Salhofer, 2016; Truong, 2014). Therefore, one of the huge challenges when looking at the picture of e-waste in Vietnam is that the e-waste treatment activities are scattered among various craft village and illegal import-export activities that makes e-waste statistical data is very narrow (Huynh, 2014; Tran and Salhofer, 2016; Truong, 2014). Moreover, the rate of formal e-waste recycling in Vietnam is still low although recycling has been widely considered one of the waste management approaches to utilize valuable materials and reduce the burden of dumping waste (Hai *et al.*, 2017; Song *et al.*, 2012; Tran and Salhofer, 2016). The reason behind this problem is that e-waste recycling facilities and laws have not been well developed by Vietnamese government (BCRCSEA, 2016); consequently, e-waste flow is now under the control of informal sector. Under unregulated conditions, after major valuable materials of e-waste are retrieved, the remaining components are improperly treated, either dumped in the landfill, burned or illegally traded overseas (Hai *et al.*, 2017). This not only causes the enormous loss of valuable and critical raw materials from the supply chain, but also leads to serious health, environmental and societal problems through illegal transboundary treatment of waste among developing countries (Roldan and Gibby, 2018). Due to the large amount of e-waste is collected by the informal sectors, there is only a small percentage of e-waste can be collected and recovered by official recycling and disposal units (Nguyen *et al.*, 2017; Tran and Salhofer, 2016; Yoshida *et al.*, 2016). Another reason comes from the fact that the investment for establishment and operation of e-waste recycling system is extremely high; thus, it requires the cooperation among all stakeholders including the government, producers, retailers, and consumers in sharing this financial responsibility (Hai *et al.*, 2017). In fact, according to Cai *et al.* (2019), e-waste is considered not to be economical for formal recyclers to process, that is the reason why cheap manual labors can take the advantage of doing informal e-waste activity. In addition, according to Honda *et al.* (2016), the lack of Vietnamese residents' awareness and willingness to pay (WTP) a recycling fee is one of the barriers which hampers the achievement of recycling program. Many Vietnamese end users are more likely to send their e-waste to the informal mechanisms for getting the cash benefit, while the treatment activities of these sectors are causing environmental damages. Facing to this serious problem of e-waste, in 2015, the Prime Minister released Decision 16 stipulating that manufacturers and importers of electronic products must take responsibility for collecting their product waste (Nguyen *et al.*, 2017; Tran and Salhofer, 2016). Recently, Circular No. 34/2017/TT-BTNMT dated October 4$^{th}$, 2017 of Ministry of Natural Resources and Environment on recall and treatment of discarded products, emphasizes the responsibility of producers on establishment of the site for collecting obsolete devices. However, e-waste still has not been put under control because there have been no other legal documents that guide the implementation of the decision (BCRCSEA, 2016). Accompanying with the governmental sector, an organization established in 2015, called "Viet Nam Tai Che" (Vietnam Recycles) made an effort to collect and recycle defective products or e-waste in a safe and environmentally friendly way. Nevertheless, the Vietnam Recycles just ran the pilot

