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Informal recycling and social preferences: Evidence from household survey data in Vietnam

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Informal recycling and social preferences: Evidence from household survey data in Vietnam

Highlights

- We assess private provision of environmental public goods in a developing country.
- Household recycling in Vietnam is empirically analyzed using household survey data.
- Majority of sample households recycle even though such recycling is not obligatory.
- Altruistic households recycle more at any income level.
- Inequality averse households recycle more among the rich.

Abstract:

This study examines the association between social preferences and recycling behavior in a developing country. A conceptual framework that modifies the impure altruism model with heterogeneous preferences and further incorporates the impure public good model is presented to study informal recycling behaviors. Based on survey data collected from 755 households in Hanoi, Vietnam, we find that the majority of sample households recycle all the recyclable materials they consume even though such recycling is not obligatory. Half the recycling households sell their

recyclables to informal junk buyers, whereas the other half provide recyclables without monetary compensation. Our finding of voluntary recycling implies that a certain proportion of households have a positive marginal willingness to pay for an increase in the environmental public good. The results of the regression analyses show that recycling behavior is associated with altruism, as measured by a modified version of the self-report altruism scale. Among high-income households, recycling behavior is associated with inequality aversion, as elicited from a hypothetical game. These findings suggest that social preferences are important determinants of the private provision of public goods through the informal sector in a developing country.

Keywords: Altruism; Household recycling; Inequality aversion; Informal sector; Private provision of a public good; Solid waste

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1. Introduction

Households can privately provide public goods through their daily activities such as participating in green-electricity programs (Kotchen, 2006) and recycling at home (Brekke et al., 2003). The private provision of public goods is particularly important in developing countries where environmental quality is poor. One reason is that the collection of taxes in developing countries is difficult (Besley and Persson, 2013), which raises the costs of public-good provision by governments. Owing to their limited budgets, governments in developing countries thus often try to promote the private provision of public goods.

Empirical studies of households' private provision of environmental public goods in the developed world are widespread. One strand of this literature attempts to estimate the willingness

to pay (WTP) for green products or programs, while the other analyzes the determinants of private provision. An example of the latter body of research is Kotchen and Moore (2007), who study the factors that influence household decisions to participate in green-electricity programs in the United States and find that environmental concerns and altruistic attitudes are important determinants. However, while previous studies focus on the developed world, little investigation has been carried out on the private provision of environmental public goods in the developing world, especially quantitative analyses using household survey data. The present study aims to bridge this gap in the literature.

Waste management has recently emerged as an important issue in the developing world as an increasing amount of goods is consumed in the rapidly growing economies. The volume of waste has sharply risen, and the environmental burden is expected to increase. According to Hoornweg and Bhada-Tata (2012), the amount of solid waste in the world's cities is expected to increase from 1.3 billion tonnes in 2010 to 2.2 billion tonnes by 2025, and the annual solid waste management cost is expected to increase from 205.4 billion USD to 375.5 billion USD in the corresponding period. In particular, solid waste in the developing countries will dramatically increase as the share of global solid waste from non-OECD countries is projected to increase from 55.7% in 2010 to 71.3% in 2025.

Households can help reduce the social cost of solid waste management, conserve natural resources, and save governmental expenses by participating in recycling activities at home. In contrast to most developed countries, which implement policies such as recycling mandates and/or curbside recycling, however, no such recycling programs exist in developing countries. Nonetheless, the absence of government policies does not necessarily mean that households do not recycle. A number of studies have reported on the business of so-called "junk buyers" in developing countries

(e.g., Hayami et al., 2006). Junk buyers are informal waste collectors who visit door-to-door, collecting specific recyclable materials from households, which they then buy or barter (Wilson et al., 2009). This business is widespread across the developing world,[1] including urban areas of Vietnam, the setting of the present research.

This study uses original survey data collected from 755 households in four central districts of Hanoi, Vietnam, to study behavioral factors that influence household recycling through the informal sector in a developing country.[2] From our survey, it is shown that more than 80% of households in Hanoi recycle at least one recyclable material despite the lack of recycling policy. More surprisingly, among those households recycling, around half supply recyclable materials without receiving monetary compensation. This result implies that a certain proportion of households do not receive any revenue from junk buyers; instead, they are happy to separate, store, and provide recyclable waste free of charge, just as a donation.

In addition to the variables collected in existing studies on household recycling (Jenkins et al., 2003; Viscusi et al., 2011), two social preference variables are elicited in our survey: degree of altruism, from the psychological framework developed by Rushton et al. (1981), and inequality aversion, from the hypothetical game proposed by Engelmann and Strobel (2004). Our regression analyses show that informal recycling in Vietnam is associated with the altruism scale. Furthermore,

[1] Previous studies of junk buying have documented such behavior in Mexico (Ojeda-Benitez et al., 2002), India (Hayami et al., 2006), China (Li, 2002), Nigeria (Wilson et al., 2009), Indonesia (Sembiring and Nitivattananon, 2010), Pakistan (Asim et al., 2012), and Vietnam (Kawai et al., 2012). Several of these studies use the term "itinerant waste buyers/pickers" instead of junk buyers.

[2] A large body of the literature in economics studies the informal sector both theoretically and empirically. Examples for the theoretical literature include Albrecht et al. (2009) and Baksi and Bose (2016). Schneider and Enste (2000) provide estimates for the size of the informal sector for a large number of countries.

we find that inequality averse households are more likely to recycle if they are relatively rich, suggesting that people believe that informal recycling by high-income households reduces inequality between themselves and the relatively poor.

The remainder of this paper is organized as follows. Section 2 provides a brief review of the literature to show the contributions of this study within the relevant context. Section 3 presents the conceptual framework of this study. Section 4 describes our study site and data collection, and Section 5 presents the descriptive statistics. The empirical specifications and main results on the determinants of recycling are presented in Section 6, followed by the results on the determinants of giving and selling. Section 7 summarizes our findings and discusses the implications for future studies.

2. Previous Research

This study contributes to the literature on the economics of household recycling (e.g., Hong et al., 1993; Fullerton and Kinnaman, 1996; Jenkins et al., 2003; Ando and Gosselin, 2005; Ferrara and Missios, 2005; Kipperberg, 2007; Halvorsen, 2008; Viscusi et al., 2011).[3] Recent empirical studies focus on behavioral factors such as social and moral norms. Halvorsen (2008) is the first to attempt to empirically examine the effects of social and moral norms on recycling, using a household survey conducted in Norway. Halvorsen (2008) asks respondents whether they recycle because they

[3] The empirical literature on recycling using household-level datasets dates to Hong et al. (1993), who collect data on the frequency of households' participation in recycling activities in the United States and examine the effect of disposal fees and socioeconomic factors. The most comprehensive and detailed analysis is conducted by Jenkins et al. (2003), who use a unique dataset of 20 metropolitan statistical areas in the United States and find that curbside recycling programs significantly increase recycling, whereas unit pricing programs do not. Kinnaman (2006, 2016) and Viscusi et al. (2012) provide reviews of this strand of the literature.

consider themselves to be responsible and finds a positive association between this self-image of responsibility and recycling. Brekke et al. (2010) investigate the association between perceived responsibility, certainty about one's belief about others' behavior, and household glass recycling, using data from a survey conducted in Norway. Viscusi et al. (2011), in their seminal work, survey 608 households across the United States to examine the extent to which social norms influence the recycling of plastic bottles, but find no significant impact.[4]

All the above studies on household recycling focus on developed countries, but research on developing countries is surprisingly limited. An exception is Chong et al. (2015), who conduct randomized field experiments by using a flier with messages to promote household recycling in Peru. The results show that messages that encourage recycling in developed countries are ineffective. This finding suggests that developing countries, given their different norms and attitudes compared with developed countries, need a different strategy to encourage recycling. While Chong et al. (2015) try and fail to change non-recyclers into recyclers, the present study aims to explain the difference between existing non-recyclers and recyclers, using a detailed survey, following studies of developed countries (Halvorsen, 2008; Viscusi et al., 2011).

Theoretical studies consider household recycling to be the private provision of a public good. For example, Brekke et al. (2003) and Bruvoll and Nyborg (2004) present the moral motivation model to study intrinsic motivation for recycling, which is modeled as the private provision of pure public goods. Building on this, our study presents a simple framework that modifies the impure

[4] Relatedly, Czajkowski et al. (2017) conduct a choice experiment in Poland to study why some people prefer at-home recycling compared with recycling in a central sorting facility. They find that the WTP to sort at home is associated with moral or intrinsic norms.

altruism model of Andreoni (1989, 1990) and incorporates the impure public good model of Cornes and Sandler (1984) to show that informal recycling in Vietnam can be interpreted as the private provision of public goods.[5] Thus, this study extends the empirical literature on the determinants of the private provision of environmental public goods (e.g., Kotchen and Moore, 2007; Jacobsen et al., 2012; Mitra and Moore, 2017) to obtain evidence in the developing world.[6] As is found in the United States by Kotchen and Moore (2007), our analyses show that social preferences are important determinants of the private provision of public goods, even in Vietnam. As a result, this study relates to the emerging literature on behavioral environmental economics (for reviews, see Carlsson and Johansson-Stenman, 2012; Croson and Treich, 2014; Shogren and Taylor, 2008).

