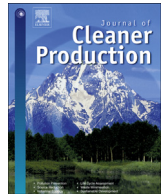




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Assessing the intention-behavior gap in electronic waste recycling: the case of Brazil

Fabian Echegaray^{a, *}, Francesca Valeria Hansstein^{b, 1}

^a Market Analysis, Rua Felix Kleis, 23, Florianópolis, SC 88035330, Brazil

^b School of Public Economics and Administration, Shanghai University of Finance and Economics, 111 Wuchuan Road, Yangpu District, 200433 Shanghai, China

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ABSTRACT

Recycling electronic waste (e-waste) is a major concern due to the risks associated with waste management, namely environmental pollution and negative consequences on individual health. Besides the need for appropriate policies and legislation for e-waste management, consumer awareness about recycling is an important factor. This paper discusses determinants of consumer intentions and behavior towards e-waste recycling in the major metropolitan areas of Brazil, where the consumption of electronic devices and appliances has significantly increased in the past decade. Modeling measures obtained from a general population survey sample after the Theory of Planned Behavior (TPB), we find that the majority of respondents hold a positive intention towards recycling electronic appliances - particularly, female, middle-aged individuals from lower income groups, and residents of the South-east region. Favorable views of recycling and the perceived social acceptance of recycling significantly explain the intention to recycle. In contrast, only a minority of respondents actually adopts adequate recycling practices connected to e-waste, a behavior which is socially skewed among the higher income echelons of Brazilian society. Differences and forces underlying this intention-behavior gap are discussed.

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1. Introduction

Waste from Electrical and Electronic Equipment (WEEE), or e-waste, indicates any electronic goods that have reached its end-of-life (OECD, 2001). These include computers, televisions, cell-phones and also traditional home appliances, such as refrigerators or ovens. The use of electronic devices and appliances has drastically increased in the last decades, both in developed and developing economies, spurred by an ever-expanding electronics market and the rising obsolescence rate of electronics equipment; as a result, e-waste is the fastest growing component of solid waste stream (Widmer et al., 2005). E-waste is chemically different from other forms of municipal or industrial waste, and it contains several hazardous materials as lead, mercury, polybrominated biphenyl and diphenyl, dangerous for individual and environmental health if not properly treated (Araújo et al., 2012). Responsible solid waste

management and reduction is thus at the core of strategies to advance sustainability (UNEP, 2011). Treatment of electronic waste involves reuse, remanufacturing, recycling and, in some cases, incineration or landfilling. E-waste recycling refers to the disassembling of electronic devices and appliances, followed by the recovering of materials. In a key strategic document from UNEP (M. Schlupe, C. et al.), efficient practices of e-waste recycling are described as follows: “More collection of electric and electronic appliances (...) keeps valuable e-waste components (e.g. metals) in the economy and safely disposes of its harmful components in order to prevent risks to human health and the environment”. Recycling has been identified as a key strategy for reducing pollution and depletion of natural resources, as well as for increasing energy savings (Cui and Zhang, 2008; Debnath et al., 2015; King et al., 2006; Zeng et al., 2015). Recycling is also relevant from a social and economic perspective when it encourages the adoption and development of green technologies and enables the expansion of economic activity and jobs generation by fostering a recycling industry (UNEP, 2008).²

* Corresponding author. Tel.: +55 48 3364 0000.

E-mail addresses: fabian@marketanalysis.com.br (F. Echegaray), f.v.hansstein@mail.shufe.edu.cn (F.V. Hansstein).

¹ Tel.: +86 2135120847; fax: +86 2165104294.

² Nevertheless, e-waste recycling in Latin America is, for now, limited to disassembling because is a relatively new activity (Ongondo et al., 2011).

Motivating and furthering recycling behaviors is pivotal to the success of responsible e-waste management, and it seems particularly relevant for developing societies, like Brazil, given the fast-paced increase in goods disposal and waste volume resulting from a consumption-avid middle-class (World Bank, 2012). Accordingly, in addition to facilitating conditions and long-term incentives, successful large-scale adoption of recycling practices strongly relies on public's attitudes and behaviors (Do Valle et al., 2005).

This article aims at elucidating the characteristics favoring individual pro-recycling behaviors and the forces that leverage and downplay the adoption of these practices among metropolitan residents of Brazil, using the Theory of Planned Behavior (TPB) (Ajzen, 1991). We contend that engagement with responsible waste management like recycling does not solely rely on environmental awareness, positive views of environmental goals, or sympathetic attitudes towards recycling technologies. Rather, it requires a sense of personal efficacy and a sense of social legitimacy for adopting those actions in order to effectively engage individuals. Proper understanding of influences molding pro-recycling behaviors offers valuable insights for policy-making and helps to identify the key touch-points that government, corporations and grassroots initiatives can explore to address environmental pressures more effectively.

To the authors' knowledge, this is the first study on consumer intention to recycle electronic waste conducted in Brazil. We therefore begin by outlining the context of e-waste in Brazil, illustrating both aggregate figures as well as the state of public opinion with regards to relevant solid waste-related issues, to characterize this society. Then, we review the literature in order to assess the underlying forces conducive to pro-recycling behaviors, and to acknowledge the limitations and alternative readings brought forth by cumulative evidence. Given the paucity of research covering developing societies like Brazil, whenever possible, we use lessons learned from studies based on similar emerging contexts. Elements of the theory of planned behavior (TPB) are then discussed given its adequacy to properly model individual choices. Next, we detail the methodological procedures, measurement model and data characteristics used for testing the adequacy of the TPB model. In the last section, data findings and implications for policy are discussed.

2. Background

2.1. E-waste in Brazil

Following economic boom that paved social mobility and higher consumption rates throughout the 2000's, Brazilians per capita solid waste generation amounted to 1.06 kg per day (Abrelpe, 2014). Between 2008 and 2014, total urban solid waste generation jumped from 52.9 million of tons to nearly 78.6 tons (Abrelpe, 2014), a 48.6% increase which far exceeded GDP and population growth over that period of time. According to official sources (BRASIL, 2014), only 20% of municipalities rely on regular solid waste management services and despite improvements in broadening the number of townships with selective recollection of garbage, government statistics recorded a decrease from an average properly managed waste of 15 kg/per person per year to 11.3 kg per person per year from 2011 to 2012. When extrapolating coverage to the entire country and considering all waste mass generated, estimates reckon that only 3.1% of total household public waste is adequately managed and treated (BRASIL, 2014).