phase and took place in the Hanoi and Ho Chi Minh city regions only. As stated in several previous studies (Bhat and Patil, 2014; Nixon and Saphores, 2007; Song *et al.*, 2012), end users play an important role in the success of e-waste recycling program; hence, understanding what drives people to engage in recycling plays a fundamental role in order to design more effective environmental policies to deal with arising e-waste problems. Recent studies that have aimed to find out the relationship between individuals' WTP for e-waste recycling and both internal and external variables showed the mixed results (Saphores *et al.*, 2006). Take two studies conducted in China as example, besides education level and household income, age and region were statistically significant predictors of residents' WTP in Macau and national scale in China (Song *et al.*, 2012; Yin *et al.*, 2014). Similarly, Nixon and Saphores (2007) concluded that age, living area, income, education level, convenience, recycling habit, and environmental attitudes significantly affected the consumers' WTP. However, Vassanadumrongdee and Kittipongvises (2018) revealed that none of the socio-economic factors was significant while environmental awareness, subjective norms, and inconvenience had significant effects on households' WTP. In agreement with the latter point, it was found that environmental awareness, laws and regulations were key factors clarifying the willingness towards e-waste recycling (Wang *et al.*, 2016; Yu *et al.*, 2014). In contrast, Wang *et al.* (2011) revealed that knowledge of environmental laws were not significant factors for the explanation of the individual's willingness to recycle e-waste. It can be seen that there are mixed dimensions showed the links between demographic, socio-economic and psychological characteristics and WTP for recycling. However, little is known about end users' WTP and their preferences toward e-waste recycling in Vietnam so far. It is true that the research on the consumers' WTP for e-waste recycling is critically rare in Vietnam, compared to other countries such as America (Nixon and Saphores, 2007; Nixon *et al.*, 2009), Nigeria (Nnorom *et al.*, 2009), India (Dwivedy and Mittal, 2013), Malaysia (Afroz *et al.*, 2013), Macau (Song *et al.*, 2012), and national scale of China (Cai *et al.*, 2019; Wang *et al.*, 2011; Yin *et al.*, 2014), where various studies have placed emphasis on the WTP and preferences toward e-waste recycling. The limited published academic paper related to the WTP and preferences of Vietnamese consumers toward e-waste recycling causes difficulties for environmental managers and legislators to design effective policies to tackle e-waste recycling problems. Therefore, it is very important to explore the relationship between influencing factors and end users' decision to pay for e-waste recycling. Especially, if Vietnamese government aims to achieve appropriate future policies and develop properly e-waste recycling facilities, it is an urgent request to carry out an in-depth study on the end users' WTP for recycling programs and their preference in terms of payment method toward this waste stream. Based on the understanding of end users' preferences and their WTP for recycling e-waste, it is expected to provide the new look at Vietnamese's WTP for e-waste recycling, which is a useful reference for policy-makers to establish recycling strategies and set proper level of recycling fee. This will, in turn, encourage people to be willing to pay the fee for recycling programs, helping to improve the e-waste situation in Vietnam. Moreover, such study may contribute to a narrow current multidisciplinary literature on pro-environmental behavior (PEB) including recycling by eliciting the combined influences of both socio-economic and psychological antecedents on the willingness of end users to pay for e-waste recycling. Finally yet importantly, this kind of research will provide a useful lesson and scientific knowledge from the outlook of an emerging nation, by introducing e-waste policy schemes to the global e-waste community and sharing experience to other countries which are currently facing similar e-waste challenges. Overall, in response to the critical concern of e-waste, this study targets to examine the key socio-economic and psychological determinants motivating the willingness of end users to pay e-waste recycling fee by employing logistic regression as a data analysis tool. In addition, the end users' preferences of e-waste recycling pattern were analyzed from two pillars: recycling payment methods, and reasons for respondents' disagreement to pay for recycling. To achieve these objectives, the research survey was conducted in residential areas of Danang city, Vietnam in 2018.

## MATERIALS AND METHODS

*Survey design and data collection*

The questionnaire used for this study included three major parts, which was developed to examine the key socio-economic and psychological factors influencing the end users' WTP for recycling e-waste

and their preferences toward four recycling payment patterns. In the first section, a five-point Likert-scale was adopted to obtain the information of influencing variables namely environmental awareness, laws and regulations, inconvenience of recycling, cost of recycling, and past experience. The ranges of Likert-scale were from one to five, referring to a series from "strongly disagree" to "strongly agree". The second section uncovered the end users' willingness to participate, WTP (binary "yes or no" questions were used) and their recycling preferences (favorite payment methods, and reasons for respondents' rejection to pay for recycling). The last section gathered socio-demographic information including gender, age, education level, family size, monthly household income, and residential area. Before asking the respondents to answer all the questions in three above-described main parts, the trained interviewers informed respondents about the purposes of study and explained clearly all the specific terms used in the content of questionnaire, with the aim to make sure the respondents understood. There were six typical discarded appliances used as the targets of this study, including fridge, air conditioner, television, mobile phone, personal computer (desktop), and laptop. The questionnaire was pretested and had minor changes before conducting the actual survey. The data of this study was collected through face-to-face interviews between July and August 2018. With the aim to have better capture the variety of the city's population, the proportionate stratified random sampling was employed in this study, which involves taking random samples from stratified groups, in proportion to the population. In this approach, the sample size of each subgroup (which was classified by district) was directly proportional to the population size of the entire population of districts. That means each district sample has the same sampling fraction. After that, a systematic random sampling was taken to select the interviewees who were asked to fill the survey's questionnaires. As a result, 545 questionnaires were distributed to households living in six urban districts namely Lien Chieu, Thanh Khe, Cam Le, Ngu Hanh Son, Hai Chau, and Son Tra, shown in Fig. 1. After removing unqualified questionnaires, a set of 520 qualified ones was used for further examination. Danang, the fourth big city in Vietnam with a population of 1.08 million, is located in the zone of typical tropical monsoon. The city's average temperature is about 26.5$^0$C, the highest is 28.9 - 30.1$^0$C from May to September and the lowest is 21.5 - 24.2$^0$C from December to March. The average humidity is 79.7%, while the average annual rainfall is 2539.1 mm/ year (GSO, 2019). The reason why Danang was chosen to be a survey's area is the fact that the city government has a determination to build Danang as an environmentally-friendly city. The city's environmental plan covers the goal of achieving 70% of solid waste recycled and reused. In order to fulfill that objective and ensure the effectiveness of recycling program in the future, it is very important to have a better understanding of end users' recycling preferences, which is worthwhile for e-waste recycling policy design and implementation.