Furthermore, this study provides evidence of voluntary recycling by a certain proportion of households (more than 30% of sample households consuming recyclables), which can be interpreted as a positive marginal WTP for an increase in the total amount of the environmental public good provided privately through the informal sector. Unlike previous studies of the informal sector in a developing country that examine its external costs (e.g., Blackman and Bannister, 1998; Baksi and Bose, 2016), our finding implies an external benefit.

[5] Viscusi et al. (2011) and Viscusi et al. (2013) also discuss the association between warm-glow and recycling. Relatedly, Abbott et al. (2013) examine the association between recycling volume and a measure of curbside quality (defined as the ratio of recycling capacity to the length of time between collections), using a panel dataset of 317 English local authorities. They consider that the warm-glow is present if a rise in the quality of curbside provision increases recycling volume. The association between altruism and recycling was originally discussed by psychologists (e.g., Hopper and Nielsen, 1991); however, little attention has been paid to formally examine this linkage.

[6] This study also relates to a field that is emerging at the intersection of environmental and development economics (for a review, see Vincent, 2010; Greenstone and Jack, 2015). Several studies attempt to develop revealed preference estimates of marginal WTP associated with changes in environmental quality. Most recent studies in this strand examine health-related self-protection behavior and emphasize that the marginal WTP for environmental quality improvements is substantially low in the developing world (e.g., Kremer et al., 2011). In contrast to previous research, the present study examines the private provision of an environmental public good.

3. Conceptual framework

In the urban areas of Vietnam, including Hanoi, households can dispose of their solid waste to municipal collectors without recycling. At the same time, however, they have the option to separately store and provide (either sell or give) recyclable waste to informal collectors.[7]

The impure altruism model developed by Andreoni (1989, 1990) is modified to model recycling behaviors in Hanoi. Consider a society that consists of N households with heterogeneous preferences.[8] Household *i* manages an amount of recyclable waste, $W_i > 0$, which generates a negative externality. For simplicity, W_i is assumed to be exogenously given.[9] There are three possible options to manage W_i: dispose into the garbage without separating from other waste, denoted by $d_i \geq 0$; recycle by separately storing recyclables and selling them to waste collectors, denoted by $s_i \geq 0$; and recycle by giving, denoted by $g_i \geq 0$. We denote household *i*'s supply of waste for recycling as $r_i = s_i + g_i$.

Following Brekke et al. (2003) and Bruvoll and Nyborg (2004), we model recycling behaviors as a choice between leisure and time spent in contributing to the provision of the public good. Let the utility function of household *i* be

$$U_i = U(c_i, l_i, R, g_i;\ \theta),$$

where c_i is household *i*'s consumption of a private good, $l_i \geq 0$ is leisure, and θ is a vector of the taste parameters that characterize heterogeneous preferences. The sum of recyclables collected for

[7] In this study, informal waste collectors include all those who collect recyclables from households, such as junk buyers, street waste pickers, and others.

[8] See Andreoni (1988) for the model of the private provision of pure public goods with heterogeneous preferences and Kotchen and Moore (2007) for the model of the private provision of impure public goods with heterogeneous preferences. More recently, Jacobsen et al. (2017) study the first- and second-best environmental policy instruments by using a model of the private provision of a public good with heterogeneous preferences and costs of provision.

[9] Viscusi et al. (2013) also make this assumption and provide its conceptual underpinning. This assumption is easily relaxed by, for example, making W_i a function of the consumption of private good c_i. If we make this extension, the model captures the impact of selling recyclables, which leads to an increase in revenue, c_i and $W_i(c_i)$, and finally decreases leisure. However, this extension would not alter the discussions below.

recycling in the society, which can be written as $R = \sum_{j=1}^{N} r_j$, is considered to be the total provision of the public good. The utility function of households is assumed to be continuous and strictly quasi-concave. The fourth argument in the utility function reflects households' utility gain from the amount they donate (i.e., warm-glow).

The amount of waste managed by each option is determined by the time spent on option t_x, where $\frac{\partial x}{\partial t_x} > 0$ for $x = d, s, g$. Assume that one unit of a recyclable can be sold to waste collectors at a given price, $p > 0$. Then, the household maximizes the above utility function subject to the constraints below:

$$I_i + ps_i = c_i, \qquad l_i + t_d(d_i) + t_s(s_i) + t_g(g_i) = T, \qquad d_i + s_i + g_i = W_i,$$

where I_i is the exogenously given income level other than revenues from selling recyclable waste (ps_i) and the price of private goods is normalized to one. T is the exogenous total time constraint minus exogenous labor supply. This assumption, which is also made in previous studies, implies that the model focuses on the allocation of time between leisure and recycling behaviors, while disregarding any effects disposal choices may have on labor supply (Bruvoll and Nyborg, 2004). Unlike the models by Brekke et al. (2003) and Bruvoll and Nyborg (2004), however, our model considers the effect of disposal choices on pecuniary income, which may be generated through recycling by selling (ps_i). We focus on the most likely and interesting case where recycling requires more time, $\frac{\partial t_d}{\partial d} < \frac{\partial t_x}{\partial x}$ for $x = s, g$. This assumption is discussed further in the next section.

Each household takes the contribution of all other households, denoted by $R_{-i} = \sum_{j \neq i} r_j = \sum_{j \neq i}(s_j + g_j)$, as exogenously given (the Nash assumption). By substituting $s_i = R - R_{-i} - g_i$ into the above and in turn substituting the constraints into the utility function, the maximization problem is equivalent to

$$\max_{R, g_i} U_i = U\big(I_i + p(R - R_{-i} - g_i), T - t_d(W_i - R + R_{-i}) - t_s(R - R_{-i} - g_i) - t_g(g_i), R, g_i;\ \theta\big).$$

(1)

Both g_i and r_i take values within $[0, W_i]$ owing to the non-negativity of d_i. For an interior solution, solving the first-order conditions of the problem (after suppressing the notation for $p, t_d, t_s, t_g,$ and T) yields a giving function that can be written as $g_i = g_i(I_i, W_i, R_{-i}; \theta)$ and a recycling function $R = f_i(I_i, W_i, R_{-i}; \theta)$ or, equivalently, $r_i = f_i(I_i, W_i, R_{-i}; \theta) - R_{-i}$.

The setup of this framework not only extends the impure altruism model but also possesses a property of the impure public good model developed by Cornes and Sandler (1984). The amount of recycling by selling s_i can be thought of as an impure public good since increasing it generates a public characteristic by raising R and a private characteristic by raising c_i.[10] The Cornes and Sandler (1984) model has been extended by Kotchen and Moore (2007) to include substitutes for the impure public good and heterogeneous preferences. Note that Kotchen and Moore (2007) discuss that if θ is defined such that greater values indicate a greater taste for a public good, then households with higher values of θ are more likely to contribute to the provision of a public good.

The present empirical study treats the two social preference variables examined herein as elements of θ and investigates the influence of θ on recycling behavior. Since we are interested in the amount of r_i after controlling for the impact of W_i, the share of recycled materials $\left(\frac{r_i}{W_i}\right)$ is used as the dependent variable in our main analysis. This leads us to undertake a similar approach to Jenkins et al. (2003) and Viscusi et al. (2011), who analyze proportions of materials recycled. Although the above setup assumes homogeneity in t_d, t_s, t_g, and T, this might not be the case in the

[10] Dubin and Navarro (1988) consider the waste collection services in the United States to be impure public goods. Kipperberg and Larson (2012) consider that recycling programs in the United States also have the feature of impure public goods. Mitra and Moore (2017) also develop the impure public good model with impure altruism to explain widespread participation in green-electricity programs with the all-or-nothing green tariff mechanism.

real world. To consider the possible heterogeneity of these factors, we collect and control for various socioeconomic variables in the regression analyses.

4. Study site and data collection

4.1. Study site

Our study site is Hanoi, the capital of Vietnam, where the amount of solid waste is increasing (Kawai and Tasaki, 2016). In the four central districts of Hanoi, municipal solid waste is collected by the Urban Environment Company (URENCO), entrusted by the city of Hanoi. URENCO collects all types of waste together, and households are not obligated to separate recyclable materials from other waste.

