Journal of Cleaner Production 19 (2011) 977–984

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Willingness and behavior towards e-waste recycling for residents in Beijing city, China

Zhaohua Wang [a,*], Bin Zhang [a], Jianhua Yin [b], Xiang Zhang [a]

[a] School of Management and Economics, Beijing Institute of Technology, Beijing 100081, PR China
[b] Business School, University of International Business and Economics, Beijing 100029, PR China

ARTICLE INFO

Article history:
Received 16 April 2010
Received in revised form
7 August 2010
Accepted 26 September 2010
Available online 8 October 2010

Keywords:
E-waste
Willingness and behavior
Factors of recycling
Beijing city

ABSTRACT

This paper is to investigate the behavior of residents towards electrical and electronic waste (e-waste) recycling in Beijing. For this purpose a large sample questionnaire survey was performed to explore the residents' characteristics of recycling behavior and preference of e-waste recycling pattern. Besides, the willingness of residents to participate in e-waste recycling was also assessed in our study. For this a logistic regression model was developed to estimate and explain residents' willingness in e-waste recycling. The model showed that *Convenience of recycling facilities and service, Residential conditions, Recycling habit* and *Economic benefits* are four determinants of Beijing residents' willingness and behavior in e-waste recycling. And centralized recycling pattern by professional recovery spots would have a broad prospect if various kinds of channels can be provided to make the residents feel more convenient in e-waste recycling.

1. Introduction

With the rapid development of electrical industry, the problem of electrical and electronic waste (e-waste) generation and management has become more and more serious in China. Here e-waste is defined as all out-used or discarded electrical and electronic equipments. There are appropriately 6 million washing machines, 7 million TV sets, 10 million computers, 70 million mobile phones being scrapped every year in China. The total amount of e-waste is about 2 million tons and is predicted to increase by 10% every year (National Development and Reform Commission, 2008). Beijing, the capital as well as one of the biggest consumer markets of electrical and electronic products of China, is especially puzzled by the increasing e-waste. The generation of e-waste in 2010 is coming to 158.3 thousand tons, while the reclaim and disposal of e-waste are not well put into effect: large amounts of e-waste are stored in the office or household and not effectually reused or recycled due to lack of reclaiming channels. And inappropriate disposal processing (e.g. disposal with municipal solid waste and open burning) of e-waste creates grave environment pollution. However, the residents of Beijing seems not realizing the rigorous problem of e-waste. A large number of people prefer to sell their e-waste to the peddlers rather than select the legal dealers, while those peddlers usually dispose the e-waste inappropriately. Therefore, the survey of factors influencing the willingness of residents to participate in the e-waste recycling and how to regularize the residents' e-waste recycling behavior are pressing needed in Beijing.

Considering the increasing quantities of e-waste, various studies have been focusing on the e-waste disposal. Extended producer responsibility (EPR), firstly proposed by Lindhqvist in 1992, states that producers should extend their responsibility to the whole product life, not only the production and sale, but also the reclaiming and disposal of the end-of-life product (Lindhqvist, 1992). Many studies conducted their researches of e-waste disposal based on EPR (Milanez and Bührs, 2009; Lin et al., 2002; Fleckinger and Glachant, 2010), and many polices according to e-waste disposal in EU countries were also implemented under the framework of EPR. However, as the biggest developing country, the national condition of China is quite different from the EU countries. Most electrical companies in China are relatively small and competitions with each other are more serious. They cannot afford enough money to bring the recycling activities into effect as large foreign companies. Therefore, to solve the e-waste problem in China should not only focus on the EPR, but also consider the performance of government and the behavior of residents (Nnorom, 2009). In the developing countries, government and municipalities play an important role in product take-back and in providing recycling infrastructure (Hicks et al., 2005). And many recent studies according to e-waste disposal in China have been focusing on the how to implement EPR and the function of government in e-waste recycling (Fleckinger and Glachant, 2010;

* Corresponding author. Tel.: + 86 10 68918213; fax: +86 10 68912483.
E-mail address: wangzhaohua@bit.edu.cn (Z. Wang).

0959-6526/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jclepro.2010.09.016

Nnorom, 2009; Zhao et al., 2010; Mo et al., 2009; Tucker et al., 1998), while the researches on the willingness or behavior in e-waste recycling have not attracted enough attention. Nevertheless, without willingness of residents to participate in the recycling activities, the policies by government and measurement by producers cannot be well put in to practice. Comparatively, there have been many researches on e-waste in perspective of residents in foreign countries (Davis et al., 2006; Hage et al., 2009; Sidique et al., 2010; Darby and Obara, 2005; Hansmann et al., 2006; Tonglet et al., 2004; Berglund, 2006; Guerin et al., 2001; Tucker and Lewis, 1993). It is necessary to conduct an in-depth study on the residents' willingness and behavior in e-waste recycling in China.

This paper takes a questionnaire survey towards residents' willingness and behavior of e-waste recycling in Beijing, which intends to find out three problems:

- The characteristics of residents' recycling behavior in Beijing.
- The main factors influence the willingness of residents in Beijing to participate in e-waste recycling.
- The preference of e-waste recycling pattern in Beijing.

2. Electrical and electronic waste in Beijing

2.1. The sources and generation of e-waste in Beijing

Being one of the largest consumer markets of Chinese electrical industry, Beijing is facing large quantities of e-waste generation and various channels of e-waste sources. It is investigated that there will be 158.3 thousand tons e-waste in 2010 with the growth rate of 5.2% per year in the following few years (National Development and Reform Commission, 2008). Beijing e-waste sources include both domestic generation and imports. E-waste imports are divided into legal and illegal imports. The former is managed and controlled by China Customs and State Environmental Protection Administration (SEPA). Domestic generation mainly comes from post-consumer e-products. Only small quantities come from industrial processes (Yang and Lu, 2008).

