What is the Destination of Brazilian families' waste? A Regional Analysis

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Abstract

Current global of municipal solid waste generation levels are approximately 1.3 billion tonnes per year, and are expected to increase to approximately 2.2 billion tonnes per year by 2025. Solid waste is one of the challenging environmental issues in developing countries, especially in urban areas. As a consequence of population expansion, urbanization, higher income, and intensive use of packaging, the quantity of municipal solid waste (MSW) in urban areas continues increasing. The following questions are pertinent: do social, economic, and regional characteristics determine the option of improperly disposing of waste? And, what is the destination of Brazilian families' waste? To answer these questions, the present study analyzes the determinants of waste disposal and separation in Brazil, using the micro-data from the 2008-2009 Household Budgets Survey (POF) and a probit model. The main results indicate that increased income and years of study reduce the chance of an individual disposing of their waste improperly, as well as increase the chances of separating the biodegradable waste, and finally, we noticed that there are regional differences on the decision of waste disposal and separation.
Keywords: Waste; Urban Economics; Micro-data; Brazil; POF

Resumo

Os atuais níveis globais de geração de resíduos sólidos urbanos são de aproximadamente 1,3 bilhão de toneladas por ano e devem aumentar para aproximadamente 2,2 bilhões de toneladas por ano até 2025. Os resíduos sólidos são um dos problemas ambientais mais desafiadores nos países em desenvolvimento, especialmente nas áreas urbanas. Como conseqüência da expansão populacional, urbanização, maior renda e uso intensivo de embalagens, a quantidade de resíduos sólidos urbanos (RSU) em áreas urbanas continua aumentando. As seguintes questões são pertinentes: as características sociais, econômicas e regionais determinam a opção de descartar inadequadamente os resíduos? E qual é o destino do lixo das famílias brasileiras? Para responder a essas questões, o presente estudo analisa os determinantes da disposição e separação de resíduos no Brasil, utilizando os microdados da Pesquisa de Orçamentos Familiares (POF) 2008-2009 e um modelo *probit*. Os principais resultados indicam que o aumento da renda e dos anos de estudo reduzem a chance de um descarte indevido de seus resíduos, bem como aumentam as chances de separação os resíduos biodegradáveis e, finalmente, percebemos diferenças regionais na decisão de descarte de resíduos e da separação dos resíduos biodegradáveis.
Palavras-chave: Resíduos; Economia Urbana; Micro-dados; Brasil; POF

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Introduction

The environment provides services directly to consumers. The air we breathe, the nourishment we receive from food and drink, and the protection we derive from shelter and clothing are all benefits we receive, either directly or indirectly, from the environment (Tietenberg and Lewis, 2011). The society has been transforming for centuries, regarding to the production of goods and services. With each passing year, new technologies are added, and with this reaches higher levels of efficiency in production. In fact, this corroborates an improvement in the welfare of the population, since a larger part of society ends up having access to goods and services that were not previously available for their consumption. However, there is a great difficulty in measuring the welfare of society, since in counterpart to the increases obtained in the production of goods and services, there are: environmental degradation, air pollution, reduction of stocks of natural resources, soil and water pollution, among other effects that reduce social welfare.

Modak, Wilson and Velis (2015) point out that not having a solid waste collection service has a direct health impact on residents, particularly children. As well as, the uncontrolled burning of waste creates particulate and persistent organic pollutant emissions that are highly damaging locally and globally. Accumulated waste and blocked drains encourage vectors to breed, resulting in the spread of cholera, dengue fever and other infectious diseases and are a major contributing factor to flooding. Solid waste is one of the challenging environmental issues in developing countries, especially in urban areas. As a consequence of population expansion, urbanization, higher income, and intensive use of packaging, the quantity of municipal solid waste (MSW) in urban areas continues increasing Vassanadumrongdee and Kittipongvises (2018).

Hoornweg and Bhada-tata (2012) indicate that current global MSW generation levels are approximately 1.3 billion tonnes per year, and are expected to increase to approximately 2.2 billion tonnes per year by 2025. This represents a significant increase in per capita waste generation rates, from 1.2 to 1.42 kg per person per day in the next fifteen years. However, global averages are broad estimates only as rates vary considerably by region, country, city, and even within cities.

Similar to other developing countries, MSW has been a major environmental problem in Brazil. Waste generation per capita per day of Brazilian people is estimated to be 0,95 kg, which is higher than the average figure of other middle-income countries that is 0.79 kg reported by the World Bank, the average waste produced by Brazil is like East Asia and the Pacific Region. However, there are differences in the five major regions of the country. For the southeast and Midwest regions, 1.14 kg, for the South 0.77 kg, for the North 0.86 kg, and for the Northeast 0.96 kg. This demonstrates the heterogeneity related to waste production in the country.