The majority of households dispose of their garbage directly to URENCO workers, who patrol the streets with handcarts once a day at a fixed time (usually from 5 p.m. to 9 p.m.). A smaller proportion of households have an easier option in that they can discard their waste in containers placed near housing complexes or along main streets; this garbage is also collected regularly by URENCO. Regardless of their method of disposal, households are levied a lump-sum tax for garbage collection. The tax is fixed at 3,000 VND per person per month, and the household tax amount depends solely on the number of household members. Therefore, households in Hanoi have no incentive to reduce their amounts of waste for tax-reduction purposes. Note that the average household size is 4.2 and the average household tax for waste management is 12,600 VND, which accounts for only 0.1% of average household income.[11]

Households in Hanoi also have the option to sell their recyclables to junk buyers—unskilled informal workers who collect recyclable materials to earn a living. The presence of junk buyers is reported in a number of developing countries (see note 1), and Vietnam is no exception. Junk buyers

[11] Note that 10,000 VND was equivalent to 0.47 USD as of October 2013.

collect or purchase recyclables such as paper, metals, plastics, and bottles from households and sell the collected materials to junk shops—small shops that purchase recyclables. Workers in junk shops sort the collected materials and sell each type of material (e.g., PET bottles) to a local trader specializing in a specific material. Local traders then transport the materials to a recycling manufacturer, which processes them into new products. Kawai et al. (2012) survey junk buyers and shops in Hanoi and find that junk buyers are responsible for the recycling of 8.8% of household waste by weight or 26% by volume, which would otherwise have ended up at a dumpsite.

From our survey in April 2013, there were 175 junk shops and 290 junk buyers in the four central districts of Hanoi. Households can call junk buyers from morning to evening; they can even make a phone call to ask that they come to their house at their convenience. The required effort for disposal is presumably lower than that for recycling $\left(\frac{\partial t_d}{\partial d} < \frac{\partial t_s}{\partial s} \text{ and } \frac{\partial t_d}{\partial d} < \frac{\partial t_g}{\partial g}\right)$ for most households since they have to dispose of waste other than recyclables (e.g., kitchen waste) every day, and thus, the additionally required effort might be negligible.

4.2. Data collection

Out of an average of 18 wards in each district, two wards were randomly selected in three of the four districts in central Hanoi. In the fourth district, Dong Da, which is larger in area, we selected three wards for our survey. Thus, our survey was conducted in nine wards in the four districts of central Hanoi.

In each selected ward, we held a meeting with the Ward People's Committee to obtain a permit to conduct the household survey. We conducted the survey in certain residential areas recommended by the Ward People's Committees. Admittedly, therefore, the selection of sample households in the nine wards was not random. In addition, our enumerators visited each household in the evening, without an appointment. Although evenings were chosen to maximize the number of household members present, some members were still unavailable. In those cases, the enumerator

visited the next-door neighbors until they found householders who were available. Unfortunately, we did not record how many or which households the enumerators visited (the number of such unavailable cases was reported by our enumerators to be about 10–15%). In 75.8% of our sample, respondents were interviewed in this manner (i.e., at their own houses). The remainder of the sample respondents from two wards were given questionnaires at a community meeting, which they self-completed. By using these procedures, we collected data from 755 households in October and November 2013.

Although sample households were not randomly selected, as noted above, we believe that they are representative of average households in central Hanoi to a reasonable degree. For example, according to the Vietnam Household Living Standards Survey (VHLSS) 2012, average household income in Hanoi is 12.1 million VND (General Statistics Office, 2012), which is similar to the average in our sample (12.2 million VND). Similarly, the average level of educational attainment in Hanoi in the VHLSS is close to our sample average.

In our interviews, we asked sample households if we could speak to the household member responsible for waste management. The interviews took an average 45 to 50 minutes. In 62.8% of the interviewed households, we were able to interview the person in charge of waste management. When this person was absent, we collected information from another household member who helped with waste management.[12] In our empirical analyses, the main results show data from all sample households; however, in Appendix A we also present the results where sample households were excluded if the respondent was not the person primarily responsible for waste management.

5. Descriptive statistics

[12] Some households (3.8% of our sample) employ a housekeeper (called an oshin), who lives in the same house. In these cases, while waste removal is managed by the oshin, we interviewed a household member who helps with waste management.

5.1. Household recycling behaviors

To analyze the recycling behaviors of sample households, we collected information on whether each household consumes and recycles the following nine materials: cardboard, newspapers, magazines, notebooks, printing paper, metals, glass bottles, PET bottles, and other plastic bottles. Table 1 shows the percentages of households that consume each of the nine materials as well as the percentages of those consuming households that recycle each of the recyclable materials. For example, 86% of sample households consume cardboard and 84.3% (donors of 38.1% plus sellers of 46.2%) of those households recycle it. If they do not recycle (15.7%), cardboard is disposed of to URENCO with other household waste. Overall, most households that consume each type of recyclable material recycle it; this is particularly true for paper products. Furthermore, more than half of households (53.4% of those consume at least one recyclable material) recycle all the recyclable materials they consume (not reported in the table). Therefore, Table 1 shows that despite the absence of a public recycling program, Vietnamese households recycle their recyclable materials and the majority of them even recycle enthusiastically. Note that biases may exist in self-report studies (e.g., social desirability bias). This study also possesses such a validity problem since it relies on self-reported data. However, our data are comparable to the objective measurement by Kawai et al. (2012).

We also collected information on whether households give or sell their recyclables. In most cases of selling, junk buyers purchase the recycled materials from households. In most cases of giving, junk buyers receive the recycled materials; however, URENCO workers do informally receive the recycled materials separately from other waste in some cases. Columns 3 and 4 of Table 1 show the share of the giving and selling of recycled materials. About half of recycling households give

away their recycled materials, and the other half sell them. While existing studies of waste collection markets in developing countries emphasize the role of economic incentives as the motivation of informal recycling, our study unmasks household recycling behaviors that are not driven by monetary compensation.

To analyze the determinants of household recycling behaviors, we use the share of recycled materials $y_i = \frac{r_i}{W_i}$ as the dependent variable. This share is computed by dividing the number of recycled materials by the number of materials consumed.[13] The share ranges from zero (no materials recycled) to one (all consumed recyclables recycled). This approach enables us to analyze the proportions of materials recycled, similar to Jenkins et al. (2003) and Viscusi et al. (2011), but for aggregate recyclable materials. Figure 1 shows the distribution of the share of recycled materials, which has a pileup at the value of one. When sample households recycle, they do so for all, or most, of the recyclables they consume. There is another smaller pileup at the value of zero, illustrating that a certain proportion of households do not recycle at all. Hence, Figure 1 shows that sample households can largely be divided into enthusiastic recyclers and non-recyclers, which is commonly observed in developed countries (e.g., Jenkins et al., 2003; Viscusi et al., 2011).

Panel A in Table 2 shows the recycling behaviors of sample households stratified by whether the share of recycled materials is equal to or larger than the share of unrecycled materials. A household that recycles equal to or more than half of the consumed materials ($y_i \geq 0.5$) is defined as a recycler, whereas a household that does not ($y_i < 0.5$) is a non-recycler. Among recyclers, we

[13] To conduct empirical analyses consistent with our conceptual framework, it is ideal to measure both the weight of recyclable waste generated (W_i) and supply of waste for recycling (r_i) for each household. However, it is costly to conduct this measurement for a large number of households. Kawai et al. (2012) survey 101 households in urban Hanoi and measure the weight and volume of both W_i and r_i. Their physical composition analysis shows that recyclable waste can be categorized into paper, plastic, glass, metal, rubber, and leather. Furthermore, they find that the average household supplies 58 g of r_i per person per day, where paper (48.3%), plastic (29.3%), and glass (12.1%) are the major components. According to these findings and to approximate the weights of W_i and r_i, we surveyed consumption and recycling behavior for the above nine materials. Paper and plastic products are counted five times and twice, respectively, which reflects the findings by Kawai et al. (2012). Note that the prices of these nine materials are different in junk shops.

define a household as a donor when more than half of the recycled materials are provided for free and as a seller when more than or equal to half of the recycled materials are sold.

Panel A in Table 2 shows that recyclers separate most recyclable materials from other waste (92.7%) and donors give away most of their recyclable materials (88.6%), whereas sellers sell most of theirs (86.6%). Hence, sample households tend not to mix their waste management methods. Donors provide recycled materials 1.82 times a month and sellers sell their recycled materials 1.77 times a month. Sellers receive 12,070 VND a month on average; this accounts for only 0.1% of the average household income of 12.1 million VND.

5.2. Households' social preferences

Following the literature on altruism and demand for environmental public goods (e.g., Kotchen and Moore, 2007; Lusk et al., 2007), psychometric scales are used to measure households' degree of altruism. One advantage of using a psychometric scale to measure altruism, instead of a dictator game with real money that is widely used in experimental economics, is that individuals can easily respond with little direction; as such, they are readily amenable to large-scale surveys (Lusk et al., 2007).

