Waste Management xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

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

Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia

Alcides J. Padilla [a,*], Juan C. Trujillo [b]

[a] Programa de Economía, Universidad del Atlántico, Puerto Colombia, Atlántico, Colombia
[b] Environment Department, University of York, Wentworth Way, Heslington, York, YO10 5NG, United Kingdom

ARTICLE INFO

Article history:
Received 9 January 2017
Revised 27 November 2017
Accepted 28 November 2017
Available online xxxx

ABSTRACT

Solid waste management in many cities of developing countries is not environmentally sustainable. People traditionally dispose of their solid waste in unsuitable urban areas like sidewalks and satellite dumpsites. This situation nowadays has become a serious public health problem in big Latin American conurbations. Among these densely-populated urban spaces, the Colombia's capital and main city stands out as a special case. In this study, we aim to identify the factors that shape the attitudes towards source-separated recycling among households in Bogotá. Using data from the Colombian Department of Statistics and Bogotá's multi-purpose survey, we estimated a multivariate Probit model. In general, our results show that the higher the household's socioeconomic class, the greater its effort for separating solid wastes. Likewise, our findings also allowed us to characterize household profiles regarding solid waste separation and considering each socioeconomic class. Among these profiles, we found that at lower socioeconomic classes, the attitudes towards solid waste separation are influenced by the use of Internet, the membership to an environmentalist organization, the level of education of the head of household and the homeownership. Hence, increasing the education levels within the poorest segment of the population, promoting affordable housing policies and facilitating Internet access for the vulnerable population could reinforce households' attitudes towards a greater source-separated recycling effort.

1. Introduction

Separating solid waste is a fundamental condition to reversing its negative environmental impacts (Adeniran et al., 2017; Akil et al., 2015). Globally, the growing waste production threatens public health and city environments in developing countries (Dedinec et al., 2015; Vergara et al., 2015). It is expected that in less than a decade, solid waste production (measured in tons/day) in Africa, Latin America and the Caribbean grew 160% and 66%, respectively.[1] These figures are quite high compared with other regions of the world.[2] An important fraction of the total municipal solid waste is generated by the households (Suthar and Singh, 2015). In fact, the amount of household waste produced has been increasing in developing countries as a direct result of rapid population growth and urbanization (Ghani et al., 2013; Gundupalli et al., 2017).

Due to the absence of state-led planning controls, waste recycling at the household level is becoming a worrisome issue in developing countries. Espinoza et al. (2010) find that in developing countries separation of solid waste at the household level is seldom practiced. These authors reveal that only 3.6% of Colombian cities perform source-separated recycling.[3] Comparatively, this level of recycling at the source is below a middle-income country,

* Corresponding author at: Programa de Economía, Universidad del Atlántico, Kilómetro 7, antigua vía a Puerto Colombia, Atlántico, Colombia
E-mail addresses: alcidespadilla@mail.uniatlantico.edu.co (A. J. Padilla), juan.trujillo@york.ac.uk (J.C. Trujillo).

[1] Solid waste is defined as "any object, material, substance or element, mainly solid resulting from the consumption or use of a good in domestic, industrial, commercial, institutional or service activities, that the generator presents for collection by the person providing the public cleaning service. It is also considered as solid waste, that from the sweeping and cleaning of public areas and roads, lawn cutting and pruning of tree" (CONPES 3874, 2016; p. 63). Note: Translation of the authors from document in Spanish.

[2] The countries of South Asia and Sub-Saharan Africa have an average solid waste generation of 0.45 and 0.65 kg/per capita/day, respectively. Latin America and the Caribbean region's solid urban waste projections for 2025 are above most regions of the world (Africa 0.85%, East Asia and Pacific 1.5%, Europe and Central Asia 1.5%, Middle East and North Africa 1.43%, and South Asia 0.77%), except for OECD countries (Hoornweg & Bhada-Tata, 2012; p. 10).

[3] For our purposes, source-separated recycling is defined as the process of separating solid waste by type at home so they can be recycled.

https://doi.org/10.1016/j.wasman.2017.11.052
0956-053X/

such as Brazil, which achieved 7.3% in 2006, and even below low-middle-income countries like the Philippines, which in 2006 reached a percentage of 28%, and Malaysia, which attained a percentage of 9% in 2012 (Akil et al., 2015). Yet, in the latest years, Malaysia has seen a progressive increase of source-separated recycling, and it has projected a city participation rate of 25% for 2020 (Zen et al., 2014).

This is all consistent with population growth projections. For Latin America, the World Bank projects population growth of 17% by 2005–2025 (Hoornweg and Bhada-Tata, 2012). In fact, high population growth is a primary cause of fast-increasing solid waste production (Minghua et al., 2009; Dedinec et al., 2015). Like other Latin American countries, Colombia's waste production has kept pace with intense demographic and economic growth of the last years and follows the direction of the National Policy for the Integral Management of Solid Waste (CONPES 3874, 2016). Bogotá, Colombia's capital, has a population growth rate of 1.4% per year (Bolívar and Moreno, 2013). The increase in Bogotá's population has necessarily generated higher levels of solid waste production, which local environmental authorities send to its only landfill, *Doña Juana*. In 2013, *Doña Juana* received 6516.44 tons of this waste per day, up from 5000 tons thirteen years earlier (OAB, 2015). Waste disposal was at approximately 0.30 tons per capita yearly between 2001 and 2014 (OAB, 2015). The recycling rate is unsurprisingly very low at less than one ton per inhabitant per day (Piña and Martínez, 2014). The population has no cultural inclination to source-separated recycling and the city depends almost exclusively on open-pit disposal (Bolívar and Moreno, 2013). Thus, the city urgently needs to develop a culture of caring for the environment through household recycling incentives.

Notwithstanding, in order to design and implement an urban policy that encourages incentives for recycling at the household level, direct information from the households is required. In that sense, the lack of studies on the issue of source-separated recycling is abyssal in Colombia. This study is a first attempt. In it, we use a survey concerning the separation of solid waste and a broad set of individual variables for Bogotá's households. The aim of our study is to explore factors associated with source-separated recycling there while considering households' socio-economic classes (SECs). The SECs geographically identify sectors with different socioeconomic characteristics. In Colombia, SECs 1, 2 and 3 correspond to households with the lowest incomes, which are beneficiaries of subsidies in utilities; SECs 5 and 6 correspond to households with higher incomes, which must pay an additional contribution on the value of public utilities; while SEC 4 is not a beneficiary of subsidies nor does it have to pay overcharges. The households in SEC 4 pay the fair market value of utilities.

The evidence accrued elsewhere on the influence of socioeconomic conditions as a driver of change to improve environmental quality confirms our results, through which some unique households' characteristics are also revealed. For instance, we found that the greater the SEC, the greater the probability of source-separated recycling. Likewise, our results allow for establishing a profile of source-separated recycling per SEC. In such a sense, this study is a step forward in the literature for estimating the households' preferences in solid waste management alternatives and their corresponding attitudes towards source-separated recycling in a Latin American metropolis. This would contribute to rectify the lack of research on the recycling chain in developing countries, and, *pari passu*, would provide useful information for policymakers about the households' incentives to perform recycling at the source.

This study is organized into five sections including this introduction. In the second section, we conduct a literature review and a research approach about the dynamics of waste collection, management and recycling in Bogotá. In the third section, we describe our data sources and explain the econometric strategy. We present the results and a discussion on the subject in the fourth and fifth sections of the paper. Finally, we highlight the main findings and their implications for public policy.

2. Literature review and research framework

2.1. Literature review

Consumption and production processes are directly related to the generation of solid waste (Pandey, 2017; Widyaningsih et al., 2015). Due to changes in consumption patterns and increased production, the management of solid waste is now one of the cities' challenges (Kolekar et al., 2016). In fact, these aspects are part of the Sustainable Development Goals (SDG) declared by the UN in 2015. Among other objectives, the SDG propose the transformation of cities into sustainable territorial entities as well as the promotion of consumption and production systems in accordance with the balance of the ecosystems in which these sub-national spaces are located. Given the current concern of the world community for the increasing amount of waste generated, several urban initiatives have been proposed to reduce the problem. One of them is the zero-waste program, which has been applied in cities such as Nova Scotia (Greyson, 2007); San Francisco, Toronto, and Canberra (Veleva et al., 2017); Adelaide and Stockholm (Zaman and Lehmann, 2011). Likewise, the source-separated recycling has gained a strong momentum in the last decade and today local governments of cities such as Nagoya (Zheng et al., 2017) and Seoul (Lee and Paik, 2011) have been implementing it with relative success. As has been shown, the analysis of the link between solid waste production and municipal urban waste management programs has not gone unnoticed in the literature. In another context, the study by Miezah et al., (2015) is a sample of the effectiveness of source-separated recycling in a developing country. These authors estimate that the percentage of households in the cities of Ghana that resort to source-separated recycling is approximately 80%.[4]

As in the case of Ghana, the evidence about the implementation of solid waste management programs orientated to households in other developing countries has barely emerged in recent years. Verma et al. (2016), for example, find that due to population and economic growth as well as changes in the lifestyle of residents of Ho Chi Minh, solid waste generation has intensified. Other cities in Southeast Asia do not have efficient waste management programs due fundamentally to the lack of adequate information on the operation of these programs, although there are some notable exceptions. Cities such as Surabaya, Bangalore, Quy Nhon, and Matale are a model of efficiency in solid waste management (Aleluia and Ferrão, 2016).

There are other models of solid waste management implemented within institutions that could serve as a reference for potential applications at the urban level. Zen et al.,'s (2016) study on the solid waste management plan implemented inside the Universiti Teknologi Malaysia—a small city on its own—brings out useful insights. The study presents two components. The first is the generation and characterization component whose objective is to obtain information for good practices in solid waste management through the opening of a 'green' office. Results in 2011 showed a decrease in waste production from 3.47 to 0.83 kg per person. The second component is based on participating in governing and institutionalizing waste minimization (Zen et al., 2016; p. 1407). As per these results, implementing an environmental sustainability program empowers governments and one of its elements is the evaluation of good practices within public management.

[4] It is worth noting that Ghana generates 12,710 tons of urban waste per day, mostly composed of organic material (65%) and plastic (14%). For more details on Ghana's waste composition, see Miezah et al., (2015).

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

At the household level, Sukholthaman and Sharp (2016) consider that the separation of solid waste has a positive impact on waste management systems. However, despite the importance of recycling, waste generation in many countries continues to grow vertiginously and current waste management systems do not deliver the expected results. This had led to the existence of multiple factors associated with the effective treatment and separation of wastes, wherein households' own practices are an inescapable problem.

There are several pre-existing studies on the factors associated with treating and separating solid waste. Nguyen et al. (2015), for example, inquire into the factors that influence households to separate solid waste in Hanoi. These authors used the contingent valuation methodology, obtaining the willingness to pay as a proxy to the intention of separating solid waste at the household level. Findings indicate that intent to recycle increases if community members are compensated by the government for recycling. Conversely, the intent to recycle decreases relative to the number of years one resides in a community. Nguyen et al. (2015) suggest implementing some state measures to improve source-separated recycling. Among these, they recommend initiatives to boost community confidence, such as establishing clear and effective rules for recycling and encouraging community involvement. López-Mosquera et al. (2015) found comparable results to those of Nguyen et al. (2015) when they conducted a study in Spain on the decision to recycle. López-Mosquera et al. (2015) analyzed how different socio-economic and demographic factors and attitudes relate to environmental sensitivity. They explained three different pro-environmental behaviors: (1) recycling, (2) reducing car use, and (3) consumer's choice in pro-environmental goods.

From an approximate intend-to-recycle perspective, Tadesse et al. (2008) studied factors that influence the decision to dispose of domestic solid waste in the city of Mekelle, North Ethiopia. These authors, using a multinomial logit model, found that demographic characteristics such as age, education and household size have a negligible impact on the choice of waste disposal (i.e., containers, tractors, trailers arranged by the municipality, open areas and roadsides, garbage collection by private contractors and informal recyclers).