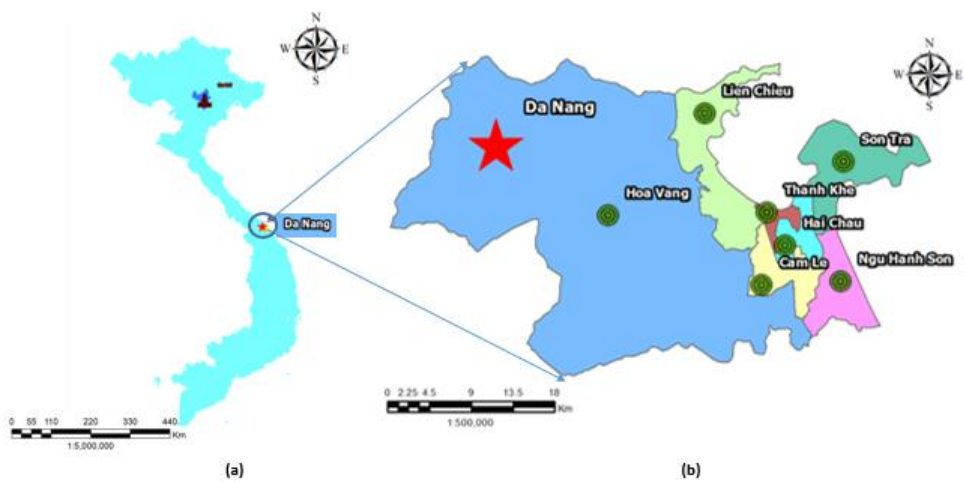


Fig. 1: Geographic location of the study area; (a) Vietnam, (b) Danang city

*Analytical framework*

In this study, respondents were asked to answer the question "Are you willing to pay e-waste recycling fee?" to express their WTP for recycling by making a choice from two alternatives either "Yes" (coded as "1") or "No" (coded as "0"). As the dependent variable is in 0 - 1 style, a logistic multiple regression was utilized in this work to explore the significant determinants influencing end users' WTP for recycling e-waste. The explanatory variables included socio-demographic, psychological and other external variables and were estimated in two stages. In the first step, socio-demographic predictors (gender, age, education, household size, income, and residential area) were entered into the model. Psychological and other external variables (environmental awareness, social pressure, laws and regulations, inconvenience of recycling, cost of recycling, past experience and willingness to participate) were then included in the second step. The data in this work were analyzed by using the statistical package of social sciences (IBM SPSS 22.0) software.

## RESULTS AND DISCUSSION

*Descriptive statistics and factor analysis for variables entering the analysis*

The principal component analysis with varimax rotation was conducted to reduce a large set of Likert-scale variables (16 items of psychological and situational factors) to a small set that entered into the logistic regression model. To determine the appropriateness of the data for factor analysis, The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to check the data. KMO test is a statistic that measures the proportion of variance among variables might be caused by underlying factors. The higher value of KMO (close to 1) is, the more suited the data is. Bartlett's test of sphericity checks the hypothesis of whether a matrix is significantly different from an identity matrix. Therefore, a significant Bartlett's test of sphericity is required ($p < 0.05$) indicates that a factor analysis may be useful with your data (Hair, 2010). The results from this run showed that the KMO value was 0.739, greater than a critical value of 0.7 (Hair, 2010), and the Bartlett's test is highly significant at p-value < 0.001, approved that the factor analysis could be applied. The result of the factor analysis performance indicates that five components were extracted with the explained variance was 72.74%. Two items whose factor loadings were smaller than 0.5 were deleted, therefore, the remainders were 14 items. To assess the reliability of the components, Cronbach's alpha test was used to check how closely related a set of items are as a factor and the results was in range of 0.672 -0.860, which was greater than the accepted value of 0.6 (Hair, 2010) (Table 1). Five factors including environmental awareness ($x_8$), laws and regulations ($x_9$), inconvenience of recycling ($x_{10}$), past experience ($x_{11}$) and cost of recycling ($x_{12}$) represents five out of twelve explanatory variables used in logistic model later.