With the increase of population and production of goods in the country, there is also the production of waste, which in turn requires logistics and infrastructure, for waste to be handled correctly and not dumped into rivers or burned and buried without proper control. Otherwise, waste can cause various social and environmental problems. As for example, cause floods, transmission of diseases, and consequently reducing the quality of life of the population. With this in mind. The following questions are pertinent: do social, economic, and regional characteristics determine the option of improperly disposing of garbage? And, what is the destination of Brazilian families' waste?

To answer these questions, the present study analyzes the determinants of waste disposal and separation in Brazil, using the micro-data from the 2008-2009 Household Budgets Survey (POF), prepared by the Brazilian Institute of Geography and Statistics (IBGE). In addition, the five major regions of the country are analyzed. Although there is a lack of empirical studies that investigate the socioeconomic and psychological determinants of environmental behavior, there are a number of studies that focus on household waste management policies and recycling and disposal behavior in response to these policies (Van Den Bergh, 2008). This, then, justifies the contribution of this study, which concerns a socioeconomic analysis of environmental behavior.

Literature Review

We can separate the literature into at least two blocks, one that covers public policy studies (for example: Jenkins et al. (2003), Bernstad (2014), Fremstad (2017), Agovino et al. (2018) and Andersson and Stage (2018)), and a second that addresses consumer issues regarding waste and socio-demographic characteristics (for example: Richardson e Havlicek (1978), Hong, Adams e Love (1993), Vicente and Reis (2008), D'amato, Mancinelli and Zoli (2016), Lee, Choi and Koo (2017), Tarfasa and Brouwer (2018)) which will be our focus in this section.

Richardson e Havlicek (1978) make an analysis of social and economic factors that affect the quantity and composition of household solid waste. The authors find that family income, household size, and age structure of the population are the main variables that affect the amounts of these components. In addition, they indicate that if all glass, metals, plastics, newspapers, other papers and textiles were recovered, then about 53% by weight of the solid waste residues would be usable resources.

According to Hong, Adams e Love (1993) in the face of rising disposal costs, communities are implementing programs to encourage recycling activities. Therefore, the authors investigate the role of price incentives and other socioeconomic factors in household recycling. The participation in recycling is modeled as an ordered *probit* choice using a large sample of families from the Portland, Oregon metropolitan area. The demand for solid waste collection is estimated using two-stage least squares. The results indicate that increases in disposal rates encourage recycling, although the demand for solid waste collection services is not substantially reduced.

According to Van den Bergh (2008), urban solid waste in OECD countries has grown significantly in recent decades. This is due, in part, to increased incomes, more intensive use of packaging materials and disposable goods, and increased purchasing of durable goods. According to the author, the undesirable environmental impacts of solid waste are twofold, namely the inefficient use of material resources and the generation of environmental pollution by waste, landfills and solid waste incineration.

According Vicente and Reis (2008), the success of a recycling programme depends on the active and sustained participation of citizens in the correct separation and collection of recyclable waste. The authors make an effective study of strategies aimed at augmenting people's involvement in recycling involves understanding which factors influence the decision to co-operate with a recycling programme. The research investigates the influence of attitudes, incentives, presence of children in household and information through direct media, on households' participation in recycling. The results suggest that positive attitudes toward recycling and information are important factors in

explaining recycling participation. Some guidelines that may be considered in future communication and intervention strategies designed to promote recycling participation are discussed

D'Amato, Mancinelli, Zoli (2016) investigate whether any relationship exists between waste reduction and recycling efforts and, in this case, if they turn out to be complements or substitutes in individuals' preferences. They theoretical results, supported by empirical evidence for England, suggest that waste policies and environmental motivations may affect recycling and waste reduction both directly and indirectly, through their reciprocal interactions.

Lee, Choi and Koo (2017) appointed that pro-environmental activities, such as waste sorting, are considered inconveniencing; the higher the inconvenience, the more difficult it becomes to encourage active public participation. The study defines waste sorting behavior considering certain attributes and estimates the inconvenience costs associated with each attribute. The definition also considers how and when waste is disposed of as well as the hygiene of a disposal spot. They apply a conjoint analysis for data collection and latent class logit model to calculate the inconvenience costs. The model incorporates consumers' heterogeneity as a finite number of homogenous groups. The results show that the inconvenience cost for the hygiene of the disposal spot is generally higher than that of sorting itself; this tendency is strongest among young women. Moreover, older people report lower inconvenience costs than do younger ones. Further, some groups prefer manual sorting to an automated sorting service for food waste. Our findings offer policy implications considering such inconvenience costs.

