Exploring in-depth joint pro-environmental behaviors: a multivariate ordered probit approach

Olivier Beaumais*, Apolline Niérat†

January 2019

Abstract

As commitment levels to pro-environmental activities are usually coded as ordered categorical variables, we argue that the multivariate ordered probit model is an appropriate tool to account for the effect of common observable *and* unobservable variables on joint pro-environmental behaviors. However, exploring in-depth joint pro-environmental behaviors using the multivariate ordered probit model requires not only to assess whether some variables are found to be significant, but also to calculate joint probabilities, conditional probabilities and partial effects on these quantities. As an illustration, we explore the joint commitment levels of households to recycling of materials in France. We show that beyond the estimation of the multivariate ordered probit model, much can be learned from the calculation of the aforementioned quantities. (JEL C35, Q53)

Keywords: Joint pro-environmental behavior, multivariate ordered probit model, waste recycling

1 Introduction

Policy makers commonly wonder how to foster the level of households' commitment to pro-environmental behaviors. Of course, this legitimate question has inspired, and still inspires, lots of academic works, be in the field of political science, sociological science or in economics, to name but a few. From an economics standpoint, pro-environmental behaviors may be encouraged by monetary, as well as non-monetary incentives. When it comes to household recycling behavior, monetary incentives include deposit-and-refund systems, pay-as-you throw (PAYT) schemes or fines for households discarding recyclables (Bel and Gradus, 2016). For example, Viscusi et al. (2012) found convincing evidence that plastic water bottle deposits in the US can turn nonrecyclers into diligent recyclers. Non-monetary incentives range from improving accessibility of recycling services to providing information and even "nudges" to households (Kirakozian, 2016). Likewise, a still growing strand of

*Corresponding author: olivier.beaumais@hotmail.fr, UMR CNRS 6240 LISA; Università di Corsica - Pasquale Paoli; Campus Mariani, BP 52, 20250 Corte, France.

†CREAM EA-4702, University of Rouen Normandy

literature focuses on the role of social norms and attitudes on household recycling, besides economic instruments (Berglund, 2006; Halvorsen, 2008; Brekke et al., 2010; Czajkowski et al., 2014).

Thus, the identification of enablers and constraints to households' commitment to pro-environmental behavior is still of primary importance. Also, it requires appropriate data and appropriate data analysis techniques. Most of the time, the level of households' commitment to pro-environmental behaviors is measured through Likert-style questions/items[1] and, in the case of household recycling behavior, through ordinal variables constructed from recycling intensities (Jenkins et al., 2003; Kipperberg, 2007; Ferrara and Missios, 2012, 2016; Saphores and Nixon, 2014). The vast majority of these studies relies on the estimation of *univariate* ordered logit models, with the recycling levels of various materials (glass, plastic, newspaper, cardboard, cans, food, metal, etc.) as dependent variables, which implies that the recycling levels are considered as unrelated, i.e., the recycling decisions are not jointly modeled. A noticeable exception is the recent paper of Ferrara and Missios (2016) who explicitly examine the relationship between waste prevention, waste recycling and waste disposal. Estimating a three-equation system, they allow the unobservables involved in each of the three behaviors to be correlated, as the error terms in the three corresponding equations are supposed to be jointly normally distributed. Likewise, they estimate a multivariate ordered probit model in order to capture possible correlations between the unobservables governing the level of recycling of five types of material.

We agree with Ferrara and Missios (2016) that allowing for such correlations is a necessary step to analyze joint recycling behaviors, more generally to analyze the level of households' commitment to pro-environmental behaviors. Consequently, we also propose to use the multivariate ordered probit model for that purpose. However, estimating a multivariate ordered probit model and checking for the significance of predictors is not sufficient enough to explore in-depth joint pro-environmental behaviors. Indeed, as Greene (2011, p. 830) notes, "without a fair amount of extra calculation, it is quite unclear how the coefficients in the [univariate] ordered probit model should be interpreted". What is true for the univariate ordered probit model is all the more true for the multivariate ordered probit model. Despite that, most, if not all, articles based on the estimation of multivariate probit models simply discuss the statistical significance of individual parameter estimates (including correlations between the unobservables, see Cirillo et al. 2017 for an application to vehicle ownership and use), without truly exploiting the richness of the underlying data-generating process.

Therefore, the purpose of the present article is both methodological and empirical. From a methodological viewpoint, we show how computing various quantities, such as joint probabilities, conditional probabilities, partial effects on these quantities *and the associated standard errors* considerably improves the initial picture resulting from the simple estimation of a multivariate ordered probit model. Of course, this methodological contribution is not limited to environmental economics. We think that it can be applied to other fields of economic analysis, where the study of joint behaviors matters, such as transportation economics, health economics or

[1] For example, "How concerned are you about the following environmental issues?", with five possible answers for each of the listed environmental issues: "Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree".

marketing research (see Kenne Pagui and Canale, 2016 for an application to customer satisfaction data). From an empirical viewpoint, we show that joint recycling behaviors are indeed governed by common observable and unobservable variables, which results in subtle reallocation effects of the recycling effort.

The rest of the paper is organized as follows. Section 2 introduces the multivariate ordered probit model and shows how to derive some quantities of interest. Section 3 presents the data and the main results, whereas Section 4 offers some concluding insights.

2 Model

The multivariate ordered probit model can be viewed as a natural extension of the univariate ordered probit model (Greene and Hensher, 2010). Though it was initially developed for ordered categorical dependent variables, ordered-response systems are also used for count outcomes, notably in the transportation literature (Ferdous et al., 2010; Scott and Kanaroglou, 2012). Such multivariate model, for q outcomes, is specified in the seemingly unrelated regressions (SUR) q-equation system (1).

$$\begin{cases} y^*_{i,1} = x_{i,1}\beta_1 + \varepsilon_{i,1} \\ \dots \\ y^*_{i,q} = x_{i,q}\beta_q + \varepsilon_{i,q} \end{cases} \tag{1}$$

For individual i, each latent variable $y^*_{i,n}$ (for example the continuous individual recycling intensity for material n) is a function of a vector of independent variables $x_{i,n}$, a vector of parameters β_n and an error term $\varepsilon_{i,n}$ with $n = \{1, \dots, q\}$. Each error term follows a standard normal distribution $\varepsilon_{i,n} \sim \mathcal{N}(0, 1)$ and the multivariate distribution of the error terms is multivariate normal with mean 0 and *correlation* matrix R (remember that unrestricted variance parameters are unidentified, see Boes and Winkelmann, 2006; Greene and Hensher, 2010; in the following, Φ_R and ϕ_R denote, respectively, the cumulative and density of the multivariate normal with mean 0 and correlation matrix R).

$$\{\varepsilon_{i,1}, \dots, \varepsilon_{i,q}\} \sim \mathcal{N}(0, R)$$
$$\text{and } R = \begin{pmatrix} 1 & \rho_{12} & \dots & \rho_{1q} \\ \rho_{12} & 1 & \dots & \rho_{2q} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{1q} & \rho_{2q} & \dots & 1 \end{pmatrix}$$
with $\rho_{nn'}$ correlation coefficient between errors terms $\varepsilon_{i,n}$ and $\varepsilon_{i,n'}$.

Therefore, each latent variable is described by a linear equation and is linked to other latent variables through error terms which are assumed to be correlated across the equations. Consequently, the model accommodates both observable and unobservable common factors, respectively through the independent variables and the error terms included in the equations.

For the q-multivariate probit model, the relation between each latent continuous variable and each corresponding observed ordered discrete variable can be described by equation (2) and illustrated in Figure 1. Assuming the ordered variable $y_{i,n}$ can take value $j_n = \{j_{\inf,n}, \dots, j_{\sup,n}\}$, then:

$$y_{i,n} = j_n \text{ if } \delta_{(j_n-1),n} < y^*_{i,n} < \delta_{j_n,n} \tag{2}$$

where the δ's are known in the literature as threshold or cutpoint parameters. Normalization requires that $\delta_{(j_{\inf,n}-1),n} = -\infty$ and $\delta_{j_{\sup,n},n} = +\infty$.