It is necessary to have a brief summary of descriptive statistics of key variables entered into the logistic model, shown in Table 2. The values of explanatory variables $x_1$-$x_6$ come from section 3 of the research's questionnaire showing the socio-economic characteristics of the interviewees across the six

Table 1: Results of the principal component analysis with varimax rotation

| Predictors | Number of items | Loading | Variance (%) |
|---|---|---|---|
| Environmental awareness (Cronbach's alpha = 0.860, KMO=0.769, Bartlett: p<0.001) | 3 | 0.833<br>0.841<br>0.859 | 27.713 |
| Laws and regulations (Cronbach's alpha = 0.821, KMO=0.769, Bartlett: p<0.001) | 3 | 0.823<br>0.852<br>0.741 | 15.145 |
| Inconvenience of Recycling (Cronbach's alpha = 0.777, KMO=0.769, Bartlett: p<0.001) | 3 | 0.759<br>0.862<br>0.854 | 12.590 |
| Past experience (Cronbach's alpha = 0.672, KMO=0.769, Bartlett: p<0.001) | 3 | 0.822<br>0.789<br>0.710 | 9.767 |
| Cost of recycling (Cronbach's alpha = 0.749, KMO=0.769, Bartlett: p<0.001) | 2 | 0.889<br>0.868 | 7.525 |

districts. The remaining independent variables ($x_7$-$x_{12}$) come from section 1 and 2, while $x_7$ represents the willingness of end users to participate in the e-waste recycling program, $x_8$-$x_{12}$ are five variables results from factor analysis. Before performing a logistic regression analysis, multicollinearity problem was detected by testing the tolerance and its reciprocal, called variance inflation factor (VIF). The VIF value of all variables in this study was less than 1.5, indicating that there was no multicollinearity problem among 12 explanatory variables.

*Determinants of end users' WTP for e-waste recycling*

A regression model was performed under two steps to measure the predictors of end users' WTP for recycling e-waste. All socio-economic and demographic variables entered into the model in the first step were categorical variables with the highest level taken as reference category except that the baselines of gender, education level, and family size were lowest levels. The remaining factors were added in step 2 including scale variables except for the willingness to participate being binary variable. The Hosmer-Lemeshow test from the SPSS output was used to measure the goodness of fit of the logistic regression model. According to the Hosmer-Lemeshow test from step 1, $p = 0.316 > 0.05$, which was not significant, indicating that the regression model is well fitted. The classification accuracy of the model was 62.3%. The set of socio-demographic variables had a mixed influence on respondent's WTP. The results of step 1 shown in Table 3 indicated that age, which was statistically significant at the 1‰ significance level, was in accordance with the results of the previous related studies (Song *et al.*, 2012; Vassanadumrongdee and Kittipongvises, 2018). This implies that the probability of paying for recycling e-waste is associated with respondents' age. Of which the age groups of (18 - 20), (21 - 30) and (41 - 50) years old were proved to be significant factors for WTP and tended to have a higher willingness than the age group of above 60 years old (the reference group) with the coefficient being 1.059, 0.941 and 0.945, respectively. Meanwhile, the results of odds ratio indicated that the odds of approval for paying recycling fee of three above age groups were 2.56 - 2.88 times higher than that of those whose age was over 60. It can be explained that the young generation who are equipped with knowledge about environmental protection and conservation seems to be more willing to pay for recycling. In terms of education level variable, only "master or above" was significant at the 10% level and its coefficient and odds ratio were 1.439 and 4.22, respectively,

Table 2: Definitions and descriptive statistics for variables entering the analysis

| Variables | Scale | Sample size | Mean | S.D. |
|---|---|---|---|---|
| *Dependent variable* | | | | |
| Willingness to pay (WTP) | 0 = not to be WTP, 1 = to be WTP | 520 | 0.525 | 0.500 |
| *Independent variables* | | | | |
| Gender ($x_1$) | 0 = female, 1 = male | 520 | 0.406 | 0.492 |
| Age (x2) | 1 = less than and equal 20 years, 2 = (21-30) years, 3 = (31-40) years, 4 = (41-50) years, 5 = (51-60) years, 6 = 61 years and above | 520 | 3.073 | 1.276 |
| Education level (x3) | 1 = lower secondary, 2 = upper secondary, 3 = college/ vocational, 4 = university, 5 = masters or above | 520 | 3.700 | 0.975 |
| Family size (x4) | 1 = one, 2 = two, 3 = three, 4 = fours, 5 = five, 6 = more than five | 520 | 4.058 | 1.143 |
| Monthly household income (x5) | 1 = less than 6 million VND†, 2 = (6-10) million VND, 3 = (11-15) million VND, 4 = (16-20) million VND, 5 = more than 20 million VND | 520 | 1.829 | 0.993 |
| Residential area (x6) ‡ | 1 = Thanh Khe district, 2 = Hai Chau district, 3 = Lien Chieu district, 4 = Son Tra district, 5 = Ngu Hanh Son district, 6 = Cam Le district | 520 | 2.852 | 1.728 |
| Willingness to participate (x7) | 0 = not participate in e-waste recycling, 1 = participate in e-waste recycling | 520 | 0.902 | 0.298 |
| Environmental awareness (x8) | 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree | 520 | 4.348 | 0.715 |
| Laws and regulations (x9) | | 520 | 4.121 | 0.723 |
| Inconvenience of recycling (x10) | | 520 | 3.508 | 0.983 |
| Past experience (x11) | | 520 | 2.181 | 0.861 |
| Cost of recycling (x12) | | 520 | 3.651 | 0.941 |