Some studies found that certain demographic characteristics have an impact on waste disposal choices. In Lake Victoria, Uganda, Ekere et al. (2009) found evidence for demographic characteristics including gender, geographic location of home and belonging to an environmental organization significantly affecting the separation of solid waste at the household level. The authors found that the head of the household's education does not explain source-separated recycling. On the contrary, Maddox et al. (2011) found that the head of household's education level is a decisive factor. They used a methodology based on the promotion of action at a household level called Waste Watch's "Taking Home Action on Waste" (THAW). They applied this methodology to 6705 primary school children in 39 schools in Rotherham, England.

There is empirical evidence of this sort worldwide. For instance, the city of Suzhou, China, Gu et al. (2015) estimated the influence of socio-economic and demographic variables such as income level, household size, and education level of the household head on the rate of household solid waste production. The study shows that the head of household's education level plays a key role in the rate of waste generation. Besides education, Gu et al. (2015) mention that many factors influence the rate of solid waste generation at a household level, such as local customs, consumption patterns and styles of residential life. Similarly, Ghani et al. (2013) observed a suburb of the University of Putra in Malaysia. Using a multiple linear regression analysis, Ghani et al. (2013) determine the factors influencing intent to recycle at the household level. Among the questions asked by the researchers include whether recycling is positive, interesting, or whether one should promote it nationally. They found that the head of the household's attitude is the main variable when it comes to recycling at the source. From the same perspective, in Malaysia, Akil et al. (2015) investigated socioeconomic factors' effects on recycling practices, determining socioeconomic variables in recycling activities. They point to pro-environmental behavior increasing as people age.

Similarly, the head of household's availability and the organization of housework explained the separation of waste in two housing units in Tlalpan, Mexico (Salgado-López, 2012). Previously in Brazil, Jacobi and Besen (2011) conducted a study for the city of São Paulo emphasizing the fact that, since the "Rio Summit 92", one of the priorities of sustainable solid waste government management programs is reducing production at the source. Domestic waste generation in the city of São Paulo was greater than any generated by the 39 municipalities comprising the so-called São Paulo Metropolitan Area. In 2011, households in metropolitan São Paulo generated approximately 0.8 kg/day of solid waste. In addition, the authors acknowledged the lack of policy coordination and appropriate investments in sustainable waste management. Jacobi and Jensen (2011) suggest some policies to control increasing solid waste generated in São Paulo. They emphasize investing in low-cost technologies suitable for the local context, implementing a selective collection, and adequate pay for official waste collectors in the city. Meanwhile, Echegaray and Hansstein (2016) analyze the determinants of intention and behavior of consumers towards recycling electronic waste in major metropolitan areas of Brazil. A substantial proportion of their respondents, comprised by women, middle-aged and lower-income groups of the southeast region, showed a strong propensity to recycling electronic devices.

In neighboring Colombia, and specifically its capital city, Bogotá, studies about recycling have been confined to waste production, operation of the informal sector, and integrated logistics in garbage collecting. By applying an urban material flow analysis, Piña and Martínez (2014) analyzed energy flows and materials in terms of inputs (i.e., energy, water, food and supplies) and outputs (i.e., emissions, wastewater, and construction debris) to assess impact on Bogotá's environment. Indeed, between 1980 and 2010 *per capita* energy consumption, food consumption, and solid waste production all increased. Simultaneously, recycling was minimal, and the *per capita* consumption of water, wastewater, and production emissions decreased. Regarding increase in solid waste production, these results imply greater efficiency in collection and the involvement of informal scavengers.

These scavengers are important in Bogotá. Martínez and Piña (2015), using a matrix of strengths-weaknesses/opportunities-threats (SWOT), evaluated the city's informal recycling sector, showing the main actors in the formal and informal waste management sector identifying weaknesses, opportunities, strengths and threats of the recycling process. Among the sector's weaknesses are factors such as shortage of working capital, job insecurity, and low investment in machinery that values recycled materials. A lack of awareness about the importance of source-separated recycling and legal instability are also threats to the industry. In another study, Bolívar and Moreno (2013) assessed the city's waste management system, identifying several critical areas in the whole process. They found a general lack of coordination between agents and a limited understanding of roles in the Bogotá system of solid waste management.

2.2. Garbage collection in Bogotá

The huge amount of waste produced by households is a significant concern in large cities. Latin American cities are no exception. Bogotá, D.C. is in the geographical area of Sabana de Bogotá at an altitude of 2600 m above sea level. Its annual average temperature oscillates between 14 and 23 degrees Celsius, with an annual

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

average of relative humidity of 78%. The city has an area of 1775 km^2, divided into 20 localities. Like in all Colombian cities, Bogotá's households are classified into six SECs per income intervals.

Bogotá's 2010 population was 7,363,782 (DANE, 2010). This figure places Bogotá as the first Colombian city in demographic terms. The gross domestic product (GDP) of Bogotá represents 24.5% of the Colombian economy. Bogotá's households produce 1.66 kg of solid waste per resident per day (Martínez and Piña, 2015). In 2010, from the city's total produced waste, approximately 52% is from households and 42% is from manufacturing (Piña and Martínez, 2014). Surprisingly, when comparing these statistics to their similar from other cities like México, D.F., Buenos Aires, and São Paulo, it is noted that Bogotá outperforms the daily average production of solid waste per resident. Thus, the Mexican capital, for example, generated about 0.69 kg per day in 2013 (SEDEMA, 2014); Buenos Aires produced 1.108 kg per day in 2010 (ONGIRS, 2012), whereas São Paulo reached around 1 kg per day in 2011 (Jacobi and Besen, 2011). As we had anticipated, as important as knowing the figures of waste generation, the characterization of these cities' waste complements the analysis of any waste management program implemented.

In terms of the characterization of the wastes related to human activities, Bogotá generated, per UAESP (2013), organic waste (food) with 60.56%; plastic with 10.45%; domestic hazardous waste with 12.94%; paper and paperboard with 7.1%; textiles with 1.89%; rubber and leather with 0.42%; metals with 0.85%; glass with 2.08%, and wood with 0.32%. This is consistent with the evidence shown in the international context. For instance, Miezah et al. (2015) show how organic waste and plastic are the most generated wastes by Ghana's households. The sector of small industrial producers can also serve as a reference in the analysis of the composition of solid waste. Thus, for example, small producers in Bogota generated organic waste (food) with 46.48%; plastic with 17.83%; domestic hazardous waste with 6.95%; paper and paperboard with 11.91%; textiles with 1.93%; rubber and leather with 0.91%; metals with 1.57%; glass with 3.88%, and wood with 2.91% (UAESP, 2013). We could also contrast these aggregated figures of Bogotá's households with what happens within institutions such as educational ones, which can be considered as a sample of the waste characterization at the urban aggregate level. In this sense, the characterization of wastes in Bogotá presents some similarities with the results found by Zen et al. (2016) at Universiti Teknologi Malaysia.[5]

Bogotá's functional chain of recycling has seven segments: (1) generation, (2) retrieval, (3) collection and transport, (4) storage, (5) pre-transformation, (6) transformation and (7) reuse (Corredor, 2010). This study considers only the first two. In terms of generation of solid waste, households are classified as users, residential sector, non-residential sector (i.e., manufacturing) and multi-users (i.e., residential centers, residential complexes, condominiums, malls, among others). The retrieval process is organized in two ways—on the platform in-front-of the property, which is usually done in bags or cans; the other is garbage rooms in homes. It is here where recycling becomes a challenging problem. The behavior of those places that do not separate solid waste hinders the recovery of recyclable material. If a prior separation is not performed, recovery is done by digging through piles of containers, cans or garbage bags and then separating recyclable materials. This phenomenon, in the case of Bogotá, shows the pervasive informality of this sector of the Colombian economy (Corredor, 2010).

Despite Bogotá's high levels of waste production, the dynamics of the services provided in the management of solid waste began officially with the District Public Service Company (EDIS) in the 1970s. This company was responsible for managing recycling, although some tasks of the recycling process were given to the Association of Recyclers of Bogotá (ARB). Founded in 1990, the ARB responded to the doubt that EDIS could at that time handle the complete process. The ARB was formed out of a merger of four poorly recognized recycling cooperatives. A decade later, the ARB comprised 24 cooperatives. It should be noted that from 1994 to 2001, four private entities provided collection services for solid waste in the capital district, due to the liquidation of EDIS in compliance with Law 159 of 1994 – *Decreto 159 de 1994* – (UAESP, 2011). The current system is based on a collective of private companies. Despite service regularity, its high costs and lack of incentives for separating and recycling at a household level have turned the system ineffective.

In the early 2000s, Bogotá saw the implementation of a policy framework for solid waste management—The Integrated Solid Waste Management Master Plan (PMIRS). The objectives of this plan were, among others, to generate a culture of minimizing waste production, achieve economies of scale, increase competitiveness and productivity in managing waste, and reduce social and environmental impact on the provision of public sanitation service, and the prevention, control and timely response to sanitation emergencies. This plan provides the foundation of the System for Solid Waste Management (SGIRS) the city established in 2004. When the PMIRS took effect in Bogotá, serious problems rapidly became evident stemming from the open-sky landfill *Doña Juana* (Fig. 1).[6] Méndez et al. (2006) found problems such as the proliferation of odor, vectors such as flies and rodents, leachates volume greater than the capacity of the treatment plant, and many others. Such problems severely affected surrounding communities, wherein many reported less fertile land and livestock infection. By 2005, Bogotá contributed 5484 tons to *Doña Juana* daily (OAB, 2015). Later, PMIRS and SGIRS gave rise to new regulations.

With the launch of the Bogotá Development Plan in 2012, *Bogotá Humana*, the city implemented the Zero Waste Program – *Programa Cero Basuras* – through Law No. 489 of 2012 – *Acuerdo del Concejo Distrital No. 489 de 2012.* This initiative sought to minimize the city's solid waste impact on the environment and citizens' health. Specifically, Bogotá's environmental authorities planned to improve household waste management, in the process stimulating reusable or biodegradable goods consumption. The idea was to minimize solid waste disposal in sanitary landfills from households. Despite good intentions, the Zero Waste Program did not generate the expected results and reduce the waste disposed in the *Doña Juana* by 30%. By 2015, it was reduced by only 3.2% (Contraloría de Bogotá, 2016).

However, Torres-González (2014) showed considerable progress in social and business organization within the recycling population after the implementation of *Programa Cero Basuras*. Informal recyclers have increased their daily income, and there has developed a favorable attitude towards their work from Bogotá's residents.[7]

3. Materials and methods

3.1. Data source

In this study, we use data from two surveys (DANE, 2011, 2014). In order to improve the precision of the estimates and generate city level results, we followed the criteria for socioeconomic classification of Bogotá as defined by the *Secretaría Distrital de Planeación*, in

[5] For example, Bogotá generates plastic and paper wastes with a proportion of 19.76%, and 16.35%, respectively (UAESP, 2013). For the same categories of waste, Universiti Teknologi Malaysia shows proportions of 19.9% and 16.1%.

[6] The landfill *Doña Juana* is close to the end of its useful life by 2015 (SSPD, 2013).