2.2. E-waste recycling and disposal in Beijing

E-waste recycling and disposal in Beijing are not well put into effect. According to Jianjin Yang, 70%of end-of-life e-products are stored in homes or offices, which make these reusable resources unable to enter the recycling system. The storage time varies from several months to several years (Yang and Lu, 2008). Only 12% of e-waste is disassembled or dismantled for material recovery collection, which will be sorted and treated for reuse or recovery of base materials. Most of reclaimed e-wastes by various backward channels are flowed to the second hand market after simple repairing, upgrading or refurbishing. Although these second hand products are still technically in working order, many of them do not utilize the latest technical standards, which may cause serious energy dissipation. Some of them are even beyond the durable years, which exists potential safety hazard for consumers. Besides, at the end-of-life of these second hand products, they will reenter the e-waste flow.

There are four kinds of reclaiming channels for e-waste recycling in Beijing:

- By peddlers. About 60% recycled e-waste (equivalent to 18% e-waste) are reclaimed by the peddlers. These peddlers ride their bikes or small trucks around communities or residential areas to purchase various kinds of e-waste products. Then they sell these reclaimed e-wastes to the specialized collectors or waste treatment plant.
- By dealers/retailers. About 20% recycled e-waste are reclaimed by the dealers or the retailers. Many dealers/retailers in Beijing conduct the programme of "traded-in home appliances", which allow consumers to deduct the new products price by handing in their e-waste products. Some of them also provide onsite services to pick up the e-waste.
- By specialized collectors. Only 10% recycled e-wastes are directly reclaimed by the specialized collectors. They seldom provide onsite services for picking up the e-waste. In most cases, they received the e-waste from the peddlers and the dealers. After sorted out and classification, the e-wastes are sent to the waste treatment plants for further disposal or sale to the second hand market.
- By second hand market. Only a few e-wastes are directly reclaimed by the second hand markets. Most of second hand products are received from the specialized collectors and waste treatment plants after certain degree of repairing or upgrading. In rural areas or poorer regions, the second hand markets are more prosperity.

The disposal technology and process of e-waste in Beijing are relatively backward compared with western countries. Small and medium-sized plants are the main forces of e-waste disposal. About 80% of recycled e-wastes are simply repaired or refurbished before flowing to the second product market. About 4.2% of e-wastes are dismantled into small parts which are often reused downgraded especially on the electronic toys. 7.2% of e-wastes are disassembled for the recovery material, majority of which are plastics and precious metals such as gold, silver that can be used on the industry of chemical, metallurgy, manufacturing correspondingly. The disposal processing methods are still mainly on burning and Acidolysis, which usually cause serious pollution towards the environment. The rest of uneasily disposed e-wastes are often discarded as normal wastes, which result in vicious waste of resources.

The integral profile of e-waste flow in Beijing can be seen in Fig. 1.

2.3. Policies by the government in Beijing

The crisis of e-waste generation and management has attracted keen attentions of the government. In 2003, Beijing was honored as the first city in China to conduct "Discarded Appliances Demonstration Project", which the government allocates special funds to support the disposal of discarded appliances. Moreover, *Waste Electrical and Electronic Product Recycling Regulations* was proclaimed in 2009 and will be conducted by the year 2011. This is the first regulation of China for supervising the proper disposal of e-waste. It provides the catalog of e-wastes that must be recycled and illustrates how to carry out corresponding rewards and punishments. Besides, in June 2009, the State Council issued a *Home Appliance Trade-in Policy*, which affords financial subsidies to encourage consumers to participate in the recycling of end-of-life household appliances. The activity by the government, to some extent, not only reduces the cost of enterprises to take the responsibility for reclaiming and disposing the e-waste, but also mobilizes the general public to participate in e-waste recycling.

3. Behavior of residents in e-waste recycling

3.1. Attitude towards behavior of residents in e-waste recycling

As the national situations are different, scholars from various counties hold diverse attitudes towards the responsibility the

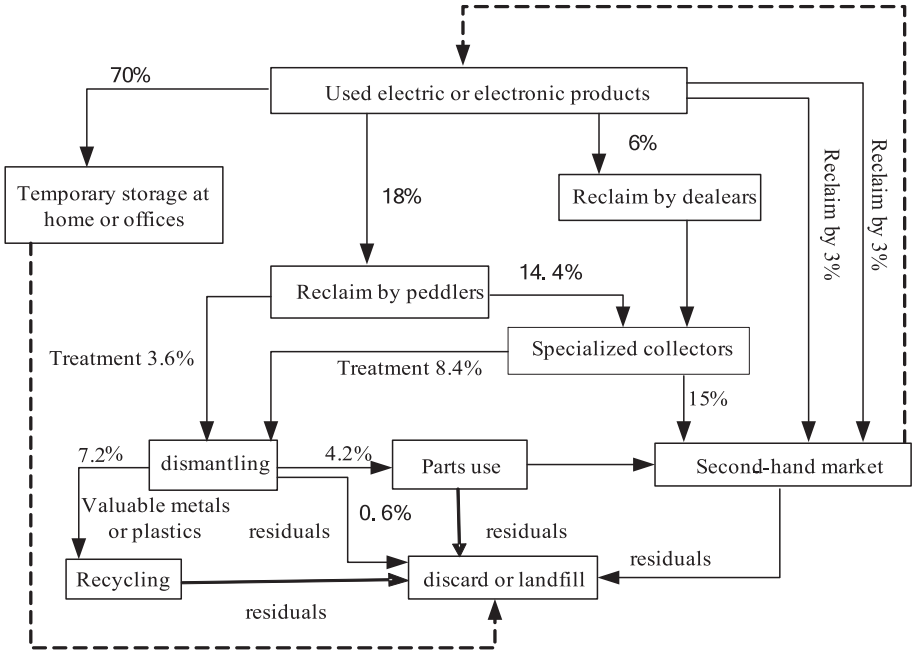

Fig. 1. E-waste flow in Beijing. (Part of the data in the graph is estimated based on an investigation by Jianjin Yang in 2008, see Ref. (Yang and Lu, 2008). Other part of data is from NDRC, see Ref. (National Development and Reform Commission, 2008)).