Estimating e-waste generation per capita is far more complicated and several methods have been proposed. Market estimates point Brazil's e-waste in excess of 1 m ton annually and it is

expected to hit the 1.25 m ton in 2016 (SDP/MDIC-ABDI, 2012) – a prognosis deemed conservative once the segments of electronic household devices, mobile handsets, and computer equipment have exhibited double-digit growth rates per year (ABINEE, 2013). Currently, the e-waste volume increases three times faster than regular waste and, among developing nations, Brazil stands out with the highest per capita e-waste rate (annual increase of 0.8 kg/per capita), currently totaling 7.1 kg/per person, as projected for 2015 (World Bank, 2012). Given that less than 60% of total solid waste is adequately disposed in authorized landfills and only 4% of total waste is actually recycled, the implications of waste generation in Brazil are enormous.³

Regulation that directly tackles e-waste issues in Brazil has largely been related to mandatory extended producer responsibility, enacted in 2010. However, these legal arrangements remain largely unfamiliar to consumers and poorly enforced among both manufacturers and local authorities. In addition to these limitations, scholars point to the lack of formal and continuous feedback instruments to provide all stakeholders with information about their respective roles and possible sanctions, and the ineffective implementation of collection, recycling, and reverse logistics mechanisms, particularly with regards to electronic appliances (de Oliveira et al., 2012). This situation further heightens the salience of individual awareness and engagement of consumers for successfully addressing the environmental and social problems of e-waste.

Key stakeholders' approaches in promoting pro-recycling behavioral change have traditionally put emphasis on awareness rising campaigning. Government has taken for granted that extended producer responsibility will be conducive to improved disposal practices by consumers while social movements presupposed that guilt-oriented communications and available information on e-waste point of disposal would guide individuals towards responsible recycling. Yet, public opinion surveys reveal serious limitations both in awareness and favorable attitudes towards recycling, which suggest that conditions for green behavior adoption exceed legal, cognitive, or infrastructure opportunities. Large-scale surveys conducted with representative samples of urban Brazilians report that garbage segregation at home ranges reaches between ¼ and ½ of households, at best, a practice geographically biased towards South and South-East regions.⁴ Self-reported recycling rates largely trail the increasing willingness to engage in garbage segregation (from 68% in 2001, to 78% in 2006, to 86% in 2012).⁵ Improper waste management practices by consumers, like mixing-up of batteries with organic waste, are the rule for a majority of the population (58%),⁶ a fact that sends a warning signal concerning the limited effectiveness of current approaches that overemphasize awareness rising campaigns, default upon producers campaigns to educate and guide consumers, or bet exclusively on broader waste collection coverage. Furthermore, opinion data suggest self-guided recycling involvement as

³ UN/Step E-Waste World Map Initiative 2015. See: http://www.step-initiative.org/Overview_Brazil.html.

⁴ Incidences obtained by the two largest, continuous polls on the subject were 23% (by NGO Akatu, see Instituto Akatu, 2012. See: <http://www.akatu.org.br/pesquisa/2012/PESQUISA-AKATU.pdf>) and 48% (according to Ministry of the Environment survey, MMA, 2012. See: <http://mma.gov.br/publicacoes/responsabilidade-socioambiental/category/90-producao-e-consumo-sustentaveis?download=989:0-que-o-brasileiro-pensa-do-meio-ambiente-e-do-consumo-sustentavel>).

⁵ See: <http://mma.gov.br/publicacoes/responsabilidade-socioambiental/category/90-producao-e-consumo-sustentaveis?download=989:0-que-o-brasileiro-pensa-do-meio-ambiente-e-do-consumo-sustentavel>.

⁶ Other irresponsible disposal practices of solid waste mix up with organic waste includes mobile phones (18%), household appliances (16%), and notebooks or PC accessories (9%) (MMA, 2012).

declining (from 28% in 2006 to 24% in 2010 and 23% in 2012),⁷ which is openly at odds with the alleged increasing willingness to treat waste properly.

2.2. Literature review

Recycling electronic waste belongs to the broader category of pro-environmental behaviors in line with proposals for a sustainable consumption model. Early research on motivating sustainable performance at the individual level has theorized green behavior as contingent to individuals' socio-structural characteristics like education, gender, age group, and related demographics (Jones and Dunlap, 1992; Van Liere and Dunlap, 1980) and, also, to value alignment with environmental priorities and a deep-seated concern with ecological crisis (Dietz et al., 2002, 1998; Jackson, 2005).

Pioneers in scholarly work about green behavior posited structural conditions like income disposition or educational achievements as shaping the odds of attaining the necessary cognitive understanding and resourcefulness for ascertaining the effects of waste generation and overruling the costs-benefits disadvantages of getting engaged in recycling practices. For sure, unless individuals are aware of environmental problems and recycling solutions, as well as of government-supplied services for selective garbage recollection, all which require a fairly decent degree of literacy, it is unlikely that people will follow suit. Likewise, garbage segregation before disposal requires financial resources and extra time to proceed according to the standards demanded by the solid waste recollection companies.

This rationale was backed by studies suggesting a well-defined social base behind environment-friendly behaviors like recycling, mainly composed by young urban women with a high socio-economic status and level of education (Xiao and Dunlap, 2007). However, additional research found important deviations such as higher income households displaying poorer recycling behaviors (Hadler and Haller, 2011) which raised doubts about the universal nature of social correlates across a wide range of pro-environmental behaviors (Dietz et al., 1998). Inconsistencies with theory also appeared in studies for developing countries like Brazil, even when examining highly homogeneous samples like students, where eco-friendly behaviors could be correlated only to age differences, among several other demographic elements.⁸ As a result, some scholars rapidly concluded that social factors trail the influence of psychological forces (Diamantopoulos et al., 2003), which then emerged as the main focus of most analyses.