[7] The "Zero Waste" program created 17 trade-recycling organizations in Bogotá (UAESP, 2014). For their creation and promotion, Bogotá's Prefecture (*Alcaldia Mayor de Bogotá*) makes accompanying work through an NGO.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

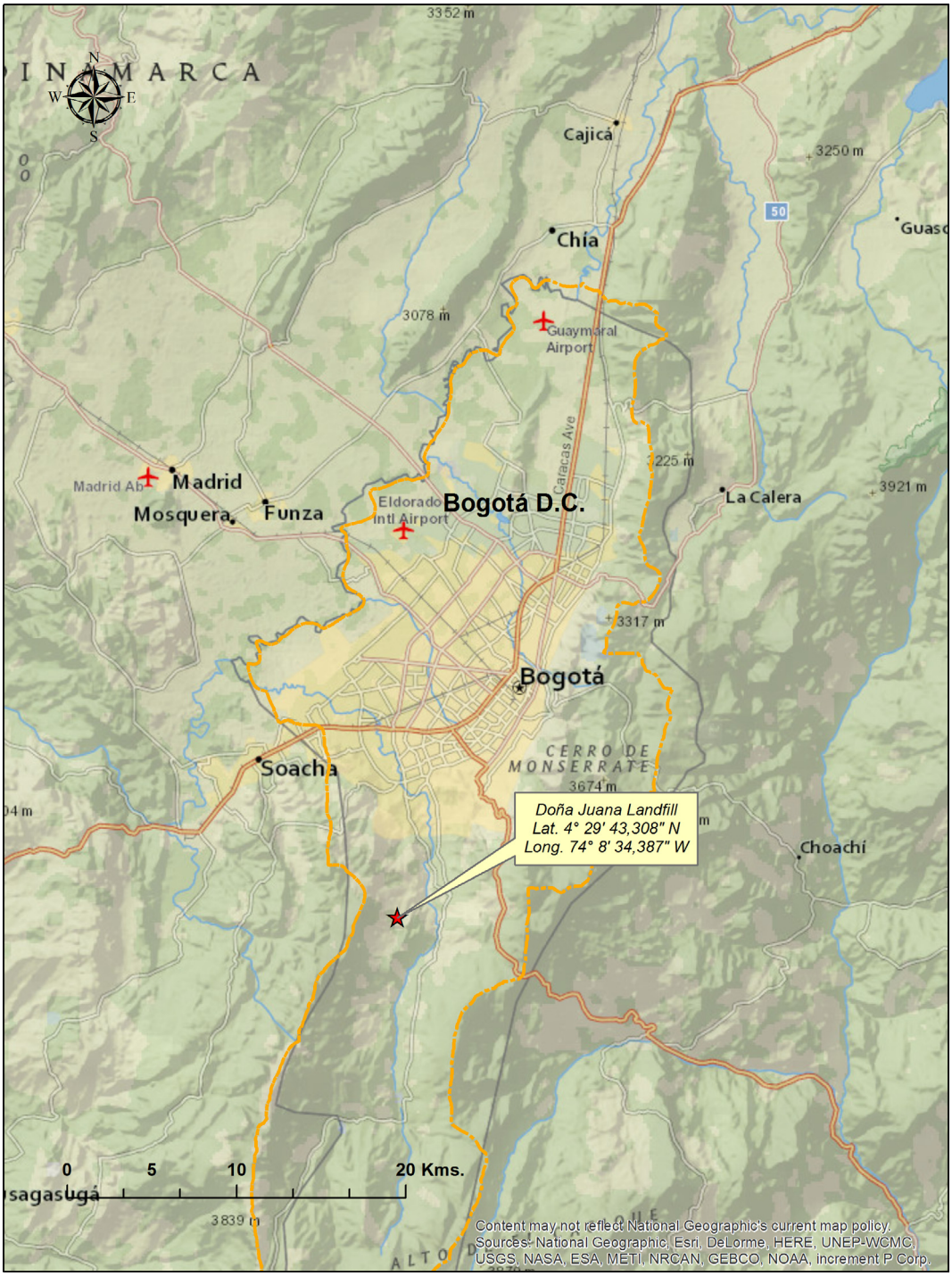

Fig. 1. Map of Bogotá, D.C. showing the geographical location of *Doña Juana* landfill. Source: Authors' elaboration based on ArcGIS 10.4.

which each block of the sampling frame is allocated within a determined SEC. It is worth mentioning that the 2011 survey was applied only within the perimeter of the Bogotá District; in 2014, however, the scope of the survey went further by including 19 new areas within Bogotá plus 11 municipal seats of the Department of Cundinamarca, which have a high economic dependence on the capital city. Both surveys provide data on housing and its surroundings, public utilities, household composition and demography, health, education, use of information technologies, environmental organization participation, and income. Having organized the information about the characteristics of the households and their corresponding heads, our next step was purifying the database by extracting the outliers. Once removed, we realized that many households surveyed provided no information about their income. To skip this void in the available information, we reduced the sample by considering only those households that had declared their income.[8]

This study considers the households' SEC. This classification differs from the concept of socioeconomic status, which is commonly associated with education, income and occupation of the individ-

[8] We took information from the family group only in the case of income.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

ual or social group (Waters and Waters, 2016). In Colombia, households are classified in SECs to determine the charges on residential utilities. The methodology is determined by the Colombian Department of Planning (DNP) based on households' disparities within cities or small towns. This classification process considers population variables, the number of blocks, building indicators, production, trade and services indexes, and unsatisfied basic needs. The District of Bogotá has its own methodology of household classification. That is, the variables considered are the characteristics associated with the dwelling itself, the urban environment, and the location area of the property (CONPES, 1997). Altogether, there are six SECs where the first is the lowest socioeconomic level and the sixth the highest. As we mentioned above, the spirit of this classification is to charge utility fees progressively, allocating subsidies more efficiently and collecting fairer tax rates for each SEC.[9]

The average number of users estimated for Bogotá with their respective tariffs is shown in Table 1.

In 2011 and 2012, 13.1% and 11.6% of households in Bogotá were in poverty, respectively, and 2% of the entire population was in extreme poverty; Bogotá also ranked second as the Colombian city with the highest inequality in 2011 (DANE, 2013).

3.2. Econometric strategy

In this paper, we estimate a multivariate discrete choice model through maximum likelihood. To find a possible correlation between three decisions of a given household, we estimate a trivariant Probit model. This type of model belongs to the univariate and bivariate Probit family and its structure is like the seemingly unrelated regression models (SUR), except that the dependent variables are dichotomous. The estimation of a system of equations of this kind allows us to consider the households' unobservable characteristics that can affect their attitudes towards source-separated recycling. In addition, the estimation of a system of equations can improve the efficiency of the whole set of estimates if there is indeed a correlation between the error terms of the equations in the system (Martínez-Espiñeira et al., 2014). The multivariate Probit has been already used in studies like the current one. For example, Martínez-Espiñeira et al., (2014) investigated the determinants and attitudes of Spain's households to recycle, while Arbués and Villanúa (2016) estimated a multivariate Probit model to analyze the factors influencing the decision to recycle used batteries in Spain. Likewise, Meng et al. (2016) estimated a multivariate Probit model to account for the recycling decisions of common plastic wastes for a set of horticulture firms in Georgia.

Specifically, our model is a trivariate Probit composed of three simultaneous equations and three dichotomous dependent variables corresponding to those previously described. This methodology allowed us to correlate error terms of the different alternatives. Our goal is to estimate the probability that households recycle. Households face three decision alternatives, determining their preferences in terms of these alternatives rather than choosing on one. This is the rationale for applying the multivariate Probit model.

The functional form of the multivariate Probit model follows Cappellari and Jenkins' (2003) earlier form:

$$y_{ij}^{*} = \beta_j X_i + \varepsilon_{ij}, j = 1,2,3 \quad (1)$$

[9] According to the Colombian Law No. 142 of 1994, the tariff regime of utilities includes a contribution of solidarity and redistribution from higher SECs and commercial and industrial users to lower SECs users to help pay utility tariffs on basic needs. In addition, this law, in its fifth article, determines that the classification of residential property should be in accordance with a methodology drawn up by the Colombian national government.

Table 1
Number of residential users and average rates of the cleaning service by SEC.. Source: Unidad Administrativa Especial de Servicios Públicos (UAESP, 2015). Empresa de Acueducto, Alcantarillado y Aseo de Bogotá (2015)

SEC	Average July–December	%	Tariff[a]
1	148,118	9	3357
2	760,701	45	6714
3	585,121	35	9511
4	143,844	8	11,599
5	31,757	2	18,503
6	22,251	1	25,631
Total	1,691,792	100	

[a] Tariff after subsidies.

$y_{ij} = 1$ if $y_{ij}^{*} > 0$ and $y_{ij} = 0$ otherwise (for i = 1, 2, 3).

where y_{ij}^{*} represents the estimate for the three alternatives $j(j = 1,2,3)$ in a pooled cross section sample composed by two waves (2011 and 2014). X_i, represents the vector $1 \times K$ of characteristics associated with the ith household; β_j, is the vector of coefficients $K \times 1$ to be estimated, and $\varepsilon_{ij}, j = 1,2,3$ are the error terms distributed as multivariate normal, $\varepsilon_{ij} \sim N(0,\Omega)$ each with a zero mean and variance-covariance matrix Ω, where Ω has values of 1 in the main diagonal and the correlations $\rho_{ij} = \rho_{ji}$ are the elements other than the main diagonal.

We proceeded as follows. First, we estimated the model using the full sample including the dummy variables for each SEC. Second, we estimated simultaneously three models of pro-environmental behavior splitting the sample into five SECs in order to test the relevance of each SEC for interpreting the waste separation strategy.

3.3. Empirical analysis

As shown in Table 2, the explained variable is the management and use of waste and its components. Each one of the households interviewed had the choice to separating solid waste into food and organic waste; paper and cardboard; and glass, metal and plastic. From this information, we built three dichotomous variables that take the value of 1 if the household separated waste and 0 if they did not. In addition, we count with 19 explanatory variables grouped into six blocks. The first block describes the data on housing conditions; the second block comprises topics about the use of information technology; the third block includes issues of participation in organizations and social networks represented by a single variable "*organization*"; the fourth block deals with the head of households' perception on both their living conditions and the institutional performance of local public entities. To control the heterogeneity of each SEC, we included the head of households' socio-demographic characteristics and education as the fifth block of explanatory variables. Finally, the households' income (expressed in natural logarithm) constitutes the sixth block.

3.4. Survey results

Data from the EMB (2011) and microcensuses from EM (2014) used in this study contain self-declared attitudes towards the source-separated recycling, understanding as attitude the behavior of the household towards source-separated recycling. Such an attitude can be either positive or negative (0 = Negative, 1 = Positive). Table 3 shows the heads of household answers to the questions on attitudes, which allow making two inferences. The first inference is that the higher the socio-economic level, the probability of source-separated recycling increases; That is, there is a differential role of SECs on the households' pro-environmental attitudes. In this respect, our findings are like those found by Fobil et al., (2010) in

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table 2
Description of the outcome variables. Source: Encuesta Multipropósito para Bogotá (2011 and 2014). Authors' elaboration.

Variable	Description
Dependent variable	
wasteseparation1	=1 if the household separates food and organic waste. Otherwise, the variable is equal to 0
wasteseparation2	=1 if the household separates paper and cardboard from other garbage. Otherwise, the variable is equal to 0
wasteseparation3	=1 if the household separates glass, metal and plastic from other garbage. Otherwise, the variable is equal to 0
Independent variables:	
Household's housing conditions	
housingtenure	=1 if the household owns the dwelling. Otherwise, the variable is equal to 0
householdsize	Number of household members
residence_time(1)	=1 if the household has one year and less than three years living at the current house. Otherwise, the variable is equal to 0
residence_time(2)	=1 if the household has three years and less than five years living at the current house. Otherwise, the variable is equal to 0
residence_time(3)	=1 if the household has more than five years living at the current house. Otherwise, the variable is equal to 0
Use of information technologies	
internet	=1 if the household has Internet service. Otherwise, the variable is equal to 0
Participation in organizations and social networks	
Participation in environmental, health or charity organizations (organizations)	=1 if a household member participates in any environmental, health or charity organization. Otherwise, the variable is equal to 0
Perception of living conditions and institutional performance	
environment_water	=1 if the head of the household finds that between 2007 and 2011 the city has improved in an environmental aspect such as the quality of water. Otherwise, the variable is equal to 0
environment_air	=1 if the head of the household finds that between 2007 and 2011 the city has improved in an environmental aspect such as the quality of air. Otherwise, the variable is equal to 0
environment_waste_disposal	= if the head of the household finds that between 2007 and 2011 the city has improved in an environmental aspect such as the waste disposal. Otherwise, the variable is equal to 0.
environment_cleaning_streets	=if the head of the household finds that between 2007 and 2011 the city has improved in an environmental aspect such as sweeping and cleaning the streets. Otherwise, the variable is equal to 0
poverty	=1 if the head of the household considers himself/herself poor. Otherwise, the variable is equal to 0
Socio-demographic characteristics and Education	
pre-kindergarten_(0–4 years)	=1 if years of schooling of the head of the household is between (0–4). Otherwise, the variable is equal to 0
elementary_(5–10 years)	=1 if years of schooling of the head of the household are between (5–10). Otherwise, the variable is equal to 0
high-school_(11–14 years)	=1 if years of schooling of the head of the household are between (11–14). Otherwise, the variable is equal to 0
university_(15–17)	=1 if years of schooling of the head of the household are between (15–17). Otherwise, the variable is equal to 0
postgraduate_(>17)	=1 if years of schooling of the head of the household is (>17). Otherwise, the variable is equal to 0
age_young(18–26)	=1 if age in years of the head of the household is between (18–26). Otherwise, the variable is equal to 0
age_adulthood(27–59)	=1 if age in years of the head of the household is between (27–59). Otherwise, the variable is equal to 0
age_old(60 and > 60)	=1 if age in years of the head of the household is between (60 and > 60). Otherwise, the variable is equal to 0
male	=1 if the head of the household is male. Otherwise, the variable is equal to 0
married	=1 if the head of the household is married. Otherwise, the variable is equal to 0
Economic	
Log of per capita income (lnincome_percapita)	Logarithm of household per capita income

the city of Accra, Ghana. These authors found statistical evidence that SECs prove to be important in urban environmental quality with respect to waste generation. The second inference revolves around the type of waste. Households in Bogotá separate more glass, metal, and plastic in relation to food waste, paper and cardboard. Accordingly, our results indicate that the attitudes of the heads of household towards source-separated recycling have a substantial effect on the decision to recycle itself. Therefore, the incorporation of SECs into the analysis of households' attitudes towards source-separated recycling contributes to the understanding of the heterogeneity of households in relation to such decisions.