residents should be taken in e-waste recycling. Jofre and Morioka compared the e-waste management strategies of Japan, United States and the European Union. It is found that although all these countries follow the principle of extended product responsibility, there are different requirements for the responsibilities and obligations of residents involved in the e-waste recycling (Jofre and Morioka, 2005). Many EU countries (e.g. Germany, Spain) have emphasized the process of e-waste recycling fee should mainly burden on the producers, while the residents would only fulfill the obligations of sending the e-waste to collection points. Contrarily, in Japan, the consumer have to take charge of the e-waste recycling fee, which the EPR related laws and regulations have allowed the producers could pass the fee to the consumers though embedding the fee in the price of products. While in the United States the responsibility of e-waste recycling are shared by producers, government and the residents. Different from the developed countries, the income level of residents and environmental awareness of developing countries is relatively low, and there is still a certain gap on the enthusiasm of the residents involved in the recovery. According to Van Beukerin and Van den Bergh, the willingness to pay for waste management and green electronics may not be as high as to pay the water and electricity fees in most of developing countries (Saphores et al., 2006).

Although there are different attitudes towards responsibility and obligation the residents should be taken in waste recycling, the importance of residents in waste recycling is gotten the consensus. According to Nnorom, less knowledge of the toxicity of e-waste and the dangers of inappropriate recycling techniques is considered the primary barriers in e-waste recycling (Nnorom, 2009). The willingness and behavior of residents in e-waste recycling brings some uncertainties (Ravi, 2005): the diversity of consumers' recycling habits directly affects the time and place of e-waste recycling; the willingness of residents to afford the e-waste recycling fee could also affect the quantity of reclaimed e-waste. Therefore, even where recycling infrastructure is available, an understanding of household's willingness to participate in the recycle program is still necessary (Saphores et al., 2006).

3.2. Factors affecting the behavior of residents in e-waste recycling

Hornik et al. (2005) had conducted a detailed literature research towards determinants of recycling behavior. In this study, they reviewed more than 400 articles in more than 20 years and did meta-analysis on 67 empirical studies. The factors affecting the recycling behavior were divided into five categories: Extrinsic Incentives; Intrinsic Incentives; External Facilitators; Internal Facilitators; Demographic Variables (Hornik et al., 2005).

Based on Jacob's study, many scholars have explored and verified a number of more specific influence factors towards the recycling behavior. Darby and Obara (2005) did a case study on small electronics waste recycling of Cardiff and explored the relationship between income and recycling behavior: on the one hand, low-income people rarely participate in the recycling program because of inconvenient transportation, on the other hand, low-income people more incline to extend product life and use the second hand product than high-income people. The study also showed that the recovery behavior of other resources (waste paper, plastic, etc.) has important spillover effects on recycling behavior (Darby and Obara, 2005). Van Beukering and van den Bergh (2006) shared the view that consumers with high-income levels are more likely to participate voluntarily in recycling, however, he also pointed out that this willingness declines if such recycling is time-intensive (Van Beukering and van den Bergh, 2006). This implies that the time which the residents involved in e-waste recycling as well as the attitude of the residents towards time are critical variables affecting residents' behavior in waste recycling. These variables are closely related to the convenient of recycling infrastructure.

Demographic variables are taken special attentions of scholars in e-waste recycling. Some surveys indicate that age is a factor in recycling, with older persons participate in recycling schemes to a larger extent than younger persons while others indicate no such significant relationship between age and recycling (Tonglet et al., 2004; Azjen, 1985). Some studies noted that gender is not a vital determinant of recycling behavior (Guagnano et al., 1995; Azjen,

1985). However, the demographic factors explain only part of differences in recovery behavior (Oskamp et al., 1991).

According to Hansmann, the individual's behavior is largely determined by the social and cultural background. Educating consumers about the importance of recycling, as well as how and where to recycle can enhance public participation in recycling (Guagnano et al., 1995). Besides, the individual recycling behavior can be easily influenced by the family and the friends around you. The family typology and the socioeconomic stratum where the family belongs to also resulted in differences in e-waste recycling of residents. As Ojeda-Benitez said, "family exerts a profound and lasting influence on the perception and behavior of its members, both in the consumption and in waste generation and handling" (Ojeda-Benıtez et al., 2008).

3.3. Common research methods towards behavior of residents in recycling

The common research methods towards recycling behavior are usually based on empirical survey. And the research model can be divided into three kinds:

- Econometric Model. This model was used to analysis the elements affecting the recycling behavior by explore the relation between the dependent variables and independent variables, such as Multi-level analysis (Guerin et al., 2001), Variance analysis and Multiple regression analysis (Hansmann et al., 2006).
- System Simulation Model. This model was first introduced in the recycling behavior field by Tucker and Lewis in 1993 to forecast recycling program implementation results. The residents' recycling behavior can be simulated by developing a number of assumptions and constraints and entering the statistical data to estimate the level of individual's participation and the amount of recycling resources (Tucker and Lewis, 1993; Guagnano et al., 1995)
- Psychology Model. The most popular psychology model is Theory of Planed Behavior (TPB) which was first proposed by Icek Ajzen in 1985. Then the model was modified by many other scholars such as Jones (1990); Boldero (1995); Goldenhar and Connell (1993). Besides, many empirical studies in residents' recycling behavior are also based on the theory of planned behavior, such as McCarty and Shrum (1994); Jackson et al. (1993); Tonglet et al. (2004) and Davis et al. (2006)

4. Methodology

4.1. Questionnaire design and data collection

A questionnaire was designed to elicit residents' willingness in e-waste recycling and preferences of recycling patterns. In the questionnaire introduction, the objective of research and the importance of truth answers were clearly emphasized in order to reduce hypothetical market bias. An information session about e-waste was also stated to avoid the confusion of scope of e-waste.

Moreover, the formulation of questions included in the questionnaire was based on the literature review in section 3, with the content covered by three main areas: demographic information; e-waste recovery behavior; preference patterns of e-waste recycling. The first part included some warm-up questions about residents' income level, residential condition, education level and other demographic information. The second part focused on the perception and practice of respondents about e-waste recycling, aiming at finding out the determinants of residents' e-waste recycling behavior. The third part contained the questions about residents' attitudes towards different patterns of e-waste recovery.