Cross-national studies using attitudinal data on top of a social base model not only improved the explanatory power of the environmental state under analysis but also evidenced the fragility of structural interpretations (Pisano and del Carmen Hidalgo, 2014; Saphores et al., 2012; Saphores et al., 2006). Research suggests that unless issue salience is high, pro-environmental priorities overcome concerns with the economy, and eco-friendly choices prevail, then it is unlikely that individuals would adopt responsible behaviors like recycling (Dietz et al., 1998). When individual values or orientations insufficiently account for pro-environmental behaviors, scholars have stressed the importance of self-interested motivation, modeling an economic rational theory of eco-friendly action that sees pro-environmental behaviors as the private provision of public goods (Saphores et al., 2006; Wang et al., 2011b), or

–alternatively– studies have advanced a norm-activation interpretation of eco-friendly decisions that interprets those choices as based upon the recognition of a strong moral obligation towards society (Bamberg et al., 2007). However, scholars testing the empirical connections between these range of attitudes and the targeted behaviors favoring sustainability goals soon found different types of problems. If it makes sense to assume that being aware of the issues it is likely to increase the chances that an individual will engage in recycling behaviors by affecting his motivation, empirical evidence suggest that awareness insufficiently promoted a conversion towards responsible behaviors (Hadler and Haller, 2011). For example, studies in developing nations indicates that self-reported awareness remains a distant cousin of consistent environmental knowledge (Zhao et al., 2014). Moreover, even when awareness about the causes and consequences of waste do exist, waste considerations hardly enter the purchasing decision-making processes consciously (Bekin et al., 2007).

Perhaps the most widespread adverse effect relates to a persistent belief-behavior gap confronting sustainable consumption practices like recycling (Do Valle et al., 2005; Gamba and Oskamp, 1994; Kollmuss and Agyeman, 2002). Research clarifies that gap size relates to the tangibility of benefits (be them of economic or symbolic nature) (Kollmuss and Agyeman, 2002), a fact that tend to leverage energy saving choices and eco-lifestyle purchases (Arslan et al., 2011) but that hampers the success of other sustainable behaviors like recycling that rise to individuals as an apparently benefit-deprived option, especially when refund schemes or other incentives are inexistent.

The attitude-behavior gap has also been interpreted as concealing either a naïve over-estimation of environmental or ethical ideology in individuals' minds (Devinney et al., 2010) or an oversimplification of contributing factors to the adoption of sustainable behaviors (Carrigan and Attalla, 2001). The limits of value-based interpretations of pro-environmental behaviors could be equally confirmed in developed (Hadler and Haller, 2011) and developing nations where, for example, expected links between life priorities and eco-responsible standings exhibit anti-intuitive patterns (Abramson, 1997; Echegaray F. Armesto M., 2000).

Value-based explanations of sustainable consumption decisions also find a different type of obstacle in developing contexts. Qualitative studies in Brazil indicate that a prevailing rationale for garbage segregation and recycling/re-usage of products among low income and emerging poor classes is not related to pro-environmental beliefs but to economic survival and community solidarity reasons (Waquil, 2014). For example, research concerning fluorescent lamps recycling in Brazilian cities concludes that economic incentives rather than ecological consciousness encourage the acceptability of responsible waste disposal (Laruccia et al., 2011). On the other hand, it is a prevailing economic rationale, rather than environmental beliefs, which re-signifies solid waste for Brazilians as an opportunity (rather than burdensome, as it occurs in the UK for example), especially among so-called popular classes (Bekin et al., 2007). Accordingly, the perception of waste as valuable resource and the understanding of recycling or re-use behaviors as optimization behaviors tend to be publicly presented as consistent with a community-prone orientation, that is, as a choice potentially beneficial to the geographically-nearby network of friends, neighbors and contacts (Bekin et al., 2007).

Given the limited influence of personal norms and environmental attitudes, scholars turned to specific orientations like perceived self-competence, perceived behavior control, and the weight of social norms in order to understand pro-recycling choices (Do Valle et al., 2005). These elements represent moderators of the effect of values and information upon ultimate individual decisions but they may serve as drivers of these previous forces, as well.

⁷ NGO Akatu, see Instituto Akatu, 2012. See: <http://www.akatu.org.br/pesquisa/2012/PESQUISAATU.pdf>.

⁸ According to the MMA (2012) study, differences in solid waste recycling habits remain void within the upper 65% of the population (that is, non-differences among social classes A, B and C).

Social norms have been theorized as major forces to curbing undesirable behaviors (like environmentally unfriendly choices) and fostering responsible practices (like recycling) (Schultz et al., 2007). For example, the extent to which an action is considered legitimate (social norms) can encourage individuals to embrace the goals of such action as a guiding principle or value (a personal norm). In the case of Latin American societies that have been described as strongly influenced by a culture of conformity and deference to family and community norms (Inglehart, 1997), the weight of collectively defined criteria of worth are expected to count substantively upon individuals actions.

Feelings of subjective competence in pursuing a course of action (like learning and recognizing which waste to segregate), or a sense of control over performing that action (like identifying where or when to dispose recyclable waste), are also likely to enhance the salience of the issue that action is affecting, moving it from the periphery to the center (Bamberg et al., 2007). Perceived behavior control, as a synthetic compound of both feelings, is greatly influenced by the degree of proximity and permeability of garbage collection services, as well as operations transparency and accountability, which qualitative studies with Brazilians suggest hardly warranted. Lack of information on waste destination, poorly communicated mobilization campaigns by government, and the hermetic nature of the entire collection process characterized the consumer landscape (Bekin et al., 2007).

3. Research model and hypotheses

3.1. An extension of the Theory of Planned Behavior (TPB)

Acknowledging this plurality of influences in shaping recycling intention and behaviors requires comprehensive theoretical lenses like the one proposed by the Theory of Planned Behavior (TPB) which reads individual behaviors not merely as a reflection of values or concerns but also motivated by the social acceptance of those behaviors and the extent to which individuals feel capable of setting those behaviors in motion (Ajzen, 1991). This theoretical framework has already been employed to explain intention to recycle and other pro-environmental behaviors, suggesting its appropriateness in this context (Do Valle et al., 2005; Largo-Wight et al., 2012; Oreg and Katz-Gerro, 2006; Park and Ha, 2014; Wang et al., 2011a, 2011b).

In its most simplified form, the TPB explains behavioral intention as a function of three components: attitude, subjective norm and perceived behavioral control. In general terms, attitudes towards a behavior indicate the individual evaluation of the action under study from negative to positive. Subjective norm corresponds to the degree of individual perception of the social desirability that the person should perform that action. Perceived behavioral control includes both measures of self-efficacy and perceived control and indicates how well an individual feel that he or she can overcome the obstacles, or taking advantage of the facilitators, when performing an action. The theory assumes that intention is a good predictor of the behavior itself, together with related past behaviors. Several variants of the TPB have been proposed according to the behavior under study. In this paper, besides the key components of the TPB, we also included socio-demographic and socio-economic variables, the degree of awareness towards the problem, and the personal assessment of the environmental situation of Brazil as predictors of e-waste recycling. A representation of the extended version of the theory of planned behaviors is depicted in Fig. 1.