Table 4 summarizes the descriptive statistics of the variables that can affect pro-environmental attitudes used in the estimated models. In households that displayed attitudes towards recycling, the lowest SECs show a higher presence of male and single leading the families, while levels of education and Internet access increase as SECs increase. In addition, the pro-environmental attitude increases as the SEC increases, and concerning housing tenure, more than 50% of heads of households in SECs 4, 5 and 6 are proprietors of their houses. In the homes of the SEC 2, we found the fewest owners in all types of waste separation. Finally, heads of household surveyed in greater proportion are adults (ages > 70%).

3.5. Regression results

To find the associated waste management factors, we estimated six multivariate Probit models using the software Stata 15 (StataCorp, College Station, TX). Following the methodology described above, the three types of waste separation were modeled together. The final models were estimated based on the complete data set, including four dummy variables corresponding to each of the SECs (SEC 1 as reference). Table 5 describes the results of the multivariate probit model for the complete sample of 25,622 observations. The results show that all SECs and most of the explanatory variables are statistically significant, which confirms the importance of SECs in the separation of solid wastes in Bogota's households. In addition, we observed that the correlation coefficients of the error terms (rho) in the multivariate probit of the complete sample, ranging from 0.8821 to 0.9403, are positive and statistically significant. This would support the notion of interdependence between different attitudes towards recycling. Sometimes interdependence can be reflected in the complementarity of the types of attitudes towards recycling. On other occasions, interdependence can be linked to the omission of specific factors of the heads of household's behavior, which, in turn, affects all types of attitudes. Based on this premise, we estimated five models, one for each SEC. As anticipated, the contribution of our research is to find

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table 3
Attitudes survey results 2011 and 2014. Source: Encuesta Multipropósito para Bogotá (2011 and 2014). Authors' elaboration.

Questionnaire item	SECs									
	1 Obs = 2112		2 Obs = 9074		3 Obs = 9814		4 Obs = 3235		5 and 6 Obs = 1387	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
The household separates food and organic waste										
Negative	1540	73	5795	64	5009	51	1050	32	370	27
Positive	572	27	3279	36	4805	49	2185	68	1017	73
The household separates paper and cardboard from other garbage										
Negative	1491	73	5501	61	4684	48	998	31	330	24
Positive	621	27	3573	39	5130	52	2237	69	1057	76
The household separates glass, metal and plastic from other garbage										
Negative	1470	73	5326	59	4560	46	978	30	329	24
Positive	642	27	3748	41	5254	54	2257	70	1058	76

Table 4
Descriptive statistics. Source: Encuesta Multipropósito para Bogotá (2011 and 2014). Authors' elaboration.

Variable	Full simple			SEC 1			SEC 2			SEC 3			SEC 4			SECs 5 and 6		
	No. Obs.	Mean	Std. Dev.	No. Obs.	Mean	Std. Dev.	No. Obs.	Mean	Std. Dev.	No. Obs.	Mean	Std. Dev.	No. Obs.	Mean	Std. Dev.	No. Obs.	Mean	Std. Dev.
wasteseparation1	25,622	0.46	0.50	2112	0.27	0.44	9074	0.36	0.48	9814	0.49	0.50	3235	0.68	0.47	1387	0.73	0.44
wasteseparation2	25,622	0.49	0.50	2112	0.29	0.46	9074	0.39	0.49	9814	0.52	0.50	3235	0.69	0.46	1387	0.76	0.43
wasteseparation3	25,622	0.51	0.50	2112	0.30	0.46	9074	0.41	0.49	9814	0.54	0.50	3235	0.70	0.46	1387	0.76	0.43
housingtenure	25,622	0.38	0.49	2112	0.40	0.49	9074	0.32	0.47	9814	0.38	0.49	3235	0.49	0.50	1387	0.57	0.50
householdsize	25,622	3.17	1.59	2112	3.64	1.81	9074	3.44	1.61	9814	3.11	1.52	3235	2.59	1.32	1387	2.34	1.23
residence_time(1)	25,622	0.13	0.34	2112	0.11	0.31	9074	0.12	0.32	9814	0.13	0.34	3235	0.17	0.37	1387	0.19	0.39
residence_time(2)	25,622	0.12	0.32	2112	0.00	0.29	9074	0.11	0.32	9814	0.11	0.32	3235	0.13	0.34	1387	0.14	0.34
residence_time(3)	25,622	0.66	0.48	2112	0.72	0.45	9074	0.67	0.47	9814	0.66	0.48	3235	0.60	0.49	1387	0.56	0.50
internet	25,622	0.54	0.50	2112	0.28	0.45	9074	0.39	0.49	9814	0.59	0.49	3235	0.84	0.37	1387	0.89	0.31
organizations	25,622	0.01	0.08	2112	0.00	0.07	9074	0.01	0.07	9814	0.01	0.08	3235	0.01	0.11	1387	0.01	0.11
environment_water	25,622	0.41	0.49	2112	0.40	0.49	9074	0.45	0.50	9814	0.41	0.49	3235	0.36	0.48	1387	0.26	0.44
environment_air	25,622	0.12	0.33	2112	0.17	0.37	9074	0.14	0.35	9814	0.11	0.32	3235	0.07	0.26	1387	0.07	0.25
environment_ waste_disposal	25,622	0.28	0.45	2112	0.23	0.42	9074	0.30	0.46	9814	0.28	0.45	3235	0.26	0.44	1387	0.20	0.40
environment_cleaning_streets	25,622	0.35	0.48	2112	0.30	0.46	9074	0.38	0.49	9814	0.36	0.48	3235	0.32	0.47	1387	0.21	0.41
poverty	25,622	0.22	0.41	2112	0.36	0.48	9074	0.30	0.46	9814	0.19	0.39	3235	0.06	0.23	1387		
pre-kindergarten_(0–4 years)	25,622	0.10	0.30	2112	0.14	0.35	9074	0.11	0.31	9814	0.09	0.29	3235	0.08	0.27	1387	0.04	0.19
elementary_(5–10 years)	25,622	0.24	0.43	2112	0.45	0.50	9074	0.35	0.48	9814	0.19	0.39	3235	0.04	0.19	1387	0.02	0.13
high-school_(11–14 years)	25,622	0.33	0.47	2112	0.33	0.47	9074	0.42	0.49	9814	0.36	0.48	3235	0.14	0.35	1387	0.06	0.23
university_(15–17)	25,622	0.09	0.29	2112	0.05	0.21	9074	0.07	0.26	9814	0.12	0.32	3235	0.09	0.28	1387	0.06	0.23
postgraduate_(>17)	25,622	0.24	0.43	2112	0.03	0.17	9074	0.05	0.22	9814	0.24	0.43	3235	0.66	0.48	1387	0.83	0.38
age_young(18–26)	25,622	0.06	0.25	2112	0.10	0.30	9074	0.08	0.27	9814	0.06	0.23	3235	0.04	0.21	1387	0.03	0.17
age_adulthood(27–59)	25,622	0.74	0.44	2112	0.78	0.42	9074	0.77	0.42	9814	0.73	0.45	3235	0.68	0.47	1387	0.66	0.47
age_old(60 and > 60)	25,622	0.20	0.40	2112	0.12	0.33	9074	0.15	0.36	9814	0.22	0.41	3235	0.28	0.45	1387	0.31	0.46
male	25,622	0.65	0.48	2112	0.67	0.47	9074	0.66	0.47	9814	0.65	0.48	3235	0.62	0.49	1387	0.66	0.47
married	25,622	0.31	0.46	2112	0.21	0.41	9074	0.25	0.43	9814	0.34	0.47	3235	0.41	0.49	1387	0.46	0.50
lnincome_percapita	25,622	13.8	0.99	2112	13.2	0.74	9074	13.0	0.73	9814	13.8	0.86	3235	14.7	0.90	1387	15.2	0.96

pro-environmental attitudes for each SEC and to determine differences or similarities between them (Table 6).

We also seek to investigate whether the estimated model simultaneously fits better as the alternative for estimating the three equations for each type of SEC, so we applied the chi-square test (Table 6). The results demonstrate that it is preferable to estimate the multivariate Probit to the alternative of estimating three independent equations for each SEC.

The likelihood ratio test (LR) indicates that the parameters of the cross-section equation are significantly different from zero (*rho21*, *rho31* and *rho23*). The results of the test confirm that the multivariate Probit of the models is more robust than independently estimating.

In terms of the estimates of the multivariate Probit models by SECs, differences can be found between them. For example, for lower SECs households' conditions generate positive pro-environmental attitudes, but they have no effect on SEC 4 in the separation of food and organic waste and glass, metal and plastic from other garbage. However, in the separation of paper and cardboard in SEC 4, some of these variables were significant. Similarly, for the higher SECs, age does not determine the pro-environmental behavior, but it does for the lower SECs, although it generates a negative effect. Another substantial difference is presented in the variable education. In the lowest SECs, the highest levels of education were significant and positive. In SECs 5 and 6, the highest levels of education have a negative sign. However, as part of the analysis, it is possible to determine some similarities. For example, the male variable is always statistically significant for all types of separation and negative sign in the low and medium SECs; however, it is not statistically significant in the higher SECs. Likewise, Internet access for *wasteseparation1* is statistically significant and positive for all SECs. However, while Internet access continues to be statistically significant and with a positive sign for the lowest SECs, for *wasteseparation2* and *wasteseparation3* and the higher SECs is not found to be statistically significant. We underline the fact that this analysis would not have been possible to perform if we kept the sample in its aggregated form. In other words, the sample breakdown is what enabled us to analyze the households' environmental attitudes within such a heterogeneous urban territory as Bogotá is.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table 5
Results of multivariate probit analysis for full sample.

Dependent variables	Independent variables		
	wasteseparation1	wasteseparation2	wasteseparation3
Household's housing conditions			
housingtenure	0.1156***	0.1088***	0.0716***
householdsize	0.0119**	0.0157***	0.0150***
residence_time(1)	0.0957***	0.1036	0.1207***
residence_time(2)	0.0264	0.0680**	0.0619*
residence_time(3)	0.0793***	0.1186***	0.1428***
Use of information technologies			
internet	0.2191***	0.2266***	0.2420***
Participation in organizations and social networks			
organizations	0.3432***	0.4944***	0.3508***
Perception of living conditions and institutional performance			
environment_water	0.0599***	0.0935***	0.0989***
environment_air	−0.0858***	−0.07196***	−0.0686***
environment_ waste_disposal	0.1369***	0.1280***	0.1281***
environment_cleaning_streets	−0.0019	0.0189	0.0167
poverty	−0.0537***	−0.0347*	−0.0504***
Socio-demographic characteristics and Education			
pre-kindergarten_(0–4 years)	−0.1725***	−0.1688***	−0.1395***
elementary_(5–10 years)	−0.2138***	−0.2044***	−0.2040***
high-school_(11–14 years)	−0.1971***	−0.1602***	−0.1808***
university_(15–17)			
postgraduate_(>17)	0.0182	0.0628**	0.0372
age_young(18–26)	−0.3858***	−0.3846***	−0.4143***
age_adulthood(27–59)	−0.0915***	−0.1034***	−0.1095***
age_old(60 and >60)			
male	−0.1523***	−0.1387***	−0.1403***
married	0.1769***	0.1434***	0.1285***
Economic			
lnincome_percapita	0.0272***	0.0236**	0.0224**
sec_1			
sec_2	0.1921***	0.1894***	0.2062***
sec_3	0.3786***	0.3777***	0.3743***
sec_4	0.6588***	0.6120***	0.5951***
sec_5	0.7614***	0.7591***	0.7322***
_cons	−0.8654***	−0.8155***	−0.7470***
atrho21	1.4043***		
atrho31	1.3853***		
atrho32	1.7414***		
rho21	0.8862***		
rho31	0.8821***		
rho32	0.9403***		
Log-likelihood	−31454.81		
Wald chi2(57)	3316.68		
Likelihood ratio test – chi2(3)	35001.30		
N	**25622**		

4. Discussion

The estimated model with the complete sample, including the dummy variables, shows that the higher the SEC, the higher the head of household's attitude towards recycling. In general terms, head of households' socio-demographic characteristics and education, perception of living conditions and institutional performance (except the head of household's perception on the cleanliness of the streets), participation in organizations and social networks, the use of information technologies (i.e. Internet), and the household's housing conditions are determinants in the heads of the household's behavior towards recycling.