Data for this study were collected through the distribution of 1173 questionnaires to available respondents between February and August 2009. Family was selected to be the survey subject with the help of neighborhood which is the community management organization of residential area in China. There are mainly two reasons for this:

- Disposal of end-of-life electrical products is a family practice as the electrical products are common properties of the family.
- Unlike foreign countries, Chinese residents in cities are mainly living in apartment-style residential area. Collecting the questionnaires on the spot by the neighborhood can improve the credibility and raise response rate of the survey.

This paper conducted the survey in Beijing urban area including 6 administrative divisions: Dongcheng, Xicheng, Xuanwu, Chongwen, Haidian, Chaoyang. The specific distribution of the questionnaire is shown in Table 1. It is exhibited that the survey is not strictly subjected to the stratified sampling as it is hard to control the response rate according to different population density in different administrative divisions. However, to solve this problem *location* is introduced as the control variable in our following discussion to analysis the regional disparities of residents' e-waste recycling behavior in Beijing. And the survey process in each region is under the principle of random sampling, which made the collected date credible. Finally, questionnaires were collected with the response rate coming to 83.38%.

4.2. Modeling willingness to participate in e-waste recycling based on logistic regression

A regression model was developed to explore the influence factors on recycling willingness and behavior of residents in Beijing. Here respondents selected their willingness in e-waste recycling in two alternatives: 0-willing to participate in e-waste recycling; 1-not willing to participate in e-waste recycling, which make the dependent variable of the regression model non-continuous.

When the dependent variable is in 0–1 style, researchers have a choice between logistic regression and probit regression. According to Borsch-Supan, logistic model is a better choice if the

Table 1
Distribution of samples and the recycle rate of questionnaires.

Location	Information of administrative divisions	Quantities of issued questionnaire	Quantities of responded questionnaire	Response rate
Xicheng	In the center of northwest side of Beijing with a population of 112 thousand.	195	90	46.15%
Dongcheng	To the east of Xicheng with a population 101 thousand	120	111	92.50%
Haidian	To the northwest of Xicheng with a population 906 thousand	285	285	100%
Chaoyang	To the northeast of Dongcheng with a population 998 thousand	360	294	81.67%
Xuanwu and Chongwen	In the south of Beijing with a population 168 thousand	213	198	78.87%
Total		1173	978	83.38%

response decision is made based on maximization of utility (Borsch-Supan, 1990). Considering that residents' willingness in e-waste recycling is mainly depending on the expected utility from the recycling behavior, the logistic model was selected in this work. The following specification was used:

$$\text{Logit(R)} = \frac{1}{1+e^{-z}}z = \beta_0 + \sum_{i=1}^{n}\beta_i x_i + \epsilon_i \quad (4.1)$$

where Z = latent and continuous measure of residents' willingness in e-waste recycling, x_i = a vector of observations of explanatory variables, β = a vector of parameters to be estimated, ϵ = a random error term (assumed to follow a standard normal distribution).

The observed and coded discrete willingness variable, R, is determined from the model as follows: 0-willing to participate in e-waste recycling; 1-not willing to participate in e-waste recycling. In the questionnaires, the designed question for R is "How do you deal with the end-of-life electrical products?", five answers are given as follows: A – disposal as normal waste; B – sell to the collectors as scrap metal; C – sell to the collectors as second hand product; D – store at home; E – other choices. This work considers the selection of B or C as 0-willing to participate in e-waste recycling.

5. Results

5.1. Specimen description of residents' e-waste recycling behavior in Beijing

The effective sample size of this paper is 957 after deleting the questionnaires whose response rates are lower than 60%. The criteria, mean and standard deviation of all variables are shown in Table 2. It is shown that some independent variables are not strictly following the normal distribution due to special characteristics of the population. However, there are not special requirements for the independent variables in logistic regression model to be normality (Wang, 2001). All the items in Table 2 are directly from the corresponding questions in the questionnaire. The values of independent variables x_1–x_5 come from the part of demographic information in the questionnaire. Residential condition is measured by the question "the house you living now is rent or your own". Family number, income level and education level are ordinary variables according to actual value that the respondents fill out. Engel's coefficient is measured by the value from the calculation that income divided by consumption. The rest independent variables x_6–x_{10} come from the part of e-waste recovery behavior in the questionnaire. *Recycling habit* is measured by past experience of whether participate in recycling or not. *Convenience of recycling facilities and service* is measured by the recycling condition of recovery spot around their residential areas. x_8 and x_9 are respectively evaluated by the awareness about environmental protection and laws. The significant level that residents perceived towards economic benefits is used to measure x_{10}.

In our questionnaire, respondents were given the option of filling the disposal status of their e-waste. It is shown that each family had 1.93 end-of-life electrical products in average need to be disposal in recent three years, 41.79% of which were collected by various recycling channels, 36.79% of which were discarded as normal municipal waste. Other 21.62% were stored at home (Fig. 2).

It is residents' responsibility to afford a part of charge for the disposal of their e-waste product in some developed countries, such as Japan (Jofre and Morioka, 2005). However, there are no such systematic strategies for household payment on e-waste recycling in China. It is necessary for China to increase the emphasis on the probability to implement such payment system. Accordingly, we conduct a survey about household willingness to pay for e-waste recycling. It is shown that only 22.57% of respondents said they were willing to afford the e-waste recycling payment; most respondents (54.23%) said that they would accept only if there are mandatory laws or regularities. And as seen in Fig. 3, there are no significant differences in the willingness to afford the payment between rich residents and poor residents (Pearson Chi-square = 10.544, Sig. = 0.229).