More specifically, this study adopts the self-report altruism (SRA) scale developed by Rushton et al. (1981) and subsequently applied to public and environmental economics by Eckel and Grossman (2003) and Loureiro and Loomis (2012), among others. The original SRA scale consists of 20 items developed for students in Canada. We modify the items to suit the Vietnamese population and reduce them to eight. The score of the SRA scale is computed on the basis of how frequently the respondent has engaged in the altruistic behaviors described in the eight items (see Appendix B). These eight items included, for example, "I have given directions to a stranger" and "I have donated goods or clothes to a charity." If the respondent chose "very often," we assigned a score of five and one for "never." We aggregated the scores for the eight items to construct a single altruism scale

ranging from 8 to 40. The greater the score, the more altruistic the respondent. Our interpretation of the SRA scale is that it captures both the pure and the impure altruistic attitudes of sample households. Figure 2 shows the distribution of the SRA scale, which seems normally distributed among sample households.

In addition to the altruism of households, our survey measured inequality aversion. Inequality aversion is understood as the disutility arising from the differences between one's own payoff and that of others (Engelmann and Strobel, 2004). It is often problematic to elicit social preferences by using a simple game, for example, that asks a subject to choose one society from two societies that differ in allocations. The reason is that the results of those games cannot distinguish inequality aversion from efficiency concerns or maximin preferences. Engelmann and Strobel (2004) propose a game that asks participants to choose one from three types of allocations instead of two. Their game thus allows us to disentangle inequality aversion from all selfishness, efficiency concerns, and maximin preferences. By adopting their game, the dummy variable of inequality aversion is created that took one if the respondent chose a society with an equal allocation in the hypothetical question presented in Appendix C.[14]

Panel B in Table 2 shows the differences in income, altruism scale, inequality aversion, and other characteristics among households that dispose of and recycle waste materials. Households that recycle have lower average income and are more altruistic than those that do not; these differences are statistically significant at the 10% level and 1% level, respectively. Among households that recycle, donors and sellers seem to have similar household incomes and degrees of altruism, suggesting that income and altruism influence the decision of whether to recycle, but not the

[14] Choosing a society with an equal allocation in the game presented by Engelmann and Strobel (2004) implies that a respondent not only averts inequality between oneself and a relatively poor person, but also strongly averts inequality between oneself and a relatively rich person. Therefore, the interpretation of the results of the regression analyses demands caution.

decision of whether to sell them or give them away. In the following sections, we formally analyze these observations by using regression analyses.

6. Econometric analyses of the determinants of recycling

6.1. Empirical specification

We use regression analyses to analyze the extent to which social preferences influence the recycling behaviors of sample households, controlling for the other characteristics presented in Panel B in Table 2. Our primary outcome variable, y_{wi}, is the share of recycled materials of household *i* in ward w. Although existing empirical studies adopt ordered logit models with dependent variables that take values in the range [0,1], such as the proportion of the material recycled (e.g., Jenkins et al., 2003; Viscusi et al., 2011), the choice of thresholds becomes arbitrary and may affect the results. Therefore, following Papke and Wooldridge (1996), we adopt a fractional response model, which does not impose thresholds in the estimation arbitrarily. Another candidate for the estimation is the two-limit Tobit model. Wooldridge (2010) suggests using the two-limit Tobit model only when we observe pileups at both endpoints with a continuous distribution in between. While our outcome variable shows a large pileup at the value of one, a pileup at the value of zero is not large and a distribution in between is not continuous (see Figure 1). Hence, our preferred specification is a fractional logit model and we estimate Equation (2) by adopting the Bernoulli quasi-maximum likelihood estimation:[15]

$$E(y_{wi}|SRA_{wi}, IA_{wi}, \boldsymbol{X}_{wi}) = G(\beta_0 + \beta_{SRA}SRA_{wi} + \beta_{IA}IA_{wi} + \gamma'\boldsymbol{X}_{wi} + \sigma_w), \quad (2)$$

where SRA_{wi} is the score of the SRA scale, which represents the degree of altruism, IA_{wi} is a dummy variable that indicates inequality aversion, $\boldsymbol{X}_{wi}$ is a vector of the household characteristics,[16]

[15] We also report the estimation results using an ordered logit model and two-limit Tobit model in Appendix D.

[16] As mentioned earlier, household income is defined as the total sum of the income of household members where revenue from selling recyclable waste (ps_i) is excluded from the calculation.

σ_w is a ward dummy variable that captures ward-level unobserved factors affecting recycling, and $G(\cdot)$ is the logistic function. The coefficients β_{SRA} and β_{IA} and vector γ are our parameters of interest to be estimated.

To capture environmental concerns of households, we asked sample households whether they believe that junk buyers improve the environment (*Concern for the environment*) with a five-point Likert scale from strongly agree to strongly disagree. We also asked whether they believe that junk buyers contribute to reducing public expenditure because they reduce the amount of waste and thus the cost of waste collection (*Concern for public expenditure*) with the same five-point Likert-scale. We construct dummy variables taking one for each response for the two questions and these dummies are included in $\boldsymbol{X}_{wi}$, although their results are not always reported. As an alternative specification to analyze the effect of the price of recyclables, we estimate the following equation:

$$E\left(y_{wi}\middle|SRA_{wi}, IA_{wi}, \boldsymbol{X}_{wi}, p_w^{js}\right) = G\left(\beta_0 + \beta_{SRA}SRA_{wi} + \beta_{IA}IA_{wi} + \gamma'\boldsymbol{X}_{wi} + \delta_p p_w^{js}\right), \quad (3)$$

where p_w^{js} is a ward-level price index of recyclable materials.[17] We exclude the ward dummy variables in Equation (3) because the price index is the same for all households in the same district. We report the estimation results of Equation (3) as a robustness check.

6.2. Share of recycled materials

In Table 3, columns 1 to 3 show the estimation results of Equation (2), based on fractional logit regression, and columns 4 to 6 show the estimation results of Equation (3), which includes the ward-level junk shop buying price index. Average marginal effects are reported. Column 1 shows that the altruism scale is positively associated with recycling behavior, while inequality aversion is not. This

[17] The actual transaction takes place by providing all recyclable waste to junk buyers in front of the door of the household. We assume that the transaction price is equal to the junk shop's buying price and is homogeneous within wards. We surveyed two to four junk buyers per ward and asked for junk shops' buying prices for six materials. We then calculated the average price of each material within a ward. Finally, we calculated the average price of six recyclable materials to define the ward-level junk shop buying price index (p_w^{js}). The mean p_w^{js} of the nine wards is 2,784 VND/kg, and the standard deviation is 201 VND/kg.

positive association between altruism and recycling remains even after a number of household characteristics are controlled for (columns 2 and 3) and alternative specifications are used (columns 4 to 6). Appendix A presents the results of estimation corresponding to those in Table 3, but for a subsample of households whose waste managers responded in person to our data collection interviews (see Section 4). These are similar to those in Table 3—indeed, the statistical significance is even higher—suggesting that if a household's degree of altruism coincides with that of the waste manager of the household, the association between altruism and recycling strengthens. The computed average marginal effect is 0.12 (column 1), indicating that a 1% increase in the SRA scale increases the recycling rate by 0.12 percentage points. For instance, if the SRA scale increases by one standard deviation from the mean (i.e., a 25% increase from 20 to 25), the recycling rate increases from 76% to 79% (0.12 × 25 = a 3 percentage point increase). This finding that altruism scale is positively associated with the private provision of an environmental public good is consistent with that of Kotchen and Moore (2007), who study a household's participation in green-electricity programs in the United States. From a laboratory experiment on the all-or-nothing green tariff mechanism, Mitra and Moore (2017) also find a positive association between the altruism scale and contributions to an environmental public good.

Household income is negatively associated with recycling, although the coefficients are marginally significant only in columns 1 and 2. This result is in contrast to the positive association between income level and recycling observed in developed countries (e.g., Halvorsen, 2008;[18] Viscusi et al., 2011). In developing countries with informal waste markets, household income may influence recycling behavior through several channels. One channel can be that increased income raises demand for environmental quality and thus encourages recycling behavior. Evidence for such demand for environmental quality as a normal good is found in existing studies of developed

[18] Halvorsen (2008) finds a negative correlation between the opportunity cost of the time used for recycling, as estimated from a contingent valuation method, and actual recycling behavior as well as a positive correlation between income level and recycling behavior.

countries (for a review, see Viscusi et al., 2012). Another channel can be that increased income leads to decreased marginal utility from selling additional recyclables and buying private goods to consume, which therefore decreases the share of recycling. This effect can exist only where recyclables are salable, as is often the case in urban areas of developing countries. Our result suggests that the latter effect dominates the former in Hanoi.