Importantly, the models estimated by each SEC allow knowing the separation of waste considering the heterogeneity of the households and their attitudes towards the separation of waste. It is precisely within this heterogeneity of factors that shape the attitudes of Bogotá's households towards source-separated recycling, in which *housingtenure* is a key factor. Only in SEC 2 most variables were statistically significant and with positive sign for the three types of separation of wastes, except the variable *housingtenure* for *wasteseparation1* and *wasteseparation3*. It should be noted that with *housingtenure,* similarities occur in SECs 3, 5 and 6. In these SECs, *housingtenure* was found to be statistically significant and with a positive sign. This is plausible because the probability of recycling all types of waste increases according to the length of stay in their places of residence and the household size. However, our results differ from Tadesse et al.'s (2008), who found that household size has an insignificant impact on waste disposal choice. Interestingly enough, the likelihood of separating wastes in SECs 3, 5 and 6 increases if the head of the household owns the property.

Moreover, in Colombia, it is logical to think a higher SEC would lead to greater access to information technologies, including the Internet. In this regard, Chigona et al., (2009) point out that Internet use has not been successful as a key tool for social inclusion in developing countries. This is exactly what is happening in Bogotá—households in the lower SECs have kept a low level of Internet use. In SECs 1, 2 and 3 only 35%, 48% and 66% of households that recycle on average use this service for all types of waste separation (see

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table 6
Results of multivariate probit analysis per SECs. Source: Encuesta Multipropósito para Bogotá (2011 and 2014). Authors' elaboration.

Variables	SECs				
	1	2	3	4	5 and 6
wasteseparation1					
Household's housing conditions					
housingtenure	0.1526**	0.0245	0.2054***	0.0495	0.1564*
householdsize	0.0072	0.0150*	0.0118	−0.003	0.0227
residence_time(1)	0.1659	0.1486***	0.0505	−0.0211	0.2327*
residence_time(2)	−0.2507*	0.1060*	0.0014	0.002	0.1974
residence_time(3)	0.0502	0.1530***	0.0214	0.0866	0.1675
Use of information technologies					
Internet	0.1710***	0.2359***	0.2332***	0.1451*	0.2218*
Participation in organizations and social networks					
organizations	0.8598**	0.2089	0.1410063	0.4667**	0.2952
Perception of living conditions and institutional performance					
environment_water	0.1443**	0.0273	0.1036***	−0.01895	0.0521
environment_air	−0.0043	−0.0683	−0.0819*	−0.0248	−0.4315***
environment_ waste_disposal	0.0873	0.1353***	0.1340***	0.2213	0.1626
environment_cleaning_streets	0.0973	0.0061	−0.0085	−0.0843***	−0.0102
Poverty	−0.0653	−0.0486	−0.0524	0.1968**	
Socio-demographic characteristics and education					
pre-kindergarten_(0–4 years)	−0.3089**	−0.1452**			−0.5814
elementary_(5–10 years)	−0.3170**	−0.1882***	−0.0483	−0.1965	
high-school_(11–14 years)	−0.3352***	−0.2027***	−0.0161	−0.1528	−0.2738
university_(15–17)			0.1661***	0.0902	−0.4349
postgraduate_(>17)	0.1314	−0.0549	0.2539***	0.0169	−0.4044
age_young(18–26)	−0.1697	−0.3160***			
age_adulthood(27–59)	0.1316	−0.0209	0.2608***	0.5306***	−0.0607
age_old(60 and >60)			0.3663***	0.7588***	−0.043
Male	−0.2470***	−0.1156***	−0.1649***	−0.1496***	−0.1083
Married	−0.0078	0.1828***	0.1897***	0.2334***	0.2908***
Economic					
lnincome_percapita	0.0148	0.0285	0.0166	0.0296	0.0223
_cons	−0.7122	−0.8305***	−0.8872***	−0.7774**	0.1388
wasteseparation2					
Household's housing conditions					
housingtenure	0.1073*	0.0716**	0.1715***	0.0502	0.2211***
householdsize	0.0234	0.0156*	0.0173**	0.0362*	0.0401
residence_time(1)	0.0829	0.1449***	0.0453	−0.0053	0.0173
residence_time(2)	−0.1777	0.1259**	0.0472	0.1516	0.0966
residence_time(3)	0.0252	0.1867***	0.0501	0.1481*	0.005
Use of information technologies					
Internet	0.1575***	0.2371***	0.2679***	0.0538	0.1494
Participation in organizations and social networks					
organizations	0.7975*	0.1053	0.4126***	0.8301***	0.1036
Perception of living conditions and institutional performance					
environment_water	0.1414**	0.0439	0.1602***	0.0213	0.1395
environment_air	0.0481	−0.1292***	−0.0969**	0.032	−0.0532
environment_ waste_disposal	0.1630**	0.1501***	0.1085***	0.1717***	0.1989*
environment_cleaning_streets	0.0563	0.0575*	−0.0048	−0.0436	−0.0496
Poverty	−0.0611	−0.035	0.0183	0.1767*	
Socio-demographic characteristics and Education					
pre-kindergarten_(0–4 years)	−0.3835***	−0.1300**			−0.7469
elementary_(5–10 years)	−0.3788***	−0.1413***	−0.0318	−0.1614	
high-school_(11–14 years)	−0.3661***	−0.1604***	0.0364	−0.1482	−0.6398
university_(15–17)			0.2180***	0.0113	−0.7296*
postgraduate_(>17)	0.5067***	0.0243	0.2783***	0.0739	−0.7655*
age_young(18–26)	−0.3681***	−0.3003***			
age_adulthood(27–59)	−0.0197	0.0253	0.1966***	0.4568***	0.0679
age_old(60 and >60)			0.3273***	0.7038***	0.155
Male	−0.1488**	−0.0821***	−0.1760***	−0.1184**	−0.1239
Married	0.0297	0.0893***	0.1748***	0.2108***	0.3002***
Economic					
lnincome_percapita	−0.0603	0.0077	0.0408***	0.0445*	−0.0293
_cons	0.4385	−0.6053**	−1.1834***	−1.0531***	1.2925*
wasteseparation3					
Household's housing conditions					
housingtenure	0.03	0.0332	0.1406***	0.0376	0.2189***
householdsize	0.0266*	0.01551*	0.0243***	0.0037	0.0611*

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table 6 (*continued*)

Variables	SECs				
	1	2	3	4	5 and 6
residence_time(1)	0.0488	0.1669***	0.0396	−0.0437	0.0953
residence_time(2)	−0.0652	0.1200**	0.0326	0.0889	0.0037
residence_time(3)	0.1004	0.1986***	0.0691	0.1308	0.0286
Use of information technologies					
Internet	0.1719***	0.2480***	0.2769***	0.0647	0.1893
Participation in organizations and social networks					
organizations	0.7924*	−0.0362	0.3782**	0.2624	−0.0738
Perception of living conditions and institutional performance					
environment_water	0.1431**	0.0498*	0.1499***	0.0541	0.2526***
environment_air	0.0331	−0.1103***	−0.1251***	0.0514	−0.1293
environment_ waste_disposal	0.0831	0.1855***	0.1139***	0.1411**	0.1492
environment_cleaning_streets	0.1548**	0.0208	0.0126	−0.1098*	−0.0293
Poverty	−0.0452	−0.0141	−0.0543*	0.1238	
Socio-demographic characteristics and education					
pre-kindergarten_(0–4 years)	−0.3329**	−0.1727***			−0.6971*
elementary_(5–10 years)	−0.3278***	−0.2192***	−0.0421	−0.2684*	
high-school_(11–14 years)	−0.3434***	−0.2618***	0.0154	−0.2496**	−0.7267*
university_(15–17)			0.1920***	−0.1930*	−0.7453**
postgraduate_(>17)	0.4304**	−0.1143	0.2610***	−0.0517	−0.7623**
age_young(18–26)	−0.3127**	−0.3710***			
age_adulthood(27–59)	0.0091	0.0075	0.2282***	0.4659***	0.2154
age_old(60 and >60)			0.3705***	0.6922***	0.3195
Male	−0.1706***	−0.0892***	−0.1769***	−0.0888*	−0.1279
Married	0.0136	0.1056***	0.1342***	0.2105***	0.2880***
Economic					
lnincome_percapita	−0.0388	0.0212	0.0251	0.0146	0.0015
_cons	0.0875	−0.6368***	−0.9419***	−0.3691	0.5679
atrho21	1.4227***	1.3410***	1.4388***	1.5359***	1.2935***
atrho31	1.4329***	1.3597***	1.4025***	1.4730***	1.2700***
atrho32	1.8156***	1.7912***	1.8034***	1.7828***	1.6972***
rho21	0.8901***	0.8719***	0.8934***	0.9114***	0.8600***
rho31	0.8922***	0.8763***	0.88589***	0.9001***	0.8538***
rho32	0.9484***	0.9458***	0.9471***	0.9450***	0.9350***
Log-likelihood	−2294.54	−11423.57	−12349.48	−3573.1508	−1487.1315
Wald chi2(57)	169.31	474.6	790.54	208.34	104.96
Likelihood ratio test – chi2(3)	2704.68	12433.40	14166.30	4425.87	1502.7
N	2112	9074	9814	3235	1387

*** Statistically significant at 1%.
** Statistically significant at 5%.
* Statistically significant at 10%.

Appendix A). There is a coincidence between our results and the Communication Survey Colombia 2012 (Universidad Externado de Colombia, 2012). The survey reveals that 35% of the households in SEC 1 have Internet access. This variability in Internet access was statistically significant and positive for all types of separation in the SECs 1, 2 and 3 – a surprising result given the lack of access to this information technology; although for *wasteseparation1*, Internet access turned out to be statistically significant and positive in all SECs.

As for socio-demographic variables, such as education, only the highest levels of education, such as *university_(15–17)* and *postgraduate_(>17)*, were positive and statistically significant in the lowest SECs. That is, in SEC 3, in all types of waste separation, the levels of university and postgraduate education achieved by the heads of household generate a greater probability of source-separated recycling. Similarly, in SEC 1, for *wasteseparation2* and *wasteseparation3*, only postgraduate education produces a positive pro-environmental attitude towards recycling. The opposite is shown in SECs 5 and 6, in which the levels of education generate a negative pro-environmental attitude. This result is consistent with the De Feo and De Gisi (2010)'s study, for whom a higher education level does not necessarily imply a high level of environmental awareness. Nevertheless, our result differs from the study by Zen et al. (2014), for whom higher incomes and higher educational backgrounds generate positive environmental attitudes.

Usually, the influence of education on waste management is statistically insignificant (Saphores and Nixon, 2014). In this study, in SECs 1 and 2, *pre-kindergarten_(0–4 years), elementary_(5–10 years) and high-school_(11–14 years)* levels were statistically significant, although with negative signs; while in SEC 3 only the highest levels of education were found to be statistically significant and with positive signs. The hypothesis is that a higher level of education boosts the likelihood of improved and competent household waste management. Although the level of education is important, managing household solid waste relies on an awareness of the importance of environmental protection and recycling, which is facilitated by higher education levels. Education on waste management improves efficiency in handling and reduces the impact of waste on human health and the environment.