In this context, attitude towards e-waste recycling is shaped by the beliefs that recycling is good for both the environment and for one's own and his family's health. Subjective norm indicates respondent's opinion of how other people, such as friends or family, think they should behave. Perceived behavioral control is here

affected by the presence of nearby recycling sites, by the belief that recycling e-waste is a time-consuming activity, or by the level of trust towards government e-waste management and about individual control beliefs such as respondent's capacity to influence the other stakeholders. Our model adds other two components to the core constructs of the TPB, namely awareness of environmental effects of e-waste mismanagement and personal assessment of environmental situation of the country. Socio-demographics (gender, age, income, education and region of residence) are also likely to play an important role in recycling behaviors.

3.2. Research hypotheses

HP1. Intention to recycle e-waste will be much higher than actual behavior.

This expected outcome results from both the ubiquity of social desirability and acquiescence biases in response styles among Brazilians (Tellis and Chandrasekaran, 2010; Vikan et al., 2007) and structural constraints that limit solid waste recollection coverage and proper e-waste disposal.⁹ Accordingly, we expect that a high intention to recycle e-waste will not be followed by appropriate recycling behaviors.

HP2. E-waste recycling behavior and intention will be stronger among upper echelons of society Given that affluence warrants time and material resources to successfully comply with recycling scripts, we expect that e-waste recycling practices will be positively associated to higher income and education.

HP3. We expect that females, higher education, younger respondents, and being from South and South-East will be positively associated to recycling intention.

The uneven distribution of household chores across gender (Barbosa and Veloso, 2014) and the unequal coverage of segregated garbage collection services, which benefits the South and South East regions (MMA, 2012), is likely to affect recycling intention. Moreover, giving the recency of discussions around e-waste adverse impacts and the focus on youth by government and NGO issue campaigning, we expect that younger cohorts and better educated respondents will be more inclined to embrace recycling.

HP4. Among the constructs of the TPB, social norm will be the most influential factor, followed by attitude and perceived behavioral control.

Because of the normative language employed by government and responsible consumption NGOs campaigns to promote separate garbage habits, and in light of accumulated evidence indicating the role of pro-social norms, we expect social norms to be among the most influential factors favoring recycling. Similarly, favorable attitudes towards recycling are expected to stand out among factors shaping intention to recycle. On the other hand, in light of the unequal availability of solid garbage collection services and the deficits of information and infrastructure for adequate e-waste recycling, we expect perceived behavioral control to remain among the least influential factors.

HP5. Awareness towards environmental problems will be positively associated to recycling intention, while individual assessment of the environmental situation of Brazil will be negatively associated to it.

Awareness of environmental issues and concern for the state of the environment predicts a favorable disposition towards specific

⁹ Ministry of the Environment survey, MMA 2012. See: <http://mma.gov.br/publicacoes/responsabilidade-socioambiental/category/90-producao-e-consumo-sustentaveis?download=989:o-que-o-brasileiro-pensa-do-meio-ambiente-e-do-consumo-sustentavel>.

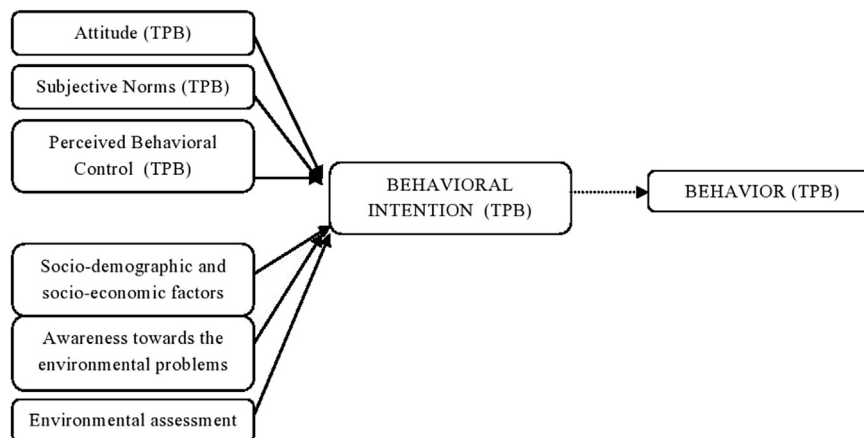


Fig. 1. The TPB applied to the intention of recycling e-waste.

pro-eco-friendly standings and behaviors (Kim and Choi, 2005; Vicente-Molina et al., 2013). Also, we expect a negative relationship between environmental assessment and recycling intention. In other words, the more the Brazilians think that the environmental situation of their country is poor, the higher their intention to recycling e-waste.

4. Data and methods

4.1. Survey design, questionnaire and data transformation

Primary data were collected by a telephone survey, which resulted in a sample of 806 Brazilian households. Respondents living in Sao Paulo, Rio de Janeiro, Belo Horizonte, Porto Alegre, Curitiba, Brasilia, Goiania, Salvador and Recife were interviewed, these cities are the most populated metropolitan areas of the country and account for the 19.3% of the total urban population¹⁰. In particular, respondents living in Sao Paulo, Rio de Janeiro, Belo Horizonte, Porto Alegre, Curitiba, Brasilia, Goiania, Salvador and Recife were included in the analysis. The sample followed a random stratified cluster design and observations were selected using interlocked quotas of gender, age group and socioeconomic class.