Finally, the other control variables such as the ward-level junk shop buying price index and type of house are not significant. The relative difficulty of waste disposal (*Throwing away waste to a handcart*) is not statistically significant, suggesting that the impact of the relative time cost of recycling on recycling behavior is small in the current context.

To further examine the heterogeneous effects of social preferences on recycling by income level, we split sample households into two groups with a cutoff of median income (10million VND). Table 4 shows the estimated results for households with incomes of more (less) than 10 million VND in columns 1 to 3 (4 to 6). We adopt the specification using the ward-level dummy variables, namely Equation (2), because the price index variable is not significant in Table 3. The results of the analyses show that the altruism scale is significantly associated with recycling among low-income households, but not among high-income households.

By contrast, the inequality aversion variable is significant in the high-income group. These contrasting results suggest that low-income households are particularly motivated to recycle by altruism, whereas high-income households are motivated to recycle to reduce the inequality between themselves and the relatively poor including junk buyers.[19] Appendix D, which reports the estimation results using other estimation models (i.e., ordered logit model and two-limit Tobit model), presents quantitatively similar results; altruism is associated with recycling among low-

[19] The average individual junk buyer's monthly income is around 3 million VND (as computed from our survey of junk buyers). Although the 3 million VND is each individual buyer's income, the overall average income of the junk buyer's household is most likely to be smaller than that of our sample household (12.1 million VND).

income households, whereas inequality aversion is associated with it among high-income households.

6.3. Share of the giving and selling of recyclables

Finally, the determinants of the giving $\left(\frac{g_i}{W_i}\right)$ and selling $\left(\frac{s_i}{W_i}\right)$ of recyclable waste are examined. Table 5 shows the results of the Bernoulli quasi-maximum likelihood estimation of the fractional logit regression of Equation (2), where the dependent variable is the share of donated (sold) recyclable materials, $\frac{g_{wi}}{W_{wi}}\left(\frac{s_{wi}}{W_{wi}}\right)$. We add the control variables into column 2 of Table 3.

Column 1 of Table 5 shows no association between altruism and giving. This is the consequence of a combination of the two opposite effects of high- and low-income households. The association between altruism and giving is negative, although not significant, for the high-income group (column 2) and positive and significant for the low-income group (column 3). By contrast, inequality aversion has a positive and significant association with giving for the high-income group (column 2), while it is not significant for the low-income group (column 3). As for the demographic variables, a large household is less likely to give. Among the high-income group, a household with a non-working adult member is more likely to give. A household among the low-income group is more likely to give if the highest education level of a member is beyond college.

Columns 4 to 6 of Table 5 show no association between selling and either altruism or inequality aversion. A large household is more likely to sell. We interpret this finding as follows: the relatively high revenue from the sizable waste generated by a large household is a great incentive not to decline monetary compensation. A household with a high education level is less likely to sell.

For further analyses, Columns 1 and 2 of Table A4 in Appendix E report the results of the multinomial logit regression, where the outcome variable is whether households can be categorized as non-recyclers, donors, or sellers (see Table 2 for these definitions). As expected from the results in

Table 2, altruistic households are much more likely to be either donors or sellers. Columns 3 and 4 (5 and 6) of Table A4 in Appendix E show the results of the Bernoulli quasi-maximum likelihood estimation of the fractional logit regression of Equation (2) for the subsample of donors (sellers). Among the two groups, however, the social preference variables are not strong determinants of recycling amount conditional on being either donors or sellers. Hence, while social preferences drive households to become recyclers (either as a donor or a seller) but do not much affect giving or selling amounts once households decide to recycle.

To summarize our results, Table 3 shows that informal recycling in our study site is associated with social preferences, particularly altruism. When we divide our sample households by income level in Table 4, we find that altruism drives recycling among low-income households, whereas inequality aversion is a driver among high-income households. Furthermore, Table 5 confirms that such an association is strong for the giving (as opposed to selling) behavior of recycled materials.

7. Conclusion

This study examined the behavioral factors that affect the private provision of an environmental public good in Vietnam. Overall, we found that most households in Hanoi are enthusiastic recyclers even though recycling is not compulsory and that half of those who recycle supply their recyclables without receiving monetary compensation. These findings serve as a novel contribution to the body of knowledge on this topic and suggest that the motive for recycling is not only economic but also intrinsic motivation. Indeed, the results of our regression analyses show that household recycling is associated with the social preferences of both altruism and inequality aversion.

There is weak evidence for the negative association between income level and recycling, which is in contrast to previous findings in the developed world. Such a contrast suggests that the

motivations behind recycling in the developing world differ from those in the developed world. This result requires further studies to understand household recycling in the context of developing countries.

Will the existing private provision of public goods continue in Vietnam? With the assumption that the Vietnam economy continues to grow, such voluntary recycling behavior may disappear as average income rises. If economic growth further increases the amount of solid waste as well as the total cost of managing it, the government may plan to introduce a mandatory recycling program. In that case, whether recycling mandates crowd out intrinsic motivation will be of future interest. Moreover, the further crowding out of an informal sector by the public sector (municipal collection of recyclables) might also be a concern.

Some limitations of this study should be noted. Although the estimation of the household's WTP for environmental quality is useful to evaluate the benefit of public policy, we need to be careful to use private provisions to infer this. Chilton and Hutchinson (1999) show that if an individual derives warm-glow only from private and not from public provision, then the relationship between donations and the WTP for a *publicly* provided public good is indeterminate. We observed voluntary recycling in Vietnam, implying a positive marginal WTP for an increase in the total amount of recyclable materials provided *privately* through the informal sector. However, if existing recycling is motivated by impure altruism and non-neutrality between provision methods holds, it is not possible to infer the WTP for a *publicly* provided environmental good (e.g., the amount of recycling achieved by adopting a mandate) from a simple observation of *private* provisions. An estimation of

the WTP for publicly provided environmental goods using the observed private provision is a future research avenue.

Appendix A. Table A1: Robustness check by excluding non-waste manager respondents

	(1)	(2)	(3)	(4)	(5)	(6)
	y_i, Fractional Logit model, Average marginal effects					
Income [million VND]	-0.057**	-0.067*	-0.059*	-0.050*	-0.058	-0.052
	(-1.96)	(-1.86)	(-1.71)	(-1.69)	(-1.55)	(-1.44)
Altruism scale	0.16***	0.17***	0.16**	0.17***	0.17***	0.15***
	(2.73)	(2.83)	(2.56)	(2.99)	(3.00)	(2.66)
Inequality aversion (=1 if yes)	0.0071	0.0081	0.0068	0.0028	0.0041	0.0022
	(0.75)	(0.86)	(0.72)	(0.27)	(0.41)	(0.22)
Household size		0.051	0.042		0.045	0.036
		(1.18)	(0.96)		(1.03)	(0.81)
Non-working adult HH member (=1 if yes)		0.0018	0.0012		0.011	0.011
		(0.07)	(0.04)		(0.40)	(0.42)
House is detached type (=1 if yes)		-0.026	-0.031		-0.020	-0.022
		(-0.78)	(-0.94)		(-0.64)	(-0.72)
Sex of waste manager (=1 if male)		-0.034*	-0.033		-0.037*	-0.035*
		(-1.68)	(-1.60)		(-1.84)	(-1.75)
Age of waste manager		0.087	0.082		0.076	0.071
		(1.18)	(1.11)		(1.04)	(0.95)
Highest education level of waste manager is college		0.024*	0.024*		0.026**	0.026**
(high school is base)		(1.94)	(1.92)		(2.04)	(2.05)
Highest education level of waste manager is		-0.0047	-0.0051		-0.0053	-0.0057
beyond college		(-1.11)	(-1.18)		(-1.28)	(-1.34)
Throwing away waste to a handcart (=1 if yes)			0.033			0.033
			(1.16)			(1.16)
Concern for the environment (=1 if strongly agree)			0.44***			0.47***
			(7.26)			(6.61)
Concern for public expenditure (=1 if strongly agree)			-0.35***			-0.37***
			(-6.40)			(-6.11)
Ward-level JS buying price index				0.025	0.14	0.14
				(0.09)	(0.50)	(0.50)
Ward dummy variables	Yes	Yes	Yes	No	No	No
N	467	467	467	467	467	467

Notes: This table shows the estimation results for Equations (2) and (3) for the subsample of households whose waste managers responded in person. A Bernoulli quasi-maximum likelihood estimation of a fractional logit regression is conducted. The dependent variable is the share of recycled materials. All regressions include enumerator fixed effects. Average marginal effects are reported. Numbers in parentheses are *z*-statistics robust to heteroskedasticity. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively.