In terms of the age set by classes, we find that the *age_adulthood* (27–59) and *age_old* (60 *and >60)* ranges are statistically significant and have a positive sign in SECs 3 and 4. This indicates that the likelihood of source-separated recycling for the heads of household on in this age range increases. Interestingly, in the lowest age range the results were negative. Thus, our results coincide with those found by Akil et al. (2015) in Iskandar, Malaysia, which show that the older the head of household, the higher their pro-environmental behavior towards recycling. The gender of the head of the household also proves to be important in shaping the pro-environmental attitudes of households. As per our results, if

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

the head of the household is male, the likelihood of recycling in all types of waste separation decreases. These results are obtained in all SECs, except 5 and 6. Our results differ from those of Owusu et al. (2013), who found that male gender had a positive effect on the attitude of recycling in Ghana.

Regarding the heads of the household's perception about key environmental aspects and their effect on source-separated recycling, the disposal of garbage is statistically significant and positive in all SECs for *wasteseparation2*. This result can be attributed to the fact that most individuals surveyed associate air quality with the caring for the environment, thus generating a positive attitude towards recycling. Linked to the heads of the household's perception of environmental aspects, the social behavior of households, captured through the participation of the head of the household in environmental organizations, points out a relevant role of these institutions in the separation of waste, particularly in the households of SEC 1 for the three types of separation.

However, returning to the issue of perception about the disposal of garbage and its positive effect on recycling, we can infer that such a relationship generated some surprise because of the many problems that arose in the city due to the introduction of a new trash collection system. Thus, one of the government's control entities sanctioned the mayor of Bogotá, removing him from office for a few months for altering the traditional garbage collection service and legalizing informal recyclers. These facts polarized the residents' views on urban management. Despite this polarization, there are different perceptions about the institutional performance in all SECs and different types of waste separation. For instance, while for SECs 1 and 3 and *wasteseparation1*, only the variable *environment_water* increases the likelihood of recycling, for SECs 2, 4 and 6, three variables, that is, *environment_ waste_disposal*, *environment_cleaning_streets* and *environment_air*, are the ones that increase the likelihood of recycling.

The factors that shape the attitudes towards source-separated recycling and that allow for forming a profile among Bogotá's households by considering their SEC are summarized in Table 7. By way of illustration, the factors that determine the attitudes towards source-separated recycling in SEC 1 are Internet access, belonging to an organization that defends the environment, high water quality (associated with the care of the environment) and not being male. It is also possible to determine a household's profile per type of waste. Thus, for example, a household that separates paper and cardboard and glass, metal and plastic from SEC 1, apart from the above-mentioned characteristics, the head of the household must have a higher education level.

Likewise, for a source-separated recycling household of SEC 2, the factors that generate pro-environmental attitudes are Internet access, household size, having more than a year of living in their place of residence, garbage disposal (fundamental in their perception about the environment), not being male and being married. In SEC 3, Internet access, being homeowners, household size, garbage disposal, and water quality are key elements in their perception of institutions and the environment; additionally, to have a minimum level of university education, to be adult, not being male and being married. For SEC 4, being an adult, not being a male, and being married. Finally, for SECs 5 and 6, only the homeownership and being married generate attitudes in favor of the source-separated recycling.

5. Conclusions and policy implications

In this study, our objective was to know the attitude of households regarding separating solid waste in Bogotá, Colombia, considering their SECs. The poverty conditions measured through monetary income and households' multidimensional poverty have given us the ability to infer great heterogeneity between socioeconomic divisions. Hence, analyzing aggregate information regardless of this heterogeneity would not reflect such households' true attitudes towards recycling solid waste. Two conclusions can be drawn from this study. The first one is that, the greater the SEC, the greater the attitudes towards the source-separated recycling among the households of Bogotá. The second is the identification of a profile by SEC in the households of Bogotá, which largely reflects the attitudes of the head of the household towards source-separated recycling. From these conclusions, we can infer similarities and differences in the attitudes towards the separation of solid waste between SECs, thus facilitating the design of intervention policies from the local government as the main agent in the allocation of economic resources in favor of recycling.

Among the similarities of SECs, it is evident that in SECs 3 and 6 there are some common attitudes when heads of the household own their homes. Households with a fully paid house in Bogotá in 2014 and 2015 were 37% and 33%, respectively (DANE, 2016). These percentages rank Bogotá as the city with the lowest number of homeowners in Colombia. In this sense, policy-making efforts should aim to increase the affordability of housing in the lower SECs and it should become one of the main concerns of the local government, as these households represent an important part of the population. Other similarities in attitudes towards recycling were found between SECs 1 and 4, since they belong to an organization that defends the environment in the separation of food and organic waste and paper and cardboard. The local government can promote the affiliation to environmental organizations through institutions such as the Regional Autonomous Corporations for Sustainable Development,[10] which have among their functions this type of activities.

With respect to the differences between SECs, the evidence obtained indicates that the education level of the head of the household and having Internet access play an important role in the attitude towards the separation of wastes in households belonging to the lowest SECs. The promotion of higher education levels through the implementation of a condonable scholarship policy should become a municipal priority to reinforce the attitudes towards the source-separated recycling in the households of these SECs. In fact, nowadays, households' income levels cannot support tuition costs of higher education in private institutions, and Colombian state-supported universities only admit a small quota of students every year. Thus, facilitating access to new information technologies, such as the Internet, as well as the implementation of campaigns to care for the environment from the earliest years of school are measures that should be part of the local environmental policy, with a focus on the households of lowest SECs. Information tools have already proven to be key elements in spreading and encouraging environmental programs and improving recycling habits in the home (López-Mosquera, 2015). Finally, to complement the above-mentioned recommendations, a reform of the current tax-deductible system that incentivizes reusing solid waste at the household level should be developed[11].

[10] The Regional Autonomous Corporations for the Sustainable Development (CAR) are corporate entities of public character, integrated to administrative territorial units, called in Spanish "*Departamentos*". The function of these entities is to manage in a decentralized manner the national environmental policy and monitoring the natural resources under their jurisdiction.

[11] In 2002, the Colombian Commission for the Regulation of Drinking Water and Basic Sanitation (CRA) issued the Law No. 233 – *Resolución No. 233* – by means of which all households could resort to the option of paying a multi-user fee based on previous appraisal of a collective amount of solid waste generated. In the first years of its enforcement, there was a negligible increase in coverage for lower SECs concomitant with a significant one in higher SECs. This was partly because providers of the service did not have incentives to disseminate the benefits of 'multi-user' households among the 'user' households, due to the cost that entails their rise. For more on this, see Contraloría de Bogotá (2005).

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table 7
Attitudes towards source-separated recycling in Bogotá

Variables	SEC 1		
	Attitudes		
	wasteseparation1	wasteseparation2	wasteseparation3
housingtenure	+	+	
householdsize			+
internet	+	+	+
organizations	+	+	+
environment_water	+	+	+
environment_ waste_disposal		+	
environment_cleaning_streets			+
postgraduate_(>17)		+	+
male	–	–	–
SEC 2			
housingtenure		+	
householdsize	+	+	+
residence_time(1)	+	+	+
residence_time(2)	+	+	+
residence_time(3)	+	+	+
internet	+	+	+
environment_water			+
environment_ waste_disposal	+	+	+
environment_cleaning_streets		+	
male	–	–	–
married	+	+	+
SEC 3			
housingtenure	+	+	+
householdsize		+	+
internet	+	+	+
organizations		+	+
environment_water	+	+	+
environment_ waste_disposal	+	+	+
university_(15–17)	+	+	+
postgraduate_(>17)	+	+	+
age_adulthood(27–59)	+	+	+
age_old(60 and >60)	+	+	+
male	–	–	–
married	+	+	+
lnincome_percapita		+	
SEC 4			
householdsize		+	
residence_time(3)		+	
internet	+		
organizations	+	+	
environment_ waste_disposal		+	+
poverty	+		
age_adulthood(27–59)	+	+	+
age_old(60 and > 60)	+	+	+
male	–	–	–
married	+	+	+
lnincome_percapita		+	
SECs 5 and 6			
housingtenure	+	+	+
householdsize			+
residence_time(1)	+		
internet	+		
environment_water			+
environment_ waste_disposal		+	
married	+	+	+

We cannot overlook the limitations of this research. One of them is the heterogeneity of solid waste in terms of household recycling. We treated solid waste as a single category of waste, which is not necessarily the case. For instance, electronic waste such as batteries, mobile phones and other devices take on more risks to household health than, say, organic waste. Thus, an in-depth analysis should include a better discrimination of solid waste according to its several forms within households. Another limitation is being unable to contrast the same households' attitudes over time. Further studies might overcome this limitation as longitudinal surveys become available. By undertaking such surveys, researchers would have a much better tool for analyzing through the time the whole functional chain of recycling within cities of emerging economies.

Appendix A

See Table A1–A3.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table A1
The household separates food and organic waste. Source: Encuesta Multipropósito para Bogotá (2011 and 2014). Authors' elaboration.

Variables	SECs									
	1		2		3		4		5 and 6	
	Obs= Freq.	2112 %	Obs= Freq.	9074 %	Obs= Freq.	9814 %	Obs= Freq.	3235 %	Obs= Freq.	1387 %
0	1540	73	5795	64	5009	51	1050	32	370	27
1	572	27	3279	36	4805	49	2185	68	1017	73
Household's housing conditions										
housingtenure										
0	313	55	2110	64	2659	55	1049	48	415	41
1	259	45	1169	36	2146	45	1136	52	602	59
householdsize										
1	57	10	313	10	640	13	483	22	295	29
2	90	16	556	17	1070	22	669	31	291	29
3	137	24	773	24	1186	25	450	21	218	21
4	126	22	864	26	1148	24	424	19	158	16
5	83	15	475	14	471	10	111	5	46	5
>5	79	14	298	9	290	6	48	2	9	1
residence_time(1)										
0	507	89	2921	89	4213	88	1843	84	824	81
1	65	11	358	11	592	12	342	16	193	19
residence_time(2)										
0	542	95	2928	89	4297	89	1918	88	877	86
1	30	5	351	11	508	11	267	12	140	14
residence_time(3)										
0	132	23	951	29	1510	31	805	37	432	42
1	440	77	2328	71	3295	69	1380	63	585	58
Use of information technologies										
internet										
0	371	65	1708	52	1645	34	329	15	101	10
1	201	35	1571	48	3160	66	1856	85	916	90
Participation in organizations and social networks										
organizations										
0	566	99	3256	99	4767	99	2150	98	1001	98
1	6	1	23	1	38	1	35	2	16	2
Perception of living conditions and institutional performance										
environment_water										
0	311	54	1755	54	2730	57	1382	63	759	75
1	261	46	1524	46	2075	43	803	37	258	25
environment_air										
0	472	83	2821	86	4266	89	2022	93	960	94
1	100	17	458	14	539	11	163	7	57	6
environment_ waste_disposal										
0	417	73	2219	68	3334	69	1573	72	805	79
1	155	27	1060	32	1471	31	612	28	212	21
environment_cleaning_streets										
0	379	66	1971	60	3030	63	1477	68	950	93
1	193	34	1308	40	1775	37	708	32	178	18
poverty										
0			2394	73	4022	84				
1			885	27	783	16				
Socio-demographic characteristics and education										
pre-kindergarten_(0–4 years)	83	15	362	11	387	8	142	7	34	3
elementary_(5–10 years)	244	43	1100	34	826	17	80	4	20	2
high-school_(11–14 years)	175	31	1294	39	1560	32	294	13	58	6
university_(15–17)	39	7	308	9	635	13	209	10	57	6
postgraduate_(>17)	31	5	215	7	1397	29	1460	67	848	83
	572	100	3279	100	4805	100	2185	100	1017	100
age_young(18–26)	35	6.12	164	5.00	170	3.54	56	2.56	26	2.56
age_adulthood(27–59)	471	82.34	2604	79.41	3474	72.30	1453	66.50	665	65.39
age_old(60 and > 60)	66	11.54	511	15.58	1161	24.16	676	30.94	326	32.06
	572	100	3279	100	4805	100	2185	100	1017	100
male										
0	229	40	1158	35	1769	37	847	39	341	34
1	343	60	2121	65	3036	63	1338	61	676	66
married										
0	451	79	2301	70	2943	61	1213	56	511	50
1	121	21	978	30	1862	39	972	44	506	50

Note: Per capita income is not included insofar as we used its natural logarithm.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table A2
The household separates paper and cardboard from other garbage. Source: Encuesta Multipropósito para Bogotá (2011 and 2014). Authors' elaboration.