As for the preference payment style of e-waste recycling fee, two critical facets have to be considered: the time to pay and the amount of payment (Forslind, 2009). There are three common payment styles in terms of payment time: (1) Pay in advance: paying when purchasing the product with the payment embedded in the product price; (2) Pay afterward: pay when the product is asked for disposal; (3) Deposit system: the consumers defray the deposit when purchasing the product and return a certain proportion of money when hand in your e-waste product in accordance with the provisions. Most respondents (50.62%) prefer the first style since it is convenient for consumers to carry out e-waste recycling. The deposit system style is not widely accepted as expected, which might be largely accounted for the complicated process of the system. Furthermore, according to the amount of payment is given four kinds of recovery styles: sell to second hand markets (least costly); sell to peddlers; deliver to the specialized recovery spots; ask the specialized collectors to reclaim on site with certain payment

Table 2
Variables included in the analysis: definitions and statistics.

variables	Scale	*N*	Mean	S.D.
Dependent variable				
Recycling behavior(R)	0 = participate in recycling, 1 = not participate in recycling	951	0.42	0.495
Independent variables				
Residential condition(x_1)	1 = rent for temporarily living, 2 = rent for long living, 3 = owned a house, 4 = own more than one house	951	1.77	0.971
Family population(x_2)	1 = one, 2 = two, 3 = three, 4 = more than three	954	2.97	0.778
Income level(x_3)	1 = less than 1000RMB per month, 2 = 1000 to 2000RMB per month, 3 = 2000 to 3000 RMB per month,4 = 3000 to 4000 RMB per month,5 = more than 4000RMB per month	951	2.86	1.198
Education level(x_4)	0 = no college education member in the family, 1 = the ratio of college education member between 0 and 0.5, 2 = the ratio of college education member between 0.5 and 1.	942	0.85	0.744
Engel's coefficient(x_5)	Actual value	843	0.60	0.171
Recycling habit(x_6)	0 = used to recycling, 1 = not participate in recycling before	957	0.18	0.386
Convenience of recycling facilities and service(x_7)	0 = Inconvenient, 1 = a little convenient 2 = very convenient	957	1.60	0.601
Laws and regularities(x_8)	0 = clearly known, 1 = unknown	957	0.48	0.500
Environmental awareness(x_9)	1 = low, 2 = media, 3 = high	957	1.48	0.730
Economic benefits(x_{10})	0 = not important, 1 = no matter, 2 = important	948	1.31	0.641

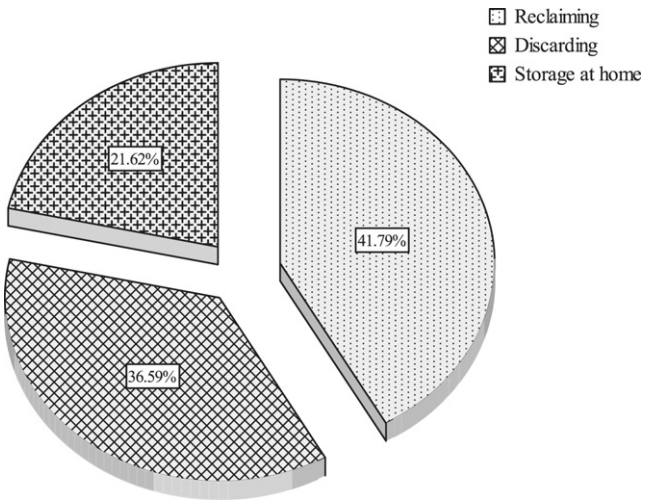

Fig. 2. The disposal status of residents' e-waste in Beijing in samples (piece, %).

(most costly). We conduct a crosstab analysis between the payment style and recovery style, and find that there are some relationships for residents' attitudes towards these two styles (Pearson Chi-square = 324.377, Sig. = 0.000). The respondents who would like to pay in advance largely prefer to dispose the e-waste in their comfortable ways. As they had taken the disposal charge, they believe that they have the right to deal with the e-waste as they like. Most of them would like to sell their e-wastes to the second market (58.59%) or the peddlers (11.36%) to get some economic benefits. Only 12.6% of respondents select to deliver the e-wastes to recovery spots. While the respondents who prefer to pay afterward hold more responsibilities to deliver the e-wastes to recovery spots. And for respondents who select the deposit system might more willing to ask the specialized collectors to reclaim on site with certain payment (Fig. 4).

Above all, two factors put vital impact on the preference of recycling style: economic benefits and convenience. As shown in Fig. 4, only a few respondents (7.63%) would like to select peddlers as their recovery style, since the inappropriate disposal by peddlers may cause heavy environmental burden. But reclaiming by peddlers is still the main channels for e-waste recycling in Beijing, because the price they offered is higher and their onsite service is convenient. It is necessary to implement the license system to restrain the environmental threat e-waste reclaiming channels. And based on this, centralized recycling pattern by professional recovery spots would

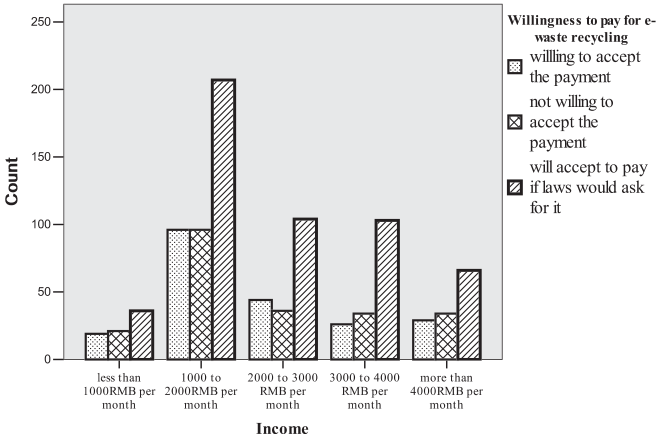

Fig. 3. Crosstabs analysis between income and willingness to pay for recycling (pieces).