Appendix B. Questions for the SRA scale (modified for Vietnamese households)

We would like to play a kind of game. The following questions are a kind of psychological test. There are no right or wrong answers. We are simply interested in your past behaviors.

Please tell me the frequency of your past behaviors when you faced the following situations.

Read the situations for each question and please remember your past experiences.

Please answer the frequency using the categories “Never,” “Once,” “More than once,” “Often,” and “Very often.” Please check the columns you select.

For example, Q1 asks whether you have helped a stranger to lift a vehicle when she/he had failed. If you have many experiences of helping such people and you help those people every time you can, you might answer “Very often.” Then, check the fifth column of Q1.

Please fill in only one column for each question. Multiple answers for one question are not accepted.

	Situations	1- Never	2- Once	3- More than once	4- Often	5- Very often

Q1	I have helped a stranger to lift a vehicle when she/he had failed.					
Q2	I have given directions to a stranger.					
Q3	I have made change for a stranger.					
Q4	I have donated goods or clothes to a charity.					
Q5	I have done volunteer work for a charity.					
Q6	I have helped carry a stranger's belongings (books, parcels, etc.).					
Q7	I have returned money to a seller when he/she has undercharged me.					
Q8	I have voluntarily looked after a neighbor's pets or children.					

(Five points were assigned when the respondent replied "Very often", four points for "Often," three points for "More than once," two points for "Once," and one point for "Never." We aggregated the points for these eight questions to construct a single altruism scale for the analyses.)

Appendix C. Question for inequality aversion

We are interested in your attitudes based on some hypothetical situations. Again, there are no right or wrong answers.

Please imagine three societies consisting of three people, including yourself, as summarized in the table below.

In Society 1, you are allocated 80,000 VND. On the contrary, Person A is allocated 90,000 VND, whereas Person B is allocated 40,000 VND. This society is endowed with 210,000 VND in total.

In Society 2, you are allocated 80,000 VND. In contrast to Society 1, however, Persons A and B are also allocated 80,000 VND each. This society is endowed with 240,000 VND in total.

In Society 3, you are allocated 100,000 VND. On the contrary, Person A is allocated 110,000 VND, whereas Person B is allocated 90,000 VND. This society is endowed with 300,000 VND in total.

Which society do you prefer?

Answer _____ 1- Society 1, 2- Society 2, 3- Society 3, 4- I do not know.

(A household that chose Society 2 was defined as an inequality averse household.)

Appendix D. Table A3: Robustness check by the ordered logit and two-limit Tobit models

	(1)	(2)	(3)	(4)	(5)	(6)
	y_i, Ordered Logit model, Coefficients			y_i, Two-limit Tobit model, Coefficients		
	All	Income above median	Income below median	All	Income above median	Income below median
Income [million VND]	-0.026*	-0.017	0.023	-0.0070	-0.0047	0.014
	(-1.94)	(-0.93)	(0.33)	(-1.09)	(-0.54)	(0.48)
Altruism scale	0.033**	0.0072	0.062***	0.011	0.0017	0.020*
	(2.17)	(0.32)	(2.85)	(1.42)	(0.16)	(1.93)
Inequality aversion (=1 if yes)	0.17	0.67**	-0.18	0.11	0.29**	-0.0059
	(0.90)	(2.30)	(-0.66)	(1.29)	(2.23)	(-0.05)
Household size	0.065	0.019	0.18*	0.019	0.016	0.036
	(1.17)	(0.25)	(1.86)	(0.75)	(0.44)	(0.94)
Non-working adult HH member (=1 if yes)	0.15	0.26	0.25	0.038	0.11	0.069
	(0.85)	(1.00)	(0.88)	(0.45)	(0.88)	(0.56)
Non-HH member manages waste (=1 if yes)	0.21	0.34	-0.23	0.12	0.16	0.046
	(0.50)	(0.68)	(-0.21)	(0.61)	(0.74)	(0.09)
Highest education level is college	-0.12	0.25	-0.34	-0.013	0.12	-0.070
	(-0.47)	(0.56)	(-1.02)	(-0.12)	(0.63)	(-0.50)
Highest education level is beyond college	-0.25	0.015	-0.31	-0.30	-0.13	-0.56**
	(-0.56)	(0.02)	(-0.32)	(-1.63)	(-0.49)	(-2.06)
House is detached type (=1 if yes)	0.17	0.16	0.28	0.12	0.095	0.17
	(0.77)	(0.50)	(0.81)	(1.16)	(0.64)	(1.17)
Ward dummy variables	Yes	Yes	Yes	Yes	Yes	Yes
N	746	371	375	746	371	375

Notes: Columns 1 to 3 of this table show the estimation results for the ordered logistic regression. There are three categories for the dependent variable: less than 25% (base outcome), between 25% to 75%, and more than 75%. Columns 4 to 6 of this table show the estimation results for the two-limit Tobit regression. All regressions in this table include enumerator fixed effects. Coefficients are reported. Numbers in parentheses are *z*-statistics robust to heteroskedasticity. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively.

Appendix E. Table A4: Giving and selling behavior (multinomial and fractional logit models)

	(1)	(2)	(3)	(4)	(5)	(6)
	Multinomial Logit, Coefficients		y_i, Fractional Logit model, Average marginal effects			
	Donor	Seller	Among donors		Among sellers	
Income [million VND]	-0.023	-0.036**	-0.024	-0.023	0.0086	0.0019
	(-1.46)	(-1.99)	(-1.44)	(-1.44)	(0.68)	(0.15)
Altruism scale	0.060***	0.056***	-0.050*	-0.046	-0.015	-0.029
	(3.18)	(3.08)	(-1.70)	(-1.56)	(-0.57)	(-1.08)
Inequality aversion (=1 if yes)	0.18	0.081	0.0024	0.0021	0.0046	0.0042
	(0.77)	(0.35)	(0.58)	(0.50)	(1.45)	(1.29)
Household size	0.0014	0.13*	0.020	0.016	-0.013	-0.0048
	(0.02)	(1.94)	(1.17)	(0.96)	(-0.59)	(-0.23)
Non-working adult HH member (=1 if yes)	-0.018	-0.15	0.0092	0.011	0.019**	0.016*
	(-0.08)	(-0.65)	(1.06)	(1.20)	(1.98)	(1.70)
Non-HH member manages waste (=1 if yes)	1.07*	0.27	-0.0019	-0.0024	-0.00077	-0.00081
	(1.65)	(0.39)	(-0.70)	(-0.83)	(-0.50)	(-0.56)
Highest education level is college	-0.086	-0.34	0.00093	0.0038	0.0016	0.0024
	(-0.28)	(-1.13)	(0.06)	(0.25)	(0.10)	(0.15)
Highest education level is beyond college	-0.16	-0.79	-0.0034	-0.0034	0.00021	0.00071
	(-0.31)	(-1.53)	(-0.89)	(-0.88)	(0.12)	(0.41)
House is detached type (=1 if yes)	0.37	0.17	0.0072	0.0078	-0.00076	0.0046
	(1.32)	(0.63)	(0.45)	(0.49)	(-0.05)	(0.31)
Throwing away waste to a handcart (=1 if yes)				0.015		-0.0042
				(1.30)		(-0.37)
Concern for the environment (=1 if strongly agree)				0.0092		0.0046
				(1.06)		(1.09)
Concern for public expenditure (=1 if strongly agree)				-0.0085		0.0017
				(-0.93)		(0.44)
Ward dummy variables	Yes		Yes	Yes	Yes	Yes
N	746		289	289	312	312

Notes: Columns 1 and 2 of this table show the estimation results for the multinomial logit regression, where the outcome variable is whether households can be categorized as non-recyclers, donors, or sellers (see Table 2 for the

definitions). The base outcome is non-recyclers. Coefficients are reported. Columns 3 and 4 (5 and 6) of this table show the estimation results for Equation (2) for the subsample of donors (sellers). A Bernoulli quasi-maximum likelihood estimation of a fractional logit regression is conducted. Average marginal effects are reported. All regressions in this table include enumerator fixed effects. Numbers in parentheses are *z*-statistics robust to heteroskedasticity. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively.

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Table A2

Allocation	Society 1	Society 2	Society 3
Person A	90,000	80,000	110,000
YOU	80,000	80,000	100,000
Person B	40,000	80,000	90,000
Total	210,000	240,000	300,000

Table 1: Household recycling behavior for each recyclable material

	(1)	(2)	(3)	(4)
		Of the HHs with consumption		
	HHs with consumption (%)	HHs not recycling (%)	HHs recycling by giving (%)	HHs recycling by selling (%)
Cardboard	86.0	15.7	38.1	46.2
Newspapers	84.1	14.5	38.6	46.9
Magazines	79.2	15.7	39.1	45.2
Notebooks	79.6	14.5	39.6	45.9
Printing paper	75.5	16.1	38.9	44.9
Metals	74.4	24.6	33.3	42.2
Glass bottles	88.7	42.7	31.0	26.3
PET bottles	95.8	22.7	39.3	38.0
Other plastic bottles	96.3	28.8	35.9	35.4

Note: Number of sample households (HHs) is 755.