Variables	SECs									
	1		2		3		4		5 and 6	
	Obs= Freq.	2112 %	Obs= Freq.	9074 %	Obs= Freq.	9814 %	Obs= Freq.	3235 %	Obs= Freq.	1387 %
0	1491	73	5501	61	4684	48	998	31	330	24
1	621	27	3573	39	5130	52	2237	69	1057	76
Household's housing conditions										
housingtenure										
0	342	55	2278	64	2876	56	1067	48	429	41
1	279	45	1295	36	2254	44	1170	52	628	59
householdsize										
1	62	10	348	10	691	13	489	22	301	28
2	96	15	586	16	1127	22	677	30	307	29
3	145	23	874	24	1261	25	450	20	233	22
4	131	21	926	26	1232	24	454	20	158	15
5	94	15	501	14	514	10	115	5	47	4
>5	93	15	338	9	305	6	52	2	11	1
residence_time(1)										
0	553	89	3195	89	4500	88	1894	85	863	82
1	68	11	378	11	630	12	343	15	194	18
residence_time(2)										
0	586	94	3191	89	4580	89	1956	87	907	86
1	35	6	382	11	550	11	281	13	150	14
residence_time(3)										
0	145	23	1017	28	1611	31	819	37	451	43
1	476	77	2556	72	3519	69	1418	63	606	57
Use of information technologies										
internet										
0	402	65	1867	52	1746	34	342	15	111	11
1	219	35	1706	48	3384	66	1895	85	946	89
Participation in organizations and social networks										
organizations										
0	615	99	3549	99	5084	99	2199	98	1041	98
1	6	1	24	1	46	1	38	2	16	2
Perception of living conditions and institutional performance										
environment_water										
0	335	54	1887	53	2890	56	1403	63	777	74
1	286	46	1686	47	2240	44	834	37	280	26
environment_air										
0	508	82	3079	86	4545	89	2065	92	983	93
1	113	18	494	14	585	11	172	8	74	7
environment_ waste_disposal										
0	447	72	2395	67	3564	69	1607	72	830	79
1	174	28	1178	33	1566	31	630	28	227	21
environment_cleaning_streets										
0	410	66	2113	59	3230	63	1502	67	828	78
1	211	34	1460	41	1900	37	735	33	229	22
poverty										
0			2602	73	4256	83	2106	94	1023	97
1			971	27	874	17	131	6	34	3
Socio-demographic characteristics and education										
pre-kindergarten_(0–4 years)	90	14	388	11	412	8	140	6	37	4
elementary_(5–10 years)	261	42	1209	34	867	17	84	4	22	2
high-school_(11–14 years)	188	30	1421	40	1690	33	301	13	61	6
university_(15–17)	43	7	321	9	688	13	206	9	64	6
postgraduate_(>17)	39	6	234	7	1473	29	1506	67	873	83
	621	100	3573	100	5130	100	2237	100	1057	100
age_young(18–26)	38	6	177	5	191	4	56	3	26	2
age_adulthood(27–59)	505	81	2850	80	3706	72	1486	66	685	65
age_old(60 and >60)	78	13	546	15	1233	24	695	31	346	33
	621	100	3573	100	5130	100	2237	100	1057	100
male										
0	236	38	1266	35	1902	37	859	38	360	34
1	385	62	2307	65	3228	63	1378	62	697	66
married										
0	484	78	2551	71	3163	62	1237	55	533	50
1	137	22	1022	29	1967	38	1000	45	524	50

Note: Per capita income is not included insofar as we used its natural logarithm.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Table A3
The household separates glass, metal and plastic from other garbage. Source: Encuesta Multipropósito para Bogotá (2011 and 2014). Authors' elaboration.

Variables	SECs									
	1		2		3		4		5 and 6	
	Obs= Freq.	2112 %	Obs= Freq.	9074 %	Obs= Freq.	9814 %	Obs= Freq.	3235 %	Obs= Freq.	1387 %
0	1470	73	5326	59	4560	46	978	30	329	24
1	642	27	3748	41	5254	54	2257	70	1058	76
Household's housing conditions										
housingtenure										
0	364	57	2405	64	2970	57	1084	48	430	41
1	278	43	1343	36	2284	43	1173	52	628	59
householdsize										
1	60	9	365	10	703	13	504	22	303	29
2	99	15	608	16	1158	22	684	30	299	28
3	147	23	919	25	1290	25	462	20	237	22
4	146	23	979	26	1259	24	446	20	160	15
5	95	15	528	14	521	10	111	5	49	5
>5	95	15	349	9	323	6	50	2	10	1
residence_time(1)										
0	577	90	3346	89	4611	88	1907	84	860	81
1	65	10	402	11	643	12	350	16	198	19
residence_time(2)										
0	601	94	3351	89	4697	89	1977	88	912	86
1	41	6	397	11	557	11	280	12	146	14
residence_time(3)										
0	148	23	1066	28	1640	31	831	37	450	43
1	494	77	2682	72	3614	69	1426	63	608	57
Use of information technologies										
internet										
0	413	64	1957	52	1790	34	349	15	108	10
1	229	36	1791	48	3464	66	1908	85	950	90
Participation in organizations and social networks										
organizations										
0	636	99	3725	99	5208	99	2222	98	1043	99
1	6	1	23	1	46	1	35	2	15	1
Perception of living conditions and institutional performance										
environment_water										
0	347	54	1972	53	2964	56	1416	63	775	73
1	295	46	1776	47	2290	44	841	37	283	27
environment_air										
0	527	82	3221	86	4660	89	2084	92	985	93
1	115	18	527	14	594	11	173	8	73	7
environment_ waste_disposal										
0	467	73	2502	67	3645	69	1634	72	832	79
1	175	27	1246	33	1609	31	623	28	226	21
environment_cleaning_streets										
0	416	65	2226	59	3299	63	1529	68	828	78
1	226	35	1522	41	1955	37	728	32	230	22
poverty										
0			2716	72	4383	83				
1			1032	28	871	17				
Socio-demographic characteristics and education										
pre-kindergarten_(0–4 years)	95	15	420	11	429	8	152	7	37	3
elementary_(5–10 years)	274	43	1274	34	896	17	85	4	22	2
high-school_(11–14 years)	192	30	1459	39	1737	33	305	14	59	6
university_(15–17)	43	7	358	10	698	13	202	9	65	6
postgraduate_(>17)	38	6	237	6	1494	28	1513	67	875	83
	642	100	3748	100	5254	100	2257	100	1058	100
age_young(18–26)	40	6	181	5	192	4	60	3	24	2
age_adulthood(27–59)	525	82	2988	80	3797	72	1501	67	688	65
age_old(60 and > 60)	77	12	579	15	1265	24	696	31	346	33
	642	100	3748	100	5254	100	2257	100	1058	100
male										
0	248	39	1329	35	1960	37	868	38	359	34
1	394	61	2419	65	3294	63	1389	62	699	66
married										
0	502	78	2671	71	3269	62	1259	56	531	50
1	140	22	1077	29	1985	38	998	44	527	50

Note: Per capita income is not included insofar as we used its natural logarithm.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

References

Adeniran, A.E., Nubi, A.T., Adelopo, A.O., 2017. Solid waste generation and characterization in the University of Lagos for a sustainable waste management. Waste Manage. (Oxford) 67, 3–10.

Akil, A.M., Foziah, J., Ho, C.S., 2015. The effect of socio-economic influence on households' recycling behaviour in Iskandar, Malaysia. Procedia-Soc. Behav. Sci. 202, 124–134.

Aleluia, J., Ferrão, P., 2016. Characterization of urban waste management practices in developing Asian countries: a new analytical framework based on waste characteristics and urban dimension. Waste Manage. (Oxford) 58, 415–429.

Arbués, F., Villanúa, I., 2016. Determinants of behavior toward selective collection of batteries in Spain. A bivariate probit model. Resour. Conserv. Recycl. 106, 1–8.

Bolívar, L., Moreno C., 2013. Towards a sustainable and collaborative supply chain paradigm in municipal solid waste management: an evaluation of the proposed framework in Bogotá, Colombia. In: Kersten, W., Blecker, T., Ringle C. (Eds.), Supply chain, logistics and operations management. Sustainability and collaboration in supply chain management: A comprehensive insight into current management approaches supply chain. Editores BoD – Books on Demand, pp. 163–177.

Cappellari, L., Jenkins, S.P., 2003. Multivariate probit regression using simulated maximum likelihood. Stata J. 3 (3), 278–294.

Chigona, W., Beukes, D., Vally, J., Tanner, M., 2009. Can mobile internet help alleviate social exclusion in developing countries? Electron. J. Inform. Syst. Dev. Countries 36 (7), 1–16.

CONPES 2904, 1997. Consejo Nacional de Política Económica y Social, 1997. La estratificación socioeconómica avance y retos. Departamento Nacional de Planeación. República de Colombia. Santa Fe de Bogotá, D.C. <https://colaboracion.dnp.gov.co/CDT/CONPES/Econ%C3%B3micos/2904.pdf> (Accessed 04.03.16).

CONPES 3874, 2016. Consejo Nacional de Política Económica y Social, 2016. Política Nacional para la Gestión Integral de Residuos Sólidos. Departamento Nacional de Planeación. República de Colombia. <https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/3874.pdf> (Accessed 05.05.17).

Contraloría de Bogotá, D.C., 2005. Analisis al cumplimiento de las resoluciones sobre multiusuarios por parte de las empresas y entidades del sector aseo. Informe Setorial, Bogotá, D.C., Colombia. http://www.contraloriabogota.gov.co/destino.asp?solicitud=informes.htm. (Accessed 05.05.16).

Contraloría de Bogotá D.C., 2016. Evaluación de la Implementación del Programa Basura Cero en Bogotá. Plan Anual de Estudios PAE 2016. Dirección de Estudios de Economía y Política Pública Bogotá, D.C. julio de 2016 <http://www.contraloriabogota.gov.co/intranet/contenido/informes/Estructurales/Subdir%20Estudios%20Econ%C3%B3micos%20y%20Fiscales%20de%20Bogota/2016/Evaluacion%20de%20la%20Implementacion%20del%20Programa%20de%20Basuras.pdf>.

Corredor, M., 2010. El sector reciclaje en Bogotá y su región: oportunidades para los negocios inclusivos. Serie Guías Sectoriales, 2.

DANE 2011. [dataset] EMB 2011. Encuesta Multipropósito para Bogotá Distrito Capital, 2011. Departamento Administrativo Nacional de Estadística (DANE). Gobierno Nacional. Secretaria Distrital de Planeación de Bogotá. Gobierno Distrital <http://formularios.dane.gov.co/Anda_4_1/index.php/catalog/189/export> (Accessed 02.02.2015).

DANE 2014. [dataset] EM 2014. Encuesta Multipropósito, 2014. Departamento Administrativo Nacional de Estadística (DANE). Gobierno Nacional. Secretaria Distrital de Planeación de Bogotá. Gobierno Distrital <http://formularios.dane.gov.co/Anda_4_1/index.php/catalog/365> (Accessed 02.02.2015).

DANE, 2010. Departamento Administrativo Nacional de Estadística, 2010. Colombia. Proyecciones de Población Municipales por Area. 2005–2020. <https://www.dane.gov.co/files/.../poblacion/...20/ProyeccionMunicipios2005_2020.xls> (Accessed 21.02.16).

DANE, 2013. Departamento Administrativo Nacional de Estadística, 2013. Pobreza en Colombia. Comunicado de Prensa. Oficina de Prensa. Bogotá D.C. <https://www.dane.gov.co/files/investigaciones/condiciones_vida/pobreza/cp_pobreza_20122.pdf> (Accessed 05.02.16).

DANE, 2016. Departamento Administrativo Nacional de Estadística, 2016c. Encuesta Nacional de Calidad de Vida – 2015. Boletín técnico <https://www.dane.gov.co/files/investigaciones/condiciones_vida/calidad_vida/Boletin_Tecnico_ECV_2015.pdf> (Accessed 16.09.16).