†Vietnam Dong (1USD = 23,065 VND) (data from The State Bank of Vietnam on 01/06/2019)
‡1 (31%), 2 (20.4%), 3 (13.5%), 4 (14.8%), 5 (8.5%), 6 (11.9%)

implying that the odds of WTP for respondents who get higher education were 4.22 times higher than they were for those with lower secondary education level (the reference category). It is in agreement with the results from study conducted by Song *et al.* (2012) while others previous studies reported that education had no or minor role in engaging residents' PEB and readiness to afford recycling payment (Saphores *et al.*, 2012; Vassanadumrongdee and Kittipongvises, 2018). The finding from this study may be explained that those who get higher degree have more opportunities to enrich their knowledge on e-waste and understand

Table 3: Estimated regression coefficients of the logistic regression model predicting WTP

| Predictors (Independent variables) | Step 1 | | Step 2 | |
|---|---|---|---|---|
| | β | Exp(β) | β | Exp(β) |
| $x_1$-Gender *(base = "female")* | | | | |
| Male | -0.108 | 0.897 | -0.176 | 0.839 |
| $x_2$-Age *(base = age "> 60 years old")* | | | | |
| <=20 years old | 1.059* | 2.883 | 0.904 | 2.471 |
| (21-30) years old | 0.941* | 2.561 | 1.004* | 2.728 |
| (31-40) years old | 0.170 | 1.185 | 0.080 | 1.084 |
| (41-50) years old | 0.945* | 2.574 | 1.047* | 2.849 |
| (51-60) years old | -0.056 | 0.946 | -0.190 | 0.827 |
| $x_3$-Education level *(base = "lower secondary")* | | | | |
| Upper secondary | 0.536 | 1.708 | 0.872 | 2.393 |
| College/ Vocational education | 1.193 | 3.296 | 1.126 | 3.083 |
| University | 1.002 | 2.723 | 0.878 | 2.407 |
| Masters/ above | 1.439+ | 4.216 | 1.358 | 3.889 |
| $x_4$-Family size *(base = "> 5 members")* | | | | |
| 1 member | -0.072 | 0.931 | -0.058 | 0.944 |
| 2 members | 0.000 | 1.000 | 0.274 | 1.316 |
| 3 members | 0.543 | 1.721 | 0.648+ | 1.912 |
| 4 members | 0.085 | 1.089 | 0.198 | 1.219 |
| 5 members | 0.073 | 1.076 | 0.120 | 1.127 |
| $x_5$-Monthly household income *(base = "< 6 million VND")* | | | | |
| (6-10) million VND | -0.108 | 0.898 | -0.166 | 0.847 |
| (11-15) million VND | -0.493 | 0.611 | -0.512 | 0.599 |
| (16-20) million VND | 0.105 | 1.111 | 0.208 | 1.232 |
| >20 million VND | -0.357 | 0.700 | -0.345 | 0.708 |
| $x_6$-Residental area *(base = "Cam Le")* | | | | |
| Thanh Khe | 0.423 | 1.526 | 0.411 | 1.509 |
| Hai Chau | 0.220 | 1.246 | 0.324 | 1.382 |
| Lien Chieu | 0.131 | 1.140 | 0.180 | 1.197 |
| Son Tra | 0.507 | 1.660 | 0.636 | 1.889 |
| Ngu Hanh Son | -0.093 | 0.911 | -0.122 | 0.885 |
| Intercept | -1.719* | 0.179 | | |
| $x_7$-Willingness to participate | | | 2.344*** | 10.422 |
| $x_8$-Environmental awareness | | | -0.195 | 0.823 |
| $x_9$-Laws and regulations | | | 0.542** | 1.719 |
| $x_{10}$-Inconvenience of recycling | | | -0.219* | 0.803 |
| $x_{11}$-Past experience | | | 0.354** | 1.425 |
| $x_{12}$-Cost of recycling | | | 0.125 | 1.133 |
| Intercept | | | -5.742*** | 0.003 |
| -2LL | 679.122 | | 614.746 | |
| | $\chi^2$=40.450, df=24, p<0.05 | | $\chi^2$=104.826, df=30, p<0.001 | |
| Nagelkerke $R^2$ | 10.00% | | 24.40% | |
| Hosmer and Lemeshow test | p = 0.316 | | p = 0.178 | |
| Classification accuracy | 62.30% | | 66.00% | |