According to Andersson e Stage (2018), Swedish legislation makes municipalities responsible for recycling or disposing of household waste. Municipalities therefore play an important role in achieving Sweden's increased levels of ambition in the waste management area and in achieving the goal of a more circular economy. This paper studies how two municipal policy instruments – weight-based waste tariffs and special systems for the collection of food waste – affect the collected volumes of different types of waste. They find that a system of collecting food waste separately is more effective overall than imposing weight-based waste tariffs in respect not only of reducing the amounts of waste destined for incineration, but also of increasing materials recycling and biological recovery, despite the fact that the direct incentive effects of these two systems should be similar. Separate food waste collection was associated with increased recycling not only of food waste but also of other waste. Introducing separate food waste collection indirectly signals to households that recycling is important and desirable, and our results suggest that this signalling effect may be as important as direct incentive effects.

Padilla e Trujillo (2018) point out that 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, they are aiming to identify the factors that shape the attitudes towards source-separated recycling among households in Bogotá. They are use data from the Colombian Department of Statistics and Bogotá's multi-purpose survey, and is estimated a multivariate *Probit* model. In general, the results show that the higher the household's socioeconomic class, the greater its effort for separating solid wastes. Likewise, the findings also allowed to characterize household profiles

regarding solid waste separation and considering each socioeconomic class. Among these profiles, they 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.

In Brazil, the national solid waste policy (NSWP) has gone through many years of discussion, has been processed in the federal congress since 1989 and was approved in 2010 as Law nº 12305/2010. According Baptista (2015), the Law predicts that it will be a milestone in the efficient management of solid waste. It is already starting to have practical effects, as it forces municipalities to formulate waste management plans, as well as inducing them to eradicate "dumps". Regarding selective collection, the Law no.12,305/2010, through art. 3º, item V, defines it as the "solid waste separation previously segregated according to its constitution or composition". The solid waste separation is one of the main instruments of the NSWP provided for in chapter III of said law, in which, according to §1o of art. 18, municipalities implementing it with the participation of cooperatives or other forms of association of recyclable and recyclable waste pickers with low-income people will have priority access to Union resources. Upon approval of this law, it is possible to note a greater effort to implement selective collection programs in the country.

Materials and Methods

An individual faces a couple of choices, and opts for the option that provides the most utility. Many of these settings involve choosing between taking action and not taking, for example, the decision whether or not to buy health insurance. In other cases, the decision may be between two distinct choices, such as the decision to travel to work by public or private transport. In the case of binary choice, the result zero or one is only a label of yes or no, the numerical values are a mere convenience (Greene, 2012).

The models are estimated using the maximum likelihood procedure. The method selects estimates of the unknown parameters in order to maximize the value of the maximum likelihood function. The maximum likelihood function of the probit model is given by:

$$\mathcal{L} = \sum_{i=1}^{n} \Phi\left(\frac{\beta' W_i}{\sigma}\right)^{z_i} \left[1 - \Phi\left(\frac{\beta' W_i}{\sigma}\right)\right]^{1-z_i} \quad (1)$$

where Φ(.) is the cumulative distribution function.

Since the estimated coefficients, from the maximum likelihood estimator, do not allow a direct interpretation, the average marginal effect is also estimated, to have a result that allows a better discussion. The benefits of the average marginal effects allow an analysis of the quantitative implications on the estimated coefficients. In this case, the marginal effect is given by the following expression:

$$\frac{\partial E(Z/W)}{\partial W} = \Phi(W_i\beta)\beta \quad (2)$$

where $W_i\beta$ represents the coefficients vector multiplied by a vector containing values for the dependent variables. The marginal effect can be interpreted as a change in probability for an infinitesimal change in each independent variable for the continuous variables and the discrete change in probability for dummy variables (Camargo Neto et al., 2017).