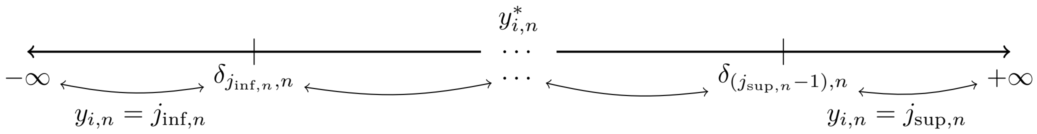

Figure 1: Relation between latent variable and dependent variable

Within the multivariate ordered probit model, joint probabilities can appropriately measure engagement in joint behaviors. For example, if we are interested in the predicted probability of $y_{i,1}$ being equal to $j_{\sup,1}$ while $y_{i,q}$ being equal to $j_{\inf,q}$, such probability can be computed using the following expression (denoting the estimated coefficients as $\hat{\delta}$, $\hat{\beta}$):

$$\widehat{Pr}(y_{i,1} = j_{\sup,1}; y_{i,q} = j_{\inf,q}) = \int_{\hat{\omega}_{(j_{\inf,q}-1),q}}^{\hat{\omega}_{j_{\inf,q},q}} \int_{\hat{\omega}_{(j_{\sup,1}-1),1}}^{\hat{\omega}_{j_{\sup,1},1}} \phi_{R_{1,q}}(\varepsilon_{i,1}; \varepsilon_{i,q}) d\varepsilon_{i,1} d\varepsilon_{i,q} \tag{3}$$
$$\text{with } \hat{\omega}_{p,n} = \hat{\delta}_{p,n} - x_{i,n}\hat{\beta}_n$$

where $R_{1,q}$ is the relevant sub-matrix of R, i.e.,

$$R_{1,q} = \begin{pmatrix} 1 & \rho_{1q} \\ \rho_{1q} & 1 \end{pmatrix}$$

Likewise, focusing now on the trivariate case ($q = 3$ as in our empirical application, see below) equation (4) gives the predicted joint probability of $y_{i,1}$ being equal to j_1, $y_{i,2}$ being equal to j_2 and $y_{i,3}$ being equal to j_3.

$$\widehat{Pr}(y_{i,1} = j_1; y_{i,2} = j_2; y_{i,3} = j_3) = \int_{\hat{\omega}_{(j_3-1),3}}^{\hat{\omega}_{j_3,3}} \int_{\hat{\omega}_{(j_2-1),2}}^{\hat{\omega}_{j_2,2}} \int_{\hat{\omega}_{(j_1-1),1}}^{\hat{\omega}_{j_1,1}} \phi_R(\varepsilon_{i,1}; \varepsilon_{i,2}; \varepsilon_{i,3}) d\varepsilon_{i,1} d\varepsilon_{i,2} d\varepsilon_{i,3} \tag{4}$$

Furthermore, both equations (3) and (4) make it possible to compute conditional probabilities (trivariate case, again, without any loss of generality). Equation (5) describes the probability of $y_{i,3}$ being equal to j_3 given that

$y_{i,1}$ is equal to j_1 and $y_{i,2}$ is equal to j_2:

$$\begin{aligned}\widehat{Pr}(y_{i,3} = j_3|y_{i,1} = j_1; y_{i,2} = j_2) &= \frac{\widehat{Pr}(y_{i,1} = j_1; y_{i,2} = j_2; y_{i,3} = j_3)}{\widehat{Pr}(y_{i,1} = j_1; y_{i,2} = j_2)} \\ &= \frac{\int_{\hat{\omega}_{(j_3-1),3}}^{\hat{\omega}_{j_3,3}} \int_{\hat{\omega}_{(j_2-1),2}}^{\hat{\omega}_{j_2,2}} \int_{\hat{\omega}_{(j_1-1),1}}^{\hat{\omega}_{j_1,1}} \phi_R(\varepsilon_{i,1}; \varepsilon_{i,2}; \varepsilon_{i,3}) d\varepsilon_{i,1} d\varepsilon_{i,2} d\varepsilon_{i,3}}{\int_{\hat{\omega}_{(j_2-1),2}}^{\hat{\omega}_{j_2,2}} \int_{\hat{\omega}_{(j_1-1),1}}^{\hat{\omega}_{j_1,1}} \phi_{R_{1,2}}(\varepsilon_{i,1}; \varepsilon_{i,2}) d\varepsilon_{i,1} d\varepsilon_{i,2}}\end{aligned} \tag{5}$$

It is important here to understand that the joint distribution involves *all the variables* included in *all the vectors* of independent variables ($x_{i,n}$) through the $\hat{\omega}_{p,n}$'s. Which means that, for example, even if a variable is not included in the $x_{i,3}$ vector of independent variables but is included in the $x_{i,1}$ vector of independent variables and/or in the $x_{i,2}$ vector of independent variables, it does actually influence the above conditional probabilities. Thus the calculation of partial effects of all the variables included in all the vectors of independent variables on all the conditional probabilities is potentially of great interest. Of course, when the correlation coefficients (ρ's) are 0, the joint probabilities factor into the products of the marginals and the above expression simplifies:

$$\widehat{Pr}(y_{i,3} = j_3|y_{i,1} = j_1; y_{i,2} = j_2) = \widehat{Pr}(y_{i,3} = j_3) \tag{6}$$

That case corresponds to a system of three *univariate* ordered probit models, which implies that the conditional probability in equation (5) is *no longer* influenced by independent variables that are *not* included in the $x_{i,3}$ vector.

The model can be estimated by full information maximum likelihood[2]. Thus, estimating the multivariate ordered probit model and computing the aforementioned quantities require the evaluation of multivariate normal integrals, which do not have closed-form solution, and have to be approximated by numerical methods. This involves high computational costs that can be further alleviated, for high q-dimensional integrals, by appropriate approximations methods such as the pairwise or tripletwise likelihood approaches (Kenne Pagui and Canale, 2016; Hirk et al., 2017) or Genz approximation (Cirillo et al., 2017). For example, the pairwise approach proceeds by replacing the full likelihood by a pseudo-likelihood constructed from bivariate margins, resulting in clear gains of computation time and tractability, at the cost of a loss in efficiency, when compared with full likelihood (Kenne Pagui and Canale, 2016).

However, since the main objective of our paper is to demonstrate the feasibility and usefulness of calculating the aforementioned quantities, we have chosen a full likelihood approach, thus restricting, for the empirical application, the number of outcomes to three ($q = 3$, trivariate ordered probit model). We leave the cost-benefit analysis of using approximations methods in this context to further research. Partial effects on conditional probabilities are calculated as differences in predicted (conditional) probabilities. The associated standard

[2]Note that DeYoero and Kottas (2017) recently introduced a Bayesian nonparametric modeling approach for univariate and multivariate ordinal regression. This approach seems very promising in terms of inferential flexibility, but goes obviously beyond the scope of the present article.

errors have been computed by bootstrap, as suggested by Mullahy (2017)[3].

3 Application

3.1 Data set

This article uses data from a periodic OECD survey: the Environmental Policy and Individual Choice (EPIC) survey and more precisely, the second round conducted in 2011. The questionnaire was developed considering the recommendations of national experts through an Advisory Committee. In order to ensure comparability between first and second rounds (respectively 2008 and 2011 surveys), the 2008 questionnaire was used as a basis and refinements were made. For example, if the five same topics (energy, food, transport, waste and water) are met in both surveys, the 2011 questionnaire asked respondents to estimate approximately the percentage of a material recycled by their household between 0 and 100% while the 2008 questionnaire suggested five answers: "0%", "25%", "50%", "75%" and "100%" (plus an opt-out option).

The full sample consisted of 12,202 observations from online household panels gathered by Global Market Insite. Between February and March 2011, the survey was conducted in 11 countries (Australia, Canada, Chili, France, Israel, Japan, Korea, Netherlands, Spain, Sweden and Switzerland) and the present paper focuses on the case of France which consists of a subsample of 1,007 observations. As the OECD performed several data checks (see OECD, 2014), we are confident that the data set is highly reliable.

3.2 Variables

As mentioned earlier, the respondents were asked to estimate the intensity of recycling for five materials (plastic, metal, paper, glass and food) out of which only the three most representative are explored in this paper (plastic, metal and paper). The dependent variable for each material reflects the household's level of recycling relatively to other households' through the assignment of 1 for "household's i recycling intensity is below first quartile / nonrecycler", 2 for "household's i recycling intensity is above first quartile but below second quartile / moderate recycler" and 3 for "household's i recycling intensity is above second quartile / diligent recycler". For example, if a dependent variable is equal to 3, it means that the household recycles that material relatively more than 50% of the households of the French sample and is thus considered as a diligent recycler. Notice that studies which analyze the intensity of recycling actually take ordinal variables, derived from the proportion of materials that is recycled, as dependent variables (see, for example, Ferrara and Missios, 2016). Also, from a policy perspective, we consider that the level of households' commitment to recycling is appropriately captured by ordinal variables as we define them[4]. Table 1 reports the Spearman rank correlations between the levels of commitment to the

[3] We used Stata MP 14. The trivariate model was estimated with cmp (Roodman, 2011) and the joint probabilities, conditional probabilities, marginal effects were computed using mvnormal (Grayling, 2015). mvnormal uses a Quasi-Monte Carlo Randomized Lattice algorithm for evaluating the required integrals, see Genz and Bretz, 2009.

[4] This way of constructing our variables of interest probably leads us to waste some of the information provided by the raw data (recycling intensities). From this point of view, it would be relevant to estimate a multivariate version of the fractional

recycling of the three materials, along with 95% confidence intervals. The Spearman correlations are found to be highly significant, and positive, suggesting as expected that households engage actively in joint pro-recycling behaviors.

Table 1: Spearman rank correlations

	Plastic	Metal	Paper
	[95% confidence interval into brackets]		
Plastic	1	-	-
Metal	0.71	1	-
	[0.68 ; 0.74]		
Paper	0.64	0.62	1
	[0.60 ; 0.68]	[0.58 ; 0.66]	

The independent variables of the model are described in Table 2. They were inspired by the independent variables in Ferrara and Missios (2012) and can be divided into three categories: household's characteristics, attitudinal variables and waste management policy variables.