Information related to our two dependent variables, that is, recycling intentions and behaviors, was obtained through different measures. In the original questionnaire, intention was measured by three items. Respondents were asked if they were willing to take some time to take their old electronic appliances to recycling, to speak to their friends about appropriate modes of disposing electronic appliances, and to get more information about collection and recycling sites for e-waste appliances. For each respondent, we generated a unique variable named intention by calculating the mean score of the items, following the procedure indicated in Acock (2008). The mean score method has the double advantage of maintaining the same scale of the original measures (in this case, values from 1 to 5) and handling missing values efficiently. After having compared the factor and the mean scores, we opted for the latter metric based on two accounts. Firstly, the three items measuring intention were tau equivalent, with their loadings being respectively 0.78, 0.73 and 0.74. The closeness of their values suggests that the three items measuring intention are equally

important. If the difference between loadings were higher, the factor score approach would have been more appropriate. Secondly, the mean score procedure retains more observations than the factor score, because, in the mean score computation, a respondent that answers at least one question is kept in the analysis whereas factor scores requires from respondents to have answered all the three items to be included in the analysis. As a robustness check, we also calculated the correlation between the factor and mean score which resulted to be very high ($r = 0.99$). This indicates that we should not expect different regression results while using the alternative approaches. Data about behaviors were obtained by probing what respondent did with a specific electronics device no longer in use and being replaced by a new one. Respondents could choose among an array of options, including disposed it in a specific collection point specific for e-waste and took it to a specific collection point as indicated by the manufacturer. We then created a dummy variable by collapsing the different options into two categories so that, for each respondent, we could determine the adequateness of his/her behavior. In particular, answers considered appropriate for e-waste recycling were: “disposed it in a specific collection point for e-waste disposal”, “took it to a specific collection point indicated by manufacturer”, and “returned it back to the store where you purchased it”. Conversely, answers not appropriate for e-waste recycling were: “disposed it along with ordinary garbage like food leftovers”, “disposed it along with segregated waste, collected by municipal service of selective garbage collection”, “donate to charity institution”, “passed over onto other people who could use it or fix it for themselves”, “sold it to someone or to a store who can use it or fix it”, and “kept it stored at home”.

The survey also contained questions that measured key components of the TPB including attitudes toward recycling home appliances, perceived behavioral control, and social norm. Questions on awareness and environmental assessment were also included in our model's specification. Each component of the model was measured using multiple items in the questionnaire which later have been reduced to selected measures strongly associated to the dependent variable thus better tapping the underlying TPB model. Respondents were asked to state their agreement or knowledge level on a five points Likert-type scale. We calculated a mean score of each measure, following the same procedure we use for generating the mean score intention. The original items used to generate mean scores are reported in the Appendix together with Cronbach's alpha (when the measured construct was based on a number of items that exceeded two) or Pearson's correlation (when only two items formed the

¹⁰ The data collection took place from August 30 to October 7, 2013 and sample estimates can be interpreted within a margin of error of $\pm 3.5\%$.

construct). Income, education and age were also transformed with respect to their original coding into fewer value categories to identify demographic contrasts more easily.

4.2. Statistical analysis

To understand which factors shape respondents' attitudes and behaviors towards recycling behaviors under the conceptual framework of the TPB different multivariate analyses are performed. Effects of socio-demographic factors (gender, age, education, income and region of residence) are assessed by means of one-way analysis of variance (ANOVA), using post-hoc Bonferroni tests to detect significant differences between groups. Results from Post-hoc tests are not reported here but available upon request. The connection of recycling intentions and behaviors to the basic components of the TPB and to key socio-demographic characteristics of the population under study are explored using multiple regressions. In particular, given the categorical nature of the mean score intention, ordered probit regression is used to test the validity of the TPB in explaining Brazilian consumers intentions', as has been done in similar studies (Gracia and Maza, 2015; Saphores et al., 2006). In addition to this, a logit regression was employed to study the associations between actual behaviors (measured via a dummy variable) and the components of the theory of planned behavior. In all the regression models, the observations were weighted to match sample demographics with the Brazilian population living in the metropolitan areas. To control for heteroskedasticity and non-normal error distribution, we used robust standard errors. The data analysis was conducted using Stata 13 (StataCorp, College Texas Station US).

5. Results

Given the paucity of knowledge about pro-recycling behaviors in developing societies, we offer a descriptive report of how attitudes distribute within the urban adult population of Brazil. Table 1 presents the descriptive statistics of the sample, together with the standard errors and the 95% confidence interval. The majority of respondents in the sample are females (54%), and the overall average age is 37.8 years old. The mean value of education is 7.1 which equals to category "high school completed". The average income is between categories 3 and 4, which corresponds to an average of 2713 Brazilian Real. The majority of respondents (62.53%) comes from the South-East, followed by South (12.66%), Central-West (12.03%) and North-East (12.78%).

Respondents hold a positive intention towards recycling their old electronic appliances, with an average value of 4.7 (values ranged from a minimum of 1 indicating very low intention and a maximum of 5 indicating very high intention). A mere 6% of consumers proceed to recycle unused electronics by following proper pro-recycling procedures a figure ultimately not too far from other developing countries like China, 11%, according to Wang et al. (2011a,b) and Yang et al. (2008). The indicators for attitude, social norm and awareness are also high with an average of respectively 4.89, 4.06 and 4.02 (possible answers also ranged from a minimum of 1 and a maximum of 5). The mean for the variable perceived behavioral control is instead not very high with an average of 2.80. The mean of the indicator environmental assessment is also not high (2.65) indicating that respondents think that the environmental situation in Brazil has remained unchanged compared to ten years ago (answers ranged from a minimum of 1 indicating that the current situation is much better, to a maximum of 5 corresponding to much worse). Table 2 reports the socio-demographic and attitudinal

background of consumers upholding different views about product disposal and recycling. Differences are further identified by reporting F-statistics and the associated p-value from the one-way ANOVA.

This analysis considers two outcomes: intention and behavioral appropriateness of e-waste recycling. Overall, the great majority of respondents hold a positive intention towards recycling, while few respondents behave appropriately. The ANOVA analysis allows to understanding significant variations among groups. The intention to recycling older e-waste appliances varies with gender ($p < 0.05$), age ($p < 0.001$), income ($p < 0.01$) and region of residence ($p < 0.05$). Females and respondents between 30 and 49 years old tend to report slightly more often to have a positive intention to recycle than, respectively, males and other age groups. Similar results are observed for lower income individuals' respect to higher income, and for respondents from North and South-East regions compared to South and Central-west residents. These results are somewhat dissonant with our expectations in HP1 and HP2 and should be examined in greater detail in the multivariate model. Concerning behavior, significant differences only exist among income classes. In particular, respondents with a higher income behave slightly better than respondents in the medium and lower income categories ($p < 0.1$).

Table 3 reports the results of the ordered probit regression with the intention as outcome. The results improve as long as we add one of the key components of the TPB. Model 1 only includes attitude, model 2 adds the variable subjective norm, model 3 perceived behavioral control and model 4 awareness towards the e-waste management.