Database and Empirical strategy

In this study we used the Family Budget Survey (POF), data from Brazilian Institute of Geography and Statistics (2018). The functional structure of the probit model has a dummy as dependent variable, being constructed from the following question: *"The garbage from this home is: burned or buried in the property; played on vacant lot or backyard; or thrown into river, lake or sea".* To obtain the dummy, the three answers were added. Regarding the independent variables, we used: gender, breed, age, years of study, income, whether residing in urban or rural areas, whether they know how to read, whether they live near a dump, whether they live near the river, whether they live near hillside, and region dummies. For the second model, we have that the dependent variable is the following question: *"Is household waste segregated from biodegradable material (food, paper, cardboard) and non-degradable (plastics, glass, metals)? Yes or No".* In addition, the models are estimated for the five large Brazilian regions, with the purpose of capturing the regional effects in the decision to discard the garbage. The functional structure is presented is below:

$$Y_i = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n + \varepsilon_n$$

Since Y_i is a dummy, β_0 a constant, $\beta_1, \ldots, \beta_n$ the coefficients to be estimated, $X_1, \ldots, X_n$ are the independent variables.

Tables 1 and 2 show the descriptive statistics of the variables used. As can be seen, in the total sample, 81.48% of the individuals have the household waste collected directly or indirectly, not opting for disposal by means that degrade the environment. In addition, 18.52% of the individuals answered that household trash is burned or buried in the property, or thrown in wasteland or grounds, or thrown in river, lake or sea. Regarding the variable "separates biodegradable waste", 79.68% of the individuals interviewed do not separate the biodegradable waste. As well as 20.32% separate the waste, for the regions there are changes in these values, in the Southeast, South, North, Northeast and Midwest (27%, 59%, 6%, 11% and 13%) respectively. The sample contains 132,882 individuals.

Table 1. Descriptive statistics of dependent variables

Improper disposal	*Frequency*	*Percentage*	*Cumulative*
0 – No	108,272	81.48	81.48
1 – Yes	24,610	18.52	100
Total	132,882	100.00	
Separate biodegradable waste			
0 – No	105,881	79.68	79.68
1 – Yes	27,001	20.32	100
Total	132,882	100.00	

Source: own elaboration based on data from POF2008-2009

24,610 answered that the destination of the waste was: "burned or buried in the property (20,776); discarded in wasteland or yard (3,834); or thrown into river, lake or sea (151)". In addition, of these 24,610 individuals, 21,083 (86%) are residents of rural areas. Of the 27,001 that separates domestic waste, 23,026 reside in urban areas, and 3,975 in rural areas.

Table 2. Descriptive statistics of independent variables

Variable	*Description*	*Average*	*Maximum*	*Minimum*	*Standard-Error*
Gender	Men: 1 Women: 0	0.49	1	0	0.4998
Breed	White: 1 Others: 0	0.41	1	0	0.4913
Age	Years	38.6	104	10	17.99
Years of study		7.34	15	0	7.62
Per capita income	In Real*	766	87,430	0	1,271.18
Urban area	Yes: 1; No: 0	0.7740	1	0	0.42
If you can read	Yes: 1; No: 0	0.8753	1	0	0.33
Near dump	Yes: 1; No: 0	0.03	1	0	0.17
Near sewer	Yes: 1; No: 0	0.0914	1	0	0.288
Near river	Yes: 1; No: 0	0.108	1	0	0.31
Near hillside	Yes: 1; No: 0	0.029	1	0	0.17

Source: own elaboration based on data from POF2008-2009. * Brazilian currency

Results and discussion

The results show that men are more likely to dispose of garbage improperly than women. However, the difference in probability is very small, so that men in the North and Midwest of Brazil have 1.23% and 1% more in the chance of disposing of garbage improperly, respectively. In relation to the breed, it is generally stated that white individuals are less likely to dispose of garbage improperly in relation to the other declared breeds; in addition, the southern region is the one with the highest probability, about 3.8% less chance. The age had no relevant effects. On the other hand, the years of study presented statistical significance, but with low effect on the probability. Per capita income also followed the effect of schooling, presenting significance, but not capturing effect on probability.

The most relevant variable within the results of this model is the one that represents the individuals residing in urban area. Considering that in the Southeast, individuals are 21.8% less likely to dispose of waste improperly than those who do not live in urban

areas. In the South region 26.5% less, in the North region 34.25%, in the Northeast region 34.11%, and in the Midwest region 28.6%. These results suggest that much of the effect captured by the model is related to the availability of gathering, considering that non-urban areas have a higher incidence of burning and burial. This information can easily be observed when we disaggregate our dependent variable, of the 24,610 individuals who dispose of waste improperly, 21,083 (86%) are residents of rural areas.