Table 2: Independent variables

Household characteristics	
AGE_CLASS_18_24	Age between 18 and 24 indicator
AGE_CLASS_25_34	Age between 25 and 34 indicator
AGE_CLASS_35_44	Age between 35 and 44 indicator
INCOME_CONT	Annual income after tax
AREADESC_SUBURBAN	Residence in a suburban indicator
RESDYRS_2_5	Living in the current residence for 2 to 5 years indicator
Attitudinal variables	
DUTY_MOTIVE	Civic duty motivation
Waste management policy	
FLAT	Flat fee indicator
COLLFREQ_EVDAY	Mixed waste collected everyday indicator
RCYCLCOLDTD_PLST	Door-to-door plastic collection service indicator
RCYCLCOLDTD_MTAL	Door-to-door metal collection service indicator
RCYCLCOLDTD_PAPR	Door-to-door paper collection service indicator

The final model was selected based on the Bayesian Information Criterion (BIC). Our goal was to get a simple, yet effective, model to explore the joint pro-recycling behavior. Most of the variables are binary variables, notably household characteristics and waste management policy variables. $INCOME\_CONT$ is an exception, as it represents the household's annual income in euros. $DUTY\_MOTIVE$ is an attitudinal variable, captured by an eleven-point Likert variable, ranging from 0 indicating that the statement "I think it is my civic duty" is

response model introduced by Papke and Wooldridge (1996, 2008) by taking the recycling intensities of each of the three materials as dependent variables. However, in addition to the fact that we are not aware of any work based on the estimation of multivariate fractional response models for the study of pro-environmental behaviors, while many models explore these behaviors using ordinal regression analysis, this would take us away from our main objective, which focuses on the properties of the multivariate ordered probit model. We therefore leave the exploration of a multivariate version of the fractional response model to future work.

considered "not important" to 10 indicating that it is considered "very important" in motivating the respondent to recycle.

Table 3 provides summary statistics for the independent variables. According to our sample, door-to-door collection systems are common since 59% of households claim that their plastic waste is collected door-to-door, 55% that their paper waste is collected door-to-door while only 50% of them benefit from door-to-door collection for metal waste. Likewise, mixed waste collection would appear to be mostly charged through flat fee. Not surprisingly, we observe that most of households' mixed waste is not collected everyday. On average, the respondents indicate that the civic duty motive is equal to 8 on the eleven-point Likert question and thus is perceived as an important motive to recycle.

Table 3: Summary statistics for independent variables - mean (std)

Household characteristics	
Age between 18 and 24 indicator	0.14 (0.35)
Age between 25 and 34 indicator	0.15 (0.36)
Age between 35 and 44 indicator	0.21 (0.41)
Income	38,554 (17,376)
Residence in a suburban indicator	0.22 (0.41)
Living in residence for 2 to 5 years indicator	0.23 (0.42)
Attitudinal variables	
Civic duty motivation	8.22 (1.90)
Waste management policy	
Flat fee indicator	0.61 (0.49)
Mixed waste collected everyday indicator	0.12 (0.32)
Door-to-door plastic collection service indicator	0.59 (0.49)
Door-to-door metal collection service indicator	0.50 (0.50)
Door-to-door paper collection service indicator	0.55 (0.50)

3.3 Joint Pro-recycling Behaviors

The three-equation system (7) describes the latent variables system associated with an individual i's recycling intensities for three materials respectively for "plastic (1)", "metal (2)" and "paper (3)".

$$\begin{cases} y^*_{i,1} = x_{i,1}\beta_1 + \varepsilon_{i,1} \\ y^*_{i,2} = x_{i,2}\beta_2 + \varepsilon_{i,2} \\ y^*_{i,3} = x_{i,3}\beta_3 + \varepsilon_{i,3} \end{cases} \tag{7}$$

Estimation of the corresponding trivariate ordered probit model will allow us to calculate joint and conditional probabilities for an individual. As an example of the latter, if we assume that an individual is nonrecycler for plastic and metal, we can compute his/her probability of being a diligent recycler for paper. This probability may be or may not be lower for this individual than the same conditional probability for a diligent recycler of plastic and metal.

Such results might be interesting for decision-makers. Indeed, recycling policies are costly and not always coordinated between materials. Such barriers favor inertia and force authorities to focus on a particular material when seeking to improve recycling policy. Yet, most of the time, effects of a change for one material on other materials' recycling intensity are not taken into account and when they are, the existing levels of recycling are not considered. The decision-maker may then overestimate or underestimate the benefits of his investment. For example, the introduction of a specific material door-to-door service is expected to increase this material recycling intensity, but what about the other materials' recycling intensities? One can expect that the door-to-door service may awaken environmental concerns and lead to an increase in all recycling intensities but one can also expect that the time allocated to recycle this particular material will be spent at the expense of the time allocated to other materials. Both effects may co-exist, but one may apply when existing recycling intensities are low and the other when existing recycling intensities are high. Conditional probabilities are then relevant to unravel the potential impacts of a recycling policy change.

3.4 Results

The results of the trivariate probit model are reported in Table 4. Notice, as recalled in the Introduction, that the significance of individual parameters does not say much on the significance of the marginal effects of variables on the joint/conditional probabilities of being nonrecycler, moderate recycler or diligent recycler.

First, the estimated coefficients of correlation between the unobservables[5] governing the three levels of commitment to recycling (ρ's) are found highly significant and positive, which supports the use of a multivariate ordered probit model to analyze the data. In line with the observed positive Spearman rank correlations, a random increase in the level of commitment to the recycling of any material tends to correspond to a random increase in the level of commitment to the recycling of all the other materials.

Second, of the household characteristics, age (18-24) seems to be only a significant predictor of the level of commitment to paper recycling while age (25-34) and (35-44) matter for plastic and metal. Income, which is often presented as a proxy of the opportunity cost of time spent recycling, appears to influence significantly and negatively the level of commitment to paper recycling. However, the interpretation of the income as reflecting the opportunity cost of time spent recycling has to be taken with caution. In a recent paper, using a discrete choice experiment approach, Beaumais and Prunetti (2018) show that the opportunity cost of recycling is highly heterogeneous across individuals, making it difficult to be captured by a single income coefficient. Both AREADESC_SUBURBAN and RESDYRS_2_5—describing the area of the residence as a suburban and living in the residence for 2 to 5 years—appear to have a clear significant negative effect on the commitment to

[5]The degree of environmentalism of individuals might be one of the unobservables. For example, Kahn (2007) argues that the community's share of Green Party registered voters in California is a good proxy for environmentalism. He then shows, based on California data, that greens are more inclined to use public transport, consume less gasoline, and buy more hybrid vehicles.

Table 4: Trivariate ordered probit model

	Plastic coefficient (std)	Metal coefficient (std)	Paper coefficient (std)
AGE_CLASS_18_24	-	-	-0.314***
			(0.091)
AGE_CLASS_25_34	0.355***	0.336***	-
	(0.085)	(0.094)	
AGE_CLASS_35_44	0.154**	0.218***	-
	(0.075)	(0.082)	
INCOME_CONT	-	-	-0.005**
			(0.002)
AREADESC_SUBURBAN	-0.116*	-	-0.174**
	(0.066)		(0.080)
RESDYRS_2_5	-	-0.218***	-0.211***
		(0.070)	(0.074)
DUTY_MOTIVE	0.138***	0.159***	0.152***
	(0.019)	(0.021)	(0.021)
FLAT	0.148***	-	-
	(0.052)		
COLLFREQ_EVDAY	-	-0.257***	-0.250**
		(0.091)	(0.098)
RCYCLCOLDTD_PLST	0.255***	-	-
	(0.064)		
RCYCLCOLDTD_MTAL	-	0.382***	-
		(0.067)	
RCYCLCOLDTD_PAPR	-	-	0.392***
			(0.070)
$\delta_{1,n}$	0.690***	0.890***	0.415**
$\delta_{2,n}$	1.468***	1.628***	1.168***
ρ_{1n}	-	0.832***	0.769***
ρ_{2n}	0.832***	-	0.734***
ρ_{3n}	0.769***	0.734***	-

* Significant at 10%; ** significant at 5%; *** significant at 1%.

recycling plastic and paper for the former and metal and paper for the latter.

Conversely, the civic duty motive acts significantly and positively on the level of commitment to the recycling of the three materials, which is in line with the findings of Ferrara and Missios (2012). This personal motive, based on social considerations, can be seen as a desire to behave responsibly.

Finally, we did not find evidence that PAYT schemes increase the level of commitment to recycling, which can be explained by the fact that, for now, PAYT is rarely implemented in France (about 4% of the respondents). Of the policy variables, door-to-door waste collection (availability of curbside disposal) improves the intensities of recycling, which, again, is in line with the previous literature (see, for example, Ferrara and Missios, 2012).

Beyond these results, we now turn to the calculation of additional quantities, both to illustrate the richness of the multivariate ordered probit model and to assess the significance and magnitude of partial effects of the independent variables on the level of households' commitment to recycling of materials. Due to space limitation, we present *some* of the conditional probabilities (see equation (5)) in the text body, while the full results are given in Appendix. Also, we only comment the marginal effects for one variable of each of the categories listed in Table 2, namely living in a suburban area, door-to-door metal collection services and civic duty motive, while all the marginal effects are given in Appendix.