Table 2: Recycling behavior and characteristics of sample households

	Non-recycler HH	Recycler HH		
	$y_i < 0.5$	$y_i \geq 0.5$		
		All	Donor	Seller
No. of observations	145	601	289	312
Panel A: Recycling behavior				
% of recycled materials	8.3	92.7	93.2	92.2
% of recycled materials by giving	4.7	45.4	88.6	5.6
% of recycled materials by selling	3.6	47.2	4.6	86.6
Frequency of giving per month	0.1	1.0	1.8	0.3
Frequency of selling per month	0.2	1.1	0.3	1.8
Monthly revenue from selling [VND]	938	6,918	1,356	12,070
Panel: B: Characteristics				
Household income [million VND/month]	13.1	11.9	12.2	11.7
Altruism scale	19.0	20.7	20.9	20.5
Inequality aversion (=1 if yes)	0.27	0.29	0.30	0.28
Household size	4.1	4.2	4.1	4.3
Non-working adult HH member (=1 if yes)	0.66	0.66	0.66	0.66
Non-HH member manages waste (=1 if yes)	0.03	0.04	0.06	0.03
Highest education level is high school or below	0.13	0.17	0.15	0.18
Highest education level is college	0.77	0.77	0.77	0.77
Highest education level is beyond college	0.10	0.06	0.08	0.05
House is detached type (=1 if yes)	0.73	0.76	0.77	0.75
Throwing away waste to a handcart (=1 if yes)	0.70	0.75	0.79	0.71
Concern for the environment (=1 if strongly agree)	0.18	0.22	0.22	0.22
Concern for public expenditure (=1 if strongly agree)	0.18	0.18	0.18	0.17
Vinh Phuc (=1 if yes)	0.08	0.11	0.12	0.10
Kim Ma (=1 if yes)	0.12	0.11	0.11	0.10
Cua Nam (=1 if yes)	0.10	0.08	0.09	0.07

Hang Gai (=1 if yes)	0.07	0.09	0.09	0.09
Lang Thuong (=1 if yes)	0.09	0.13	0.11	0.15
Bach Mai (=1 if yes)	0.12	0.12	0.12	0.11
Truong Dinh (=1 if yes)	0.10	0.13	0.12	0.14
Quoc Tu Giam (=1 if yes)	0.14	0.13	0.16	0.11
Quang Trung (=1 if yes)	0.17	0.11	0.08	0.13

Notes: Households that recycle at least half of the purchased materials are defined as recycler households. Among recycler households, households giving more materials than selling are defined as donors, while those selling at least half of the purchased materials are defined as sellers. Nine households do not consume any of the recyclable materials and thus are omitted from this table. One million VND was equivalent to 47 USD as of October 2013. Throwing away waste to a handcart takes one if a household disposes of its waste to URENCO workers with handcarts, and zero if the household has an easier option where it can dispose of its waste in containers placed near the house. Self-reported data on altruism, inequality, and concern for the environment and public expenditure were collected from the respondent of our survey, who is supposed to be the person who manages household waste.

Table 3: Recycling behavior and social preferences

	(1)	(2)	(3)	(4)	(5)	(6)
	y_i, Fractional Logit model, Average marginal effects					
Income [million VND]	-0.038*	-0.045*	-0.040	-0.034	-0.036	-0.030
	(-1.73)	(-1.73)	(-1.58)	(-1.54)	(-1.34)	(-1.20)
Altruism scale	0.12**	0.11**	0.090*	0.12***	0.12***	0.098**
	(2.51)	(2.45)	(1.92)	(2.79)	(2.81)	(2.22)
Inequality aversion (=1 if yes)	0.0079	0.0075	0.0073	0.0050	0.0046	0.0043
	(1.08)	(1.02)	(1.00)	(0.66)	(0.60)	(0.56)
Household size		0.044	0.041		0.033	0.030
		(1.25)	(1.16)		(0.94)	(0.84)
Non-working adult HH member (=1 if yes)		0.0048	0.0016		0.0086	0.0054
		(0.26)	(0.09)		(0.47)	(0.30)
Non-HH member manages waste (=1 if yes)		0.0023	0.0022		0.0024	0.0022
		(1.25)	(1.23)		(1.33)	(1.20)
Highest education level is college		-0.015	-0.015		-0.013	-0.013
		(-0.51)	(-0.53)		(-0.44)	(-0.44)
Highest education level is beyond college		-0.0068	-0.0059		-0.0068	-0.0059
		(-1.17)	(-1.06)		(-1.16)	(-1.05)
House is detached type (=1 if yes)		0.029	0.025		0.013	0.0095
		(1.14)	(1.02)		(0.57)	(0.42)
Throwing away waste to a handcart (=1 if yes)			0.019			0.023
			(0.91)			(1.15)
Concern for the environment (=1 if strongly agree)			0.019			0.017
			(1.46)			(1.30)
Concern for the environment (=1 if agree)			0.00038			-0.0011
			(0.01)			(-0.04)
Concern for the environment (=1 if disagree)			-0.0012			-0.00094
			(-0.17)			(-0.13)
Concern for the environment (=1 if strongly disagree)			-0.00047			-0.00041
			(-0.42)			(-0.32)
Concern for public expenditure (=1 if strongly agree)			-0.0040			-0.0021
			(-0.32)			(-0.17)
Concern for public expenditure (=1 if agree)			0.035			0.040

			(1.32)			(1.54)
Concern for public expenditure (=1 if disagree)			-0.0010			-0.00041
			(-0.14)			(-0.06)
Concern for public expenditure (=1 if strongly disagree)			0.000026			-0.00014
			(0.01)			(-0.07)
Ward-level JS buying price index				0.015	0.044	0.0073
				(0.07)	(0.22)	(0.04)
Ward dummy variables	Yes	Yes	Yes	No	No	No
N	746	746	746	746	746	746

Notes: This table shows the estimation results for Equations (2) and (3). A Bernoulli quasi-maximum likelihood estimation of a fractional logit regression is conducted. The dependent variable is the share of recycled materials. All regressions include enumerator fixed effects. Average marginal effects are reported. Average marginal effects of ε imply that a 1% increase in the independent variable increases the dependent variable by ε percentage points. For instance, column 1 shows that a 1% increase in the altruism scale increases the share of recycled materials by 0.12 percentage points (e.g., 76% to 76.12%). Numbers in parentheses are *z*-statistics robust to heteroskedasticity. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively.

Table 4: Recycling behavior and social preferences by household income level

	(1)	(2)	(3)	(4)	(5)	(6)
	y_i, Fractional Logit model, Average marginal effects					
	Income above median			Income below median		
Income [million VND]	-0.040	-0.038	-0.031	0.035	0.030	0.021
	(-0.94)	(-0.79)	(-0.66)	(0.62)	(0.45)	(0.32)
Altruism scale	0.047	0.045	0.012	0.18***	0.18***	0.17***
	(0.63)	(0.61)	(0.16)	(3.22)	(3.20)	(2.90)
Inequality aversion (=1 if yes)	0.021***	0.022***	0.021***	-0.0068	-0.0081	-0.0082
	(2.96)	(3.06)	(2.84)	(-0.52)	(-0.61)	(-0.61)
Household size		0.022	0.021		0.082**	0.082**
		(0.37)	(0.36)		(1.98)	(1.99)
Non-working adult HH member (=1 if yes)		0.019	0.014		0.017	0.012
		(0.65)	(0.46)		(0.71)	(0.51)
Non-HH member manages waste (=1 if yes)		0.0048*	0.0044		-0.00028	-0.000064
		(1.67)	(1.44)		(-0.10)	(-0.03)
Highest education level is college		0.035	0.028		-0.039	-0.038
		(0.66)	(0.52)		(-1.11)	(-1.10)
Highest education level is beyond college		-0.0028	-0.0019		-0.0049	-0.0041
		(-0.22)	(-0.17)		(-1.20)	(-1.04)
House is detached type (=1 if yes)		0.024	0.018		0.040	0.036
		(0.61)	(0.47)		(1.21)	(1.10)
Throwing away waste to a handcart (=1 if yes)			0.026			0.014
			(0.95)			(0.47)
Concern for the environment (=1 if strongly agree)			0.016			0.022
			(0.84)			(1.47)
Concern for public expenditure (=1 if strongly agree)			-0.0033			-0.0062
			(-0.18)			(-0.43)
Ward dummy variables	Yes	Yes	Yes	Yes	Yes	Yes
N	371	371	371	375	375	375

Notes: This table shows the estimation results for Equation (2) for the subsample. Columns 1 to 3 show the results for high-income households and columns 4 to 6 show the results for low-income households. All regressions include enumerator fixed effects. A set of dummy variables for "concern for the environment" and "concern for public expenditure" are included, although some of their results are not reported. Average

marginal effects are reported. Numbers in parentheses are *z*-statistics robust to heteroskedasticity. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively.