Table 3. Determinants of improper disposal of waste

	Probit (Marginal effects)				
Variables	***Southeast***	***South***	***North***	***Northeast***	***Midwest***
Gender (men)	0.0087***	0.0096**	0.0123***	0.0069***	0.0106***
	(0.0025)	(0.0039)	(0.0041)	(0.0025)	(0.0035)
Breed (white)	-0.0139***	-0.0382***	-0.0057	-0.0167***	-0.0052
	(0.0026)	(0.0050)	(0.0051)	(0.0030)	(0.0036)
Age (years)	0.0002***	0.0001	-0.0002*	-0.0002**	-0.0000
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Years of study	-0.0016***	-0.0012***	-0.0016***	-0.0010***	-0.0037***
	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0004)
Per capita income	-0.0000***	-0.0000***	-0.0001***	-0.0001***	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Urban area	-0.2176***	-0.2650***	-0.3425***	-0.3411***	-0.2860***
	(0.0018)	(0.0025)	(0.0026)	(0.0019)	(0.0028)
If you can read	-0.0280***	-0.0264***	-0.0519***	-0.0461***	-0.0139**
	(0.0044)	(0.0073)	(0.0063)	(0.0034)	(0.0061)
Near dump	0.0106	-0.0633***	-0.0122	0.0542***	-0.0606***
	(0.0080)	(0.0193)	(0.0177)	(0.0057)	(0.0169)
Near sewer	-0.0242***	-0.0517***	-0.0352***	-0.0301***	-0.1104***
	(0.0055)	(0.0107)	(0.0087)	(0.0041)	(0.0214)
Near river	0.0182***	0.0062	-0.0079	0.0108***	0.0480***
	(0.0036)	(0.0064)	(0.0062)	(0.0038)	(0.0064)
Near hillside	0.0109*	0.0026	0.0112	0.0034	0.0390**
	(0.0066)	(0.0198)	(0.0134)	(0.0067)	(0.0163)
Reside	-0.0619***	-0.0629***	0.0092***	0.0170***	Reference
	(0 .0024)	(0 .0030)	(0.0025)	(0.0021)	-
LR test	$\chi_i^2 = 10437$	$\chi_i^2 = 5831$	$\chi_i^2 = 10972$	$\chi_i^2 = 26178$	$\chi_i^2 = 10108$
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Predictive of Classification	91.25%	89.54%	90.92%	91.14%	92.81%
Observations	33,367	15,218	17,927	47,311	19,059

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Based on the results found, knowing how to read reduces the probability of an individual disposing of their waste improperly, which may be related to access to information. However, heterogeneity was found in the results, so that in the Southeast region this probability is reduced by 2.8%, in the South region by 2.64%, in the North region by 5.2% in the region Northeast in 4.61%, and finally in the Midwest region in 1.39% (Table 3).

About this four dummies, which represent the people who have residences near the dump, open sewage, river and hillside. The objective is to capture if the environment around the residence has any influence on the decision of the destination of the waste. Therefore, the following results are obtained. For residences near the dump, there is

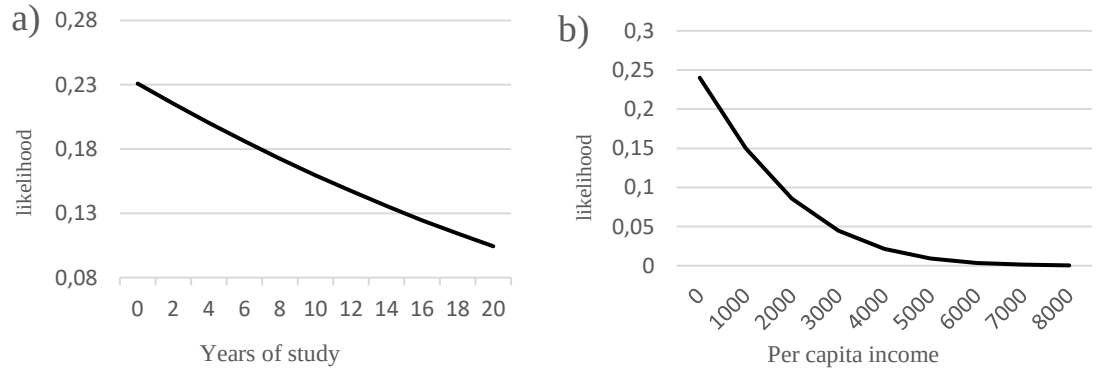
significant effect for the South, Northeast and Midwest regions, all with near effects to each other. In the South, residing near a dump reduces the likelihood of an individual disposing of garbage improperly in 6.33%, as well as in the Northeast region the probability is 5.42%, and in the Midwest 6.06%.