Table 5 provides the predicted conditional probabilities derived from the estimated model for an average individual[6]. Each and every one of these probabilities are found highly significant. Of particular interest are the cases in which the given recycling levels are extreme (nonrecycler or diligent recycler): consistent with the intuition of linked recycling levels, the highest predicted probability is that the households' recycling level for the third material is the same as the others' (for example, $Pr(nonrecycler|(nonrecycler \wedge nonrecycler))$. We can also notice that the lowest probability is for the opposite recycling level (for example, $Pr(diligentrecycler|(nonrecycler \wedge nonrecycler))$. This can be interpreted as a commitment to recycling: once an individual chooses to be a diligent recycler or a nonrecycler for two materials, he is most likely to act in the same way for the third material. More generally, one can observe a consistency across recycling levels: given that the recycling levels for two materials are the same, the highest probability is that the third material is recycled at the same level as the others'.

In the extreme cases mentioned above, the highest and lowest conditional probabilities are around 0.850 and 0.010 respectively, with one exception: when the household is a plastic and metal nonrecycler, the conditional probabilities of commitment to paper recycling tend to be more equally distributed (see Table 9 in the Appendix). This result may indicate that households dissociate more the paper recycling from the plastic and metal recycling.

Table 5: Conditional probabilities

		Probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic nonrecycler and a paper...	nonrecycler	0.826***	0.158***	0.016***
	moderate recycler	0.631***	0.317***	0.052***
	diligent recycler	0.459***	0.427***	0.114***
given that the household is a plastic moderate recycler and a paper...	nonrecycler	0.411***	0.452***	0.137***
	moderate recycler	0.270***	0.491***	0.239***
	diligent recycler	0.149***	0.457***	0.394***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	0.129***	0.445***	0.426***
	moderate recycler	0.064***	0.347***	0.590***
	diligent recycler	0.013***	0.134***	0.852***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Looking at all the conditional probabilities, one can notice that if the household is a diligent recycler for at least one of two materials, the lowest probability tends to be that the household is a nonrecycler for the third material and, to a lesser extent, the highest probability tends to be that the household is a diligent recycler for the third material. This can be seen as a ripple effect in which the commitment to be a diligent recycler for at least one material favors the recycling of another material. Likewise, an opposite ripple effect is found in the results: if a household is a nonrecycler for at least one of two materials, the lowest probability tends to be that the household is a diligent recycler for the third material.

[6]This average individual is not living in a suburban area, his mixed waste are not collected everyday and are charged through flat fee. He assessed civic duty to be equal to 8 on the Likert scale used to estimate the importance of this motive. His plastic, metal and paper wastes are collected by door-to-door services.

It may be worth noting that the paper recycling level appears less effective than the plastic recycling level to predict the metal recycling level. Indeed, regardless of the paper recycling level, the predicted metal recycling level is almost always the same as that for the plastic.

Additionally, in order to clarify the interpretation of the coefficients, we compute partial effects (Tables 6, 7, 8). While living in a suburban area was not included in the metal equation in the estimated model, its marginal effects on the metal recycling level conditional probabilities were found significant and appear to increase the probability of being a metal diligent recycler. Conversely, though living in a suburban area was significant for plastic, no significant marginal effects were found for the plastic recycling level of our given individual (see Table 26 in the Appendix). However, and as could have been expected according to the estimated model, the effect of living in a suburban area—when significant—is negative on the probability of being a diligent paper recycler.

Table 6: Suburban marginal effects on the commitment to metal recycling

		Marginal effects of residence being in an area described as a suburban on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.046**	0.037**	0.009*
	moderate recycler	−0.077**	0.052**	0.026**
	diligent recycler	−0.078**	0.034**	0.043*
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.076**	0.027	0.049**
	moderate recycler	−0.064**	−0.005	0.068**
	diligent recycler	−0.041**	−0.035*	0.076**
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.038**	−0.043*	0.081**
	moderate recycler	−0.022**	−0.054**	0.076**
	diligent recycler	−0.005**	−0.026**	0.030**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Some marginal effects are strong enough to change the predicted behavior. For example, while an individual who is not living in a suburban (our average individual), who is a plastic nonrecycler and a paper diligent recycler is predicted to be a metal nonrecycler (highest predicted conditional probability, $Pr = 0.459$, see Table 5), an individual living in a suburban area, whose characteristics, in all other respects, are identical to those of our average individual, who is a plastic nonrecycler and a paper diligent recycler, is predicted to be a metal moderate recycler (highest predicted conditional probability, $Pr = 0.427 + 0.034$, see Table 5 and Table 6). This result illustrates the fact that, within the multivariate ordered probit model, a variable can have strong effects on the predicted recycling behavior for a given material while not included as an explanatory variable in the individual equation for that material. As mentioned above, this is due to the fact that joint probabilities actually include all the model variables.

How can we further interpret the suburban effect? Actually, recent literature has shown the importance of what Mueller (2013) or Bell et al. (2017) call inconvenience costs on recycling behavior. Inconvenience costs notably include the cost of space devoted to in-home waste storage, or low accessibility to recycling drop-off

Table 7: Door-to-door metal collection marginal effects on the commitment to metal recycling

		Marginal effects of a door-to-door metal collection on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.115***	0.102***	0.013***
	moderate recycler	−0.210***	0.169***	0.041***
	diligent recycler	−0.258***	0.173***	0.084***
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.266***	0.166***	0.099***
	moderate recycler	−0.259***	0.101***	0.157***
	diligent recycler	−0.209***	−0.013	0.222***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.198***	−0.033	0.231***
	moderate recycler	−0.134***	−0.123***	0.257***
	diligent recycler	−0.041***	−0.127***	0.168***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

centers. With our data, we cannot control directly for these convenience costs, given that we have no detailed information on the amenities made available to individuals to support their recycling efforts. Thus, the effects of convenience costs are mainly captured though the unobservable variables, and / or proxied by some of the observed variables included in the model. Here, it is likely that when living in a suburban area, an individual may lack of space to stock recyclables compared to rural area, but may also not be close enough to a drop-off center (compared to an urban area). These two effects may lead individual to decrease his recycling levels of paper and plastic (voluminous waste) and to reallocate part of his recycling effort in favor to metal sorting.

Likewise, such a result is observed with door-to-door metal collection. The availability of a metal curbside disposal increases the probability for the household to be a metal diligent recycler and decreases the probability to be a metal nonrecycler. Here, the magnitude of some marginal effects is sufficient to shift the predicted behavior to a higher recycling level. To a lesser extent, the availability of a door-to-door metal collection service has significant marginal effects on paper and plastic conditional probabilities while not included as explanatory variables of those materials' recycling probabilities (see Table 42 and Table 44 in the Appendix). Those marginal effects tend to increase the probability of the household to be a paper or a plastic nonrecycler and are strong enough to favor lower predicted recycling levels. Implementing a door-to-door metal collection service may not result in increased recycling efforts, but rather in a reallocation of recycling efforts in favor of metal. This "reallocation rather than increase" effect could be interpreted as a time limit effect, keeping in mind that the opportunity cost of time spent recycling is known to be a major determinant of household recycling (Beaumais and Prunetti, 2018).

Finally, although civic duty is found to be the most significant variable in the estimated model, the associated marginal effects exhibit low significance and magnitude. When it comes to the conditional probabilities of plastic recycling level, only two marginal effects are significant at 10% and these effects are very weak (see Table 32 in the Appendix). Though, an increase in believing that civic duty is an important factor appears to favor

Table 8: Civic duty marginal effects on the commitment to metal recycling

		Marginal effects of civic duty being a very important motive on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.022***	0.018***	0.003*
	moderate recycler	−0.025**	0.018**	0.008**
	diligent recycler	−0.027**	0.013**	0.014**
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.026**	0.011**	0.015**
	moderate recycler	−0.021**	0.000	0.021**
	diligent recycler	−0.016**	−0.012**	0.028**
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.013**	−0.013*	0.026**
	moderate recycler	−0.008**	−0.018**	0.026**
	diligent recycler	−0.003***	−0.018***	0.021***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

diligent recyclers.Those marginal effects also shift some of the predicted decisions to a higher metal recycling level which is in line with the literature (Ferrara and Missios, 2012; Halvorsen, 2012). The civic duty may be more associated with metal since it was the first recycled material since Bronze Age.

We believe that our results are in line with the findings of Bell et al. (2017) who support single-stream recycling as an incentive to recycling. By enabling household to recycle materials without sorting them, single-stream recycling reduces recycling time costs and can thus increase recycling commitment. *Had we estimated a system of three univariate ordered probit models, we could not have revealed such a reallocation effect.*

3.5 Discussion

What is the benefit, in terms of policy recommendation, of modeling joint pro-environmental behavior? From the results we obtain for recycling behaviors, we believe that we have first to underline what it means that a variable not included in the equation modeling recycling of a given material, but included in the equations (at least one) modeling recycling for the other materials may actually influence the probability of being a diligent recycler for this material, conditional on being diligent, or not, for the other materials. In concrete terms, this means that a policymaker who is interested in ways of influencing the commitment of a given sub-population of recyclers (diligent, moderate, nonrecycler) to the recycling of an additional material, can have a more precise idea of the levers at his disposal to move in the desired direction. The multivariate approach broadens the spectrum of policy interventions by broadening the set of variables identified as being associated with joint pro-environmental behavior: a variable that might have appeared unimportant, not significant, to explain the recycling of a specific material may prove to be a relevant instrument when recycling behaviors are jointly analyzed.