+p<0.10, *p<0.05, **p<0.01, ***p<0.001

the importance of environmental protection; as a result, they tend to have more probability to pay for recycling fee that is used for running recycling system. Therefore, it can be concluded that education is expected to play a key factor to enhance the level of environmental awareness of households. Other variables considered include gender, monthly income, family size, and residential area but they were not statistically significant. While respondents' gender and family size were not statistically significant and supported by other studies (Cai *et al.*, 2019; Song *et al.*, 2012; Vassanadumrongdee and Kittipongvises, 2018), the residential area had insignificant influence which was different to what found by Dwivedy and Mittal (2013). Similarly, the non-significance of gender and household income was contrasted with similar findings in the study of community's willingness to join in drop-off recycling activity in California (Dwivedy and Mittal, 2013; Nixon and Saphores, 2007; Nnorom *et al.*, 2009; Saphores *et al.*, 2006).

Moving to the second step, along with demographic variables, psychological and external factors including five variables from factor analysis and one variable of willingness to participate were introduced into the model, altogether yielded a model of 66% corrected classification. The test of Hosmer-Lemeshow had p = 0.178, proving that the model with these factors was a perfect fit to the data. Omnibus tests of model coefficients showed a significant beyond 0.001, implying that there was an improvement over the model in step 1. Nagelkerke $R^2$ and the 2-Log likelihood also showed the improvement from step 1. While the values of Nagelkerke $R^2$ rose from 10% to 24.4%, the 2-Log likelihood fell from 679.122 to 614.746, presenting more accuracy of the predicted model. Hence, all goodness-of-fit indices indicated that the inclusion of psychological factors and other factors strengthened the accuracy of the model. In the full model, age still had a positive impact on WTP; specifically, respondents whose age at (21 - 30) and (41 - 50) years old had more WTP for recycling e-waste compared with those whose age was over 60 years old. In addition, while education level variables became insignificant which was similar to the report of previous studies (Vassanadumrongdee and Kittipongvises, 2018; Wang *et al.*, 2011), a household with three members showed the significant positive impact on the WTP of end users. The odds of WTP was 1.91 times higher for a family of three than they were for a family with over five members. Similar to the first step, it is also observed that gender, income, and residential area had no significant impact on end users' WTP in this step. Regarding one binary independent variable in this model, willingness to participate become the strongest variable which affected the willingness of end users toward recycling fees, its coefficient was 2.344 and significant at 1‰ level. From the odds ratio, it can be seen that the odds of respondents who showed their willingness to participate were 10.42 times more likely to pay for e-waste recycling fee than those who were not willing to participate. It is also found that past experience and laws and regulations could have a positive effect on end users' WTP, which is similar to the outcome of recent studies (Nduneseokwu *et al.*, 2017; Vassanadumrongdee and Kittipongvises, 2018). Their odds ratios reveal that for each one point increase on the five-point past experience and laws and regulations scale, there were 1.43 and 1.72 times of the odds that people will be willing to pay for recycling, respectively. However, it is in disagreement with the results from Wang *et al.* (2011), those authors reported that law was not an influential factor motivated Beijing residents' e-waste recycling behavior. Out of four variables from factor analysis that showed statistically significant influence on WTP, only inconvenience of recycling had negative coefficient (-0.219, sig. at 5% level) which was similar to the results from other researches (Nixon *et al.*, 2009; Nguyen *et al.*, 2018; Vassanadumrongdee and Kittipongvises, 2018). In fact, Nixon *et al.* (2009) stated that inconvenience as a major factor restricting residents from appropriate e-waste management. Alternatively, the work's finding could be interpreted that inverting the odds ratio for the inconvenience of recycling indicates that with one point increase on the five-point inconvenience of recycling scale being associated with the odds of not being willing to pay increasing by a multiplicative factor of 1.25. It indicates that the more inconvenient people feel, the less willingness they have to do e-waste recycling. The remaining variables such as environmental awareness and cost of recycling were not statistically significant, which confirms previous survey result of Nixon *et al.* (2009). From those above mentioned findings, it is obvious that the crucial importance is to encourage more and more people to engage themselves in e-waste recycling systems. Once they get used to the recycling performance, and in turn, forming their recycling habit, then the possibility of paying the recycling fee will increase. This suggestion can be proved by the study's findings demonstrated

the statistically significant impacts of both the willingness of end users' participation and their past recycling experience on WTP for recycling e-waste. To fulfill the goal of encouraging the participation of end users toward recycling, it should be emphasized that the establishment of recycling services and facilities plays an extremely crucial roles, which helps to open the door to end users' WTP. With this in mind, in the context of the lack of formal recycling channels and services in Vietnam, building up e-waste recycling infrastructure should be put on the top priority as the cornerstone step for the enhancement of e-waste management system.