Attitudes, subjective norm and perceived behavioral control are all significant and positively related to recycling intention ($p < 0.001$). Among the key components of the TPB, social norm is the most significant predictor for the behavioral intention; this confirms our HP4. Social norm has also a positive effect ($\beta = 0.35$, $p < 0.001$) and it is the second most important predictor. Perceived control is significant, but is the least important factor in explaining the variability of intention ($\beta = 0.16$, $p < 0.001$). The roles of social norm and perceived control are also consistent with HP4. Similarly, environmental assessment is negatively correlated to recycling intentions ($\beta = -0.09$, $p < 0.01$), indicating that as evaluations about the state of the ecology go grimmer, the more motivated individuals are to embrace responsible waste disposal practices. Awareness towards e-waste recycling is positively associated to intention ($\beta = 0.20$, $p < 0.001$). The more a respondent is aware

Table 1
Sample descriptive statistics (n = 806).^a

Variable	Mean	Linearized SE	95% confidence interval	
Gender (Male = 1)	0.46	0.02	0.41	0.51
Age	37.81	0.68	36.48	39.14
Education	7.16	0.10	6.94	7.38
Income	3.48	0.09	3.30	3.67
Intention	4.7	0.02	4.64	4.76
Behavior: appropriate behavior for e-waste (Adequate = 1; not adequate = 0)	0.06	0.01	0.04	0.09
Attitude	4.89	0.02	4.85	4.92
Social norm	4.06	0.03	3.99	4.13
Perceived behavioral control	2.80	0.04	2.72	2.89
Awareness	4.02	0.03	3.96	4.09
Environmental assessment	2.65	0.07	2.51	2.80

^a Data were weighted to match sample demographics with the Brazilian population living in the metropolitan areas.

Table 2
Frequency distribution and ANOVA results for recycling intention and behavior.

	Intention to recycle electronic-appliances ANOVA (n = 806)			F-test (p-value)	Behavior: adequate for e-waste ANOVA (n = 447)		F-test (p-value)
	Positive	Neutral	Negative		Adequate	Not adequate	
<i>Gender</i>				4.08**			0.08
Female	92%	7.4%	0.58%		6.77%	93.23%	
Male	87%	11.08%	1.14%		6.08%	93.92%	
<i>Age group</i>				4.70***			0.02
18–29	84.18%	13.78%	2.04%		6.72%	93.28%	
30–49	93.19%	6.28%	0.52%		6.54%	93.46%	
>50	90.79%	8.77%	0.44%		6.14%	93.86%	
<i>Education</i>				1.42			0.01
Primary	93.48%	6.52%	0.00%		7.14%	92.86%	
High school	91.61%	7.06%	1.32%		6.48%	93.52%	
University	87.95%	11.73%	0.33%		6.45%	93.55%	
<i>Income</i>				7.39***			2.86*
Low	92.63%	7.37%	0.00%		4.04%	95.96%	
Medium	90.78%	8.41%	0.81%		7.95%	92.05%	
High	82.45%	14.8%	2.74%		12.50%	87.50%	
<i>Region</i>				3.30**			1.19
South-east	92.06%	6.55%	1.39%		5.42%	94.58%	
South	83.33%	16.67%	0.00%		4.65%	95.35%	
Central-west	85.57%	14.43%	0.00%		8.33%	91.67%	
North East	93.20%	6.80%	0.00%		11.48%	88.52%	

Note: p-value: ***p < 0.01, **p < 0.05, *p < 0.1.

about the importance of recycling electronic waste, the higher its intention to recycle. The findings on environmental assessment and awareness are consistent with HP5. Concerning socio-demographics and socio-economic variables, in the ordered probit regression the only significant variables are income and education which are both negatively associated to intention of recycling (respectively, p-value < 0.1 and p-value < 0.05). This finding apparently contradicts our HP1 and HP2.

The examination of pro-recycling behaviors yields a somewhat different picture. This should not be a surprise given the gap between pro-recycling intentions and behaviors already reported. Table 4 reports the odds ratios from the logistic regression using the appropriate pro-recycling behavioral variable as outcome.

Table 3
Ordered Probit Regression for recycling intentions (n = 806).

Variable	Intention to recycle			
	Model 1	Model 2	Model 3	Model 4
Attitude	0.50*** (0.08)	0.44*** (0.08)	0.42*** (0.08)	0.35*** (0.08)
Subjective norm	–	0.42*** (0.06)	0.41*** (0.06)	0.37*** (0.06)
PBC	–	–	0.19*** (0.06)	0.16*** (0.06)
Awareness	–	–	–	0.20*** (0.05)
Environmental Assessment	–0.08** (0.03)	–0.09*** (0.03)	–0.1*** (0.03)	–0.09*** (0.03)
Gender	–0.12 0.09	–0.11 (0.09)	–0.12 (0.09)	–0.12 (0.08)
Age group	0.13** (0.06)	0.06 (0.06)	0.06 (0.06)	0.05 0.06
Education	–0.16* (0.09)	–0.11 (0.08)	–0.13 (0.09)	–0.15* (0.08)
Income	–0.17*** (0.06)	–0.15*** (0.09)	–0.16*** (0.06)	–0.17*** (0.06)
Region dummy (1 = South East)	–0.01 (0.09)	0.01 (0.09)	0.02 (0.09)	–0.00 (0.09)
Observations	806	806	806	806
Pseudo R2	0.04	0.07	0.07	0.08

Notes: Robust standard errors in parentheses; ***p < 0.01, **p < 0.05, *p < 0.1.

In contrast with results using intention as dependent variable, we find that a higher income increases by 133% (p < 0.01) the odds of following an appropriate behavior towards e-waste. Higher subjective norm and perceived control also increase the odds of adopting an appropriate behavior (p < 0.01). This is consistent with HP1. Furthermore, having a higher attitude is not associated to the behavioral outcome.

6. Discussion

The great majority of respondents hold a positive intention towards recycling electronic appliances. Our findings suggest that female, individuals between 30 and 49 years old, lower income groups and people living in the South-east are slightly more likely to have a positive intention than their peers. The finding that Brazilian women have more positive intention to recycling is consistent with a review conducted by Schultz et al. (1995) and Saphores et al. (2006). However, if we look at the actual behavior, results reveal that only few respondents behave appropriately when recycling e-waste. Looking at their socio-economic characteristics, respondents with a higher income are more likely to adequately dispose e-waste.