According to our findings, the implementation of a door-to-door collection system for a new material results in a reallocation of the recycling effort. We believe that this develops further Bell et al. (2017)'s results on the value of collecting recyclable materials in single-stream systems, rather than in dual-stream systems. Single-stream collection involves organizing the sorting so that individuals can place all recyclable materials into one container, rather than asking them to sort each of the materials in separate containers. When waste is collected in single-stream systems rather than dual-stream systems, and in the case of Wisconsin, Bell et al. (2017) find that the sorting intensity is boosted by about 5%. Focusing on a specific Wisconsin county (Winnebago County) they find that a shift from a dual-stream recycling to a single-stream recycling provides a positive net social benefit. However, note that Bell et al. (2017) do not model joint sorting behaviors by a multivariate approach, but by a univariate approach: the decision to recycle paper, cans, plastic and glass is modeled separately, notably by estimating a series of univariate probit. As a result, it is not possible for them to capture the reallocation effects that our results identify.

In France, according to the French Environment and Energy Management Agency (ADEME, 2016), apart from glass, which is collected separately, waste is mainly collected in single-stream systems (63% of the population). Dual-streams systems (paper / other packaging including metal, or paper and cardboard / other packaging including metal) cover about 25% of the population. The rest of the population is served by mixed, heterogeneous systems throughout the territory.

Material by material, our results confirm the value of offering door-to-door collection. Door-to-door collection has a positive effect on the commitment of individuals to sorting. The French Environment and Energy Management Agency has calculated (ADEME, 2016) that the quantities of waste (per capita per year) collected door-to-door were about 20% higher than the quantities collected on a voluntary basis (community bins).

However, for several years now, French public authorities have observed that recycling rates hit a ceiling, particularly for plastics. Since 2012, they have been trying to promote plastic recycling through extended sorting instructions. These extended sorting instructions indicate to individuals that it is now possible to place more plastic packaging in their recycling bin than before. For the groups of municipalities that have implemented these extended sorting instructions, the collection of plastic packaging has increased from 5.9 kg to 7.6 kg per capita per year. It is therefore planned to generalize these sorting instructions, which will be extended to all municipalities by 2022. Even if plastic recycling is done in single-stream systems, our results suggest that the extended sorting instructions on the plastic could be accompanied by a reallocation of sorting efforts, to the detriment of other materials. By requiring additional effort for one of the materials (plastic) it is likely that the relative effort for the other materials will decrease.

This point deserves all the more attention as extended sorting instruction implies a modernization of sorting centers, since the fine separation of materials is no longer done at household level. In the French case, to support the implementation of extended sorting instructions, ADEME calculated that the modernization of the current stock of sorting centers would cost between €1.2 and €1.8 billion, an amount that can be compared to the estimated current value of the stock of sorting centers in France (€1.5 billion; ADEME 2014). Also, the benefits of the generalization of extended sorting instructions would deserve to be precisely assessed through, as we do, a multivariate approach of sorting behavior, in order to be appropriately compared with the associated costs.

4 Concluding remarks

In this paper, we show that the multivariate ordered probit model is an appropriate tool to fully unveil the subtlety of joint pro-environmental behaviors. We acknowledge that it comes at a cost, given that the calculation of the relevant quantities—joint probabilities, conditional probabilities, partial effects—is burdensome[7]. But, the calculation of these quantities also considerably enriches the analysis. In particular, in that kind of simultaneous equation framework, the channels through which an independent variable influences the outcomes of interest cannot be summarized by simple partial effects computed on the marginal distribution of these outcomes. The calculation of additional quantities is necessary to understand all the aspects of the phenomenon at stake. Indeed, recycling policies face barriers which force authorities to improve recycling flow one material by one. But when investing in waste management infrastructure or in targeted information campaigns on recycling, decision-makers have to take into account both the expected and existing materials' recycling intensities in order not to overestimate or underestimate the benefits of the investment. This analysis refinement may be applicable in other fields such as health economics in the case of joint addictive behaviors, for example.

From a waste economics perspective, this paper contributes to the received literature by exploring factors associated with the level of commitment to recycling of materials. Households characteristics, as well as attitudinal variables and policy variables matter to explain why individuals engage more or less in recycling. The desire to act responsibly is a strong driver of the engagement in recycling activities. Also, we do not find that PAYT schemes matter, which can simply be explained by the fact that PAYT schemes just start to be implemented in France. Therefore, for now, providing door-to-door collection services seems to be an efficient way to foster households' commitment to recycling. Results regarding household characteristics which influence recycling rates could help to design targeted waste management strategies.

Finally examining other facets of households' waste management behavior in France, such as waste prevention, would require specific data, which, for now, is not available, but is clearly worthy to be made available. From a pure methodological viewpoint, we believe that it would be worth comparing the properties of the multivariate probit model with those of the multivariate logit model, as Hirk et al. (2017) do it, with an application to corporate credit ratings.

5 References

ADEME, 2014. Étude prospective sur la collecte et le tri des déchets d'emballages et de papier dans le service public de gestion des déchets, Synthèse, French Environment & Energy Management Agency, May 2014, In

[7]Using Stata MP4, it took approximately two months to compute all these quantities on a computer with a quad-core i7, 3.4 Ghz processor and 8 GB of RAM.

French.

ADEME, 2016. Organisation de la collecte des déchets d'emballages ménagers et papiers graphiques dans le SPGD, Synthèse, French Environment & Energy Management Agency, May 2016, In French.

Bhat, CR., Varin, C., Ferdous, N., 2010. A comparison of the maximum simulated likelihood and composite marginal likelihood estimation approaches in the context of the multivariate ordered-response model. In: Greene W., Hill RC. (eds) *Advances in econometrics: maximum simulated likelihood methods and applications*, Emerald Group Publishing Limited, Bingley, 65–106.

Beaumais, O., Prunetti, D., 2018. Time for waste, waste of time? Assessing heterogeneous values of saving time from recycling using a latent-class rank-ordered logit approach. *Revue d'Économie Politique*, forthcoming.

Bel, G., Gradus, R., 2016. Effects of unit-based pricing on household waste collection demand: A meta-regression analysis. *Resource and Energy Economics*, 44, 169-182.

Bell, J., Huber, J., and Viscusi, W.K., 2017. Fostering recycling participation in Wisconsin households through single-stream programs. *Land Economics*, 93, 481-502.

Berglund, C., 2006. The assessment of households' recycling costs: The role of personal motives. *Ecological Economics*, 56, 560-569.

Boes S., Winkelmann, R., 2006. Ordered Response Models. In: Hübler O., Frohn J. (eds) Modern Econometric Analysis. Springer, Berlin, Heidelberg.

Brekke, K.A., Kipperberg, G., Nyborg, K., 2010. Social Interaction in Responsibility Ascription: The Case of Household Recycling. *Land Economics*, 86(4), 766-784.

Cirillo, C., Liu, Y., Tremblay, J-M., 2017. Simulation, numerical approximation and closed forms for joint discrete continuous models with an application to household vehicle ownership and use. *Transportation*, 44(5), 1105-1125.

Czajkowski, M., Kądziela, T., Hanley, N., 2014. We want to sort! Assessing households'preferences for sorting waste. *Resource and Energy Economics*, 36, 290-306.

DeYoreo, M., Kottas, A., 2017. Bayesian Nonparametric Modeling for Multivariate Ordinal Regression. *Journal of Computational and Graphical Statistics*, Published online: 07 Apr 2017.

Feng, X., Zhu, J.,Lin, P-S, Steen-Adams, MM, 2017. Composite likelihood approach to the regression analysis of spatial multivariate ordinal data and spatial compositional data with exact zero values. *Environmental and Ecological Statistics*, 24(1), 39-68.

Ferdous, N., Eluru, N., Bhat, C.R., Meloni, I., 2010. A multivariate ordered-response model system for adults' weekday activity episode generation by activity purpose and social context. *Transportation Research Part B: Methodological*, 44, 922-943.

Ferrara, I., Missios, P., 2012. A Cross-Country Study of Household Waste Prevention and Recycling: Assessing the Effectiveness of Policy Instruments. *Land Economics*, 88(4), 710-744.

Ferrara, I., Missios, P., 2016. Reduce, Reuse or Recycle? Household Decisions over Waste Prevention and

Recycling. *Working Paper 065*, Ryerson University, Department of Economics.

Gentz A., Bretz, F., 2009. *Computation of Multivariate Normal and t Probabilities.* Berlin, Germany: Springer.

Grayling M., 2015. *Efficient multivariate normal distribution calculations in Stata.* 2015 UK Stata Users Group Meeting.

Greene W. H., 2011. *Econometric Analysis*, Seventh Edition, Prentice Hall.

Greene, W.H., Hensher, D.A., 2010. *Modeling Ordered Choices*, Cambridge Books, Cambridge University Press.

Halvorsen, B., 2008. Effects of Norms and Opportunity Cost of Time on Household Recycling. *Land Economics*, 84(3), 501-516.

Halvorsen, B., 2012. Effects of Norms and policy incentives on household recycling : an international comparison. *Resources, Conservation and Recycling*, 67, 18-26.

Hirk, R., Hornik, K., Vana, L., 2017. Multivariate Ordinal Regression Models: An Analysis of Corporate Credit Ratings, Institute for Statistics and Mathematics, *Research Report Series*, Report 132.

Jenkins, R.R., Martinez, S.A., Palmer, K., Podolsky, M.J., 2003. The Determinants of Household Recycling: A Material-Specific Analysis of Recycling Program Features and Unit Pricing. *Journal of Environmental Economics and Management*, 45, 294-318.