Regarding residents near areas with open sewage, it is estimated that the probability of undue dumping for all regions is reduced, about 2.42% in the Southeast, 5.17% in the South, 3.52% in the North region, 3% in the Northeast, and 11% in the Midwest. Living in regions near to rivers increases the likelihood of improper disposal. For the South and North regions there was no statistically significant effect. For the Southeast, Northeast and Midwest regions, the probability increases by 1.82%, 1.08% and 4.8%, respectively. Finally, for people living in areas near the hillside, there are an increase in the probability of undue dumping only in the Southeast and Midwest regions, with around 1.09% and 3.9%, respectively, with statistical significance of 90% for the Southeast region, and 95% for Midwest region.

To give more detail about the results related to education, the effect of the increase of the study years due to the probability of undue discarding is estimated, and the results indicate a reduction in the probability due to the increase in the years of study of the individuals, as can be seen in Figure 1, a).

As income captured weak effects in the *probit* model, we chose to estimate the effect of increasing per capita income on the probability of improper disposal. This way, it can give more detail of the result. As can be seen in Figure 1, b). The figure shows that the higher the income per capita the lower the probability of an individual, randomly selected in the sample, to dispose of their waste improperly.

Figure 1. Addition of years of study and income due to improper disposal



Note. Predictive Margins with 95% CIs

In Table 4, the results indicate that socioeconomic and regional characteristics influence the decision of care with the destination of the garbage produced by the family. Adding, the influence on individuals' decision to separate biodegradable waste from those that are non-biodegradable is also tested, and the results are presented.

In the Southeast, South and Northeast, gender influences this decision of separation of waste. However, on a small scale and negatively, i.e., men are less likely to separate waste than women. Our results differ from those found by Gamba and Oskamp (1994) and Werner and Makela (1998), that the gender is not an important factor in explaining recycling participation. But it converges with Tarfasa and Brouwer (2018) whose result points out that women are more interested than men in the separation of waste.

Table 4. Determinants of waste separation by regions

	Probit (Marginal effects)				
Variables	***Southeast***	***South***	***North***	***Midwest***	***Northeast***
Gender (men)	-0.0154***	-0.0213***	-0.0030	-0.0055	-0.0049*
	(0.0048)	(0.0078)	(0.0036)	(0.0049)	(0.0028)
Breed (white)	0.0662***	0.0106	-0.0034	0.0193***	0.0119***
	(0.0049)	(0.0097)	(0.0043)	(0.0050)	(0.0031)
Age (years)	0.0010***	0.0020***	0.0004***	0.0009***	0.0007***
	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Years of study	0.0027***	0.0024***	0.0001	0.0015***	0.0011***
	(0.0004)	(0.0004)	(0.0002)	(0.0004)	(0.0002)
Per capita income	0.0000	-0.0000***	-0.0000	0.0000	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Total income	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Urban area	0.0542***	0.1324***	0.0132***	0.0628***	0.1051***
	(0.0065)	(0.0091)	(0.0044)	(0.0068)	(0.0045)
If you can read	0.0732***	0.0974***	0.0253***	0.0280***	0.0548***
	(0.0111)	(0.0172)	(0.0068)	(0.0103)	(0.0046)
Near dump	0.0245	0.0069	-0.0744***	0.0138	0.0180***
	(0.0149)	(0.0269)	(0.0194)	(0.0168)	(0.0065)
Near sewer	-0.0092	-0.0358**	0.0306***	0.0090	0.0258***
	(0.0098)	(0.0159)	(0.0059)	(0.0153)	(0.0039)
Near river	0.0354***	0.0374***	0.0215***	0.0487***	0.0159***
	(0.0079)	(0.0128)	(0.0053)	(0.0094)	(0.0042)
Near hillside	-0.0726***	0.0024	-0.0071	0.0366	0.0214***
	(0.0132)	(0.0298)	(0.0128)	(0.0232)	(0.0069)
Reside	0.1162***	0.3330***	-0.1027***	reference	-0.0022
	(0.0038)	(0.0041)	(0.0054)	-	(0.0039)
LR test	$\chi_i^2 = 1337$	$\chi_i^2 = 704$	$\chi_i^2 = 206$	$\chi_i^2 = 371$	$\chi_i^2 = 1846$
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Predictive of Classification	72.8%	61.74%	93.67%	86.56%	88.95%
Observations	33,367	15,218	17,927	19,059	47,311