De Feo, G., De Gisi, S., 2010. Public opinion and awareness towards MSW and separate collection programmes: a sociological procedure for selecting areas and citizens with a low level of knowledge. Waste Manage. (Oxford) 30 (6), 958–976.

Dedinec, A., Markovska, N., Ristovski, I., Velevski, G., Gjorgjievska, V., Grncarovska, T., Zdraveva, P., 2015. Economic and environmental evaluation of climate change mitigation measures in the waste sector of developing countries. J. Cleaner Prod. 88, 234–241.

Echegaray, F., Hansstein, F.V., 2017. Assessing the intention-behavior gap in electronic waste recycling: the case of Brazil. J. Cleaner Prod. 142 (1), 180–190.

Ekere, W., Mugisha, J., Drake, L., 2009. Factors influencing waste separation and utilization among households in the Lake Victoria crescent Uganda. Waste Manage. 29 (12), 3047–3051.

Espinoza, P.T., Acre, E.M., Daza, D., Faure, M. S., Terraza, H., 2010. Regional evaluation on urban solid waste management in Latin America and the Caribbean. Pan American Heath organization (PAHO), Inter-American Association of Sanitary and Environmental Engineering (AIDIS), Inter-American Development Bank (IDB).

Fobil, J., May, J., Kraemer, A., 2010. Assessing the relationship between socioeconomic conditions and urban environmental quality in Accra, Ghana. Int. J. Environ. Res. Public Health 7 (1), 125–145.

Ghani, W.A.W.A.K., Rusli, I.F., Biak, D.R.A., Idris, A., 2013. An application of the theory of planned behaviour to study the influencing factors of participation in source separation of food waste. Waste Manage. (Oxford) 33 (5), 1276–1281.

Greyson, J., 2007. An economic instrument for zero waste, economic growth and sustainability. J. Cleaner Prod. 15 (13–14), 1382–1390.

Gu, B., Wang, H., Chen, Z., Jiang, S., Zhu, W., Liu, M., Yang, J., 2015. Characterization, quantification and management of household solid waste: a case study in China. Resour. Conserv. Recycl. 98, 67–75.

Gundupalli, S.P., Hait, S., Thakur, A., 2017. A review on automated sorting of source-separated municipal solid waste for recycling. Waste Manage. (Oxford) 60, 56–74.

Hoornweg, D., Bhada-Tata, P., 2012. What a waste: a global review of solid waste management. Urban Development Series Knowledge Papers 15, 1–98.

Jacobi, P.R., Besen, G.R., 2011. Gestão de resíduos sólidos em São Paulo: desafios da sustentabilidade. Estudos Avançados 25 (71), 135–158.

Kolekar, K.A., Hazra, T., Chakrabarty, S.N., 2016. A review on prediction of municipal solid waste generation models. Procedia Environ. Sci. 35, 238–244.

Law No. 142 of 1994 (11 de julio). Por la cual se establece el régimen de los servicios públicos domiciliarios y se dictan otras disposiciones. Diario Oficial, número 41.433 del 11 de julio de 1994.

Lee, S., Paik, H.S., 2011. Korean household waste management and recycling behavior. Build. Environ. 46 (5), 1159–1166.

López-Mosquera, N., Lera-López, F., Sánchez, M., 2015. Key factors to explain recycling, car use and environmentally responsible purchase behaviors: a comparative perspective. Resour. Conserv. Recycl. 99, 29–39.

Maddox, P., Doran, C., Williams, I.D., Kus, M., 2011. The role of intergenerational influence in waste education programmes: the THAW project. Waste Manage. (Oxford) 31 (12), 2590–2600.

Martínez-Espiñeira, R., García-Valiñas, M.A., Nauges, C., 2014. Households' pro-environmental habits and investments in water and energy consumption: determinants and relationships. J. Environ. Manage. 133, 174–183.

Martínez, C.I.P., Piña, W.H.A., 2015. Recycling in Bogotá: a SWOT analysis of three associations to evaluate the integrating the informal sector into solid waste management. World Acad. Sci., Eng. Technol., Int. J. Soc., Behav., Educ., Econ., Bus. Ind. Eng. 9 (6), 1793–1798.

Meng, T., Klepacka, A.M., Florkowski, W.J., Braman, K., 2016. Determinants of recycling common types of plastic product waste in environmental horticulture industry: the case of Georgia. Waste Manage. (Oxford) 48, 81–88.

Méndez, F., Gómez, O., Girón, S., Mateus, J., Mosquera, J., Filigrana, P., ... Gulloso, L., 2006. Evaluación del impacto del relleno sanitario Doña Juana en la salud de grupos poblacionales en su área de influencia. Internet: <http://www.cerrarelbotadero.org/inicio/archivos/EstudioEpidemiologicoRSDJ. pdf> (Accessed 26.06.15)

Miezah, K., Obiri-Danso, K., Kádár, Z., Fei-Baffoe, B., Mensah, M.Y., 2015. Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. Waste Manage. (Oxford) 46, 15–27.

Minghua, Z., Xiumin, F., Rovetta, A., Qichang, H., Vicentini, F., Bingkai, L., Yi, L., 2009. Municipal solid waste management in Pudong new area, China. Waste Manage. 29 (3), 1227–1233.

Nguyen, T., Zhu, D., Le, N., 2015. Factors influencing waste separation intention of residential households in a developing country: Evidence from Hanoi, Vietnam. Habitat Int. 48, 169–176.

OAB, 2015. Observatorio Ambiental de Bogotá, 2015. Disposición de Residuos en el Relleno Sanitario Doña Juana Per Cápita-DRSPC. Bogotá, D.C. Colombia <http://oab.ambientebogota.gov.co/es/indicadores?id=184&v=l> (Accessed 02.06.15).

ONGIRS, 2012. Observatorio Nacional para la Gestión Integral de Residuos Sólidos Urbanos, 2012. Datos Estadísticos de Buenos Aires (2012). Dirección Nacional de Gestión Integral de Residuo del Ministerio de Ambiente y Desarrollo Sustentable (MAyDS), Argentina. <http://observatoriorsu.ambiente.gob.ar/estadisticas/7/buenos-aires> (Accessed 27.07.2016).

Owusu, V., Adjei-Addo, E., Sundberg, C., 2013. Do economic incentives affect attitudes to solid waste source separation? Evidence from Ghana. Resour. Conserv. Recycl. 78, 115–123.

Pandey, R.U., Surjan, A., Kapshe, M., 2017. Exploring linkages between sustainable consumption and prevailing green practices in reuse and recycling of household waste: case of Bhopal city in India. J. Cleaner Prod. https://doi.org/10.1016/j.jclepro.2017.03.227.

Piña, W.H.A., Martínez, C.I.P., 2014. Urban material flow analysis: an approach for Bogotá, Colombia. Ecol. Indic. 42, 32–42.

Salgado-López, J.A., 2012. Residuos sólidos: percepción y factores que facilitan su separación en el hogar. El caso de estudio de dos unidades habitacionales de Tlalpan. Quivera 14, 91–112.

Saphores, J.D.M., Nixon, H., 2014. How effective are current household recycling policies? Results from a national survey of US households. Resour. Conserv. Recycl. 92, 1–10.

SEDEMA, 2014. Secretaría del Medio Ambiente del Gobierno del Distrito Federal, 2014. Inventario de Residuos Sólidos de la Ciudad de México 2013 <http://www.sedema.df.gob.mx/sedema/index.php/temas-ambientales/programas-generales/residuos-solidos> (Accessed 10.09.2016).

SSPD, 2013. Superintendencia de Servicios Públicos Domiciliarios, 2013. Informe Nacional de Disposición Final 2013. Disposición Final de Residuos Sólidos en

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052

Colombia 2013. <http://www.superservicios.gov.co/content/download/3768/39428/version/1/file/INFORME+DE+DISPOCI%C3%93N+FINAL+2013+%2828.04.14%29.pdf> (Accessed 05.09.15).

Sukholthaman, P., Sharp, A., 2016. A system dynamics model to evaluate effects of source separation of municipal solid waste management: a case of Bangkok, Thailand. Waste Manage. 52, 50–61.

Suthar, S., Singh, P., 2015. Household solid waste generation and composition in different family size and socio-economic groups: a case study. Sustain. Cities Soc. 14, 56–63.

Tadesse, T., Ruijs, A., Hagos, F., 2008. Household waste disposal in Mekelle city, Northern Ethiopia. Waste Manage. 28 (10), 2003–2012.

Torres-González, J., 2014. Bogotá: social and business innovation in garbage collection – public policy beyond neoliberal vision. J. Power Polit. Gov. 2 (3&4), 77–92.

UAESP, 2011. Unidad Administrativa Especial de Servicios Públicos, 2011. Recuento Histórico de la EDIS a la UAESP <http://www.uaesp.gov.co/.../images/normatividad/20U> (Accessed 25.06.15).

UAESP, 2013. Unidad Administrativa Especial de Servicios Públicos, 2013. El Proyecto de Estudio del Plan Maestro para el Manejo Integral de Residuos Sólidos en Bogotá D.C. file:///C:/Users/Admin/Desktop/Bogota%20Waste/Review/Proyecto%20de%20estudio%20del%20plan%20maestro%20para%20la%20gesti%C3%B3n%20integral%20de%20residuos%20en%20Bogot%C3%A1.%20Informe.%202013.pdf. (Accessed 02.05.17).

UAESP, 2014. Unidad Administrativa Especial de Servicios Públicos, 2014. Avances significativos de las organizaciones de recicladores en el Programa Basura Cero. Comunicado de prensa. <http://www.uaesp.gov.co/uaesp_jo/index.php?option=com_content&view=article&id=134:avances-significativos-de-las-organizaciones-de-recicladores-en-el-programa-basura-cero&catid=1:boletines-de-prensa&Itemid=73> (Accessed 25.07.15).

Universidad Externado de Colombia, 2012. Encuesta comunicación Colombia 2012. Nuevas tecnologías de comunicación. Boletín de prensa, noviembre 21 <http://docplayer.es/5646921-Centro-de-investigacion-en-comunicacion-politica-facultad-de-comunicacion-social-boletin-de-prensa.html> (Accessed 23.07.16).

Veleva, V., Bodkin, G., Todorova, S., 2017. The need for better measurement and employee engagement to advance a circular economy: lessons from Biogen's "zero waste" journey. J. Cleaner Prod. 154, 517–529.

Vergara, S.E., Damgaard, A., Gomez, D., 2016. The efficiency of informality: quantifying greenhouse gas reductions from informal recycling in Bogotá, Colombia. J. Ind. Ecol. 20, 107–119.

Verma, R.L., Borongan, G., Memon, M., 2016. Municipal solid waste management in Ho Chi Minh City, Viet Nam. Current practices and future recommendation. Procedia Environ. Sci. 35, 127–139.

Waters, T., Waters, D., 2016. Are the terms "socio-economic status" and "class status" a warped form of reasoning for Max Weber? Palgrave Communications <http://www.palgrave-journals.com/articles/palcomms20162> doi: 10.1057/palcomms.2016.2. (Accessed 12.10.16).

Widyaningsih, N., Tjiptoherijanto, P., Widanarko, S., Seda, F.S., 2015. Linkage model between sustainable consumption and household waste management. Procedia Environ. Sci. 28, 195–203.

Zaman, A., Lehmann, S., 2013. The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city'. J. Clean. Prod. 50, 123–132.

Zen, I.S., Noor, Z.Z., Yusuf, R.O., 2014. The profiles of household solid waste recyclers and non-recyclers in Kuala Lumpur, Malaysia. Habitat Int. 42, 83–89.

Zen, I.S., Subramaniam, D., Sulaiman, H., Saleh, A.L., Omar, W., Salim, M.R., 2016. Institutionalize waste minimization governance towards campus sustainability: a case study of Green Office initiatives in Universiti Teknologi Malaysia. J. Cleaner Prod. 135, 1407–1422.

Zheng, P., Zhang, K., Zhang, S., Wang, R., Wang, H., 2017. The door-to-door recycling scheme of household solid wastes in urban areas: a case study from Nagoya, Japan. J. Clean. Prod. 163, S366–S373.

Please cite this article in press as: J. Padilla, A., Trujillo, J.C. Waste disposal and households' Heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.11.052