Kahn, M. E., 2007. Do greens drive Hummers or hybrids? Environmental ideology as a determinant of consumer choice. *Journal of Environmental Economics and Management*, 54(2), 129-145.

Kenne Pagui, E. C., Canale, A., 2016. Pairwise likelihood inference for multivariate ordinal responses with applications to customer satisfaction. *Applied Stochastic Models in Business and Industry*, 32, 273-282.

Kipperberg, G., 2007. A Comparison of Household Recycling Behaviors in Norway and the United States. *Environmental and Resource Economics*, 36, 215-235.

Kirakozian, A., 2016. One without the other? Behavioural and incentive policies for household waste management. *Journal of Economic Surveys*, 30(3), 526-551.

Mueller, W., 2013. The Effectiveness of Recycling Policy Options: Waste Diversion or Just Diversions?. *Waste Management*, 33(3), 508-518.

Mullahy, J., 2017. Marginal effects in multivariate probit models. *Empirical Economics*, 52(2), 447-461.

OECD, 2014. *Greening Household Behaviour - Overview from the 2011 Survey - Revised edition.* OECD Studies on Environmental Policy and Household Behaviour, OECD Publishing.

Papke, L.E., Wooldridge, J.M., 1996. Econometric methods for fractional response variables with an application to 401(k) plan participation rates. *Journal of Applied Econometrics*, 11, 619–632.

Papke, L.E., Wooldridge, J.M., 2008. Panel data methods for fractional response variables with an application to test pass rates. *Journal of Econometrics*, 145, 121-133.

Roodman, D., 2011. Estimating fully observed recursive mixed-process models with cmp. *Stata Journal*, 11(2), 159-206.

Saphores, J-D. M., Nixon, H., 2014. How effective are current household recycling policies? Results from a national survey of U.S. households. *Resources, Conservation and Recycling*, 92, 1-10

Scott, D.M., Kanaroglou, P.S., 2012. An activity-episode generation model that captures interactions between household heads: development and empirical analysis. *Transportation Research Part B: Methodological*, 36(10), 875–896.

Viscusi, W. K., Huber, J. , Bell, J. 2012. Alternative Policies to Increase Recycling of Plastic Water Bottles in the United States. *Review of Environmental Economics and Policy*, 6(2), 190-211.

A Conditional probabilities

Table 9: Conditional probabilities

		Probability of an household being a paper... nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic nonrecycler and a metal...	nonrecycler	0.603***	0.309***	0.087***
	moderate recycler	0.328***	0.442***	0.231***
	diligent recycler	0.194***	0.436***	0.370***
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.256***	0.446***	0.298***
	moderate recycler	0.140***	0.405***	0.455***
	diligent recycler	0.067***	0.311***	0.622***
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.097***	0.362***	0.541***
	moderate recycler	0.044***	0.255***	0.701***
	diligent recycler	0.008***	0.088***	0.903***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 10: Conditional probabilities

		Probability of an household being a metal... nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic nonrecycler and a paper...	nonrecycler	0.826***	0.158***	0.016***
	moderate recycler	0.631***	0.317***	0.052***
	diligent recycler	0.459***	0.427***	0.114***
given that the household is a plastic moderate recycler and a paper...	nonrecycler	0.411***	0.452***	0.137***
	moderate recycler	0.270***	0.491***	0.239***
	diligent recycler	0.149***	0.457***	0.394***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	0.129***	0.445***	0.426***
	moderate recycler	0.064***	0.347***	0.590***
	diligent recycler	0.013***	0.134***	0.852***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 11: Conditional probabilities

		Probability of an household being a plastic... nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal nonrecycler and a paper...	nonrecycler	0.834***	0.156***	0.010**
	moderate recycler	0.579***	0.369***	0.051***
	diligent recycler	0.336***	0.507***	0.157***
given that the household is a metal moderate recycler and a paper...	nonrecycler	0.436***	0.469***	0.095***
	moderate recycler	0.235***	0.542***	0.223***
	diligent recycler	0.091***	0.453***	0.456***
given that the household is a metal diligent recycler and a paper...	nonrecycler	0.155***	0.515***	0.331***
	moderate recycler	0.056***	0.386***	0.557***
	diligent recycler	0.007***	0.118***	0.874***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B Marginal effects

B.1 18-24 years old marginal effects

Table 12: 18-24 years old marginal effects on the commitment to paper recycling

		Marginal effects of being between 18 and 24 years old on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.159***	−0.106***	−0.053***
	moderate recycler	0.191***	−0.069**	−0.122***
	diligent recycler	0.163***	0.004	−0.167***
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.180***	−0.034	−0.145***
	moderate recycler	0.140***	0.044***	−0.184***
	diligent recycler	0.091**	0.104***	−0.195***
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.115***	0.079**	−0.194***
	moderate recycler	0.068**	0.118***	−0.186***
	diligent recycler	0.018**	0.079***	−0.098***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 13: 18-24 years old marginal effects on the commitment to metal recycling

		Marginal effects of being between 18 and 24 years old on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.037***	0.031***	0.006***
	moderate recycler	−0.066***	0.047***	0.019**
	diligent recycler	−0.056***	0.028***	0.027**
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.047***	0.017*	0.030***
	moderate recycler	−0.046***	−0.001	0.048***
	diligent recycler	−0.026***	−0.017**	0.043***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.027**	−0.033***	0.060***
	moderate recycler	−0.018**	−0.049***	0.068***
	diligent recycler	−0.004**	−0.021***	0.024***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 14: 18-24 years old marginal effects on the commitment to plastic recycling

		Marginal effects of being between 18 and 24 years old on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.049***	0.042***	0.006**
	moderate recycler	−0.093***	0.065***	0.028**
	diligent recycler	−0.070***	0.022	0.048***
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.067***	0.032**	0.035***
	moderate recycler	−0.059***	−0.008	0.067***
	diligent recycler	−0.025***	−0.036**	0.061***
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.043***	−0.038**	0.081***
	moderate recycler	−0.022***	−0.070***	0.092***
	diligent recycler	−0.003**	−0.024***	0.027***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.2 25-34 years old marginal effects

Table 15: 25-34 years old marginal effects on the commitment to paper recycling

		Marginal effects of being between 25 and 34 years old on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.125***	−0.079***	−0.046***
	moderate recycler	0.166***	−0.056**	−0.110***
	diligent recycler	0.142***	0.009	−0.151***
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.156***	−0.025	−0.131***
	moderate recycler	0.121***	0.044***	−0.165***
	diligent recycler	0.077***	0.094***	−0.171***
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.099***	0.074***	−0.172***
	moderate recycler	0.056***	0.103***	−0.160***
	diligent recycler	0.011***	0.048***	−0.060***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 16: 25-34 years old marginal effects on the commitment to metal recycling

		Marginal effects of being between 25 and 34 years old on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.075*	0.063*	0.012
	moderate recycler	−0.100*	0.069*	0.031
	diligent recycler	−0.086	0.041	0.045
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.077	0.026	0.051
	moderate recycler	−0.068	−0.006	0.074
	diligent recycler	−0.041	−0.033	0.074
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.041	−0.054	0.095
	moderate recycler	−0.026*	−0.076*	0.102*
	diligent recycler	−0.007*	−0.048**	0.054**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 17: 25-34 years old marginal effects on the commitment to plastic recycling

		Marginal effects of being between 25 and 34 years old on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.100**	0.086***	0.014*
	moderate recycler	−0.143***	0.096***	0.048*
	diligent recycler	−0.109**	0.025	0.084*
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.112**	0.050*	0.063*
	moderate recycler	−0.087**	−0.020	0.108**
	diligent recycler	−0.039**	−0.071*	0.109*
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.065**	−0.067**	0.131**
	moderate recycler	−0.030**	−0.110***	0.140***
	diligent recycler	−0.005**	−0.052***	0.056***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.3 35-44 years old marginal effects

Table 18: 35-44 years old marginal effects on the commitment to paper recycling

		Marginal effects of being between 35 and 44 years old on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.066**	−0.040**	−0.027**
	moderate recycler	0.086**	−0.022	−0.063**
	diligent recycler	0.068**	0.013	−0.082**
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.075**	−0.003	−0.072**
	moderate recycler	0.057**	0.031**	−0.088**
	diligent recycler	0.034**	0.051**	−0.085**
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.045**	0.046**	−0.091**
	moderate recycler	0.025**	0.058**	−0.083**
	diligent recycler	0.005**	0.025**	−0.030**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 19: 35-44 years old marginal effects on the commitment to metal recycling

		Marginal effects of being between 35 and 44 years old on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.067*	0.055**	0.012
	moderate recycler	−0.093*	0.063**	0.030
	diligent recycler	−0.087*	0.039*	0.048
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.082*	0.028	0.054
	moderate recycler	−0.069*	−0.006	0.075*
	diligent recycler	−0.044*	−0.038	0.082*
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.041*	−0.050*	0.091*
	moderate recycler	−0.025*	−0.066*	0.090**
	diligent recycler	−0.006*	−0.039**	0.046**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 20: 35-44 years old marginal effects on the commitment to plastic recycling