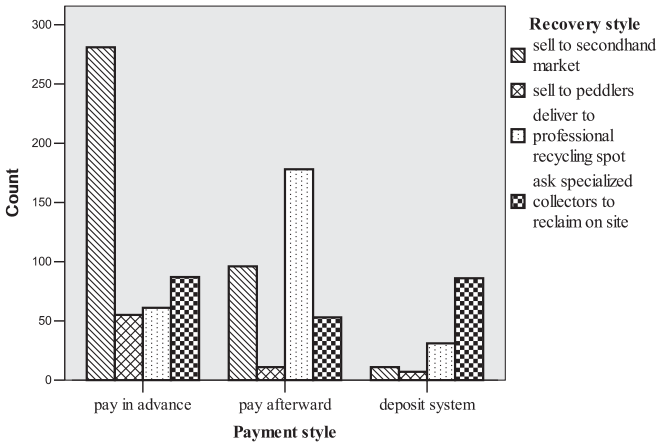

Fig. 4. Crosstabs analysis between payment style and recovery style (pieces).

have a broad prospect as its low economic benefits and environmental friendly operation. Moreover, the auxiliary convenient services and various reclaiming channels are inevitable.

5.2. Influence factors of residents' behavior in waste recycling based on logistic regression

Logistic regression as shown in Section 4.2 is introduced to explore the influence factors towards residents' willingness and behavior in waste recycling in Beijing. For the questionnaire investigation during the choice of the survey location does not meet the conditions of random sampling, the "location" was introduced in the regression as control variable which was defined as follows: 1-Xicheng, 2-Dongcheng, 3-Chaoyang, 4-Haidian, 5-Xuanwu and Chongwen. The instrument software for logistic regression was SPSS13.0. According to Hosmer and Lemeshow test, Sig = 0.521 > 0.05, which means the regression model is well fitted. The total sound judgment of the model was 74.3%, and the correct rate of judging the residents participated in recycling was 84.6% while the correct rate of judging the residents not participate in recycling was 63.1%.

The logistic regression results after iterated operation were shown in Table 3. It is indicated that *Residential condition, Recycling habits, Economic benefits* are statistically significant at the 5% significant level, and *convenience of recycling facilities and service* is significant as well at the 10% significant level. Moreover, the coefficient of *Residential properties* and *Recycling habits* are positive, while the coefficient of *Convenience of recycling facilities and service* and *Economic benefits* are

Table 3
Logistic regression results in SPSS ($N = 942$, $N' = 957$).

Variables	B	S.E.	Wald	df	Sig.
Residential condition(x_1)	0.469	0.152	9.496	1	0.002**
family population(x_2)	0.126	0.183	0.479	1	0.489
Income level(x_3)	0.169	0.151	1.240	1	0.265
Education level(x_4)	0.282	0.212	1.769	1	0.184
Laws and regularities(x_8)	0.161	0.281	0.325	1	0.568
Recycling habit(x_6)	1.551	0.382	16.481	1	0.000**
Convenience of recycling facilities and service(x_7)	−0.427	0.250	2.922	1	0.087*
Environmental awareness(x_9)	−0.187	0.196	0.906	1	0.341
Economic benefits(x_{10})	−0.480	0.231	4.332	1	0.037**
Location			34.398	4	0.000**
location = 1(Xicheng)	1.904	0.526	13.114	1	0.000**
location = 2(Docheng)	−0.153	0.506	0.091	1	0.763
location = 3(Chaoyang)	0.419	0.510	0.677	1	0.411
location = 4(Haidian)	1.896	0.393	23.229	1	0.000**
Constant	−1.823	0.930	3.841	1	0.050**

*denotes significant at 10% level; ** denotes significant at 5% level.

negative. Other variables such as *law, environment awareness, education* and *income* are not statistically significant. After introducing the *Engel's coefficient* into the regression, the total correct judgment decreased to 70.1% and *Engel's coefficient* is also not statistical significant.

From the perspective of influence power, *Recycling habit* plays the main role in residents' willingness in e-waste recycling compared with other three factors ($B = 1.551$). Once there are 1% changes in *Recycling habit*, proportional odds of logistic model would change 4.72%. And the results also show that the effects of *Residential condition, Economic benefits*, *Convenience of recycling facilities and service* have few disparities with each other. Because the absolute estimates of those three parameters are more or less the same ($B = 0.496$, -0.480, -0.427 respectively).

It is also indicated that there are regional disparities on the residents' e-waste recycling behavior in Beijing as the variable of *Location* is also statistically significant at 5% level in logistic regression. Specifically, residents living in Haidian and Xicheng are more willing to participate in e-waste recycling compared with those living in other districts, as *location = Xicheng and location = Haidian* are statistic significant at 5% level when *location = Xuanwu and Chongwen* is considered as reference item. This might be largely attributed to different e-waste disposal situations in each district. Haidian and Xicheng are both located in northwest of Beijing, with the largest electrical and electronic product markets (e.g. Zhongguancun electronic city) in Beijing. As a result, there are more e-products demand and e-waste generation than other districts. Besides, after-sale services for e-product repairing and e-waste recycling are also more prosperous here. Residents might feel more convience for their e-waste recycling.

6. Discussion

This study indicates that the willingness of Beijing residents to participate in e-waste recycling still at a lower level compared with western developed countries. According to the research, about 63.21% of e-wastes which the respondents hold were not flow to the proper recovery channel. There might be many reasons for this status, which *Recycling habit*, *Economic benefits, Convenience of recycling facilities and service and Residential condition* are four main factors verified by this study.

It is shown that *Recycling habit* plays the most significant role in Beijing residents' e-waste recycling behavior. This supports the hypothesis that the recycling habits have residual effect on residents' e-waste recycling in Beijing. Moreover, adopting recycling habits should be considered as an indispensible task for long-term construction of e-waste management system. And recycling habit training might much focus on the education from the child.

Residents in Beijing also pay close attention to economic benefits when dispose their e-wastes. It is accustomed for them to sell their e-waste to the peddlers for certain rewards, which are usually much more frequent than delivering to the professional recovery spot. As a result, the payment for e-waste recycling is hard for residents to accept according to our research. Only 22.57% of respondents indicate they would accept the payment. However, many respondents (54.23%) said they would take the charge if laws or regulations ask for the payment. It implies that the implement of recycling payment should be with the help of compulsive regulations.