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

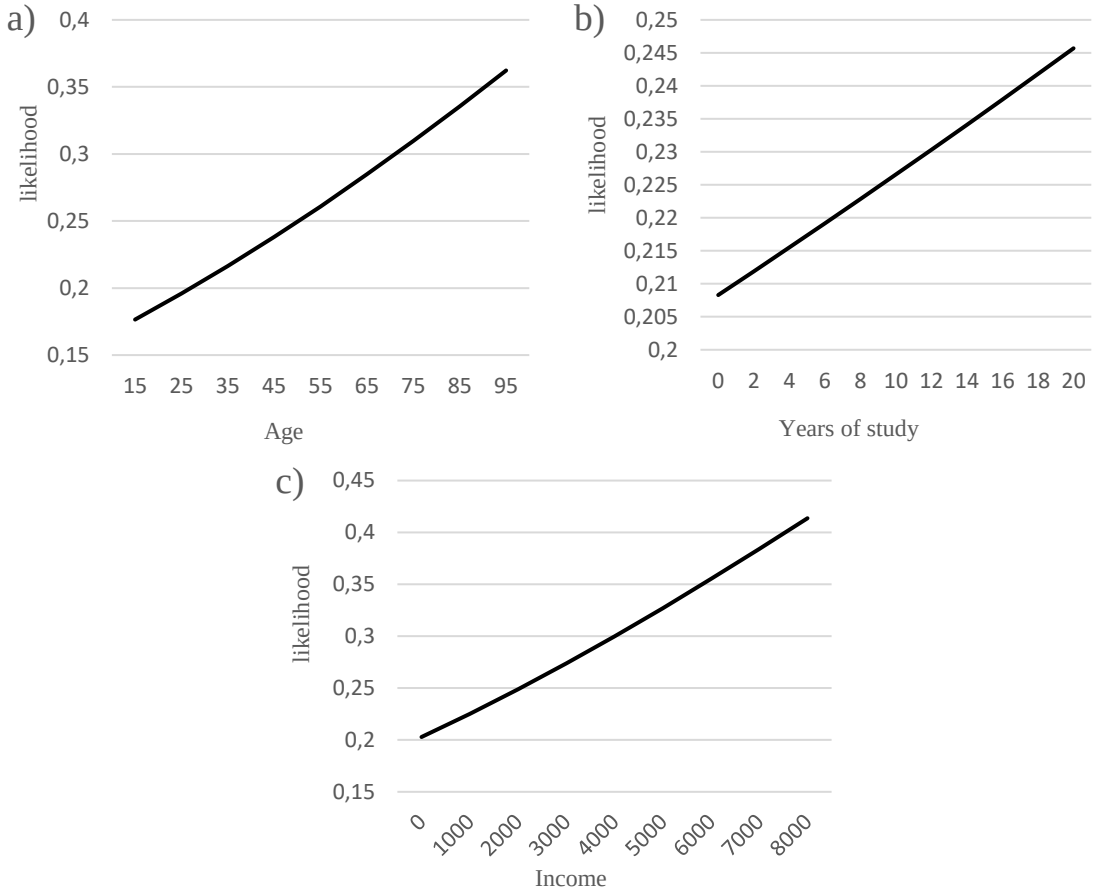
The breed exerts some influence in the Southeast, Center-West and Northeast regions, so that being white increases the probability of separating garbage in 6.62% in the Southeast, 1.93% in the Midwest, and 1.19% in the Northeast. In Brazil, breed is still correlated with social conditions, which, in this sense, corroborates with the results found by Padilla and Trujillo (2018).

Years of study, per capita income, and total income have little influence as determinants of separate waste. However, knowing how to read significantly increases the probability of a person separating waste, at about 7.32% in the Southeast region, 9.74% in the South region, 2.53 in the North region, 2.8% in the Midwest region, and finally 5.48% in the Northeast region. The studies of Lansana (1992), Derksen and Gartrell (1993), Owens, Dickerson and Macintosh (2000) and Tarfasa and Brouwer (2018) demonstrate a positive correlation between education and recycling participation, whereas those of Werner and Makela (1998) and Valle et al. (2004) reveal no correlation

between the two variables. In our results, education affects the separation of waste, but in a small proportion (see Figure 2, c).

Considering know how to read as a proxy for access to information, we can contribute with the result found by D'Amato, Mancinelli and Zoli (2016) and Padilla and Trujillo (2018). In the sense that people who know how to read have greater access to information. An increase in the education level has significant positive effects on household participation regarding recycling, as found by Hong, Adams and Love (1993).