		Marginal effects of being between 35 and 44 years old on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.025	0.023	0.003
	moderate recycler	−0.038	0.029	0.009
	diligent recycler	−0.025	0.012	0.013
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.019	0.010	0.010
	moderate recycler	−0.019	0.000	0.020
	diligent recycler	−0.007	−0.007	0.014
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.016	−0.015	0.030
	moderate recycler	−0.009	−0.031	0.040
	diligent recycler	−0.001	−0.016	0.018

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.4 Annual income marginal effects

Table 21: Annual income marginal effects on the commitment to paper recycling

		Marginal effects of an income increase on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.013**	−0.007**	−0.005**
	moderate recycler	0.014**	−0.002	−0.011**
	diligent recycler	0.010**	0.004	−0.014**
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.012**	0.001	−0.013**
	moderate recycler	0.008**	0.006**	−0.015**
	diligent recycler	0.005**	0.009**	−0.014**
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.007**	0.008**	−0.015***
	moderate recycler	0.004**	0.009**	−0.013**
	diligent recycler	0.001**	0.005**	−0.006**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 22: Annual income marginal effects on the commitment to metal recycling

		Marginal effects of an income increase on probability of an household being a metal... nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.003**	0.003**	0.000**
	moderate recycler	−0.005**	0.004**	0.001**
	diligent recycler	−0.004**	0.002**	0.002*
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.004**	0.002	0.002**
	moderate recycler	−0.004**	0.000	0.003**
	diligent recycler	−0.002**	−0.001*	0.003**
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.002	−0.002**	0.004**
	moderate recycler	−0.001*	−0.004**	0.005**
	diligent recycler	0.000**	−0.001**	0.002**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 23: Annual income marginal effects on the commitment to plastic recycling

		Marginal effects of an income increase on probability of an household being a plastic... nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.004**	0.003**	0.000*
	moderate recycler	−0.007**	0.005**	0.002**
	diligent recycler	−0.005**	0.002**	0.003**
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.005**	0.003*	0.002**
	moderate recycler	−0.005**	0.000	0.005**
	diligent recycler	−0.002**	−0.002**	0.004**
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.004**	−0.002*	0.006**
	moderate recycler	−0.002**	−0.005**	0.007**
	diligent recycler	0.000**	−0.002**	0.002**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.5 Suburban marginal effects

Table 24: Suburban marginal effects on the commitment to paper recycling

		Marginal effects of residence being in an area described as a suburban on probability of an household being a paper... nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.070*	−0.044*	−0.026*
	moderate recycler	0.074*	−0.019	−0.055*
	diligent recycler	0.056	0.012	−0.068
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.061	−0.001	−0.060
	moderate recycler	0.046	0.027	−0.074*
	diligent recycler	0.027	0.043	−0.070
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.036	0.039	−0.076*
	moderate recycler	0.021	0.051*	−0.072*
	diligent recycler	0.005	0.030*	−0.036*

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 25: Suburban marginal effects on the commitment to metal recycling

		Marginal effects of residence being in an area described as a suburban on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.046**	0.037**	0.009*
	moderate recycler	−0.077**	0.052**	0.026**
	diligent recycler	−0.078**	0.034**	0.043*
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.076**	0.027	0.049**
	moderate recycler	−0.064**	−0.005	0.068**
	diligent recycler	−0.041**	−0.035*	0.076**
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.038**	−0.043*	0.081**
	moderate recycler	−0.022**	−0.054**	0.076**
	diligent recycler	−0.005**	−0.026**	0.030**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 26: Suburban marginal effects on the commitment to plastic recycling

		Marginal effects of residence being in an area described as a suburban on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	0.022	−0.020	−0.002
	moderate recycler	0.032	−0.023	−0.009
	diligent recycler	0.039	−0.012	−0.027
given that the household is a metal moderate recycler and a paper...	nonrecycler	0.048	−0.029	−0.018
	moderate recycler	0.034	−0.003	−0.030
	diligent recycler	0.023	0.030	−0.053
given that the household is a metal diligent recycler and a paper...	nonrecycler	0.027	0.007	−0.034
	moderate recycler	0.011	0.020	−0.031
	diligent recycler	0.003	0.022	−0.024

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.6 Living in residence for 2 to 5 years marginal effects

Table 27: Living in residence for 2 to 5 years marginal effects on the commitment to paper recycling

		Marginal effects of living in residence for 2 to 5 years on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.083**	−0.052**	−0.031**
	moderate recycler	0.079*	−0.019	−0.060**
	diligent recycler	0.067*	0.015	−0.083**
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.083**	−0.007	−0.076**
	moderate recycler	0.055*	0.031**	−0.086**
	diligent recycler	0.036*	0.057**	−0.092**
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.045*	0.043*	−0.088**
	moderate recycler	0.023	0.049*	−0.072*
	diligent recycler	0.006	0.033*	−0.039*

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 28: Living in residence for 2 to 5 years marginal effects on the commitment to metal recycling

		Marginal effects of living in residence for 2 to 5 years on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	0.058**	−0.050**	−0.008**
	moderate recycler	0.095**	−0.071**	−0.024**
	diligent recycler	0.116**	−0.068*	−0.048**
given that the household is a plastic moderate recycler and a paper...	nonrecycler	0.120**	−0.065**	−0.055**
	moderate recycler	0.104**	−0.024	−0.081**
	diligent recycler	0.084**	0.031**	−0.115***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	0.072**	0.033	−0.106**
	moderate recycler	0.042*	0.059**	−0.101**
	diligent recycler	0.013*	0.055**	−0.068**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 29: Living in residence for 2 to 5 years marginal effects on the commitment to plastic recycling

		Marginal effects of living in residence for 2 to 5 years on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.078***	0.066***	0.012**
	moderate recycler	−0.133***	0.085***	0.048***
	diligent recycler	−0.113***	0.016	0.097***
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.135***	0.058**	0.077***
	moderate recycler	−0.097***	−0.027	0.124***
	diligent recycler	−0.045***	−0.092***	0.138***
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.070***	−0.065**	0.135***
	moderate recycler	−0.030***	−0.100***	0.131***
	diligent recycler	−0.004***	−0.041***	0.045***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.7 Civic duty marginal effects

Table 30: Civic duty marginal effects on the commitment to paper recycling

		Marginal effects of civic duty being a very important motive on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	−0.030***	0.018***	0.012**
	moderate recycler	−0.020*	0.002	0.017*
	diligent recycler	−0.015*	−0.006	−0.021*
given that the household is a plastic moderate recycler and a metal...	nonrecycler	−0.018**	−0.002	0.021*
	moderate recycler	−0.012*	−0.010*	0.022*
	diligent recycler	−0.007*	−0.015*	0.022**
given that the household is a plastic diligent recycler and a metal...	nonrecycler	−0.009*	−0.013*	0.022*
	moderate recycler	−0.005*	−0.014*	0.019*
	diligent recycler	−0.002**	−0.012***	0.014***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 31: Civic duty marginal effects on the commitment to metal recycling

		Marginal effects of civic duty being a very important motive on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.022***	0.018***	0.003*
	moderate recycler	−0.025**	0.018**	0.008**
	diligent recycler	−0.027**	0.013**	0.014**
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.026**	0.011**	0.015**
	moderate recycler	−0.021**	0.000	0.021**
	diligent recycler	−0.016**	−0.012**	0.028**
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.013**	−0.013*	0.026**
	moderate recycler	−0.008**	−0.018**	0.026**
	diligent recycler	−0.003***	−0.018***	0.021***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 32: Civic duty marginal effects on the commitment to plastic recycling

		Marginal effects of civic duty being a very important motive on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.006	0.006	0.000
	moderate recycler	−0.002	0.002	0.000
	diligent recycler	−0.001	0.001	0.001
given that the household is a metal moderate recycler and a paper...	nonrecycler	0.001	0.000	0.000
	moderate recycler	0.001	0.000	−0.001
	diligent recycler	0.000	−0.001	0.001
given that the household is a metal diligent recycler and a paper...	nonrecycler	0.000	−0.001	0.000
	moderate recycler	0.000	−0.001	0.002
	diligent recycler	−0.001	−0.008*	0.009*

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.8 Flat fees marginal effects

Table 33: Flat fees marginal effects on the commitment to paper recycling

		Marginal effects of flat fees on mixed waste on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.030***	−0.015**	−0.015**
	moderate recycler	0.034**	−0.002	−0.032***
	diligent recycler	0.029**	0.015*	−0.044***
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.037***	0.005	−0.042**
	moderate recycler	0.023***	0.021**	−0.044**
	diligent recycler	0.014**	0.031**	−0.045**
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.019***	0.026**	−0.044***
	moderate recycler	0.009***	0.024**	−0.033***
	diligent recycler	0.002**	0.011***	−0.013***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 34: Flat fees marginal effects on the commitment to metal recycling

		Marginal effects of flat fees on mixed waste on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	0.027***	−0.022***	−0.005**
	moderate recycler	0.049***	−0.032***	−0.017**
	diligent recycler	0.060***	−0.025*	−0.034***
given that the household is a plastic moderate recycler and a paper...	nonrecycler	0.063***	−0.024**	−0.039**
	moderate recycler	0.050***	0.002	−0.052***
	diligent recycler	0.036**	0.032**	−0.068***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	0.031**	0.030*	−0.061***
	moderate recycler	0.017**	0.036**	−0.053***
	diligent recycler	0.004**	0.021***	−0.025***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 35: Flat fees marginal effects on the commitment to plastic recycling