*End users' preferences toward e-waste recycling*

The end users' preferences of e-waste recycling pattern were analyzed from two aspects: payment methods, and reasons for respondents' disagreement to pay for recycling. The results from this survey showed that more than half of the respondents (52.5%) answered "Yes" for the question: "If the government develops a sustainable e-waste management infrastructure and recycling facilities, are you willing to pay e-waste recycling fee?" In other words, there were still nearly half of the respondents (47.5%) who were not willing to pay for recycling e-waste. Among 247 participants who disagreed to pay the fee, the majority of them (40.5%) stated that users did not have any responsibility to cover the e-waste recycling fee; followed by 30.8% of the respondents admitting that they preferred to pass their used EEE to informal sectors (peddlers, scrap dealers, and secondhand market) with the aim to get monetary benefits. It reflects the reality that informal e-waste recycling sectors have been predominating in Vietnam for years, while official recycling channels are extremely limited and show ineffective performance (Hai *et al.*, 2017; Tran and Salhofer, 2016). Not only in Vietnam, other previous studies also indicated that the end users were more likely to sell their old products rather than to cover the recycling fees (Islam *et al.*, 2016). While 27.1% of the households are concerned of their insufficient extra income which could not afford recycling fee, only 1.2% and 0.4% of them answered that they had other reasons or refused to answer this question, respectively. A small proportion of people gave the reasons that they did not believe that recycling service and infrastructure required for the recycling or appropriate management of e-waste could be settled in developing countries like Vietnam. In addition, they also added that the e-waste program should be launched in developed countries, but not in Vietnam. The findings exploring the reason why end users are not willing to cover the e-waste recycling cost in this study were completely similar to what Song *et al.* (2012) reported in their studies performed in Macau, a special administrative region of China. The explanation for the coincidence is that both countries are experiencing from the similar situation of e-waste with the predominance of informal sectors, not mention to the similarity between two countries' culture and lifestyles. Regarding the payment method, the end users' preferences were explored by asking all respondents to choose which payment method they preferred from four options, namely advanced recycling fee (ARF), pre-disposal fee (PDF), monthly recycling fee (MRF), and deposit and refund scheme (DRS). ARF is a system that consumers pay recycling fee at the time they buy a new product and the product price covered the fee; on the contrary, PDF refers to the method that consumers pay a fee at the point of disposal. While MRF is the style of paying the fee every month which is widely employed in municipal waste management (applied for solid waste and wastewater), DRS is a surcharge on a product when purchased and a rebate when it is returned (Dwivedy and Mittal, 2013; Walls, 2011). All the fee collected is subsequently invested in e-waste recovery and recycling projects (Nixon and Saphores, 2007). Most interviewees (36.0%) supported for the last style (DRS), while PDF and ARF were accepted by a roughly similar percentage of respondents, 25.8% and 21.0%, respectively, making MRF was the least preferred payment method, with only 10.2%. In addition, there were 37 out of 520 (7.1%) respondents reported that they could not make a decision of which payment style they prefer, shown in Fig. 2. Comparing to other studies, while Indian residents supported for PDF, Californian people considered PDF was least preferred and the majority of them chose the ARF style (Dwivedy and Mittal, 2013; Nixon *et al.*, 2009). The ARF was also accepted by the majority of Chinese residents since its convenience surpassed PDF, DRS and MRF (Song *et al.*, 2012; Wang *et al.*, 2011). Chinese people refused DRS because they assumed that the deposit system seems to be a complicated process. However, the favor of Vietnamese respondents in DRS method can be explained that end users felt at least they could receive a certain amount of money so-called refund at the end, being similar to what they sold their end

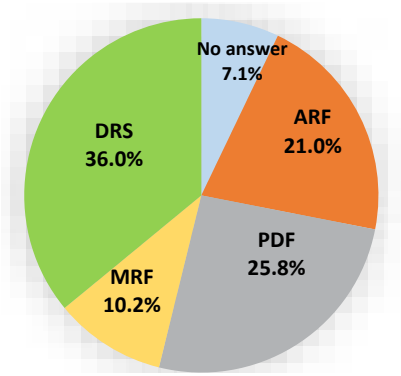


Fig. 2: End users' preferred payment modes toward e-waste collection recycling

of life devices to secondhand shops. In fact, DRS was recommended as a financial support tool for the success of e-waste collection program in Ho Chi Minh City in the study of (Le *et al.*, 2012). The study findings are also consistent with the statement of Uwasu *et al.* (2013), they concluded that DRS was relatively cheaper than the PDF payment method, especially when the consumers tended to have less concern towards product prices than recycling fees. In addition, some studies have stated that DRS are more economical than other methods of waste disposal management, among which command-and-control schemes, recycling subsidies, and advance disposal fees (Anderson and Lohof, 1997). Take a real applied DRS in South Korea as an example, the Korean consumers have responsibility for paying the e-waste recycling fee. This country is getting success in employing DRS with high rate of e-waste collection, in which deposit is set at a fixed rate on products and the refund is returned after the recycling of the items (Islam *et al.*, 2016).