Convenience of recycling facilities and service is a vital guarantee for residents' effective e-waste recycling. The recycling infrastructure and facilities are inadequate in Beijing, and there are few professional collectors providing recycling services on the spot. These bring some barriers for residents to participate in e-waste recycling. According to the research, 60% of respondents who did not participate in recycling think that it is troublesome and time-wasting for e-waste recycling; and 58.31% of respondents indicated that they would like to take part in e-waste recycling but limited to the quantities of professional recovery spots.

Besides, residential condition also attaches great importance to residents' recycling behavior. The people who rent the house for living are more willing to participate in e-waste recycling compared with the people owned a house themselves, which might be because the people with a house has more space to store the no-longer-in-use electrical products. It is implied that the layout of recovery spot should take the residential condition into account. If the houses in the residential area are mainly for rent or the house area is relatively small, more or large scale recovery spots might be needed here.

Many scholars believed that income and education level have positive relationship with the willingness of residents in e-waste recycling (Hornik et al., 2005; Hansmann et al., 2006; Tonglet et al., 2004). However, the two factors are not statistical significant according to our research. Moreover, *Engel's coefficient is* not significant as well. It is implies that there are not obvious distinct between rich families and relatively poor families in the e-waste recycling behavior in Beijing. Besides, education level is not one of the main reasons for residents' poor performance in e-waste recycling in Beijing as well.

Research by Nnorom in 2009 showed that general awareness of environmental issues has direct influence on residents' willingness in e-waste recycling (Nnorom, 2009). While the result of our study indicates that environmental awareness has not visible effect on the willingness in e-waste recycling for Beijing people. 85.89% of respondents showed their awareness of deteriorating environmental effect of inappropriately disposal of e-waste; however, only 41.79% of e-wastes were reclaimed by various channels (including some illegal recovery paths). It implies that environmental awareness is not equal to the willingness to participate in environment protected activities. It is important to improve the recycling facilities and ancillary services to erect a bridge between environment awareness and e-waste recycling behavior, which might be much helpful to change the awareness of e-waste recycling necessity into recycling behavior more availability.

In Beijing, *Law* has not been a determinant factor constrained the residents' e-waste recycling behavior effectively. For one thing, the laws towards e-waste recycling are imperfect, and the responsibilities for residents in e-waste recycling are not strictly identified. For another, law awareness of residents in Beijing is at a low level. A large number of residents (47.96%) have no idea about the e-waste disposal regulations in China. Educating consumers more information about e-wasting recycling laws is a vital work towards e-waste disposal.

7. Conclusion

The result of this study shows that a significant proportion of residents in Beijing are still not very willing to participate in e-waste recycling. Consequently, some e-waste recycling policies when introduced are uneasily accepted by the local residents. It is indicated that taking charge of certain proportion of cost in e-waste recycling is difficult to be accepted for a large number of residents in Beijing. And most residents prefer the e-waste could be reclaimed on the spot, which made reclaimed by peddlers become the most common recycling pattern in Beijing. Centralized recycling pattern by professional recovery spots would have a broad prospect if various kinds of channels can be provided to make the residents feel more convenient in e-waste recycling.

Besides, this survey research also verifies that *Convenience of recycling facilities and service, Residential conditions, Recycling habits* and *Economic benefits* are four determinants of Beijing residents' willingness and behavior in e-waste recycling. The establishment

and implementation of effective e-waste reuse and recycle management system should depend largely on those determinants.

The local government of Beijing has been aware of the deteriorating e-waste recycled condition and is actively doing much effect to curb the further deterioration such as the "Discarded appliances Demonstration Project". However, more works should focus on promoting residents' willingness in e-waste recycling. According to this study, activating household willingness in e-waste recycling should be largely dependent on improving management system on e-waste recycling on the one hand and strengthening household e-waste recycling habits training on the other. In light with the inconvenient reclaiming channels and poor recycling services in Beijing, the construction and improvement of e-waste recycling infrastructure should be highlight on the first step as the foundation work for the e-waste management system. Based on this, compulsive e-waste recycling and effective monitoring system could be tentative implemented. Because high penalties for inappropriate disposal of e-waste might force residents participate in e-waste recycling more vigorously. Besides, price incentives and subsidies should primarily be regarded as complements in the e-waste management system. Moreover, although most residents in Beijing are aware the hazards of e-waste to environment, there is a need for educational campaigns to promulgate the proper methods to recycle and reuse the e-waste for the residents. And it is necessary to enrich elementary education in environmental protection and resource conservation to foster the e-waste recycling habits from the child.

Acknowledgements

This study is supported by the Program for New Century Excellent Talents in University (Project no. NCET-10-0048), the Fok Ying Tung Education Foundation(Project no. 121079), National Science Foundation of China (Project no. 70773008, 70602021), the 3rd Period of "State 211 Project" (Project no. 73300004) and Nature Science Foundation of Beijing (Project no. 9092015). The authors also want to thank the two anonymous reviewers for their comments and suggestions.

References

Azjen, I., 1985. From intentions to actions: a theory of planned behavior. In: Kuhl, J., Beckmann, J.F. (Eds.), Action Control: from Cognition to Behavior. Springer Verlag, New York.

Berglund, Christer, 2006. The assessment of households' recycling costs: the role of personal motives. Ecological Economics 56, 560–569.

Boldero, J., 1995. The prediction of household acterising participants in activities protecting recycling of newspapers: the role of attitudes, intentions and situational factors. Journal of Applied Social Psychology 25, 440–462.

Borsch-Supan, A., 1990. On the compatibility of nested logit models with utility maximization. Journal of Econometrics 43 (3), 373–388.

Darby, Lauren, Obara, Louise, 2005. Household recycling behaviour and attitudes towards the disposal of small electrical and electronic equipment. Resources, Conservation and Recycling 44, 17–35.

Davis, Georgina, Phillips, Paul S., Read, Adam D., Iida, Yuki, 2006. Demonstrating the need for the development of internal research capacity: understanding recycling participation using the theory of planned behaviour in west Oxfordshire, UK. Resources, Conservation and Recycling 46, 115–127.