Table 5: Giving and selling behavior

	(1)	(2)	(3)	(4)	(5)	(6)
	% donated, Fractional Logit model, Average marginal effects			% sold, Fractional Logit model, Average marginal effects		
	All	Above median	Below median	All	Above median	Below median
Income [million VND]	-0.0085	0.057	0.0045	-0.039	-0.10	0.031
	(-0.28)	(1.04)	(0.05)	(-1.16)	(-1.43)	(0.38)
Altruism scale	0.077	-0.11	0.27***	0.035	0.16*	-0.084
	(1.31)	(-1.43)	(3.26)	(0.60)	(1.81)	(-1.09)
Inequality aversion (=1 if yes)	0.011	0.028**	-0.0044	-0.0030	-0.0010	-0.0026
	(1.02)	(2.01)	(-0.29)	(-0.30)	(-0.07)	(-0.18)
Household size	-0.066	-0.073	-0.078	0.11***	0.097	0.15**
	(-1.51)	(-1.08)	(-1.28)	(2.60)	(1.39)	(2.51)
Non-working adult HH member (=1 if yes)	0.021	0.073*	0.0036	-0.017	-0.050	0.011
	(0.90)	(1.93)	(0.12)	(-0.76)	(-1.44)	(0.38)
Non-HH member manages waste (=1 if yes)	0.0076**	0.012**	0.0041	-0.0044**	-0.0059	-0.0031***
	(2.55)	(2.35)	(1.38)	(-2.11)	(-1.43)	(-5.62)
Highest education level is college	0.047	0.026	0.060	-0.057*	0.015	-0.087**
	(1.37)	(0.43)	(1.47)	(-1.75)	(0.22)	(-2.38)
Highest education level is beyond college	0.0034	-0.0054	0.0077***	-0.0088*	0.0020	-0.0052**
	(0.62)	(-0.54)	(2.59)	(-1.95)	(0.16)	(-2.08)
House is detached type (=1 if yes)	0.031	0.055	0.0071	-0.0013	-0.028	0.031
	(1.00)	(1.27)	(0.16)	(-0.04)	(-0.68)	(0.71)
Ward dummy variables	Yes	Yes	Yes	Yes	Yes	Yes
N	746	371	375	746	371	375

Notes: This table shows the estimation results for the share of giving and selling of recyclables. The Bernoulli quasi-maximum likelihood estimation of a fractional logit regression is conducted. The dependent variable is the share of donated (sold) recyclable materials in columns 1 to 3 (4 to 6). All regressions include enumerator fixed effects. Average marginal effects are reported. Numbers in parentheses are z-statistics robust to heteroskedasticity. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively.

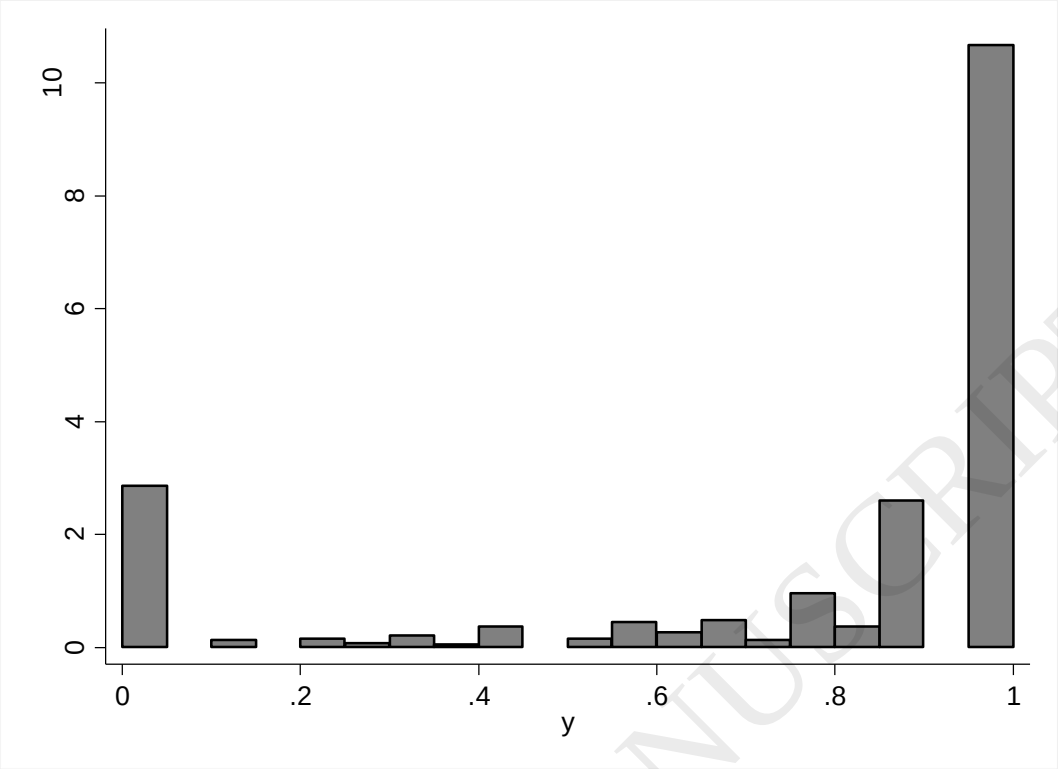

Figure 1: Distribution of the share of recycled materials

Note: This figure shows the distribution of the share of recycled materials, $y_i = \frac{r_i}{w_i}$.

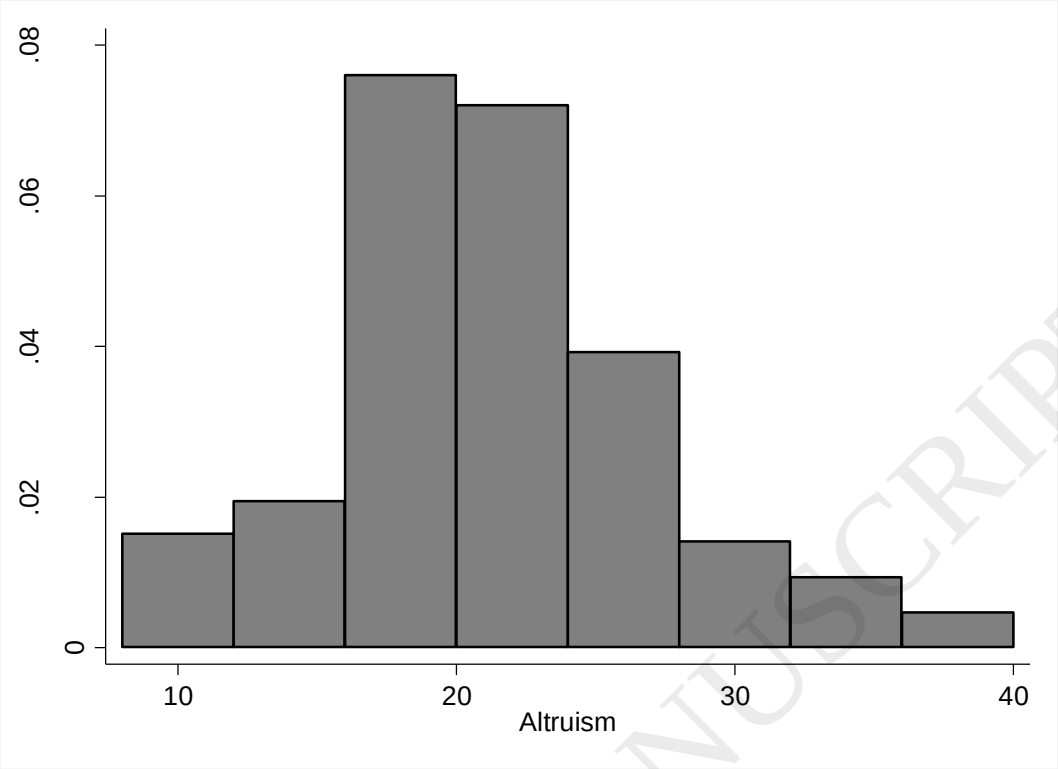

Figure 2: Distribution of altruism scale

Notes: This figure shows the distribution of the SRA scale. The score ranges from eight to 40, and a greater value for the score indicates that a respondent is more altruistic.