Table 4
Odds ratios from the logistic regression for pro-recycling behaviors.

	Behavior appropriate for e-waste (1 = appropriate)	
	Odds ratios	SE
Attitude	0.81	0.33
Subjective norm	1.77*	0.54
PBC	1.57*	0.41
Awareness	0.60**	0.12
Environmental assessment	0.88	0.13
Gender	0.82	0.34
Age group	0.89	0.27
Education	0.70	0.28
Income	2.33***	0.70
Region dummy ¹	0.67	0.27

Notes: ***p < 0.01, **p < 0.05, *p < 0.1;

¹ 1 = South East.

Results suggest that the theoretical appeal of TPB to explain intention to recycle e-waste holds when empirically tested. We found that holding a positive attitude and a stronger social norm are the constructs that better explain behavioral intention to recycle. Awareness has also an important impact on the intention. A similar finding was found in Saphores et al. (2012) who suggest that knowledge of the consequences of e-waste on the environment is a key character of e-waste recyclers. At the light of the research hypothesis outlined in the introduction, we found empirical evidence for hypothesis 1, 4 and 5 and partially for hypotheses 2 and 3. Income seems to be negatively related to intention towards e-waste recycling, while it is positively related to actual behavior, suggesting that the awareness of how dispose properly older electronic appliances is higher among more affluent respondents. Previous literature on the relationship between income and recycling behavior in developed economies is also divergent. Some authors find a positive relationship (Gamba and Oskamp, 1994) while others do not (Scott, 1999; Wang et al., 2015). Affluence may discourage recycling in context with poor infrastructure, convenience or unenforced laws for regulating extended producer responsibility as this activity becomes time-consuming (van Beukering and van den Bergh, 2006). By the same token, one can say that the presence of demotivated upscale residents strongly suggests obstacles that exceed attitudinal dispositions, such as highly inconvenient infrastructure for recycling that overcomes potential moral or economic pay-offs of adopting recycling practices.

Our results are also consistent with previous research indicating consumers' ambiguity towards waste recycling, which reflects that this issue remains peripheral to most of them. Interestingly, Brazilians perceive no conflict in upholding environmental issues as salient and exhibiting favorable attitudes towards green virtues in products,¹¹ while at the same time they neglect basic green behaviors such as environmentally responsible disposal of solid waste. Public opinion data thus suggest that eco-friendly behaviors stop at the acquisition phase; therefore those orientations remain divorced from subsequent phases of the consumption cycle such as product usage or product disposal after-usage (like recycling). Admittedly, product disposal practices remain hardly influenced by generic favorable views towards the environment.¹² Consistent with this picture is the fact that recyclable garbage seems conceptually associated to a narrow set of specific target-products like cans, bottles and paper, which downplays the role of recycling applied to high impact solid waste like electronic appliances.

Our results are relevant for policy makers and for the implementation of future programs to address the issue of e-waste recycling. The continuous increase in volumes of e-waste disposal coupled with the inadequacy of waste management practices at the household level in developing economies are attracting increasing attention from numerous stakeholders including policy makers, NGOs, media, and scholars. Accordingly, identifying which forces motivate individuals to effectively adopting a responsible approach becomes pivotal, especially in countries like Brazil with record increases in the generation of e-waste and mounting pressures over the environment and society.

¹¹ Ministry of the Environment survey, MMA 2012. See: <http://mma.gov.br/publicacoes/responsabilidade-socioambiental/category/90-producao-e-consumo-sustentaveis?download=989:o-que-o-brasileiro-pensa-do-meio-ambiente-e-do-consumo-sustentavel>.

¹² For example, the acknowledgment of environmentally-sensitive product information remains connected to healthcare or quality optimization goals but these are divorced from their post-usage properties like product recyclability (MMA, 2012: 46).

At the light of the results of our analysis, we conclude that actions to improve awareness towards the consequences of electronic waste should be taken. Behavioral triggers include for example informative campaigns that further increase issue awareness in connection to valued lifestyles (e.g. focusing on the adverse effects upon personal health and environmental surroundings of e-waste mismanagement) and communication action that leverages the weight of social norms to delegitimize inadequate waste-oriented practices and capitalize on the attributed importance to other people's opinions revealed by our findings. This is in line with findings from other developing countries (Nnorom and Osibanjo, 2008). If coupled with economic and legislation incentives, improvements in recycling behaviors are more likely to occur. Furthermore, extended producer responsibility legislation along product lifecycle, although incipient in its effects and enforcement, is largely endorsed by Brazilians¹³ and is likely to enable progress in infrastructure and opportunities for consumers to engage in greening e-waste related performance. This legal framework has the potential of favorably impacting citizens in terms of providing guidance and assuring a threshold of convenience for adopting pro-recycling practices, thus redressing obstacles related to both perceived control over the conditions that enable recycling practices and perceived personal efficacy in effectively adopting sound environmental choices with regards to e-waste. Yet, evidence from other developing countries suggests that awareness campaigns should move beyond diffusion of new laws, and focus the efforts for knowledge improvements to overcome cognitive barriers like the practical geography of disposal procedures and the personal and community dangers of inadequate disposal seeking to revert the negligence or misinformation about the toxicity of e-waste (Nnorom and Osibanjo, 2008).

The scientific community and many NGOs are also paying increasingly attention to the issue (Robinson, 2009). Through different means, these agents have developed a double focus seeking to redress current barriers (cognitive and practical). On the one hand, they seek to organize informal waste pickers networks into formal cooperatives that learned to value materials in e-waste (and also gain favorable recognition of their social role from society) (de Oliveira et al., 2012; Gutberlet, 2008).¹⁴ On the other hand, these agents disseminate a sense of responsibility-taking among individuals to manage e-waste in an environment-friendly way.

7. Conclusion

Using the TPB as conceptual framework, this study aimed at shading light on Brazilian consumers intention towards e-waste recycling and providing a better understanding of factors that can lever individual behaviors towards adequate e-waste management.

Furthermore, this paper informs about the peculiar manner in which socio-economic and demographics variables interact with these orientations toward recycling. The general positive role of attitudes, subjective norm and perceived behavioral control explained part of the variability to explain recycling behavioral intention.