		Marginal effects of flat fees on mixed waste on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.055***	0.050***	0.005*
	moderate recycler	−0.101***	0.078***	0.023**
	diligent recycler	−0.103***	0.047**	0.057**
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.111***	0.072**	0.039**
	moderate recycler	−0.095***	0.020	0.075***
	diligent recycler	−0.054**	−0.052***	0.105***
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.075**	−0.017	0.093***
	moderate recycler	−0.039**	−0.069***	0.107***
	diligent recycler	−0.007**	−0.048***	0.055***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.9 Everyday mixed waste collection marginal effects

Table 36: Everyday mixed waste collection marginal effects on the commitment to paper recycling

		Marginal effects of mixed waste being collected everyday on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.099*	−0.062*	−0.036*
	moderate recycler	0.094	−0.024	−0.070*
	diligent recycler	0.081	0.016	−0.097*
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.100*	−0.010	−0.089*
	moderate recycler	0.067	0.035*	−0.102*
	diligent recycler	0.044	0.066*	−0.110*
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.055	0.049	−0.104*
	moderate recycler	0.028	0.058	−0.085
	diligent recycler	0.008	0.039	−0.047

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 37: Everyday mixed waste collection marginal effects on the commitment to metal recycling

		Marginal effects of mixed waste being collected everyday on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	0.067**	−0.058**	−0.009**
	moderate recycler	0.111**	−0.084**	−0.027**
	diligent recycler	0.137**	−0.082*	−0.055**
given that the household is a plastic moderate recycler and a paper...	nonrecycler	0.142**	−0.079**	−0.063**
	moderate recycler	0.124**	−0.031	−0.093**
	diligent recycler	0.101**	0.032*	−0.133***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	0.087*	0.036	−0.123**
	moderate recycler	0.051*	0.068**	−0.119**
	diligent recycler	0.016*	0.065**	−0.081**

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 38: Everyday mixed waste collection marginal effects on the commitment to plastic recycling

		Marginal effects of mixed waste being collected everyday on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.093***	0.078***	0.015**
	moderate recycler	−0.156***	0.097***	0.060**
	diligent recycler	−0.131***	0.013	0.118***
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.157***	0.063**	0.094***
	moderate recycler	−0.112***	−0.037	0.149***
	diligent recycler	−0.051***	−0.111***	0.162***
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.080***	−0.081**	0.161***
	moderate recycler	−0.034***	−0.119***	0.153***
	diligent recycler	−0.005***	−0.048***	0.052***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.10 Door-to-door plastic collection marginal effects

Table 39: Door-to-door plastic collection marginal effects on the commitment to paper recycling

		Marginal effects of a door-to-door plastic collection on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.048***	−0.023***	−0.025***
	moderate recycler	0.056***	−0.001	−0.055***
	diligent recycler	0.048**	0.029**	−0.076***
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.062***	0.012	−0.073***
	moderate recycler	0.038***	0.038***	−0.076***
	diligent recycler	0.023***	0.054***	−0.077***
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.030***	0.046**	−0.076***
	moderate recycler	0.014***	0.042***	−0.057***
	diligent recycler	0.003***	0.019***	−0.023***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 40: Door-to-door plastic collection marginal effects on the commitment to metal recycling

		Marginal effects of a door-to-door plastic collection on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	0.046***	−0.036***	−0.010**
	moderate recycler	0.084***	−0.052***	−0.031***
	diligent recycler	0.100***	−0.037**	−0.063***
given that the household is a plastic moderate recycler and a paper...	nonrecycler	0.106***	−0.035**	−0.071***
	moderate recycler	0.083***	0.010	−0.093***
	diligent recycler	0.058***	0.060***	−0.118***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	0.050***	0.056**	−0.106***
	moderate recycler	0.027***	0.064***	−0.091***
	diligent recycler	0.006***	0.036***	−0.043***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 41: Door-to-door plastic collection marginal effects on the commitment to plastic recycling

		Marginal effects of a door-to-door plastic collection on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	−0.086***	0.079***	0.007**
	moderate recycler	−0.168***	0.134***	0.034***
	diligent recycler	−0.182***	0.094**	0.087***
given that the household is a metal moderate recycler and a paper...	nonrecycler	−0.189***	0.131***	0.059***
	moderate recycler	−0.172***	0.055*	0.117***
	diligent recycler	−0.104***	−0.071***	0.176***
given that the household is a metal diligent recycler and a paper...	nonrecycler	−0.141***	−0.008	0.149***
	moderate recycler	−0.077***	−0.106***	0.183***
	diligent recycler	−0.015**	−0.086***	0.101***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.11 Door-to-door metal collection marginal effects

Table 42: Door-to-door metal collection marginal effects on the commitment to paper recycling

		Marginal effects of a door-to-door metal collection on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	0.047***	−0.024***	−0.023***
	moderate recycler	0.073***	−0.006	−0.067***
	diligent recycler	0.049***	0.024	−0.073***
given that the household is a plastic moderate recycler and a metal...	nonrecycler	0.046***	0.012*	−0.058***
	moderate recycler	0.039***	0.039***	−0.078***
	diligent recycler	0.020***	0.043***	−0.063***
given that the household is a plastic diligent recycler and a metal...	nonrecycler	0.028**	0.048***	−0.077***
	moderate recycler	0.017***	0.058***	−0.075***
	diligent recycler	0.003***	0.024***	−0.028***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 43: Door-to-door metal collection marginal effects on the commitment to metal recycling

		Marginal effects of a door-to-door metal collection on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	−0.115***	0.102***	0.013***
	moderate recycler	−0.210***	0.169***	0.041***
	diligent recycler	−0.258***	0.173***	0.084***
given that the household is a plastic moderate recycler and a paper...	nonrecycler	−0.266***	0.166***	0.099***
	moderate recycler	−0.259***	0.101***	0.157***
	diligent recycler	−0.209***	−0.013	0.222***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	−0.198***	−0.033	0.231***
	moderate recycler	−0.134***	−0.123***	0.257***
	diligent recycler	−0.041***	−0.127***	0.168***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 44: Door-to-door metal collection marginal effects on the commitment to plastic recycling

		Marginal effects of a door-to-door metal collection on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	0.063***	−0.052***	−0.011***
	moderate recycler	0.113***	−0.068***	−0.045***
	diligent recycler	0.116***	−0.004	−0.112***
given that the household is a metal moderate recycler and a paper...	nonrecycler	0.155***	−0.065***	−0.089***
	moderate recycler	0.105***	0.031	−0.136***
	diligent recycler	0.053***	0.122***	−0.175***
given that the household is a metal diligent recycler and a paper...	nonrecycler	0.076***	0.068**	−0.144***
	moderate recycler	0.031***	0.099***	−0.130***
	diligent recycler	0.005***	0.050***	−0.055***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

B.12 Door-to-door paper collection marginal effects

Table 45: Door-to-door paper collection marginal effects on the commitment to paper recycling

		Marginal effects of a door-to-door paper collection on probability of an household being a paper...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a metal...	nonrecycler	−0.193***	0.132***	0.061***
	moderate recycler	−0.239***	0.097***	0.143***
	diligent recycler	−0.211***	0.010	0.201***
given that the household is a plastic moderate recycler and a metal...	nonrecycler	−0.229***	0.056*	0.173***
	moderate recycler	−0.183***	−0.040**	0.224***
	diligent recycler	−0.123***	−0.120***	0.243***
given that the household is a plastic diligent recycler and a metal...	nonrecycler	−0.153***	−0.086**	0.238***
	moderate recycler	−0.093***	−0.142***	0.235***
	diligent recycler	−0.026***	−0.103***	0.129***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 46: Door-to-door paper collection marginal effects on the commitment to metal recycling

		Marginal effects of a door-to-door paper collection on probability of an household being a metal...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a plastic non recycler and a paper...	nonrecycler	0.046***	−0.038***	−0.008***
	moderate recycler	0.083***	−0.058***	−0.025**
	diligent recycler	0.069***	−0.035***	−0.035**
given that the household is a plastic moderate recycler and a paper...	nonrecycler	0.058***	−0.020*	−0.038***
	moderate recycler	0.057***	0.003	−0.060***
	diligent recycler	0.032***	0.023**	−0.055***
given that the household is a plastic diligent recycler and a paper...	nonrecycler	0.034**	0.042***	−0.076***
	moderate recycler	0.022**	0.062***	−0.084***
	diligent recycler	0.004***	0.026***	−0.031***

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 47: Door-to-door paper collection marginal effects on the commitment to plastic recycling

		Marginal effects of a door-to-door paper collection on probability of an household being a plastic...		
		nonrecycler...	moderate recycler...	diligent recycler...
given that the household is a metal non recycler and a paper...	nonrecycler	0.060***	−0.052***	−0.008**
	moderate recycler	0.117***	−0.080***	−0.037***
	diligent recycler	0.086***	−0.024	−0.062***
given that the household is a metal moderate recycler and a paper...	nonrecycler	0.083***	−0.038**	−0.045***
	moderate recycler	0.072***	0.013	−0.085***
	diligent recycler	0.030***	0.047***	−0.078***
given that the household is a metal diligent recycler and a paper...	nonrecycler	0.052***	0.050***	−0.101***
	moderate recycler	0.026***	0.089***	−0.114***
	diligent recycler	0.003***	0.031***	−0.034***

* Significant at 10%; ** significant at 5%; *** significant at 1%.