Fleckinger, Pierre, Glachant, Matthieu, 2010. The organization of extended producer responsibility in waste policy with product differentiation. Journal of Environmental Economics and Management 59 (1), 57–66.

Forslind, K.H., 2009. Does the financing of extended producer responsibility influence economic growth? Journal of Cleaner Production 17, 297–302.

Goldenhar, L.M., Connell, C.M., 1993. Understanding and predicting recycling behavior: an application of the theory of reasoned action. Journal of Environmental Systems 22, 9–103.

Guagnano, G.A., Stern, P.C., Dietz, T., 1995. Influences on attitude-behavior relationships: a natural experiment with curbside recycling. Environment and Behavior 27, 699–718.

Guerin, Daniel, Crete, Jean, Mercier, Jean, 2001. A Multilevel analysis of the determinants of recycling behavior in the European countries. Social Science Research 30, 195–218.

Hage, Olle, Söderholm, Patrik, Berglund, Christer, 2009. Norms and economic motivation in household recycling: empirical evidence from Sweden. Resources, Conservation and Recycling 53 (3), 155–165.

Hansmann, Ralf, Bernasconi, Petra, Smieszek, Timo, Loukopoulos, Peter, Scholz, Roland W., 2006. Justifications and self-organization as determinants of recycling behavior: the case of used batteries. Resources, Conservation and Recycling 47, 133–159.

Hicks, C., Dietmar, R., Eugster, M., 2005. The recycling and disposal of electrical and electronic waste in China—legislative and market responses. Environmental Impact Assessment Review 25 (5), 459–471.

Hornik, Jacob, Cherian, Joseph, Madansky, Michelle, Narayana, Chem, 2005. Determinants of recycling behavior: a synthesis of research results. The Journal of Socio-Economics 24 (1), 105–127.

Jackson, A.L., Olsen, J.E., Granzin, K.L., Burns, A.C., 1993. An investigation of the determinants of recycling consumer behavior. Advances in Consumer Behavior 20, 481–487.

Jofre, S., Morioka, T., 2005. Waste management of electronic equipment: comparative analysis of end-of-life strategies. Journal of Material Cycles and Waste Management 7 (1), 24–32.

Jones, R.E., 1990. Understanding paper recycling in an institutionally supportive setting: an application of the theory of reasoned action. Journal of Environmental Systems 19, 307–321.

Lin, Catherine K, Yan, Linan, Davis, Andrew N., 2002. Globalization, Extended producer responsibility and the problem of discarded computers in China: an exploratory proposal for environmental protection. Georgetown International Environmental Law Review, 525–579 [M].

Lindhqvist, T., 1992. Towards an Extended Producer Responsibility-Analysis of experiences and proposals. Ministry of the Environment and Natural Resources, Stockholm.

McCarty, J.A., Shrum, L.J., 1994. The recycling of solid wastes: personal values, value orientations, and attitudes as antecedents of recycling behavior. Journal of Business Research 30, 53–62.

Milanez, Bruno, Bührs, Ton, 2009. Extended producer responsibility in Brazil: the case of tyre waste. Journal of Cleaner Production 17 (6), 608–615.

Mo, Hongpin, Wen, Zongguo, Chen, Jining, 2009. China's recyclable resources recycling system and policy: a case study in Suzhou. Resources, Conservation and Recycling 53 (7), 409–419.

National Development and Reform Commission, 2008. Management and countermeasures of waste resource in China. Environmental resources Comprehensive Utilization Department of national development and Reform Commission of China.

Nnorom, I.C., 2009. Survey of willingness of residents to participate in electronic waste recycling in Nigeria – A case study of mobile phone recycling. Journal of Cleaner Production 17, 1629–1637.

Ojeda-Benıtez, S., Vega, C.A., Marquez-Montenegro, M.Y., 2008. Household solid waste characterization by family socioeconomic profile as unit of analysis. Resources, Conservation and Recycling 52, 992–995.

Oskamp, S., Harrington, M.J., Edwards, T.C., Sherwood, D.L., Okuda, S.M., Swanson, D.C., 1991. Factors influencing household recycling behavior. Environment and Behavior 23, 494–519.

Ravi, V., 2005. Analyzing alternatives in reverse logistics for end-of-life computers: ANP and balanced scorecard approach. Computers and Industrial Engineering 48, 327–356.

Saphores, J-D, Nixon, H, Ogunseitan, O.A, Shapiro, A.A., 2006. Household willingness to recycle electronic waste–an application to California University of California post prints year 2006 paper 1165.

Sidique, Shaufique F., Lupi, Frank, Joshi, Satish V., 2010. The effects of behavior and attitudes on drop-off recycling activities. Resources, Conservation and Recycling 54 (3), 163–170.

Tonglet, Michele, Phillips, Paul S., Read, Adam D., 2004. Using the theory of planned behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK. Resources, Conservation and Recycling 41, 191–214.

Tucker, P., Lewis, K.A., 1993. Process simulation for waste management. In: Proceedings of Seminar 'Waste: Handling, Processing and Recycling'. Institute of Mechanical Engineering, London, pp. 47–54.

Tucker, Peter, Murney, Grant, Lamont, Jacqueline, 1998. Predicting recycling scheme performance: a process simulation approach. Journal of Environmental Management 53, 31–48.

Van Beukering, P.J.H., van den Bergh, J.C.J.M., 2006. Modeling and analysis of international recycling between developed and developing countries. Resources, Conservation and Recycling 46, 1–26.

Wang, Jichuan, 2001. Logistic Regression Models: Methods and Application. Higher Education Press. 1:17.

Yang, Jianxin, Lu, Bin, 2008. WEEE flow and mitigating measures in China. Waste Management 28, 1589–1597.

Zhao, W., Leeftink, R.B., Rotter, V.S., 2010. Evaluation of the economic feasibility for the recycling of construction and demolition waste in China—the case of Chongqing. Resources, Conservation and Recycling 54 (6), 377–389.