Pro-recycling behaviors towards e-waste in Brazil could find a fertile soil based on the width of favorable intentions to engage in responsible disposal by consumers. Moreover, as females feel more

¹³ WWF-Ibope 2009, available at http://d3nehc6yl9qz04.cloudfront.net/downloads/agua_brasil_ibope_nacional_divulgacao_pdf.pdf.

¹⁴ An important positive externalities coming from e-waste recycling is linked to the recovery of precious materials, that may constitutes up to 70% of the components of electric devices such as cell-phones, TV boards, or DVD players (Cui and Zhang, 2008).

engaged with this behavior and they are predominantly more responsible for household chores, the prospects for effective practice of e-waste recycling tend to be more optimistic. However, the main barriers for navigating the conversion from intentions to behaviors are structural in nature, therefore difficult to overcome, as revealed by the inequality of access to free time, information, and well-being resources which underlie differences in responses across publics (portrayed by the differences in social status and education that distinguish citizens who actually practice recycling from those that stop at the level of intentions). Accordingly, pro-recycling policies will need to provide means to overcome the heavier costs bore by lower SECs to execute their intentions to engage in responsible disposal behaviors. Concomitantly to those actions, a policy communication approach that puts emphasis on the social legitimacy of e-waste recycling should ensure a substantive level of motivation towards this action. Data also reflects that by widening the means of capabilization of individual consumers to effectively take charge of e-waste in a responsible manner (by disseminating practical and logistics-centered ways to perform such behavior), it is reasonable to expect a favorable evolution towards a broader recycling record. Making capabilization to happen is in line with enforcing the current legislation that extends manufacturers' responsibility for product lifecycle. Therefore, as points of collection by manufacturers achieve a better spatial distribution closer to those segments with high intentions but conditioned by socio-economic factors, one can expect substantive improvements in rates of recycling.

This study indicates that after and while enjoying a drive in favor of electronic goods possession and continuous renovation, Brazilians have also become sensitive to acknowledging the need for a sustainable approach towards the disposal of electronic products. Even if the majority stops at the level of intentions, there is a favorable background of attitudes, social expectations, and demand for self-capabilization means that

may help into a rapid and mass-wider conversion of intentions into behaviors.

Few shortcomings should also be acknowledged for this research. Given the commercial nature of the survey the measurement instrument used allowed for a limited number of variables to model the underlying rationality that feeds the theory of planned behavior. Furthermore, given the extremely low incidence of responsible disposal behaviors involving recycling of e-waste, data inferences to the population at large need to be taken with caution. In addition to this, the sample covered only highly urban areas which are the best served in terms of both municipal garbage collection systems (that may include or not a segregated solid waste collection) and are more likely to offer manufacturers' or retailers' point of disposal of e-waste as it is easy for governments to enforce current regulations. Accordingly, future research should include broader measures and a more representative sample of the national population in order to validate our findings.

Lastly, if our contribution brings some additional light to the forces behind the well-acknowledged intention-behavior gap in sustainable consumption, we also need to recognize the growing criticisms surrounding TPB-oriented research. These criticisms mostly highlight the limitations of the underlying view of acts as the outcome of rational, cognitive, highly individualistic decisions, neglecting the social and structural conditioning daily practices such as waste disposal (Connolly and Prothero, 2008; Moraes et al., 2012). Accordingly, future research should conceptualize and introduce measures that recognize the social embeddedness of post-consumption orientations and actions, as well as the important constraints imposed by infrastructure and convenience.

Appendix

Variables employed in building the model's key indicators.

Indicator or variables	Labels and categories	Scale resulting from variables' editing	Cronbach's alpha ^a or Pearson's correlation
Intention	I'm willing to spend some time taking my old electronic appliances to recycling I am willing to speak to my friends about appropriate modes of disposing electronic appliances I am willing to get more information about appropriate modes of disposing electronic appliances	1 = Fully disagree 5 = Fully agree	0.61 (Cronbach's alpha)
Behavior 2	What did you do with your older electronic appliances? (original options: 1. disposed with ordinary garbage; 2. disposed along with segregate waste; 3. disposed it in a specific collection point specific for electronic-waste; 4. took it to a specific collection point as indicated by the manufacturer; 5. returned to the store where you purchased it; 6. donated to a charity institution; 7. passed over onto other people who could use it or fix it for themselves; 8. keep it/stored it at home	0 = behavior inappropriate for e-waste (options: 1,2,6, 7,8) 1 = behavior appropriate for e-waste (options: 3,4,5).	
Awareness	Knowledge of electronic waste effect upon the environment and society Existence of waste collection sites that received electronic appliances no longer in use Parts of electronic appliances or components no longer in use can be recycled It's wrong to dispose electronic waste and regular waste together	1 = Never heard 5 = Knows a lot	0.70 (Cronbach's alpha)
Attitude	Taking my old electronic appliances to recycling is good for the environment Taking my old electronic appliances to recycling is good for my health and my family's health	1 = Fully disagree 5 = Fully agree	0.42 (Correlation)

(continued on next page)

(continued)

Indicator or variables	Labels and categories	Scale resulting from variables' editing	Cronbach's alpha ^a or Pearson's correlation
Subjective norm	Some of my friends take electronic appliances to recycling because it is the right thing to do I already do my share for the environment I want others to see me as environmental conscious Everybody should care about where our unused e-apps do after disposal	1 = Fully disagree 5 = Fully agree	0.35 (Cronbach's alpha)
Perceived Behavioral Control	There are not collection sites for electronic waste nearby my home or work I trust my city's system of electronic appliances selective collection Electronic waste recycling is someone else's responsibility As a consumer, I can influence an electronic waste manufacturer to be responsible for collecting and reusing electronic e-apps disposed as waste	1 = Fully disagree 5 = Fully agree	0.27 (Cronbach's alpha)
Environment assessment	How would you rate the current situation of (ITEM) compared to 10 years ago in Brazil?	1 = Much better 5 = Much worse	NA

^a The low values of Cronbach's alpha are likely to depend on the limited number of items used for each construct. The use of Cronbach's alpha as a measure of internal consistency has been largely criticized in the literature because its value is strongly related to the number of variables rather than internal consistency. See for example: Sijtsma, K. (2009). On the use, the misuse, and the very limited usefulness of Cronbach's alpha. *Psychometrika*, 74(1), 107–120.

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