## CONCLUSION

This study investigated factors affecting end users' preference and WTP for recycling e-waste in Danang city, which may have contributions to establishing a proper and effective recycling system to fix the problem of e-waste in Vietnam. The empirical results indicated that end users' participation willingness toward recycling activities, laws and regulations, past experience, and inconvenience of recycling performed orderly strongest impacts on the willingness of end users to pay recycling fee. Among four above determinants, only inconvenience of recycling showed a negative effect, while three of the remaining variables were positive. With those findings, in order to launch a successful e-waste recycling program, it is very important to have high rate of end users' encouragement, especially for those who have experience of waste recycling. In addition, the establishment of recycling services and facilities also plays an extremely crucial role in easing the participation of end users in recycling e-waste. Most importantly, future legislation which targets to an e-waste recycling policy should be established which emphasizes the responsibility of end users and a need to have a cooperation mechanism amongst various stakeholders such as the government, producers, consumers, and especially informal sectors. For example, the government should provide high-level support for informal division with financial stimulus to create a partnership with the formal sector. In this way, mutual benefits can be gained: on the one hand, the government can have better control of unofficial recycling activities; on the other hand, more individuals will turn to participate in the formal recycling system. In terms of the recycling payment mode, most of the respondents in this study showed their favor in DRS method; hence, it is really a good idea to integrate DRS in extended producer responsibility implementation in order to stimulate resident's engagement in e-waste collection, and promote return and reuse, aiming to boost recycling rates. Further studies should be conducted to examine the feasibility of integration deposit refund system as a segment of the legislative initiative. On the other hand, the recycling fee, when being imposed, should be considered carefully and appropriately. If the fee is too high, a large number of poor people cannot afford recycling fee, leading to several bad consequences, even they are more likely to have illegal disposal e-waste to avoid paying the fees. In contrast, if the recycling fee is too low, it raises a concern that such fee is lower than the actual cost invested in recycling activities. Therefore, future studies should take into consideration appropriate recycling fees, which can harmonize the sake of consumers and the effective performance of recycling activities. In summary, besides the voluntary engagement of end users and the power of laws and regulations, activating end users' WTP for recycling e-waste strongly depends on not only the readiness of e-waste recycling facilities but also their e-waste recycling habits. Findings taken from this research are expected to be an academic knowledge source

for getting the better understanding end users' WTP, which helps policy-makers and environmental managers to design and improve the effectiveness of recycling policies in Vietnam. Globally, this study also contributes the literature to lay the foundations for a successful e-waste management policy applying in the same social, cultural and economic regions.

## AUTHOR CONTRIBUTIONS

H.T.T. Nguyen, R.-J. Hung, and C.-H. Lee were responsible for the theoretical framework formulation, research design, data analysis, and writing of the manuscript. H.T.T. Nguyen managed with data collection.

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## CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this manuscript. In addition, ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy were completely observed by the authors.

## ABBREVIATIONS

| | |
|---|---|
| *%* | Percent |
| *‰* | Per thousand |
| *-2LL* | -2 Log Likelihood |
| *ARF* | Advanced Recycling Fee |
| *DRS* | Deposit and Refund Scheme |
| *EEE* | Electrical and Electronic Equipment |
| *E-waste* | Electrical and Electronic Waste |
| *Exp(β)* | The exponentiation of the coefficient, known as Odds Ratio |
| *KMO* | Kaiser-Meyer-Olkin |
| *mm* | Millimeter |
| *MRF* | Monthly Recycling Fee |
| *No. 34/2017/TT-BTNMT* | Circular number 34, released on October 4$^{th}$, 2017 of Ministry of Natural Resources and Environment |
| *$^{o}C$* | Degree Celsius |
| *PDF* | Pre-Disposal Fee |
| *PEB* | Pro-environmental Behavior |
| *S.D.* | Standard Deviation |
| *SPSS* | Statistical Package of Social Sciences |
| *USD* | United States Dollar |
| *VIF* | Variance Inflation Factor |
| *VND* | Vietnam Dong |
| *WTP* | Willingness to Pay |
| *β* | Coefficient |
| *$\chi^2$* | Chi-Square |

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