Figure 2. Increase in age, study and income due to separate waste



Note. Predictive Margins with 95% CIs

Residing in urban areas has a positive influence on the probability of individuals in separating their biodegradable wastes, by about 5.42%, 13.24%, 1.32%, 6.28%, and 10.51%, for the Southeast, South, North, Midwest and Northeast region, respectively. However, the magnitude of this effect is much lower than that found for the probability of individuals disposing of their waste improperly, which corroborates the argument that much of the effect found in the first model comes from the burning of garbage in rural areas.

Regarding the individuals that live near the dumps, there is statistical significance only for the estimated coefficients to North and Northeast region, and the effects are contradictory. That is, it reduces the probability of them separete of garbage in the North by 7.44%, and increases the probability of separation in the Northeast by 1.8%. The fact that the individuals live close to open sewage reduces their probability of separating biodegradable wastes in the South region of Brazil by about 3.58%, while in the North

region the probability increases by around 3%, as well as in the Northeast region the probability increases by about 2.58%. Living near rivers increases the probability of individuals separating biodegradable wastes, about 3.54% in the Southeast, 3.74% in the South, 2.15% in the North, 4.87% in the Midwest, and 1.59% in the Northeast region. For individuals living near slopes, there were divergent effects, being positive in the Northeast region, about 2.14%, and negative in the Southeast region, about 7.26%.

As analized, there are regional differences in the determinants of the separation of biodegradable waste by individuals, which can be explained by the results of Nyborg (2003), emphasizing that if a better system of selective collection increases the sense of individual responsibility of consumers for recycling, this may also induce them to disapprove more strongly of neighbors who do not recycle. As the author points out, social norms and moral motivation are important determinants of everyday behavior.

Figure 2 a) shows the probability of separation of biodegradable wastes as a function of increasing age, in which case only urban regions are considered. The literature indicates that, in the same vein, Gamba and Oskamp (1994), Margai (1997) and Scott et al. (1999) that found that age is a positive influence in recycling participation. In contrast, Corral-Verdugo (1997), Werner and Makela (1998) and Valle et al. (2004) reveal a non-significant correlation between age and recycling participation.

The results show that the effect of income on the separation of waste is present a short magnitude, although it did have a statistically significant effect. Therefore, this result converges with Padilla e Trujillo (2018) and Tarfasa and Brouwer (2018). Although the results are small, we estimate the effect of the income increase to test the effectiveness of this variable, and it can be observed that with the increase of income, the probability of separation of the residues increases (see Figure 2, c).

In relation to the regions, a person residing in the Southeast region is 11.6% more likely to separate biodegradable waste than an individual residing in the Midwest region (considered as a reference). A person residing in the southern region of Brazil is 33% more likely to separate biodegradable waste than a person from Midwest region. In contrast, a person residing in the North has 10.27% less chance of separating the waste. For the Northeast region it did not take effect, due to the lack of statistical significance.

Another important point to note is that in a region there may be a spillover effect, which means that the decision of an individual to separate or not their garbage can be affected by the decision of their neighbors. May be that individuals have a desire to act in accordance with their self-image, which in turn is based on their past actions. Thus, if collecting food waste strengthens the individual's perception of him or herself as an environmentally responsible person, that individual may also wish to act in accordance with this positive image in other areas, e.g. by sorting other waste (Andersson and Stage, 2018).

Conclusions

The present study seeks to assess whether socioeconomic and regional issues influence decisions related to the destination of waste in Brazil. For this, it is estimated probabilistic models that relate socioeconomic and regional issues with the probability that the individuals dispose of waste improperly and on the probability of the individuals to separate the biodegradable waste.

One contribution to the literature is that in Brazil, much of the burned and buried garbage is not located in urban areas, so that it was found that an individual living in an urban area has between 21% and 34% less chance of allocating their garbage in this condition. This effect should be conditioned by the greater presence of public garbage collection in urban environments. The effect of education was very low, but when the increase in years of study was evaluated due to the probability of improper disposal of waste, there is a reduction in the probability with the increase of the years of study.

When the schooling is increased it is possible to notice that there is a greater chance of the individuals carrying out the separation of the biodegradable residues. Of our total sample with 132,882 people, 27,001 carry out selective collection. Among those who carry out the separation, 17,306 people do not carry out this separation to participate in the collection carried out by a specialized company, another 9,695 people (36%) make the separation to attend a company specialized in selective collection. This corroborates with our results, that most people perform selective collection for different reasons, which supports our analysis and the importance of understanding some of the different factors that influence the decision of the population on waste disposal.

The limitations of this study are related to the unobservable variables of the models, that is, issues such as infrastructure and waste collection programs. Considering that our sample does not allow to work with a stratification at the municipal level, which makes it impossible to add a proxy for these omitted variables.

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